Energy Audit on College Campus

Prepared by

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CERTIFICATE

This is to certify that the Dissertation Report entitled, **"Energy Audit on College Campus"** by **Mr. Mrinmoy Halder,** a student of **M.Tech, 4th Sem**, in **Electrical Engineering** having **Roll No.21101202006, Registration No. 211010413310008 of 2021-22**, submitted to the department of **Electrical Engineering**, **Jalpaiguri Government Engineering College**, **Jalpaiguri, India**, is a record of bonafide project work carried out by him under my supervision and guidance and is worthy of consideration for the award of the degree of **Master of Technology in Electrical Engineering** with Specialization in **"Power Electronics & Drives"** of the Institute.

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MESSAGE

I take immense pleasure in certifying **Mrinmoy Halder** bearing **Roll No. 21101202006**, **Registration No. 211010413310008**, final year student of Master of Technology from the **Department of Electrical Engineering**, **Jalpaiguri Government Engineering College**, for his dissertation entitled, **"Energy Audit on college campus"** carried out under the supervision of **Dr. Subrata Majumdar, Dr. Goutam Kumar Panda & Prof Shubhasish Sarkar** a distinguished faculty member in the Department of Electrical Engineering**.** This project report has been prepared towards partial fulfillment of conditions that will enable him to obtain the degree of **"Master of Technology" in Electrical Engineering (Specialization in Power Electronics & Drives**) from **"Jalpaiguri Government Engineering College**". This report is not only a bonafide record but also true testimony of the potential and efforts put in him.

I think he will be able to deal efficiently with such problems in practice. I wish them all success in all their future endeavors.

……………………………………………

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Abstract:

An energy audit is an examination, survey, and analysis of energy flows for energy conservation in a building, process, or system to reduce the quantity of energy input into the system without influencing its output. Priority is given to reducing energy consumption while maintaining or enhancing human comfort, health, and safety when the subject of study is an occupied building. In addition to identifying the sources of energy consumption, an energy audit attempts to rank the energy uses from most cost-effective to least cost-effective energy savings opportunities.

An energy audit is an important component of a systematic approach to energy management decision-making processes. It attempts to balance total energy inputs and outputs and identifies all energy streams within a building. It quantifies energy consumption based on discrete functions. An energy audit is a useful instrument for defining and pursuing comprehensive energy management in order to accomplish and maintain optimal energy procurement and utilization across the organization.

Through this initiative, we can prioritize the energy use on our college campus based on the greatest to least cost-effective opportunities for energy savings.

Abbreviations:

W	Watts
V	Volts
AC	Air conditioners
PF	Power factor
LF	Load factors
MF	Maintenance factors
UF	Utilization factor
TV	Television
MJ/kg	Mega-joules per kilogram
DG	Diesel generator
kWh	Kilowatt hour
KVA	Kilovolt ampere
KW	Kilowatts
MW	Megawatt
MVCA	Marginal variable cost adjustment
Reb	Rebate
Asst.	Assistant
Prof	Professor
Dr	Doctor
LED	Light Emitting Diode
FLT	Fluorescent Tube Light
CRT	Cathode Ray Tube
LPG	Liquefied petroleum gas
LUX	Luminous flux per unit area
MVCA	Monthly Variable Cost Adjustment
MWH	Metered capacity value adder
KVAH	Megawatt
KV	Kilo volt ampere hour
MVA	Kilovolt- Ampere
ED.	Mega volt Ampere
EC	Electricity duty
LPSC	Energy charge
	Late payment surcharge

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Chapter 1
Introduction

1.1 Introduction

An energy audit is a comprehensive examination, evaluation, and analysis of energy transfers inside a structure or system, with the aim of achieving energy conservation. The primary objective is to minimize the energy input required by the system while ensuring that the system's output remains unaffected.

According to the Energy Conservation Act of 2001, the concept of Energy Audit is delineated as the process of verifying, monitoring, and analyzing energy utilization. This entails the submission of a comprehensive technical report that encompasses recommendations for enhancing energy efficiency, accompanied by a cost-benefit analysis and an action plan aimed at diminishing energy consumption.

The use of this strategy has shown to be highly efficient and tangible in facilitating swift enhancements in energy efficiency within both building and industrial contexts. The initial phase in the process of discovering ways to decrease energy expenses. A systematic method comprises a series of phases. Energy auditing, also known as energy assessment or energy survey, refers to the process of evaluating and analyzing energy consumption and efficiency in a particular system or facility.

1.2 Objectives:

- Determine what can be done to reduce energy consumption throughout the campus and what options are available for system improvements if funding is available.
- Observation of the energy consumption of the Collecting of data.
- Review and analysis wastage of energy and energy conservation.
- Identify and evaluate measures that could enhance the environmental performance of the campus, such as energy-efficient devices, loss minimization, and the optimization of campus uses.
- Maintenance of all equipment.
- Provide recommendations.
- Cost analysis of the audit.

1.3 Literature review:

This analysis is based on various Energy Audit-related sources. The literature shows the work accomplished in the field of energy auditing and management. The purpose of this analysis is to identify the researchers' contribution to the energy audit and their work.

[1] Manoj Kumar Lamba and Abhishek Sanghi conducted an energy audit on an academic building in order to investigate and analyze the building's energy flow. In their work, they have discussed ways to conserve energy through effective utilization, the potential for energy savings, and the significance of implementing energy-saving methods. This audit's methodology included data collection, data analysis, and recommendations. It was determined that, among all electrical loads, lightning loads and personal computers consume the most energy, at 36% and 44%, respectively. To determine how much energy can be saved by replacing appliances with more energy-efficient components, energy-saving calculations were performed. For each recommendation, the investment cost and capital cost recovery period (payback period) were also calculated. It was determined that by replacing all 12,465 conventional ballast (choke) FTL on campus with electronic ballast (choke) FTL, 311126.4 kWh can be saved annually. An investment of Rs. 1869750 with a repayment period of 0.7 years will yield annual savings of Rs. 2,644,574.4. This document also suggests replacing CRT monitors with LCD monitors, replacing geysers with a solar water heating system, and installing motion sensors in corridors and restrooms to automatically turn off the lights when no one is present. there are no other movements and additional suggestions made in this paper.

[2] In their paper on energy auditing of an educational institution, Ramya L. N. and M. A. Femina emphasize the significance of auditing by comparing the results of conventional illumination load replacement with energy-efficient lamps. Their paper emphasizes the fact that more energy is lost than is used for illumination. Lightning loads utilize more than twenty percent of a facility's total energy. By replacing traditional fluorescent tube lighting with CFLs or LEDs, significant energy conservation and cost savings can be achieved. The facility in question has 350 40-watt lamps that consume approximately 2,464 kWh per month. The 40 W fluorescent units can be substituted with 12 W CFLs or 5 W LEDs that provide an equivalent quantity of illumination without affecting consumer demand. If tube lamps are replaced with CFLs, the monthly energy consumption will decrease to 739.2 kWh. If replaced with LEDs, the monthly energy usage will decrease to 308 kWh. If tube lights were replaced with CFLs or LEDs, the monthly energy cost would be approximately Rs. 3696, and the CFL and LED repayment periods were calculated to be 5.2 and 8.1 months, respectively. Other recommendations included well-lit classrooms with insulated ceilings, turning off superfluous electrical appliances, setting timers for air conditioning units, using computers at the optimal luminance level of 15 to 30 percent, and using sensor-based automated lighting and ventilation.

[3] Sachin P. Parthe and Santosh Kompeli performed an energy audit on the Kohler Power India facility in Aurangabad. Kohler is a manufacturing concern established in 1873 in Kohler, Wisconsin. Although the business is best known for its plumbing products, it also produces engines, furniture, tile, generators, and cabinetry. In this paper, a preliminary energy audit of the Kohler facility in Aurangabad was conducted and energy-saving ideas were identified. The business utilized 250-watt sodium vapor lanterns as floodlights on the shop floor. It was suggested that conventional lighting be replaced with LED lamps of equivalent brightness. Calculated annual savings per lamp were Rs. 5832, with a repayment period of 1.4 years per lamp. It was determined that 240 Sodium vapor lamps saved a total of 43,2 kW of energy. The next opportunity for energy savings was identified in blowers. It was suggested that VFDs (variable frequency drives) be used to reduce electric power usage. By utilizing VFD, the business can save 4,069 kWh per month. It was also observed that conventional blowers were used to provide cool air for keeping the engine assembly section dust-free. Converting these

blowers to an advanced ambient air blower is the most efficient method for reducing energy consumption in this situation. By replacing the existing conventional ventilation system with an advanced circulating air system, monthly cost savings of Rs. 10,653 and unit savings of 78 kWh were calculated. With the aid of this energy audit, the plant's average total power consumption decreased by 20% compared to its previous consumption levels.

[4] In their paper, Gousia Sultana and Harsha.H.U. describe the energy audit conducted at the Nandi Institute of Technology and Management (NIT&MS) in Bangalore, Karnataka, India. Due to the fact that the campus's electricity account had exceeded Rs. 1,90,000 in the year preceding the energy audit, the purpose of the initiative was to investigate the campus's energy consumption. The objective was to collect in-depth information on energy-consuming activities and assess potential energy-saving opportunities. The objective was to attain energy savings of 20% to 60%. Consequently, extensive data was collected through observation, measurements, and interviews with key individuals during the preliminary data collection phase. The collected data was analyzed in depth. On the basis of the findings of a data analysis, measures were taken to reduce energy consumption. Energy-saving recommendations included replacing the conventional choke of every Tube Fluorescent Lamp (TFL) with an electronic choke, installing motion detectors in corridors and restrooms, avoiding the use of photocopiers when not in use, replacing all FTL with LED lights of equal output, replacing all laser printers with ink-jet printers, and replacing CRT computer monitors with LCD monitors. The total required investment would amount to Rs. 2,42,062. After a thorough audit, it was determined that implementing the recommendations would result in 41.66 percent energy savings and 30.6 percent cost savings, and the return periods for various appliances were calculated.

[5] M. Patel, A. Upadhyay, F. Battaglia, F. Singer, and M. Ohadi's paper "Energy Audit of Data Centers and Server Rooms on an Academic Campus—A Case Study" from the 2019 IEEE Intersociety Conference on Thermal and Thermo-mechanical Phenomena in Electronic Systems in Las Vegas, USA The study discusses the urgent need for energy efficiency improvements in university campus data centers and server rooms. Data centers are vital to contemporary technology; hence, energy usage has become a focus for optimization. A thorough analysis is conducted to assess energy use trends, identify inefficiencies, and provide remedies. The empirical technique of performing an energy audit on an academic campus is a strength of the study. A case study technique gives the writers practical insights into data center and server room energy utilization. This technique provides real-world data to better understand energy usage trends and variables. The research evaluates energy use using several energy audit methods. The authors may identify issues by studying data center architecture, cooling systems, and server equipment. They go beyond energy usage to find the causes of inefficiency. This multifaceted approach includes technical and operational factors to analyze energy utilization. The report also emphasizes the role of technology in reducing energy use. Modern cooling, equipment consolidation, and virtualization may minimize energy use while preserving operating performance, according to the authors. The study emphasizes the need for a dynamic energy efficiency strategy that adapts to changing technology by incorporating cutting-edge technologies. Case Study" addresses the crucial problem of data center and server room energy use. The paper's empirical methodology, rigorous research, and focus on technical innovation help explain energy efficiency in this setting. This study helps optimize data center energy use for sustainability and cost-effectiveness as data centers become more important in our digital era.

[6] TA Gudluru, A. Upadhyay, S. Okam, F. Battaglia, F. Singer, and M. Ohadi, "Energy Audit of Academic Campus Data Centers and Server Rooms: Impact of Energy Conservation Measures, With the growth of digital infrastructure, data centers and server rooms are major energy users. To reduce environmental consequences and improve operating costs, these institutions must pursue energy efficiency. The 2020 IEEE Intersociety Conference on Thermal and Thermo-mechanical Phenomena in Electronic Systems in Orlando, USA, featured T. A. Gudluru, A. Upadhyay, S. Okam, F. Battaglia, F. Singer, and M. Ohadi's paper "Energy Audit of Data Centers and Server Rooms on an Academic Campus:" Impact of Energy Conservation

Measures".The research examines how energy conservation measures (ECMs) at academic institution data centers and server rooms affect them. The authors expand their energy audit research to give practical energy efficiency advice by examining these metrics. The work builds on previous research by the same authors and focuses on energy conservation's practical applications. The case studies provide useful real-world insight into ECM implementation results. This method evaluates qualitative and quantitative results to fully comprehend energy efficiency projects' pros and cons. The authors evaluate ECMs' concrete results through data collection, analysis, and modeling. The research examines enhanced cooling, equipment optimization, and operational modifications. The study helps data center operators and facility managers balance energy consumption with operational needs by measuring energy savings and performance improvements. Energy savings and operational trade-offs are the paper's main contributions. Energy efficiency techniques may affect thermal management, equipment dependability, and maintenance, according to the authors. The report addresses these difficulties to provide a more nuanced view of ECM implementation, aligning energy conservation measures with operational objectives. Impact of Energy Conservation Measures" contributes to data center energy efficiency discussions. The case study emphasizes the necessity of practical insights and quantitative results for assessing ECMs. The research helps data centers and server rooms make energy efficiency decisions by assessing the various effects of energy conservation techniques.

[7] College Campus Energy Audit Written by Akshaya, Deepika, Gayathri, Hingish, and Pazhanimuthu Energy efficiency and sustainability have become popular in many industries, including education. Colleges and universities are realizing the necessity of energy management to save costs, decrease environmental impact, and green the future. This literature review discusses college campus energy audits, their relevance, methods, and possible effects. The article "Energy Audit on a College Campus" may examine how energy audits might be used to analyze and optimize college energy use. Energy audits examine energy use, equipment efficiency, building systems, and operations. This rigorous analysis informs energy efficiency decisions. The writers may underline college energy audits' interdisciplinary character. Engineering, architecture, environmental science, and behavioral studies professionals collaborate on such audits. This multidisciplinary method evaluates technological elements, structural design, user behavior, and building operations. Energy audit techniques are key to the paper's emphasis. Metering and monitoring, on-site equipment and system examinations, energy bill analysis, and computer simulations to simulate energy usage trends are examples. The paper may explore the pros and cons of different strategies and the necessity of choosing the best one for the school. Energy audit advantages are predicted to be a major contribution to the study. These advantages go beyond energy cost reduction to include environmental stewardship and institutional sustainability. Energy audits may identify energy-saving options that minimize carbon emissions and environmental impacts. The writers may also discuss college energy audit issues and obstacles. Financial restrictions, lack of understanding, opposition to change, and the need for continuing monitoring and maintenance to preserve energy efficiency advances may be some of these issues. The paper's results may emphasize energy audits' strategic value for institutions seeking energy efficiency and sustainability. Energy audits help colleges become environmentally friendly and resource-efficient by finding energy waste, suggesting solutions, and promoting energy awareness. The theme emphasizes energy audits' significance in promoting energy efficiency, cost reduction, and sustainability on college campuses.

CHAPTER 2

Energy Audit

2.1 Definition

An energy audit refers to a systematic and thorough procedure that involves evaluating, analyzing, and enhancing the energy consumption and effectiveness of a system, institution, or organization. The process entails a comprehensive analysis of different components, equipment, and operational processes that consume energy, with the aim of identifying potential avenues for enhancing energy efficiency, decreasing consumption, and mitigating related expenses. The primary objective of an energy audit is to optimize resource efficiency, foster sustainability, and actively participate in environmental stewardship. The energy audit process comprises many essential steps, all of which contribute to a comprehensive comprehension of energy use and possible avenues for enhancement. The process of data collecting is an essential first stage, encompassing the acquisition of comprehensive information, including energy bills, utility prices, occupancy patterns, and operating schedules. The provided fundamental data functions as a fundamental reference point for evaluating energy usage and efficiency. After the collection of data, on-site evaluations are carried out to examine and analyze the physical infrastructure, encompassing buildings, HVAC (heating, ventilation, and air conditioning) systems, lighting, appliances, and industrial processes. These evaluations frequently utilize many methods, including thermography, metering, and instrumentation, in order to identify concealed inefficiencies, equipment failures, and instances of energy wasting. The present research pertains to the examination of historical data on energy use, with the aim of identifying patterns, trends, and periods of peak demand. This research facilitates auditors in comprehending the many elements that contribute to elevated energy usage, hence providing valuable insights for the formulation of focused initiatives aimed at enhancing energy efficiency. In addition to evaluating energy consumption, an energy audit encompasses the practice of benchmarking, which entails comparing the energy efficiency of the audited system or facility to established industry standards or comparable entities. This enables the detection of departures from optimal practices and supports the establishment of attainable objectives for improvements in energy efficiency. The crux of an energy audit is in the discernment of options for conserving energy. Auditors conduct a thorough examination of data and observations in order to identify precise actions that may be implemented to enhance energy efficiency. Potential steps that might be implemented encompass the enhancement of lighting systems by substituting them with energy-efficient alternatives, the adoption of modern HVAC controls, the insulation of buildings to mitigate heat loss, and the incorporation of renewable energy sources such as solar panels or wind turbines. The findings of the energy audit are often conveyed through a comprehensive report. The present document presents an overview of the discoveries, suggested measures, approximate expenses, possible energy conservation, and anticipated return on investment timeframes for each recognized possibility. The document functions as a strategic guide for those in positions of authority, providing them with direction in the process of determining and executing energy-conservation initiatives that are in line with the objectives and financial considerations of the business. Significantly, an energy audit extends its scope beyond technological elements and incorporates an examination of human behavior and operational methods. The process may entail active involvement with building occupants and staff members to encourage the cultivation of energy-conscious behaviors, with the implementation of training initiatives aimed at fostering the long-term adoption of energy-efficient practices. In summary, an energy audit is a thorough assessment that is beyond a basic examination of energy use. The deliberate and educated approach to maximizing energy use, saving expenses, and contributing to environmental sustainability is considered a crucial endeavor. Through the identification of inefficiencies and the proposal of actionable solutions, an energy audit enables us to undertake concrete measures toward achieving a future that is both energy-efficient and ecologically responsible.

2.3 Audit Methods

Thus Energy Audit Can be classified into the Following Types:
I. Preliminary Audit
II. Detailed Audit

2.3 Preliminary Energy Audit Methodology

Preliminary Energy Audit is relatively quick Exercise to:
Establish energy consumption in the organization
Identify areas for more detailed study/Measurement
Preliminary Energy audit uses existing. Or easily obtain data

2.4 Detailed Energy Audit

A complete audit encompasses an exhaustive evaluation of all key energy-consuming systems inside a facility, hence yielding a detailed energy project execution plan.
This particular form of audit provides the most precise assessment of energy conservation and associated expenses. The analysis takes into consideration the synergistic impacts of all projects, including the energy consumption of all significant equipment, and provides comprehensive projections for energy cost savings and project expenses.
The energy balance is a crucial component in conducting a thorough audit. The present analysis relies on an inventory of energy-utilizing ms, underlying assumptions on prevailing operational circumstances, and computations pertaining to energy consumption. The predicted usage is thereafter juxtaposed with the costs reflected on the power bill.
Phase I- Pre Audit Phase
Phase II- Audit Phase
Phase III- Post Audit Phase

CHAPTER 3

Instruments Utilized in the Energy Audit

3.1 Introduction:

The conduction of an energy audit mandates the utilization of diverse measuring instruments, driven by the imperative to identify and assess energy components. These instruments, essential for the audit process, need to exhibit portability, durability, user-friendliness, and cost-effectiveness. Key parameters routinely monitored in the context of an energy audit encompass power factor (pf), energy consumption, voltages (V), currents (I), as well as light intensity, among others. The incorporation of these standards facilitates a comprehensive evaluation of energy utilization and paves the way for informed decision-making.

3.2 Lux Meter:

A Lux meter is employed for quantifying light levels. It comprises a photocell that transforms light into calibrated electrical impulses, thereby determining Lux measurements.

Figure 3. 1 Lux Meter

3.3 Measuring Tape:

For measuring length and width, a flexible tool known as a measuring tape is employed. This instrument, often referred to as a tape measure, is crafted from materials like plastic, metal strips, fiberglass, and fabric. It features markings denoted in centimetre's, inches, meters, and feet.

Figure 3. 2: Measuring Tape

3.4 Energy Meters

An electricity meter, electric meter, electrical meter, or energy meter is a device designed to measure the quantity of electric energy consumed by a residence, a business, or an electrically powered device.

Electric utilities employ electric meters that are installed at customers' premises for the purpose of measuring the electric energy supplied to customers, which is subsequently used for billing. These meters are generally calibrated in units of billing, with the most prevalent unit being the kilowatt-hour [kWh]. They are typically read once during each billing cycle.

In cases where energy conservation is desired during specific time periods, certain meters may also measure demand—the peak power usage within a given interval. "Time of day" metering facilitates the adjustment of electric rates over the course of a day, enabling the recording of usage during both high-cost peak periods and lower-cost off-peak periods. Moreover, some regions utilize meters equipped with relays to implement demand response load shedding during instances of peak load.

By facilitating accurate measurement and providing insights into energy usage patterns, these meters play a crucial role in effective energy management and cost optimization.

Figure 3. 4 : Energy Meter

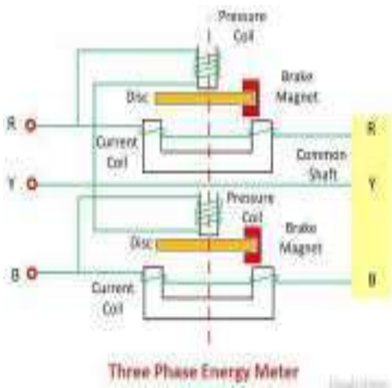


Figure 3. 3: Constructional Diagram of Energy meter

CHAPTER 4
SUPPLY AND CONSUMPTION DETAILS

4.1 Supply Details

At our institution, the college campus is provided with an 11KV power supply from the West Bengal State Electricity Board. To facilitate the appropriate voltage levels for campus usage, a Step-down transformer is employed to convert the 11KV supply to 415V. Additionally, we own two Diesel Generator as a contingency measure in the event of any disruption to the West Bengal State Electricity Board (Wbsedcl) supply or the occurrence of a power loss. The utilization of a diesel generator is seen. Additionally, various protective devices such as relays, breakers, and fuses are employed.

4.2 Consumption Details:

Table 4. 1: Details of monthly consumption

	Monthly energy consumption (Kwh)	Total electricity cost (Rs)
April, 2022	63125	53568.31
May	70970	585825.90
June	81825	653393.92
July	72905	582885.27
August	68885	567079.75
September	79045	630951.91
October	72615	589072.00
November	39420	379823.85
December	54045	471318.19
January	54910	476992.68
February	63085	530621.50
March	47365	429140.97
Total	768195	5950674

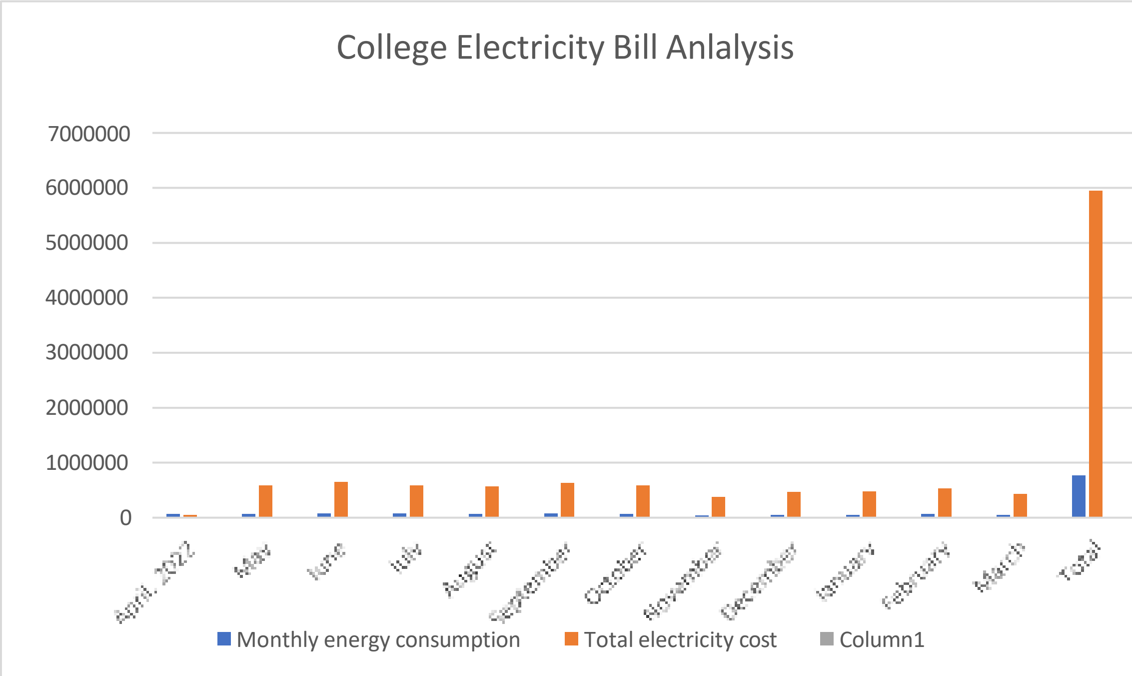


Figure 4. 1: Yearly Consumption Graph

Energy Consumption Analysis (Previous Year – 2022-2023)

The energy consumption for the preceding year (2022-2023) is depicted in the graph above. During this period, the average power factor was 0.95. Notably, the average monthly consumption for the year was measured at 62323 KWh. Consequently, the corresponding average energy cost for each month is estimated to amount to Rs 536074/-. Furthermore, the highest recorded demand within a month peaked at 26.58 KVA.

Upon examination of the graph, it becomes evident that June stands out as a month of heightened energy consumption. This increase can be attributed to the ongoing other activities. In contrast, the month of April registers a significant reduction in energy consumption. This decline is linked to the occurrence of some reason, leading to a decrease in power usage during this period.

Energy charges as per West Bengal State Electricity Board as follows:-

Normal Time: 6.40 per kWh

Peak time: 9.50 per kWh

Off-peak: 4.80 per kWh

Chapter 5
Load Details

5.1 Main building Analysis:

Table 5. 1: Analysis for Total Consumption For light

Table 5.1.1 Administrative Department

Sl no	Rating of light	No of lights	Total Wattage	KW
1	36	116	4176	4.176
2	40	72	2880	2.88
3	20	49	980	0.98
4	9	12	108	0.108
5	6	3	18	0.018
6	90	0	0	0
7	23	0	0	0

Table 5.1.2 Electrical department

Sl no	Rating of light	No of lights	Total Wattage	KW
1	36	37	1332	1.332
2	40	40	1600	1.6
3	20	103	2060	2.06
4	9	3	27	0.027
5	6	0	0	0
6	90	0	0	0
7	23	0	0	0

Table 5.1.3 Civil department

Sl no	Rating of light	No of lights	Total Wattage	KW
1	36	40	1440	1.44
2	40	47	1880	1.88
3	20	20	400	0.4
4	9	0	0	0
5	6	0	0	0
6	90	4	360	0.36
7	23	0	0	0

Table 5.1.4 Mechanical department

Sl no	Rating of light	No of lights	Total Wattage	KW
1	36	37	1332	1.332
2	40	50	2000	2
3	20	34	680	0.68
4	9	11	99	0.099
5	6	0	0	0
6	90	0	0	0
7	23	0	0	0

Table 5.1.4 Electronics & Communication Department				
Sl no	Rating of light	No of lights	Total Wattage	KW
1	36	40	1440	1.44
2	40	24	960	0.96
3	20	16	320	0.32
4	9	0	0	0
5	6	0	0	0
6	90	0	0	0
7	23	0	0	0

Table 5.1.5 Computer science department				
Sl no	Rating of light	No of lights	Total Wattage	KW
1	36	28	1008	1.008
2	40	77	3080	3.08
3	20	19	380	0.38
4	9	0	0	0
5	6	0	0	0
6	90	0	0	0
7	23	18	414	0.414

Table 5.1.5 Information technology department				
Sl no	Rating of light	No of lights	Total Wattage	KW
1	36	15	540	0.54
2	40	18	720	0.72
3	20	25	500	0.5
4	9	0	0	0
5	6	0	0	0
6	90	0	0	0
7	23	0	0	0

Table 5.1.6 Basic science & humanities dept.				
Sl no	Rating of light	No of lights	Total Wattage	KW
1	36	15	540	0.54
2	40	19	760	0.76
3	20	22	440	0.44
4	9	0	0	0
5	6	0	0	0
6	90	0	0	0
7	23	0	0	0

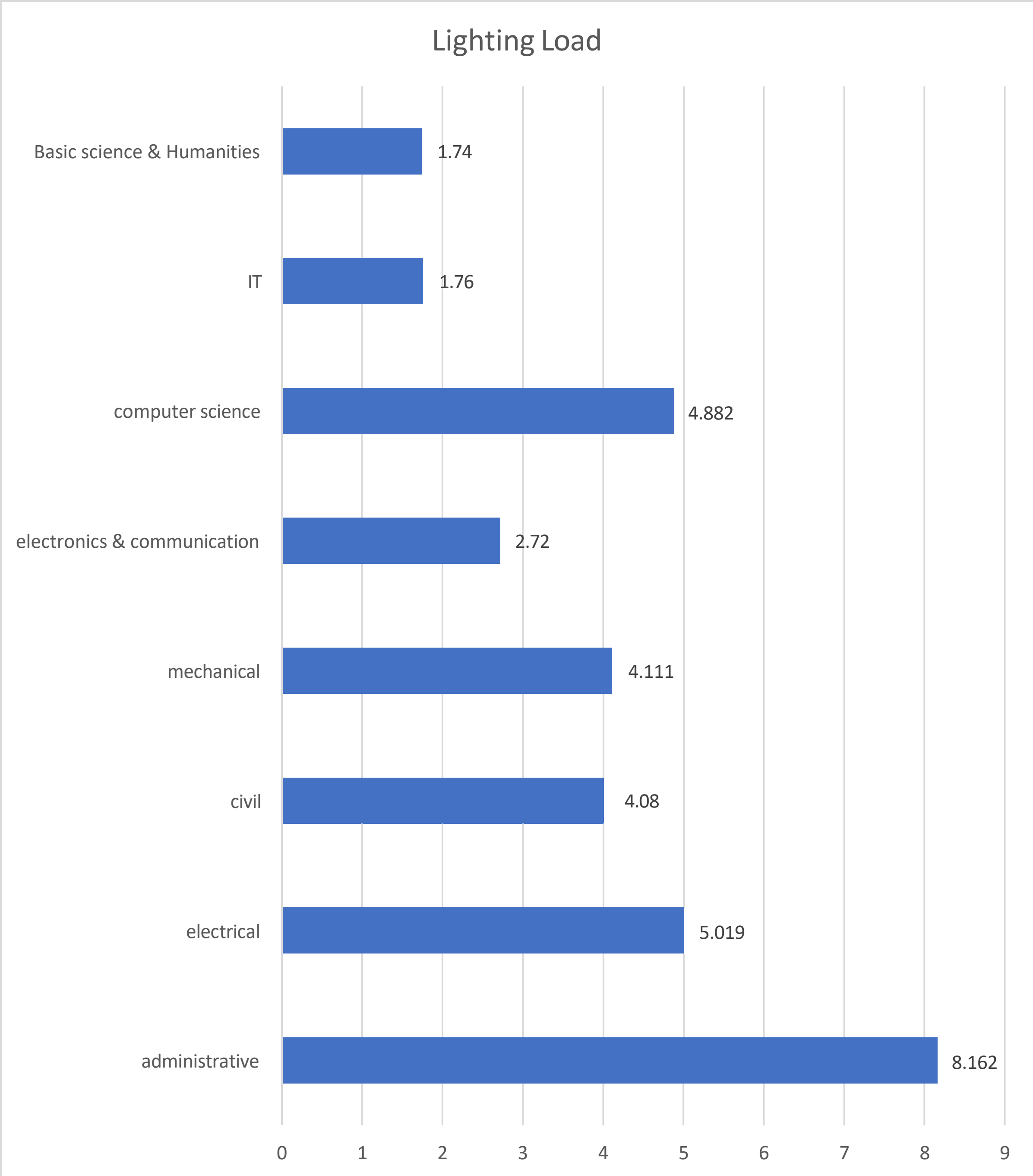


Figure 5. 1: Analysis for Total Consumption of light

5.2 Analysis of fan load:

Table 5. 2**:** For total Consumption of Fan:

Table 5.2.1 Administrative Department

Sl no	Rating of fan	No of lights	Total Wattage	KW
	Ceiling fan 60W	42	2520	2.52
2	Ceiling fan 100W	21	2100	2.1
3	Ceiling fan 80W	27	2160	2.16
4	Ceiling fan 68W	0	0	0
5	Ceiling fan 58W	0	0	0
6	Pedestal fan 45W	12	540	0.54
7	Exhaust fan	2	200	0.2

Table 5.2.2 Electrical department

Sl no	Rating of fan	No of lights	Total Wattage	KW
1	Ceiling fan 60W	82	4920	4.92
2	Ceiling fan 100W	8	800	0.8
3	Ceiling fan 80W	31	2480	2.48
4	Ceiling fan 68W	0	0	0
5	Ceiling fan 58W	0	0	0
6	Pedestal fan 45W	10	450	0.45
7	Exhaust fan	0	0	0

Table 5.2.3 Civil department

Sl no	Rating of fan	No of lights	Total Wattage	KW
1	Ceiling fan 60W	33	1980	1.98
2	Ceiling fan 100W	26	2600	2.6
3	Ceiling fan 80W	10	800	0.8
4	Ceiling fan 68W	0	0	0
5	Ceiling fan 58W	0	0	0
6	Pedestal fan 45W	0	0	0
7	Exhaust fan	0	0	0

Table 5.2.4 Mechanical department

Sl no	Rating of fan	No of lights	Total Wattage	KW
1	Ceiling fan 60W	30	1800	1.8
2	Ceiling fan 100W	24	2400	2.4
3	Ceiling fan 80W	20	1600	1.6
4	Ceiling fan 68W	2	136	0.136
5	Ceiling fan 58W	1	58	0.058
6	Pedestal fan 45W	5	225	0.225
7	Exhaust fan	0	0	0

Table 5.2.5 Electronics & Communication department				
Sl no	Rating of fan	No of lights	Total Wattage	KW
1	Ceiling fan 60W	21	1260	1.26
2	Ceiling fan 100W	3	300	0.3
3	Ceiling fan 80W	33	2640	2.64
4	Ceiling fan 68W	0	0	0
5	Ceiling fan 58W	0	0	0
6	Pedestal fan 45W	5	225	0.225
7	Exhaust fan	0	0	0

Table 5.2.6 Computer science department				
Sl no	Rating of fan	No of lights	Total Wattage	KW
1	Ceiling fan 60W	21	1260	1.26
2	Ceiling fan 100W	3	300	0.3
3	Ceiling fan 80W	33	2640	2.64
4	Ceiling fan 68W	0	0	0
5	Ceiling fan 58W	0	0	0
6	Pedestal fan 45W	5	225	0.225
7	Exhaust fan	0	0	0

Table 5.2.7 Information technology department				
Sl no	Rating of fan	No of lights	Total Wattage	KW
1	Ceiling fan 60W	31	1860	1.86
2	Ceiling fan 100W	4	400	0.4
3	Ceiling fan 80W	4	320	0.32
4	Ceiling fan 68W	0	0	0
5	Ceiling fan 58W	0	0	0
6	Pedestal fan 45W	0	0	0
7	Exhaust fan	0	0	0

Table 5.2.8 Basic science & humanities dept.				
Sl no	Rating of fan	No of lights	Total Wattage	KW
1	Ceiling fan 60W	10	600	0.6
2	Ceiling fan 100W	1	100	0.1
3	Ceiling fan 80W	9	720	0.72
4	Ceiling fan 68W	0	0	0
5	Ceiling fan 58W	0	0	0
6	Pedestal fan 45W	5	225	0.225
7	Exhaust fan	0	0	0

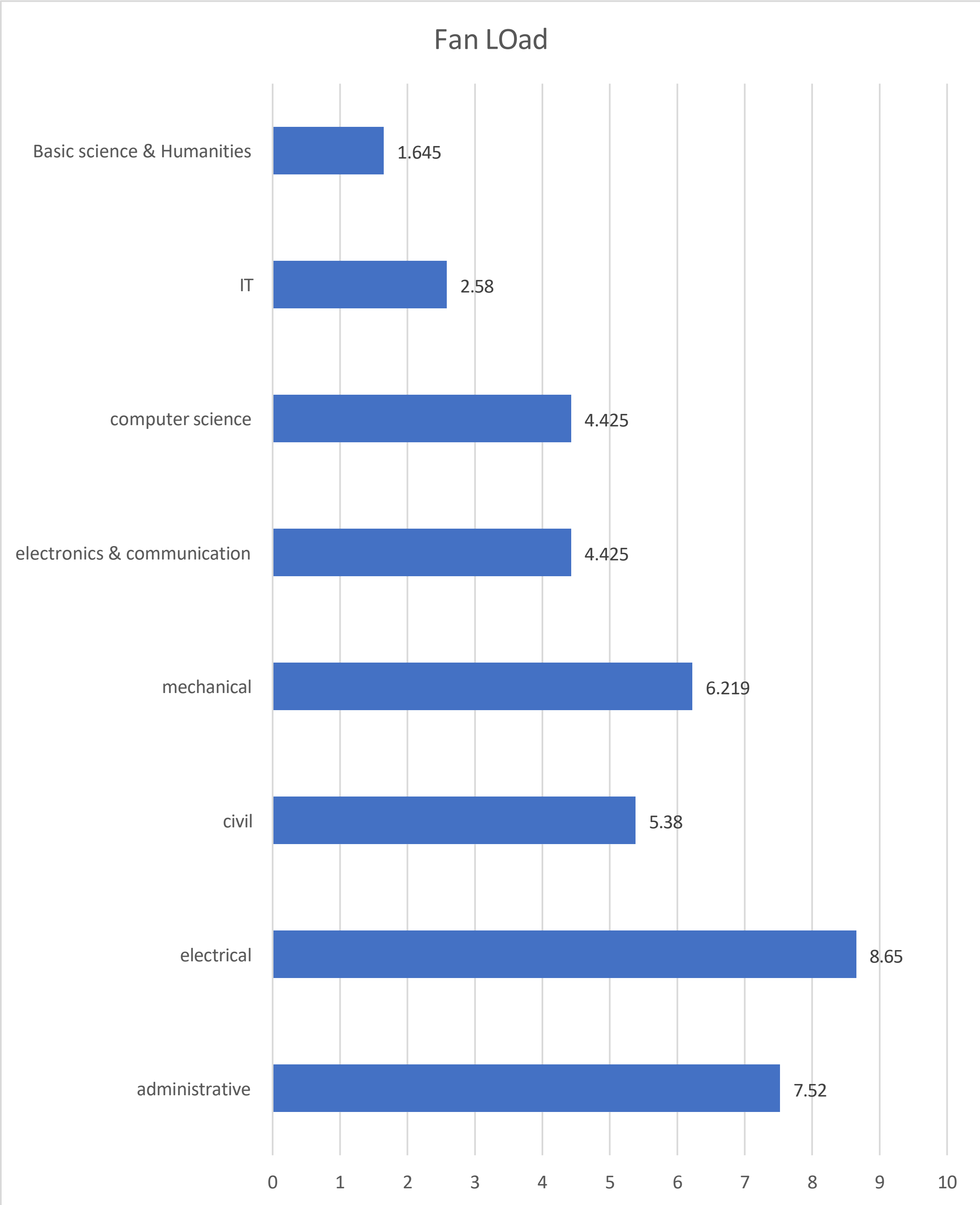


Figure 5. 2: Analysis of fan load

5.3 Analysis of Air conditioners:

Table 5. 3: Total Consumption of Ac

Table 5.3.1 Administrative Department				
Sl no	CAPACITY of AC	No of Units	Total Wattage	KW
1	1 Ton	13	13468	13.468
2	1.5 Ton	19	29526	29.526
3	2 Ton	3	8103	8.103

Table 5.3.2 Electrical department				
Sl no	CAPACITY of AC	No of Units	Total Wattage	KW
1	1 Ton	0	0	0
2	1.5 Ton	1	1554	1.554
3	2 Ton	0	0	0

Table 5.3.3 Civil department				
Sl no	CAPACITY of AC	No of Units	Total Wattage	KW
1	1 Ton	2	2072	2.072
2	1.5 Ton	5	7770	7.77
3	2 Ton	2	5402	5.402

Table 5.3.4 Mechanical department				
Sl no	CAPACITY of AC	No of Units	Total Wattage	KW
1	1 Ton	3	3108	3.108
2	1.5 Ton	8	12432	12.432
3	2 Ton	1	2701	2.701

Table 5.3.5 Electronics & Communication department				
Sl no	CAPACITY of AC	No of Units	Total Wattage	KW
1	1 Ton	2	2072	2.072
2	1.5 Ton	2	3108	3.108
3	2 Ton	6	16206	16.206

Table 5.3.6 Computer science department				
Sl no	CAPACITY of AC	No of Units	Total Wattage	KW
1	1 Ton	3	3108	3.108
2	1.5 Ton	12	18648	18.648
3	2 Ton	5	13505	13.505

Table 5.3.7 Information technology department				
Sl no	CAPACITY of AC	No of Units	Total Wattage	KW
1	1 Ton	3	3108	3.108
2	1.5 Ton	6	9324	9.324
3	2 Ton	1	2701	2.701

Table 5.3.8 Basic science & humanities dept.				
Sl no	CAPACITY of AC	No of Units	Total Wattage	KW
1	1 Ton	0	0	0
2	1.5 Ton	5	7770	7.77
3	2 Ton	3	8103	8.103

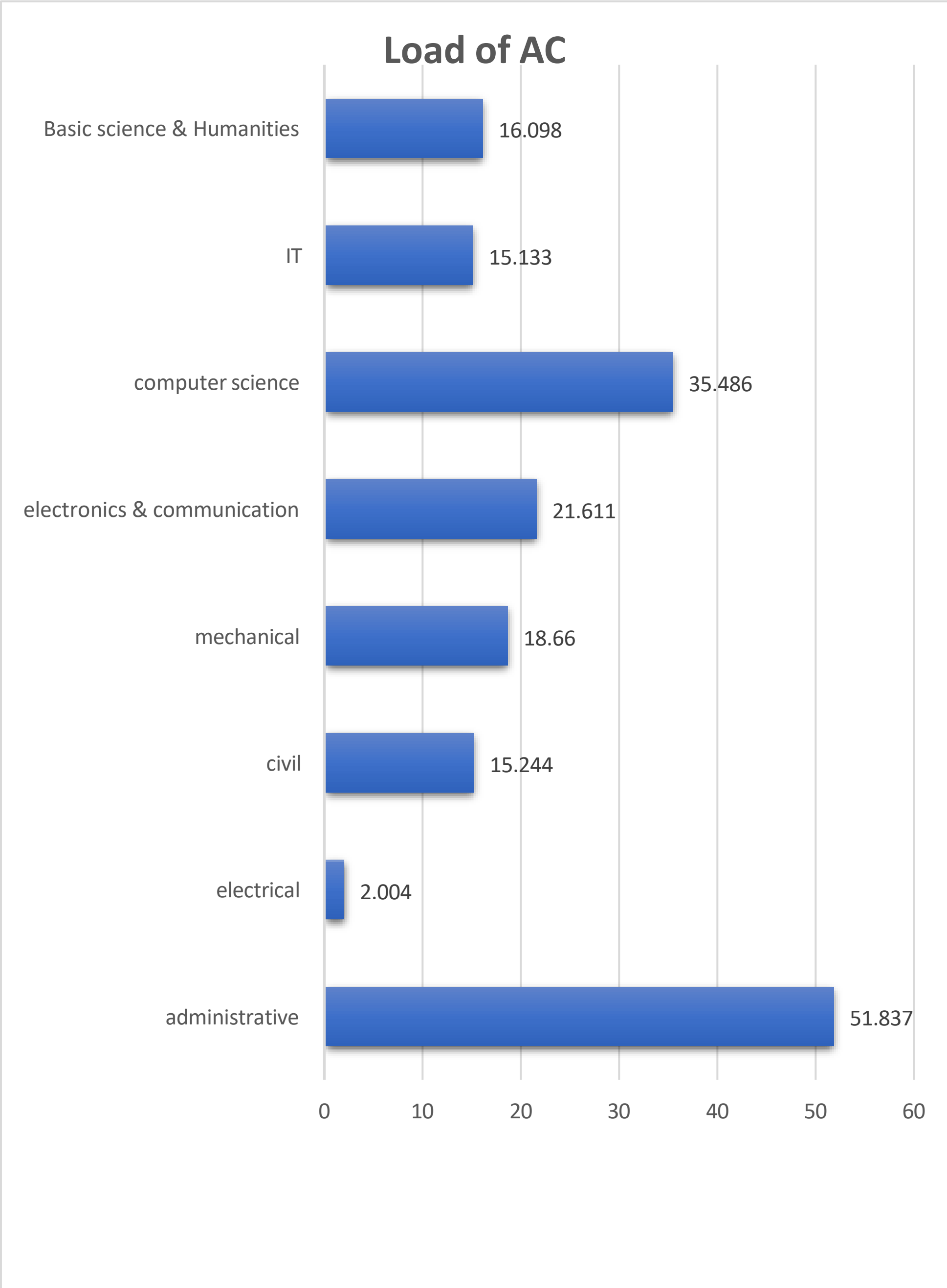


Figure 5. 3: Total Consumption of Ac

5.4 Analysis of Computers/Printers:

Table 5. 4: Total consumption of Computer and Printer

Table 5.4.1. Administrative Department				
Sl no	Type of Unit	No of Units	Total Wattage	KW
1	CRT monitor	0	0	0
2	LCD monitor	18	720	0.72
3	Single color	12	600	0.6
4	Ink jet	2	100	0.1

Table 5.4.2. Electrical department				
Sl no	Type of Unit	No of Units	Total Wattage	KW
1	CRT monitor	0	0	0
2	LCD monitor	8	320	0.32
3	Single color	5	250	0.25
4	Ink jet	2	100	0.1

Table 5.4.3. Civil department				
Sl no	Type of Unit	No of Units	Total Wattage	KW
1	CRT monitor	5	500	0.5
2	LCD monitor	27	1080	1.08
3	Single color	9	450	0.45
4	Ink jet	2	100	0.1

Table 5.4.4. Mechanical department				
Sl no	Type of Unit	No of Units	Total Wattage	KW
1	CRT monitor	6	600	0.6
2	LCD monitor	10	400	0.4
3	Single color	8	400	0.4
4	Ink jet	5	250	0.25

Table 5.4.5.electronics & telecommunication department				
Sl no	Type of Unit	No of Units	Total Wattage	KW
1	CRT monitor	41	4100	4.1
2	LCD monitor	80	3200	3.2
3	Single color	8	400	0.4
4	Ink jet	2	100	0.1

Table 5.4.6.Computer science department				
Sl no	Type of Unit	No of Units	Total Wattage	KW
1	CRT monitor	0	0	0
2	LCD monitor	43	1720	1.72
3	Single color	5	250	0.25
4	Ink jet	2	100	0.1

Table 5.4.7.Information technology department				
Sl no	Type of Unit	No of Units	Total Wattage	KW
1	CRT monitor	0	0	0
2	LCD monitor	10	400	0.4
3	Single color	5	250	0.25
4	Ink jet	2	100	0.1

Table 5.4.8.Basic science & humanities dept.				
Sl no	Type of Unit	No of Units	Total Wattage	KW
1	CRT monitor	0	0	0
2	LCD monitor	4	160	0.16
3	Single color	3	150	0.15
4	Ink jet	1	50	0.05

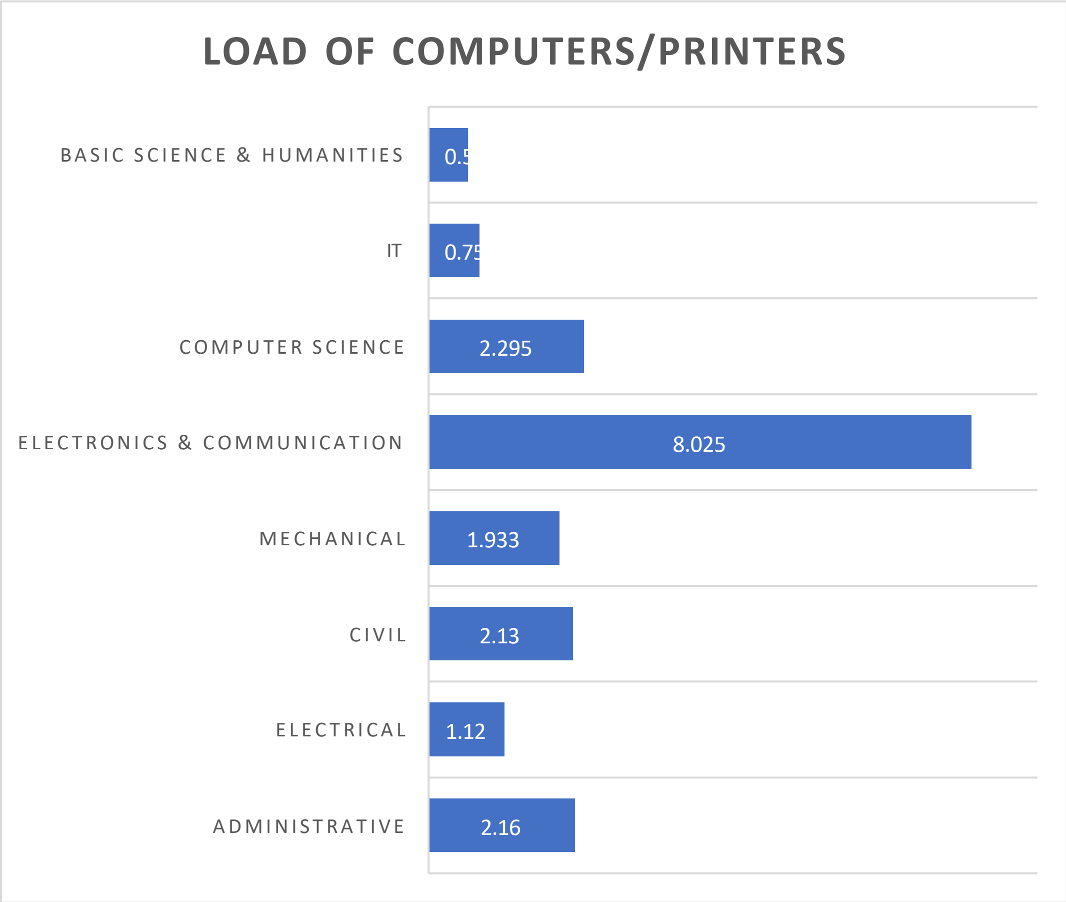


Figure 5. 4: Total consumption of Computer and Printer

5.5 Analysis of gymnasium:

There is no electrical equipment in the gym area. In this area is spread over 189.11 sq.m. the wattage of the lights used in gym is shown below.

.

Sl no	No of Units	Total Wattage	KW
Halogen light	1	100	0.1
Ceiling Hanging light	4	200	0.2
Fluorescent tube (40 watts & 36 w)	13	520	0.52
Pedestal fan (110 w)	1	110	0.11
Exhaust fan (90 W)	4	360	0.36

Table 5. 5: Total wattage of Gym

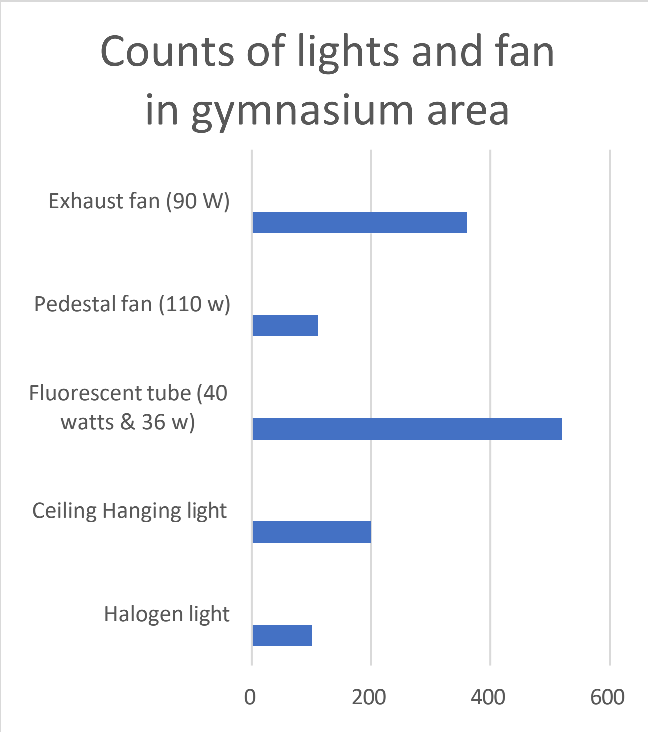


Figure 5. 5: Total wattage of Gym

5.6 OTHER ELECTRICITY CONSUMING APPLIANCES:

Sl no	Location	Academics building	Total wattage	KW
1	Xerox machine	12	13.2	0.0132
2	Microwave oven	1	750	0.75
3	Electric kettle (W)	5	7500	7.5
4	Refrigerator (W)	1	200	0.2
5	Room heaters (W)	1	1500	1.5
6	Water cooler (W)	3	240	0.24
7	Water purifier(W)	21	735	0.735
8	Server (W)	7	2555	2.555

Table 5. 6: Other Electricity Consuming Appliances

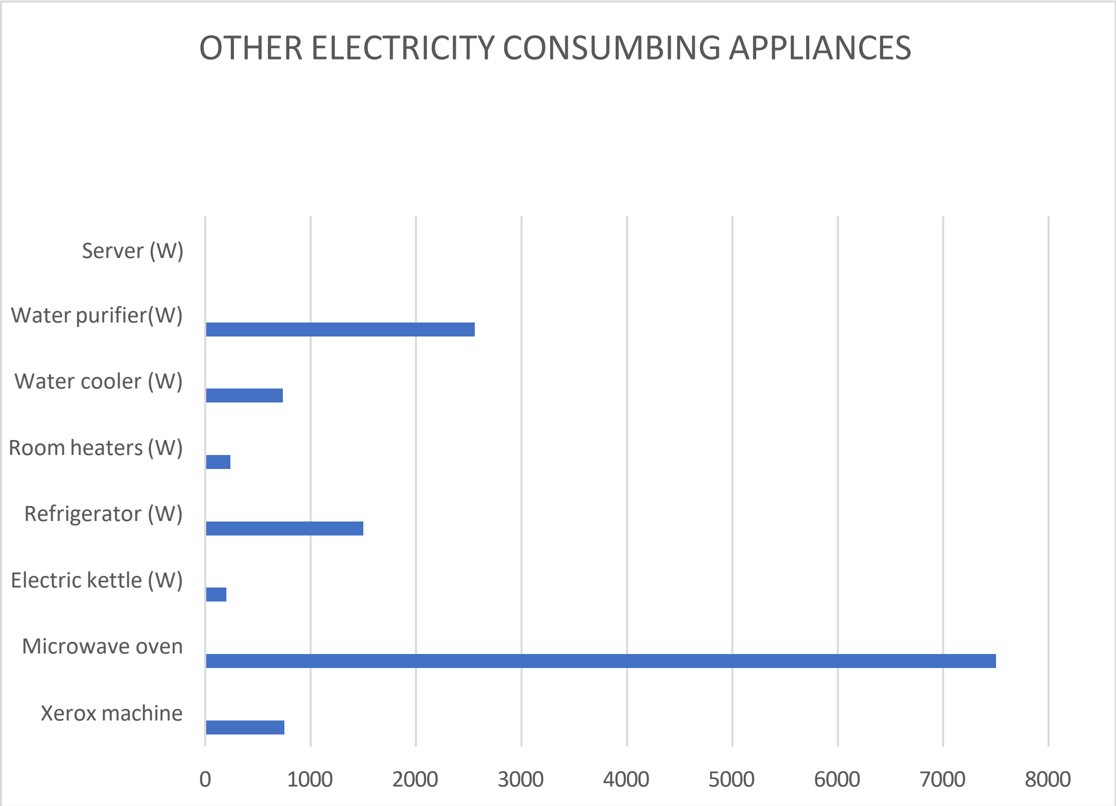


Figure 5. 6: Other Electricity Consuming Appliances

5.7 Street lighting and common area lighting:

The campus's street lighting and corridor lights were all included. The connected load is 17.67 kW. Only at night do these lights often come on. Here is the quantification.

Sl no	Fitting	Rating (W)	Number of Light	Total Wattage	KW
1	Sodium Vapor Lamp (Yellow)	100	11	1100	1.1
2	led street light	100	29	1450	1.45
3	Panel light white	30	17	680	0.68
4	Philips FTL lamp	36	56	6160	6.16
5	Philips FLT lamp	40	31	2790	2.79
6	Crompton Led Light	20	61	5490	5.49

Table 5. 7: lighting load of common area

Thus, the total number of common areas is 205.

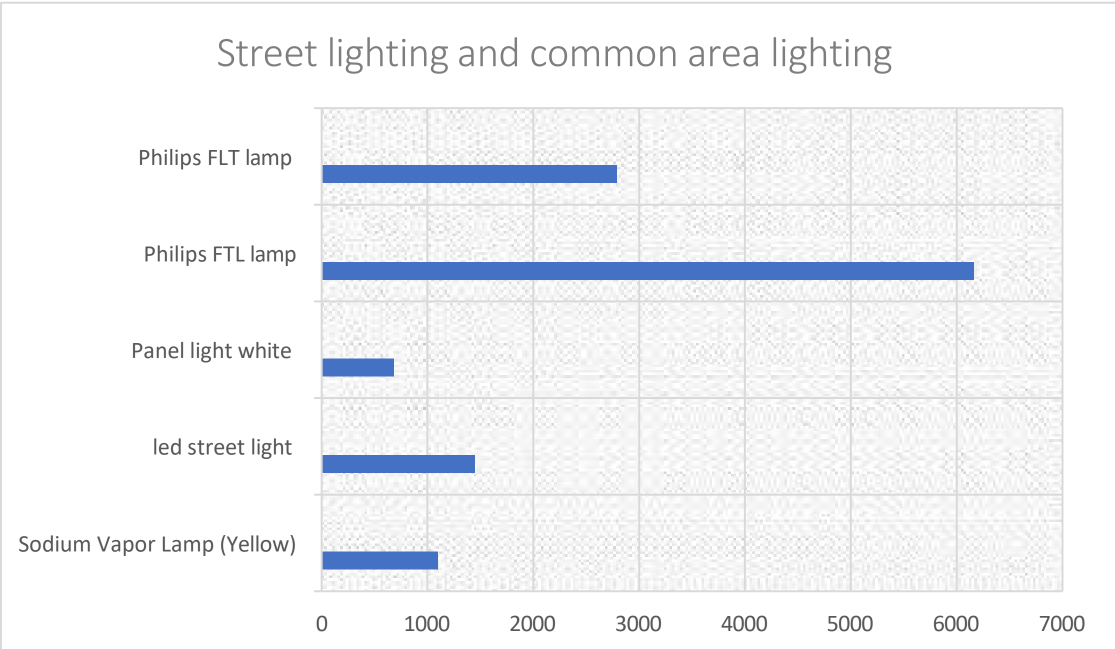


Figure 5. 7: Street lighting and common area lighting

5.8 Water pump:

The institute receives its water supply from the PHED (Public Health Engineering Department) conduits that pass just outside the campus.

There is one overhead water reservoir that stores water coming from the PHED lines. The reservoir from which all hostels and residential complexes receive their water from the overhead tank, which is located next to the stuff buildings. Water from the overhead reservoir is distributed to multiple pumps. The water tank's capacity was "three lakh and fifty thousand" liters. The three compressors operate from 5 a.m. to 11:45 p.m. The 15 HP and 17 HP motors operate only during the morning hours, whereas the 12 HP motor operates continuously until 11:45 PM.

The rating of the pumps is displayed in the table below, and when it comes to connected capacity, the motors are operated on a daily basis.

PWD provides water to the main buildings and workshop. there are "seven" such water tank and their capacity are "one thousand "liters. The rating of the pumps is display in the table below.

Serial no	Location	Motor capacity	Electrical loading	Flow rates in lbs.	Total Wattage	KW
1	hostels and stuff area	15 HP	16 Amp	36lbs	11190	11.19
2		17 HP	21Amp	36lbs	12676	12.676
3		12 HP	14Amp	36lbs	8948	8.948
4	PWD	5HP	8 Amp	15 lbs.	3728.5	3.7285
5		2HP	1 Amp	15 lbs.	1491.5	1.4915

Table 5. 8: Water Pump

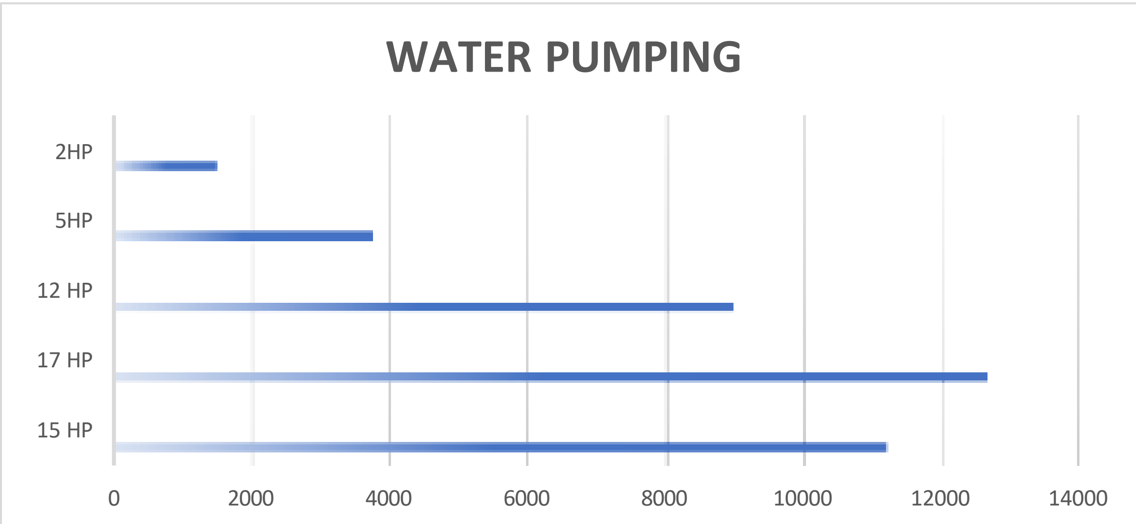


Figure 5. 8: Water Pump

5.9 PETROL CONSUMPTION OF COLLEGE VEHICLE:

The current rate for the academic year from February 2022 to January 2023 is 104 liters per month, which corresponds to a consumption of 40 liters of fuel per month. The vehicle is in operation for eight months per year. Energy Consumption is 2819.613kwh.

Table 5. 9: monthly petrol consumption

Period	Petrol consumption (in liters)	Kilocalorie Converter	kwh
February	40	326741.2	379.7459
March	42	343078.3	398.7332
April	38.5	314488.4	365.5054
May	39.6	323473.8	375.9484
June	NA		
July	NA		
August	40	326741.2	379.7459
September	36.8	300601.9	349.3662
October	NA		
November	30.1	245872.7	285.7588
December	30	245055.9	284.8094
January	NA		
Total	297	2426053	2819.613

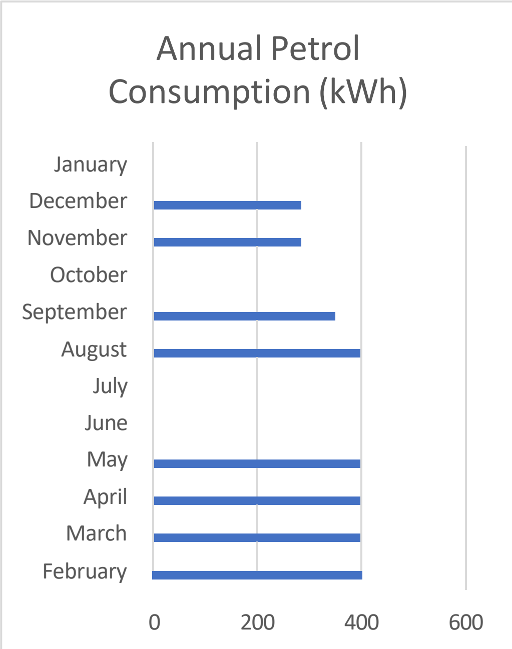


Figure 5. 9: Petrol Consumption February 2022 to January 2023

5.10 Analysis of DG sets:

On the college campus, there are three Diesel Generator (DG) units for use in the event of a power outage.

Table 5. 10: Rating of DG sets

Campus area	Brand	Count of DG sets	KVA
Academic building	Mahindra powerol	1	160
Administrative Building	Mahindra powerol	1	20
Hostel pump area	Kirloskar	1	25

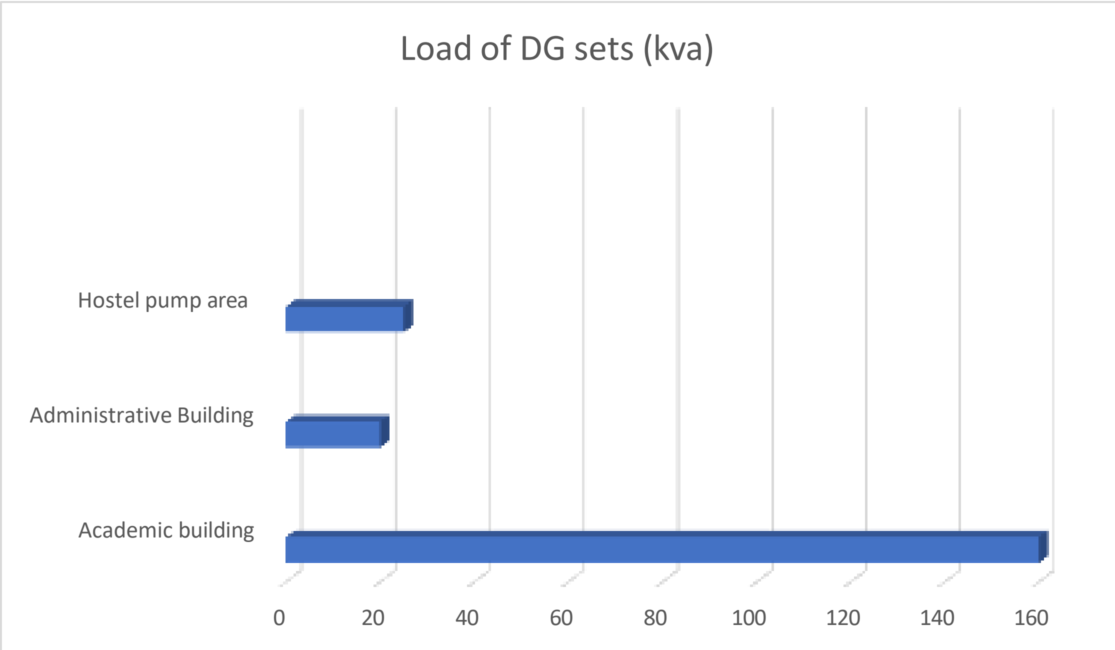


Figure 5. 10: Rating of DG sets

5.11 Hostel building load analysis:

The five hostels on the JGEC Campus have a total connected load of 1.21435 MW. The loads are examined after being divided into kitchen loads, lighting, fans, refrigerators, televisions, washroom loads, personal computers or laptops, steam irons, electric kettles, and induction loads.

Energy usage in hostel kitchens:

Each of the hostels in the campus is equipped with kitchen. The total connected kitchen load is 5.555 kW and these hostels use LPG as stated below.

Table 5. 11: Energy Consumption of Gas

Hostel	LPG usage per month NO OF GAS	total kg	Energy (KWh/mnt)
Girls hostel	28	397.6	4397.456
Boys hostel 1	45	639	7067.34
Boys hostel 2	45	639	7067.34
Boys hostel 3	45	639	7067.34
Boys hostel 4	42	596.4	6596.184
Total			32195.66

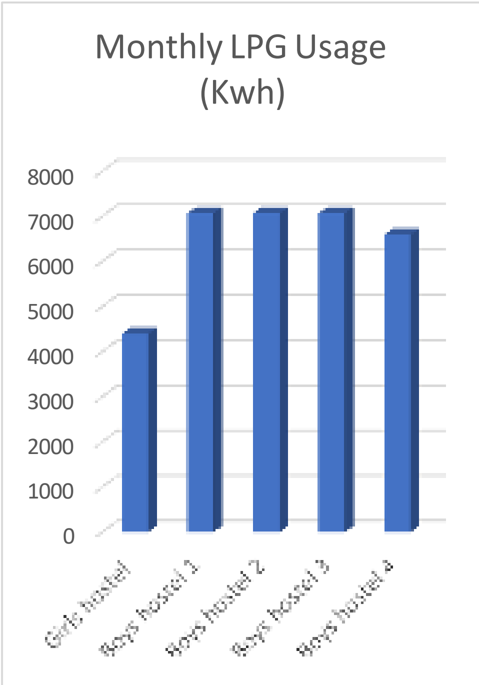


Figure 5. 11: Energy Consumption of Gas

The monthly energy consumption of LPG 32195.66kwh per month.

5.12 Analysis of other appliances in all hostels:

There is lighting load is about 25.072 kW, and the connected fan load is about 37.835 kW and others connected loads is about 87.865 kW.

Load in hostel							
	Girls hostel	Boys hostel 1	Boys hostel 2	Boys hostel 3	Boys hostel 4	Hour	KWh/Day
Connected load of lights (kw)	2.884	7.68	2.74	5.688	6.08	12	300.8
Connected load of fan (kw)	4.465	15.12	5.08	4.05	9.12	12	454
Connected load of wash room	0.513	0.972	0.72	0.72	0.96	12	46.62
Connected load of refrigerators	0	0.15	0.15	0.15	0.15	10	6
Connected load of TV(kw)	0.05	0.05	0.05	0.05	0.05	2	0.5
Connected load of other	12	17	18.5	19.2	16.43	1	83.13
Total							891

Table 5. 12: connected load of all hostels

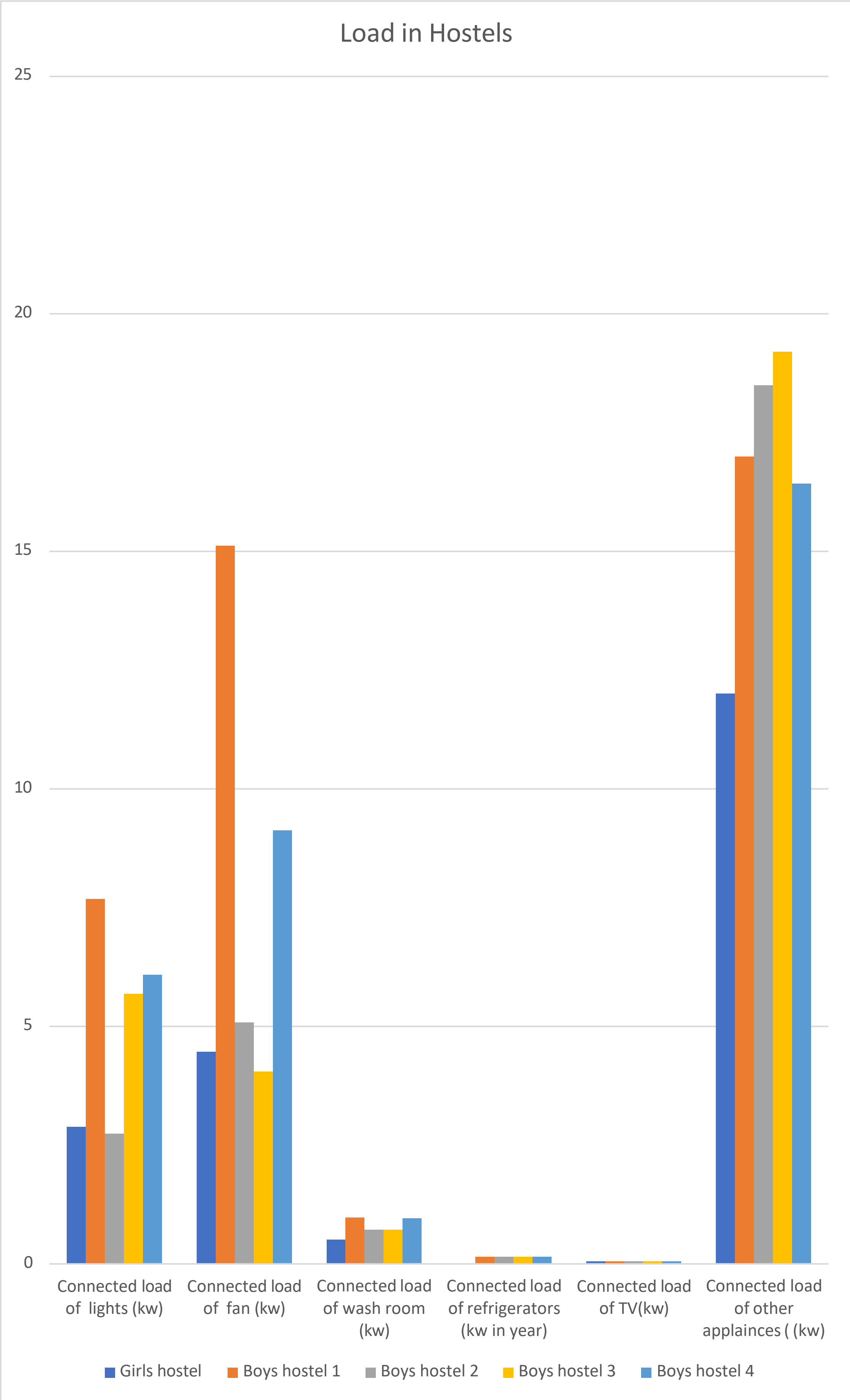


Figure 5. 12: Connected load in all hostel

5.13 Workshop Building, I & II Load analysis:

Table 5. 13: Workshop Building, I & II Load analysis

Lux Level (In All 4 Labs)	300

Load of Light (in all 4 labs)	2610
Load of Fan (In all 4 labs)	4855

Sl no	Machine Name	No of Machine	Watt (kw)		Consumption	
			Max	Min	Max (Kw)	Min(kw)
1	Lathe M/c	14	0.55	0.5	7.7	7
2	CNC	1	10		10	
3	Broaching	1	0.5		0.5	
4	Shaping	8	9		72	
5	Milling	2	5.5		11	
6	Drilling	6	10		60	
7	Grinding	2	2.5	1.5	5	3
8	Slotting	1	7.5		7.5	
9	Wood Slicer	1	1.5		1.5	
10	Cutting	2	2.4		4.8	
11	Saw	3	2.2		6.6	
12	Fire Furnace	16	0.8		12.8	
13	Pressure	2	1.8		3.6	
14	Spot Welding	1	15.0	5	15	5
15	Share	1	2	0.6	2	0.6
16	Bending	1	2.2		2.2	
17	Compressor	1	2.2		2.2	
18	Welding (ac/dc)	1	8	2	8	2

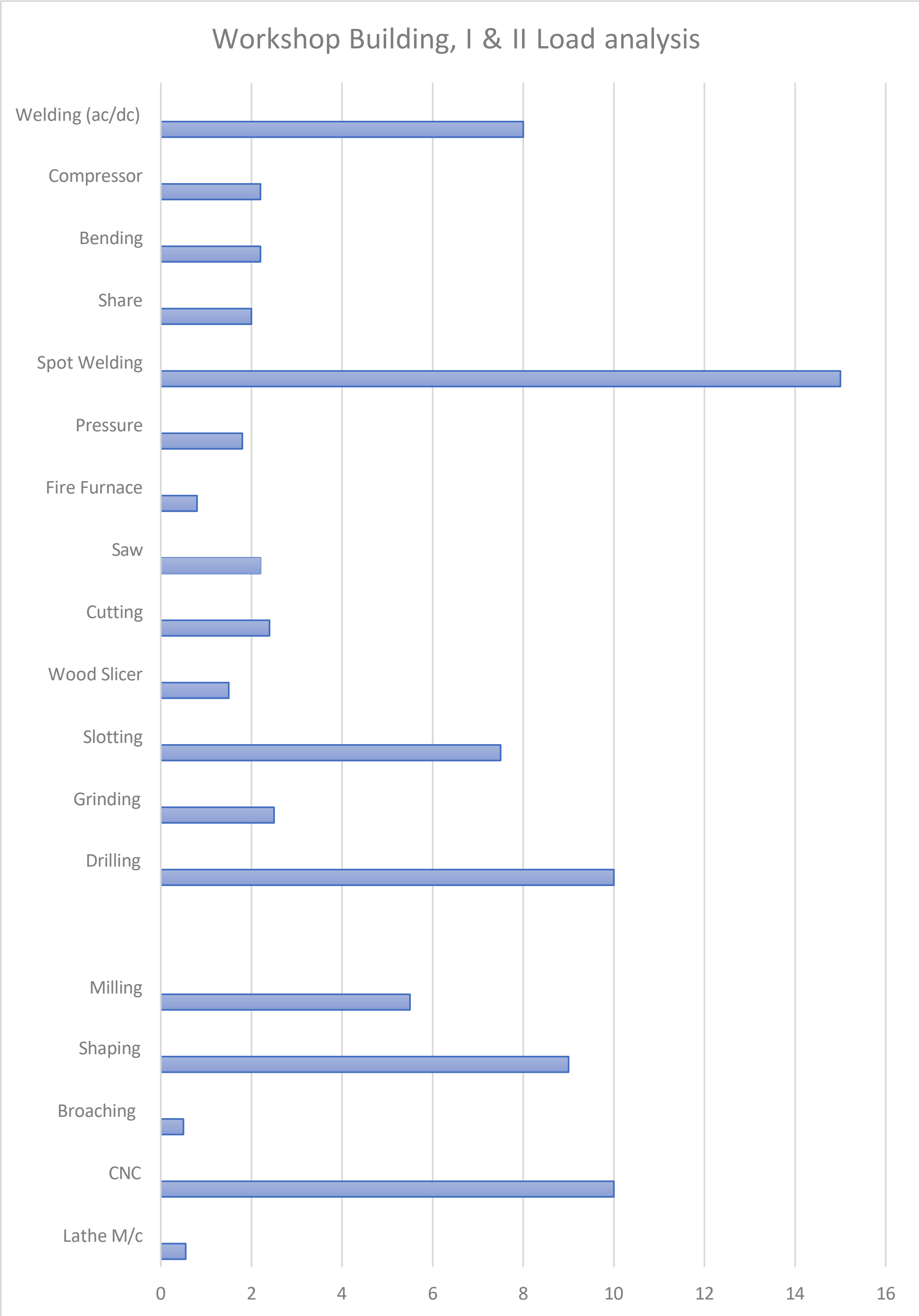


Figure 5. 13: Workshop Building, I & II Load analysis

5.14 Canteen load analysis:

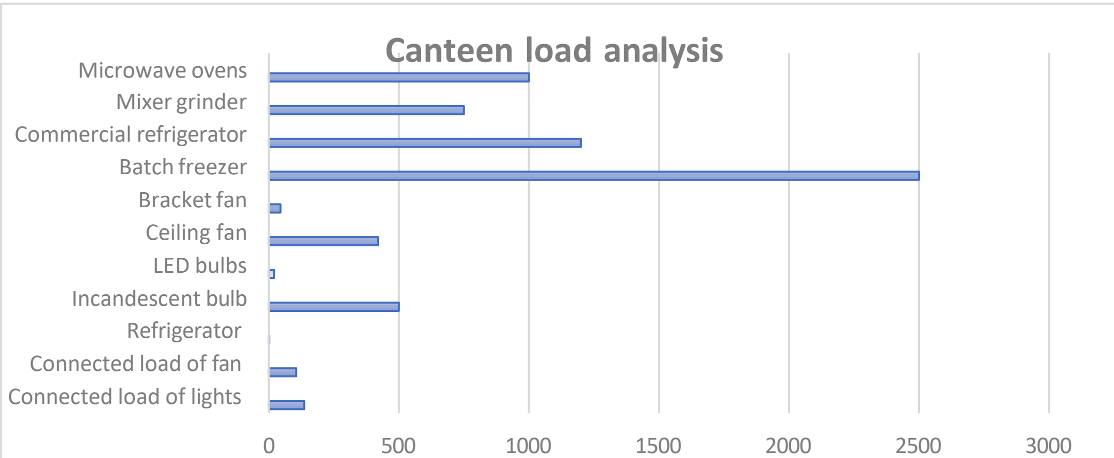
One student's canteen and one stuff canteen on the JGEC campus have a total connected load of 6677 W.

The student canteen covers an area of 93.646 sq.m. The total connected load is 6.667 KW.

Table 5. 14: Canteen load analysis

Location	Loads		Total Wattage	KW
Staff Canteen	Connected load of lights		136	0.136
	Connected load of fan		105	0.105
	Refrigerator		1	0.001
Students Canteen	Connected load	Incandescent bulb	500	0.5
		LED bulbs	20	0.02
	Connected load of fan	Ceiling fan	420	0.42
		Bracket fan	45	0.045
	Refrigerator	Batch freezer	2500	2.5
		Commercial refrigerator	1200	1.2
	Others	Mixer grinder	750	0.75
		Microwave ovens	1000	1

Figure 5. 14: Canteen load analysis



5.15 Energy Usage In College Campus:

Departments	administrative	EE	CE	ME	ECE	CSE	IT	Basic science & Humanities	Total	Hour	Energy(kWh)/Day	Energy(kWh)/Month	Energy(kWh)/Year
Light	8.162	5.02	4.08	4.111	2.72	4.88	1.76	1.74	32.473	8	259.784	7793.52	93522.24
fan	7.52	8.65	5.38	6.219	4.43	4.43	2.58	1.65	40.859	8	326.872	9806.16	117673.92
AC	51.84	2	15.24	18.66	21.6	35.5	15.1	16.1	176.04	3	528.12	15843.6	190123.2
Computer & Printers	2.16	1.12	2.13	1.933	8.03	2.3	0.75	0.59	19.013	2	38.026	1140.78	13689.36
gym	1.29								1.29	2	2.58	77.4	928.8
others	13.4932								13.493	1	13.4932	404.796	4857.552
Street Light	17.67								17.67	12	212.04	6361.2	76334.4
staff canteen	0.242								0.242	8	1.936	58.08	696.96
Student canteen	5.985								5.985	8	47.88	1436.4	17236.8
workshop	83.65								83.65	2	167.3	5019	60228
pump	38.034								38.034	1	38.034	1141.02	13692.24
Ladies hostel	891										891	26730	320760
Boys hostel 1													
Boys hostel 2													
Boys hostel 3													
Boys hostel 4													
TOTAL Electrical Energy											2527.065	75811.956	909743.472
Hostel LPG	1073.188667										1073.1887	32195.66	386347.92
Canteen LPG	41.88053333										41.880533	1256.416	15076.992
College Vehicle	7.724967312										7.7249673	93.9871023	2819.613069
TOTAL Energy											3649.9	109358	1313988

Table 5. 15: Energy Usage In College Campus

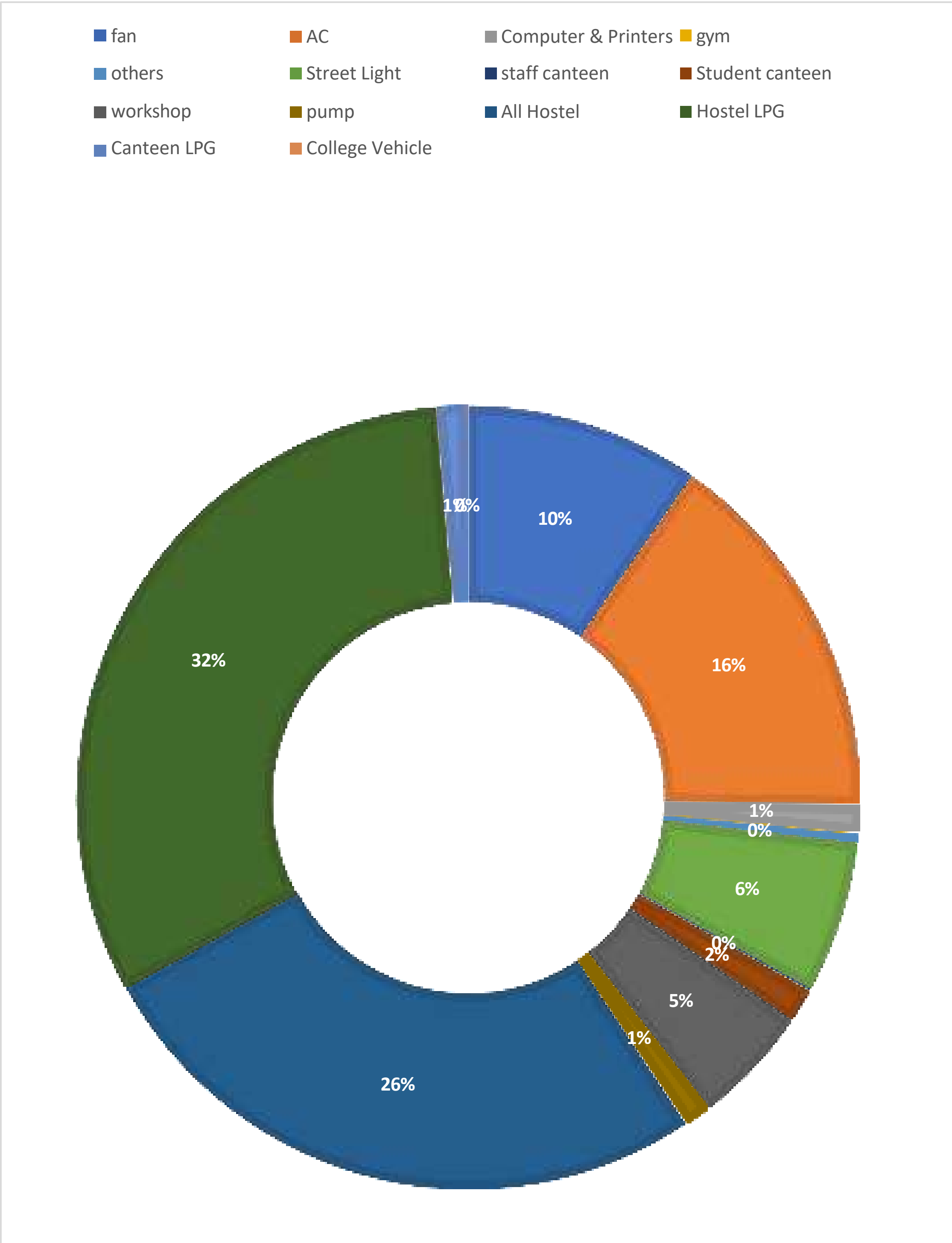


Figure 5. 15: Energy Usage In College Campus

Chapter 6

The Required amount of Illumination In the room

6.1 Illumination

The concept of illumination refers to the process of providing light or clarity to a particular subject or Lighting, often known as illumination, refers to the intentional utilization of light in order to attain a functional or aesthetic outcome. Lighting encompasses the utilization of both artificial light sources, such as lamps and light fixtures, as well as the harnessing of natural illumination through the capture of sunshine. Daylighting, which involves the utilization of windows, skylights, or light shelves, is occasionally employed as the primary means of illuminating inside spaces during daylight hours in architectural structures. The utilization of natural illumination as an alternative to artificial lighting can effectively reduce energy consumption in buildings since the latter constitutes a significant portion of overall energy usage. The use of appropriate lighting has the potential to optimize work performance, increase the aesthetic appeal of a given space, and elicit favorable psychological responses among individuals present in that environment. The provision of indoor illumination is often achieved through the utilization of light fixtures, which constitute an integral component of interior design. Lighting might furthermore serve as an inherent element within landscaping endeavors.

To find the number of light fittings 'N'

$$N=\frac{E*A}{O*CU*MF}$$

N: No of Light Fittings Needed

E: Required Illumination (lux)

A: Working Area (m^2)

O: Luminous Flux Produced Per Lamp (Lumens)

CU: Coefficient of Utilization

MF: Maintenance Factor

6.2 Lux:

The lux is the internationally recognized unit of measurement for illuminance and luminous emittance, quantifying the amount of light flux distributed over a certain area. It is equivalent to a luminous flux of one lumen distributed uniformly across an area of one square meter. Photometry is a technique employed to quantify the perceived intensity of light that interacts with or traverses a given surface, as experienced by the human visual system. The concept has resemblance to the radiometric measurement known as watts per square meter, but with a modification that involves assigning a weight to the power at each wavelength based on the luminosity function. This function is a standardized model that represents the human visual experience of brightness.

6.3 Lumens:

Lumens refer to a unit of measurement used to quantify the total amount of visible light. The lumen, denoted as Im, is the internationally recognized unit of luminous flux, which quantifies the overall amount of visible light that is emitted by a particular source. The distinction between luminous flux and power (radiant flux) lies in the fact that radiant flux encompasses all electromagnetic waves released, whereas luminous flux is adjusted based on a model that accounts for the human eye's sensitivity to different wavelengths. The relationship between lumens and lux is such that one lux is equivalent to one lumen per square meter.

The lumen is defined in proportion to the candela, as per established academic conventions.

One lumen is equal to one candela-steradian.

6.4 Coefficient of Utilization:

Luminous efficacy is defined as the quotient of the lumens received by a certain surface to the total lumens emitted by a light source. The observed horizontal illuminance is a result of the combined influence of the lighting equipment and the interior environment. An instance of a Utilization Factor (UF) equal to 0.3 signifies that the amount of luminous flux reaching a horizontal plane is 30% of the lumens emitted by the lamp when it is operating without any obstructions under typical conditions. The magnitude of this variable exhibits significant variability and is contingent upon the subsequent factors: The factors that influence the lighting system include the kind of illumination, such as direct or indirect, the type and height at which the fittings are mounted, the color and surface characteristics of the walls and ceiling, and to some extent, the shape and size of the space.

6.5 Maintenance Factor: The illuminance ratio during the midpoint of a cleaning cycle is compared to the illuminance that would be achieved if the installation were in a clean state. This element accounts for the phenomenon wherein the luminous efficacy of lamps or light sources diminishes as a result of the accumulation of soot, dust, or other contaminants on the globes and reflectors, among other components. In a similar vein, it may be observed that walls and ceilings exhibit diminished light reflection when they are not in a clean state.

6.6 Methods of lighting calculations:

Several methodologies have been utilized for illumination calculations, including the following:

1. Lumen or light flux methods.
2. Watts per square meter method.
3. Point-to-point methods.

We completed the endeavor using the lumen method, which is a very prevalent technique.

6.7 Lumen or Light Flux Method:

This method is applicable when the light source produces approximately uniform illumination over the working plane or when an average value is required. The size and efficacy of the implemented lamp or lamps determine the total lumen output. By multiplying the total lumen emission of the source by the utilization coefficient, the lumen received on the working plane can be calculated. If the lanterns and environs are not flawlessly spotless, maintenance and depreciation factors must be included in the calculation of lumens received on the working plane.

Lumens received on the working plane = number of lamps x wattage of each lamp x lumens per watt efficiency of each lamp x utilization coefficient x maintenance factors

6.8 Calculation of illumination of college Academics Departments: -

Using a lux meter, the computer science department has calculated the available illumination in lux, as shown in the table below.

Table 6. 1: LUX calculation

Location	Total (sum of four numbers)
Extreme Four corners of the room	256
In the middle four corners of the room	400
In the center four corner of the room	447

Avg. lux present in the room= total /12 corners of the room

Lumens present in the room = 1103 /12 =91.91 Lux

Calculation of Prof. Jhuma Dutta's cabin:

Length of Computer science room=15 foot 6 inches

Breadth of Computer science room =5 foot 7 inches
Area of Computer science room= 22.75 sq. m
1. case of Tube lights:
Wattage: 120watt
2. case of ceiling fan:
Fan:120 watt
4. case of desktop, printer, laptop
Desktop: 400 watts
Printer: 250 watts
Personal laptop: 250 watts
4. The room lux level
Lumens: 91.91 lux

So, we assume the maintenance factors are 0.5 and the utilization factors are 0.64.
For the professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 22.75) / (2250 x 0.64 x 0.5)
N=6.31 no's
This room contains 6.31 total lights (0.31 is negligible).

∴ Required number of fittings: 6
And currently present lamp in the room: 4
∵ (6-4) = 2
Two additional lighting will be needed in the Professor's cabin.

Calculation of Prof. Srinibas sir cabin:

Table 6. 2: LUX calculation

Location	Total (sum of four numbers)
Extreme Four corners of the room	281
In the middle four corners of the room	284
In the center four corner of the room	331

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 896 /12 = 74.66 Lux

Length of Computer science room=15 foot 5 inches
Breadth of Computer science room = 10 foot 0 inches
Area of Computer science room= 14.39 sq. m
1.case of Tube lights:
Wattage: 56watt
2.case of ceiling fan:
Fan :100 watts
4.case of desktop, printer, laptop
Desktop: 200 watts
Printer: 250 watts
4.The room lux level
Lumens: 74.66 lux

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 14.39) / (2250 x 0.64 x 0.8)
N=2.49 no's
This room contains 2.49 total lights (.49 is negligible).
∴ Required number of fittings: 3
And currently present lamp in the room: 1
∵ (2-1) = 1
One additional lighting will be needed in the Professor's cabin.

Calculation of Prof. Chinmoy Ghosh sir cabin:

Table 6. 3: LUX calculation

Location	Total (sum of four numbers)
Extreme Four corners of the room	245
In the middle four corners of the room	346
In the center four corner of the room	396

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 987 /12 = 82.25Lux

Length of Computer science room= 15 foot 7 inches
Breadth of Computer science room = 10 foot 2 inches
Area of Computer science room= 14.87 sq. m
1. case of Tube lights:
Wattage: 120watt
2. case of ceiling fan:
Fan :100 watt
4.case of desktop, printer, laptop
Desktop: 200 watts
Printer: 250 watts
4.The room lux level
Lumens: 82.25 lux

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 14.87) / (2250 x 0.64 x 0.5)
N= 4.13 no's
This room contains 4.13 total lights (.13 is negligible).
∴ Required number of fittings: 4
And currently present lamp in the room: 3
∵ (4-3) = 1
One additional lighting will be needed in the Professor's cabin.

Calculation of Prof. Dhiman sir & Prof. Dipak sir cabin:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1693 /12 = 141.08 Lux
Length of Computer science room= 15 foot 6 inches
Breadth of Computer science room = 10 foot
Area of Computer science room= 13.46 sq. m
1. case of Tube lights:
Wattage: 162 watt
2. case of ceiling fan:
Fan :145 watt
4.case of desktop, printer, laptop
Desktop: 400 watts
Printer: 500 watts
4.The room lux level
Lumens: 13.46 lux

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 13.46) / (2250 x 0.64 x 0.5)
N= 3.73 no's
This room contains 3.73 total lights (.73 is negligible).
∴ Required number of fittings: 3
And currently present lamp in the room: 4
∵ (4-3) = 1
One additional lighting will be needed in the Professor's cabin.

Calculation of Prof. Animesh sir's cabin:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1011 /12 = 84.25Lux
Length of Computer science room= 15 foot 6 inches
Breadth of Computer science room = 15 foot 4 inches
Area of Computer science room= 22.31 sq. m
1.case of Tube lights:
Wattage: 116 watt
2.case of ceiling fan:
Fan :120 watt
4.case of desktop, printer, laptop
Desktop: 400 watts
Printer: 500 watts
4.The room lux level
Lumens: 84.25lux

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 22.31) / (2250 x 0.64 x 0.5)
N= 6.19 no's
This room contains 6.19 total lights (.19 is negligible).
∴ Required number of fittings: 6
And currently present lamp in the room: 4
∵ (6-4) = 2
Two additional lighting will be needed in the Professor's cabin.

Calculation of class room I:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 988 /12 = 82.33Lux
Length of Computer science room= 31 foot
Breadth of Computer science room = 24 foot
Area of Computer science room= 69.11 sq. m
1.case of Tube lights:
Wattage: 384 watt
2.case of ceiling fan:
Fan :540watt
4.The room lux level
Lumens: 82.33 lux

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 69.11) / (2250 x 0.64 x 0.5)
N= 19.19 no's
This room contains 19.19 total lights (.19 is negligible).
∴ Required number of fittings: 19
And currently present lamp in the room: 10
∵ (19-10) = 9
Nine additional lighting will be needed in the class room.

Calculation of Prof. Hod sir's cabin:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1216 /12 = 101.33Lux
Length of Computer science room= 20 foot 4 inches
Breadth of Computer science room = 15 foot 8 inches
Area of Computer science room= 29.94 sq. m
1. case of Tube lights:
Wattage: 184watt
2. case of ceiling fan:
Fan :240 watt
4.case of desktop, printer, Xerox machine
Desktop: 400 watts
Printer: 250 watts
Xerox machine: 960 watts
4.The room lux level
Lumens: 101.33 lux

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)

N= (200 x 29.94) / (2250 x 0.64 x 0.5)
N= 8.31 no's
This room contains 8.31 total lights (.31 is negligible).
∴ Required number of fittings: 8
And currently present lamp in the room: 6
∵ (8-6) = 2
Two additional lighting will be needed in the Professor's cabin.

Calculation of Prof. Hod sir's assistant cabin:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1075 /12 = 89.58 Lux
Length of Computer science room= 16 foot
Breadth of Computer science room = 10 foot 3 inches
Area of Computer science room= 15.31 sq. m
1. case of Tube lights:
Wattage: 96 watt
2. case of ceiling fan:
Fan: 60 watt
4.case of desktop, printer, Xerox machine
Desktop: 400 watts
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 15.31) / (2250 x 0.64 x 0.5)
N= 4.25 no's
This room contains 4.25 total lights (.25 is negligible).
∴ Required number of fittings: 4
And currently present lamp in the room: 3
∵ (4-3) = 1
One additional lighting will be needed in the Professor's cabin.

Calculation of class room II :

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1398 /12 = 116.5Lux
Length of Computer science room= 31 foot 2 inches
Breadth of Computer science room = 24 foot
Area of Computer science room= 69.56 sq. m
1. case of Tube lights:

Wattage: 720watt
2. case of ceiling fan:
Fan :640 watt
3. Ac:21100 watts (does not work)
4. The room lux level
Lumens: 116.5 lux

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 69.56) / (2250 x 0.64 x 0.5)
N= 19.32 no's
This room contains 19.32 total lights (.32 is negligible).
∴ Required number of fittings: 19
And currently present lamp in the room: 18
∵ (19-18) = 1
One additional lighting will be needed in the class room.

Calculation of class room III :

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 953 /12 = 79.41Lux
Length of Computer science room= 31 foot
Breadth of Computer science room = 24 foot 3 inches
Area of Computer science room= 69.98 sq. m
1. case of Tube lights:
Wattage: 344watts
2. case of ceiling fan:
Fan :720 watts
3. The room lux level
Lumens: 79.41 lux
4. projector: 200 watts

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor

UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 69.98) / (2250 x 0.64 x 0.8)
N= 12.14 no's
This room contains 12.14 total lights (.14 is negligible).
∴ Required number of fittings: 12
And currently present lamp in the room: 9
∵ (12-9) = 3
Three additional lighting will be needed in the class room.

Calculation of Multimedia laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1120 /12 = 93.33 Lux
Length of Computer science room= 24 foot 4 inches
Breadth of Computer science room = 20 foot 9 inches
Area of Computer science room= 47.37 sq. m
1. case of Tube lights:
Wattage: 464 watts
2. case of ceiling fan:
Fan : 300 watts
3.projector: 200watts
4.case of desktop, AC
Desktop: 600 watts
AC: 1741 (1.5 ton) & 3482 (2 ton)
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 47.37) / (2250 x 0.64 x 0.5)
N= 19.73 no's
This room contains 19.73 total lights (.73 is negligible).
∴ Required number of fittings: 19
And currently present lamp in the room: 12
∵ (19-12) = 7
Seven additional lighting will be needed in the laboratory.

Calculation of computer architecture laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1075 /12 = 89.58 Lux

Length of Computer science room= 24 foot 4 inches
Breadth of Computer science room = 20 foot 9 inches
Area of Computer science room= 47.37 sq. m
1. case of Tube lights:
Wattage: 432watt
2. case of ceiling fan:
Fan: 320 watt
4.case of desktop, AC, projector
Desktop: 6000 watts (CRT monitors) & LED :800
So, we assume the maintenance factors are 0.5 and utilization factors are 0.64.
For the professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 47.37) / (2250 x 0.64 x 0.5)
N= 11.13 no's
This room contains 11.13 total lights (.13 is negligible).
∴ Required number of fittings: 11
And currently present lamp in the room: 10
∵ (11-10) = 1
One additional lighting will be needed in the laboratory.

Calculation of DBMS laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1326 /12 = 110.5 Lux
Length of ECE room= 24 foot 4 inches
Breadth of ECE room = 20 foot 7 inches
Area of ECE room= 46.92 sq. m
1. case of Tube lights:
Wattage: 480watt
2. case of ceiling fan:
Fan: 320 watt
4.case of desktop, AC
Desktop: 6200 watts
AC: 5223 watts
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp

MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 46.92) / (2250 x 0.64 x 0.5)
N= 18.5 no's
This room contains 18.5 total lights (.5 is negligible).
∴ Required number of fittings: 18
And currently present lamp in the room: 12
∵ (18-12) = 6
Six additional lighting will be needed in the Laboratory.

Calculation of Operating system laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1114 /12 = 92.83Lux
Length of ECE room= 52 foot
Breadth of ECE room = 15 foot 5 inches
Area of ECE room= 74.87 sq. m
1. case of Tube lights:
Wattage: 784watt
2. case of ceiling fan:
Fan: 400 watt
4.case of desktop, AC
Desktop: 4600 watts (Working only five & not working eighteen)
AC: 5223 watts
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 74.87) / (2250 x 0.64 x 0.5)
N= 28.35 no's
This room contains 28.35 total lights (.35 is negligible).
∴ Required number of fittings: 28
And currently present lamp in the room: 20
∵ (28-20) = 8
Eight additional lightings will be needed in the Laboratory.

Department of ECE:

Calculation of class room I:

Avg. lux present in the room= total /12 corners of the room

Lumens present in the room = 716 /12 = 59.66Lux
Length of ECE room= 30 foot 6 inches
Breadth of ECE room = 24 foot 10 inches
Area of ECE room= 68.51 sq. m
1. case of Tube lights:
Wattage: 184 watts
2. case of ceiling fan:
Fan :440 watts
3. The room lux level
Lumens: 59.66 lux
so, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 68.51) / (2250 x 0.64 x 0.5)
N= 11.15 no's
This room contains 11.15 total lights (.15 is negligible).
∴ Required number of fittings: 11
And currently present lamp in the room: 5
∵ (11-5) = 6
Six additional lighting will be needed in the class room.

Calculation of class room II:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 714 /12 = 59.51Lux
Length of ECE room= 30 foot 6 inches
Breadth of ECE room = 24 foot 6 inches
Area of ECE room= 68.54 sq. m
1. case of Tube lights:
Wattage: 220watts
2. case of ceiling fan:
Fan :520 watts
3. The room lux level
Lumens: 59.51 lux
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.

O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 68.54) / (2250 x 0.64 x 0.5)
N= 11.15 no's
This room contains 11.15 total lights (.15 is negligible).
∴ Required number of fittings: 11
And currently present lamp in the room: 6
∵ (11-6) = 5
Five additional lighting will be needed in the class room.

Calculation of class room III:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 539 /12 = 44.91Lux
Length of ECE room= 30 foot 8 inches
Breadth of ECE room = 24 foot 8 inches
Area of ECE room= 68.98sq. m
1. case of Tube lights:
Wattage: 192 watts
2. case of ceiling fan:
Fan :360 watts
3. The room lux level
Lumens: 44.91 lux
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 68.98) / (2250 x 0.64 x 0.5)
N= 11.22 no's
This room contains 11.22 total lights (.22 is negligible).
∴ Required number of fittings: 11
And currently present lamp in the room: 5
∵ (11-5) = 6
Six additional lighting will be needed in the class room.

Calculation of class room IV:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1033 /12 = 86.08Lux
Length of ECE room= 31 foot 4 inches

Breadth of ECE room = 22 foot 4 inches
Area of ECE room= 65.344sq. m
1. case of Tube lights:
Wattage: 252watts
2. case of ceiling fan:
Fan :360 watts
3. The room lux level
Lumens: 86.08 lux
so, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 65.344) / (2250 x 0.64 x 0.5)
N= 12 no's
This room contains 12 total lights.
∴ Required number of fittings: 12
And currently present lamp in the room: 7
∵ (12-7) = 5
Five additional lighting will be needed in the class room.

Calculation of Prof. HOD sir's cabin:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 390 /12 = 32.5Lux
Length of ECE room= 15 foot 2 inches
Breadth of ECE room = 9 foot
Area of ECE room= 12.86 sq. m
1. case of Tube lights:
Wattage: 20 watt
2. case of ceiling fan:
Fan :80 watt
4.case of desktop, printer, Xerox machine, AC
Desktop: 200 watts
Printer: 250 watts
Xerox machine:480 watts
AC:1741 watts
4.The room lux level
Lumens: 32.5lux
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.

E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 12.86) / (2250 x 0.64 x 0.5)
N= 2.23 no's
This room contains 2.23 total lights (.23 is negligible).
∴ Required number of fittings: 2
And currently present lamp in the room: 1
∵ (2-1) = 1
One additional lighting will be needed in the Professor's cabin.

Calculation of Prof. Sudip sir's cabin:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 493 /12 = 41.08Lux
Length of Computer science room= 19foot 5 inches
Breadth of Computer science room = 9 foot 5 inches
Area of Computer science room= 17.21 sq. m
1. case of Tube lights:
Wattage: 20 watt
2. case of ceiling fan:
Fan :120 watt
3. case of laptop, printer, AC
laptop: 150 watts
Printer: 250 watts
AC: 3482 watts
6.The room lux level
Lumens: 41.08lux
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 17.2) / (2250 x 0.64 x 0.5)
N= 2.98 no's
This room contains 2.98 total lights (.98 is negligible).
∴ Required number of fittings: 2
And currently present lamp in the room: 1
∵ (2-1) = 1
One additional lighting will be needed in the Professor's cabin.

Calculation of Prof. Alokesh sir's cabin:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 660 /12 = 55.5Lux
Length of Computer science room= 19 foot 9 inches
Breadth of Computer science room = 10 foot 9 inches
Area of Computer science room= 20.15 sq. m
1. case of Tube lights:
Wattage: 112 4watt
2. case of ceiling fan:
Fan :160 watt
4.case of desktop, printer, Xerox machine
Desktop: 200 watts
Printer: 250 watts
AC: 1741 watts
4.The room lux level
Lumens:55.5 lux

So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 200
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (200 x 20.15) / (2250 x 0.64 x 0.5)
N= 3.49 no's
This room contains 3.49 total lights (.49 is negligible).
∴ Required number of fittings: 3
And currently present lamp in the room: 2
∵ (3-2) = 1
One additional lighting will be needed in the Professor's cabin.

Calculation of digital communication system laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 551 /12 = 45.91Lux
Length of Computer science room= 32foot
Breadth of Computer science room = 19 foot 9 inches
Area of Computer science room= 59.16 sq. m
1. case of Tube lights:
Wattage: 152watt
2. case of ceiling fan:
Fan: 480 watt

4.case of AC
AC: 3482 watts
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 59.16) / (2250 x 0.64 x 0.5)
N= 14.44 no's
This room contains 14.44 total lights (.44 is negligible).
∴ Required number of fittings: 14
And currently present lamp in the room: 5
∵ (14-5) = 9
nine additional lighting will be needed in the Laboratory.

Calculation of Design laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 435 /12 = 36.25Lux
Length of Computer science room= 41 foot 9 inches
Breadth of Computer science room = 15 foot 7 inches
Area of Computer science room= 61.11 sq. m
1. case of Tube lights:
Wattage: 156 watt
2. case of ceiling fan:
Fan: 320 watt
4.case of AC
AC: 1741 watts
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 61.11) / (2250 x 0.64 x 0.5)
N= 15.91 no's
This room contains 15.91 total lights (.91 is negligible).
∴ Required number of fittings: 15
And currently present lamp in the room: 5

∵ (15-5) = 10
Ten additional lighting will be needed in the Laboratory.

Calculation of Microwave laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 647 /12 = 53.9Lux
Length of Computer science room= 41 foot 3 inches
Breadth of Computer science room = 15 foot 4 inches
Area of Computer science room= 59.08 sq. m
1.case of Tube lights:
Wattage: 120watt
2.case of ceiling fan:
Fan: 400 watt
4.case of desktop, AC
AC: 1741 watts
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 59.08) / (2250 x 0.64 x 0.5)
N= 14.42 no's
This room contains 14.42 total lights (.42 is negligible).
∴ Required number of fittings: 14
And currently present lamp in the room: 4
∵ (14-4) = 10
Ten additional lighting will be needed in the Laboratory.

Calculation of VLSI laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 1042 /12 = 86.83Lux
Length of Computer science room= 32 foot 4 inches
Breadth of Computer science room = 19 foot 9 inches
Area of Computer Science room= 59.90sq. m
1. case of Tube lights:
Wattage: 428 watt
2. case of ceiling fan:
Fan: 460 watt
4. case of desktop, AC

Desktop: 400 watts
AC: 3482 watts
So, we assume the maintenance factors are 0.5 and utilization factors 0.64.
For the professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 59.90) / (2250 x 0.64 x 0.5)
N= 14.62 no's
This room contains 14.62 total lights (.62 is negligible).
∴ Required number of fittings: 14
And currently present lamp in the room: 13
∵ (14-13) = 1
One additional lighting will be needed in the Laboratory.

Calculation of digital communication laboratory:

Avg. lux present in the room= total /12 corners of the room
Lumens present in the room = 551/12 = 45.91Lux
Length of Computer science room= 32 foot
Breadth of Computer science room = 19 foot 9 inches
Area of Computer science room= 59.16 sq. m
1.case of Tube lights:
Wattage: 152 watt
2.case of ceiling fan:
Fan: 480 watt
4.case of AC
AC: 3482 watts
So, we assume the maintenance factors 0.5 and utilization factors 0.64.
For professor's room Required lux level is 300
∴ The general formula for calculating the number of light fixtures is
N= (E x A) / (O x UF x MF)
N: Number of light fittings needed.
E: Required illumination.
A: Working area.
O: luminous flux is produced per lamp
MF: Maintenance factor
UF: Utilization factor
N= (E x A) / (O x UF x MF)
N= (300 x 59.16) / (2250 x 0.64 x 0.5)
N= 15.40 no's
This room contains 15.40 total lights (.40 is negligible).
∴ Required number of fittings: 15

And currently present lamp in the room: 5
∵ (15-5) = 10
Ten additional lighting will be needed in the Laboratory.

Table 6. 4: Standard Lux level chart as per guideline

Type of Activity	Minimum Illuminance required (in Lux)
General	200
Class Room	200
Library	300
Computer Lab	300
Others Lab	300
Corridors, Stairs	50
Bathrooms	50
Hostel Dormitory	50

Chapter 7

ECBC benchmarks and comparability:

7.1 Introduction

According to the Energy Conservation Building Code (ECBC) 2006, published by the Bureau of Energy Efficiency (BEE), government of India, the following are the recommended Illuminance levels:

Table 7. 1: ECBC recommended levels for illumination

The following are the determined values for the location on the JGEC campus:

Sl. no	location	LUX Measurement		Remarks
		With daylight +light		
1	Academic building	250		Recommend to increase the light
2	Administrative department	250		Recommend to increase the light
3	Campus corridor	40		It is recommended to increase lights.
4	Hostels (1 girls & 4 boys)	145		
5	Workshop I & II	132		Very poor lighting Recommend to increase the light
6	Student & stuff canteen	Student canteen = 208 stuff canteen = 59.25		Recommend to increase the light
7	Gymnasium	28.41		Recommend to increase the light
8	Laboratory	145		Recommend to increase the light
9	Library	150	Recommend increasing the light	

It is evident that the LUX levels in the institute do not exceed ECBC requirements.

Chapter 8

Electricity Billing Analysis

8.1 ENERGY CONSUMPTION:

We collected electricity energy invoices from March 2022 to February 2023 in order to comprehend the Energy Consumption trends and analyze the average monthly consumption.

Monthly Summary of Electricity Consumption and Bill Amount:

We collected monthly energy bills from March 2022 to February 2023 in order to comprehend the energy consumption trend and establish a baseline parameter. This is Shown in Table 4.2 above.

The Calculation electric bill for the month of DEC 2022 is shown below as an example:

The data is collected from the above table,

- Contract Demand = 350 KVA
- Power Factor = 0.9421
- Load Factor = 26.3328
- Multiplying Factor = 0.50000
- Current month meter reading = 17953.57 MVAH
- Previous months meter reading = 17837 MVAH
- Current month meter reading = 16736.93 MVAH
- Previous months meter reading = 16627.11 MVAH
- Energy charges rate (EC) = Rs.365700.6000
- Energy charge chargeable = 54910.000 KWh
- Total EC amount = Rs. 365700.6000
- Chargeable power factor = 0.9421
- Power factor = Rs. -5485.51
- Demand charges rate = Rs. 384 (Rs/KVA/month)
- Demand charge = 298 KVA
- Load factor rebate = 0.00
- Power factor rebate = -5485.51
- MVCA charges = 0.0 Paisa/KWh
- Net electricity duty = Rs. 70485.09
- Electricity duty exemption = Rs. -70485.09
- Rental of meter = Rs. 2400.00
- Late payment surcharge = Rs.0.00
- Adjustment amount = -0.09
- Timely payment rebate = Rs. -4745.93

Now, let's calculate the April month bill:

Calculate the energy charge:
Energy charge = EC Amount – power factor rebate
Energy charge = 365700.6000– 5485.51
Energy charge = Rs. 360215.09
Calculate the demand charge:
Demand charge = demand charge rate x chargeable demand rate (KVA)
Demand charge = 384 x 298
Demand charge = 114432.00
Calculate the MVCA charges:
MVCA charges = MVCA charges x
MVCA charges = MVCA charges x chargeable KWh
MVCA charges = 0.0 x54910.000 KWh
MVCA charges = Rs. 0000
Calculation of the total electricity duty:
Total electricity duty = net electricity duty + electricity duty exemption
Total electricity duty = 70485.09 – 70485.09
Total electricity duty = Rs. 0.00
Calculate the total payment before other adjustments:
Total payment before adjustments = energy charge + demand charge + MVCA charges + total electricity duty.
Total payment before adjustments = Rs. 360215.09 + 114432.00 + 0000 + 0.00
Total payment before adjustments = 476447.09
Calculate the total adjustment rebates:
Total adjustments and rebates = late payment surcharge + adjustment + timely payment rebate + rental of meter
Total adjustments and rebates = 0.00-0.09-4745.93+2400.00
Total adjustments and rebates = Rs. - 2346.02
Calculate the final payment:
Final total payment = total payment before adjustment = total adjustment & rebates
Final total payment = 476447.09+ (- 23460.02)
Final total payment = Rs. 4741010.07
The total payment of the month of April is approximately Rs. 4741010.07.

Chapter 9
Power Factor Calculation

9.1 Introduction

Resistive and inductive loads are the primary components of industrial electrical distribution networks. Incandescent lighting and resistance heating are examples of resistive loads. In the scenario of purely resistive loads, there exists a linear relationship between the voltage (V), current (I), and resistance (R).

The equation V = I x R represents the relationship between voltage (V), current (I), and resistance (R). Additionally, the equation for power (in kilowatts) is given by Power = Voltage x Current.

Common examples of inductive loads are alternating current (A.C.) motors, induction furnaces, transformers, and ballast-type lighting systems. Inductive loads necessitate the use of two distinct forms of power: firstly, active power, which is responsible for executing the intended tasks, and secondly, reactive power, which is essential for the establishment and sustenance of electromagnetic fields. The measurement of active power is often expressed in kilowatts (kW). The unit of measurement for reactive power is KVAR, which stands for Kilo Volt-Amperes Reactive. The aggregate of the active power and reactive power yields the overall (or perceived) power used. The electricity generated by the SEBS enables the user to execute a specific quantity of work. The measurement of Total Power is denoted in KVA, which stands for Kilo Volts-Amperes.

The active power, also known as the shaft power necessary or real power required, is measured in kilowatts (kW). On the other hand, the reactive power required, measured in kilovolt-amperes reactive (KVAR), is vertically displaced by 90 degrees in a pure inductive circuit.

The reactive power (KVAR) is causing a lag in the active power (KW). The combined vector quantity of the two is referred to as the apparent power or kilovolt-ampere (KVA), as seen before. The KVA value accurately represents the electrical load imposed on the distribution system. The power factor, denoted as the ratio of kilowatts (KW) to kilovolt-amperes (KVA), is a measure of electrical efficiency. It is consistently observed to be less than or equal to one. In theory, if electric utilities provide electricity and all loads exhibit a power factor of unity, the maximum power that can be transmitted remains constant for a given distribution system capacity. Nevertheless, due to the inductive characteristics of the loads and the power factor varying between 0.2 and 0.9, the electrical distribution network experiences strain on its capacity when operating at low power factors.

Using a power factor meter, we have determined the power factor of a 5HP pump employed on campus to be 0.79 lag, which is attributed to the presence of an inductive load. Therefore, the power factor (pf) is low as a result of the low power factor, which will lead to an increase in current.

9.2 Disadvantage of Low Power Factor

Now, In case of Low Power Factor, Current will be increased, and this high current will cause to the following disadvantages.

9.2.1 Large Line Loss (Copper Loss):

We know that Line Losses is directly proportional to the squire of Current "I^2"

Power Loss = I^2xR i.e, the larger the current, the greater the line losses i.e. I>>Line Losses

In other words,

Power Loss = I^2xR= 1/cosϕ^2………..Refer to Equation "I o 1/ cosϕ^2"…….

Thus, if Power factor = 0.8, then losses on this power factor=1/=1/ cosϕ^2=1/0.8^2=-1.56

times will be greater than losses on Unity power factor.

9.2.2 Large KVA Rating and Size of Electrical Equipment:

As we know that almost all Electrical Machinery (Transformer, Alternator, Switchgears etc) rated in KVA. But, it is clear from the following formula that Power factor is inversely proportional to the KVA i.e.

Cosϕ = kW/KVA

Therefore, The Lower the Power factor, the larger the KVA rating of Machines also, the larger the KVA rating of Machines. The larger the Size of Machines and The Larger the size of Machines, The Larger the Cost of machines.

9.2.3 Greater Conductor Size and Cost:

In case of low power factor, current will be increased, thus, to transmit this high current, we need a larger size of conductor. Also, the cost of large size of conductor will be increased.

9.2.4 Poor Voltage Regulation and Large Voltage Drop:

Voltage Drop = V=IZ.

Now in case of Low Power factor, Current will be increased. So the Larger the current, the Larger the Voltage Drop. Also Voltage Regulation = V.R (VNo Load-VFull Load)/VFull Load

In case of Low Power Factor (lagging Power factor) there would be large voltage drop which cause low voltage regulation. Therefore, keeping Voltage drop in the particular limit, we need to install Extra regulation equipment's i.e. Voltage regulators.

9.2.5 Low Efficiency

In the event of a low power factor, significant voltage drop and line losses may occur, resulting in reduced efficiency of the system or equipment. The presence of a low power factor can result in significant line losses, necessitating a higher excitation level for the alternator. Consequently, this might lead to reduced generating efficiency.

9.2.6 Penalty for low power Factor

Electrical Power Supply board of Wbsedcl impose a penalty of power factor below 0.92

Lagging in electric power bill . So you must improve power factor above 0.92.

9.2.7 The factors contributing to a low power factor:

The primary element contributing to a low power factor is the presence of inductive loads. In a purely inductive circuit, the current exhibits a phase lag of 90° with respect to the voltage. This substantial phase angle disparity between the current and voltage leads to a power factor of zero. In general, circuits that contain capacitance and inductance, with the exception of resonance circuits where inductive reactance is equal to capacitive reactance (X = Xc), exhibit a power factor due to the phase angle difference (0) between current and voltage caused by capacitance and inductance.

Following are the causes of low Power factor:

- Single phase and three phase induction Motors (Usually, Induction motor works at poor power factor i.e. at:
- Full load, Pf 0.8 -0.9
- Small load, Pf 0.2-0.3
- No Load, Pf may come to Zero (0).
- Varying Load in Power System (As we know that load on power system is varying. During low load period, supply voltage is increased which increase the magnetizing current which cause the decreased power factor)
- Industrial heating furnaces
- Electrical discharge lamps (High intensity discharge lighting). Are lamps (operate at

  very low power factor).

- Transformers
- Harmonic Currents

9.3 Methods For Power Factor Improvement

The Following devices and Equipment's are used for Power factor Improvement.

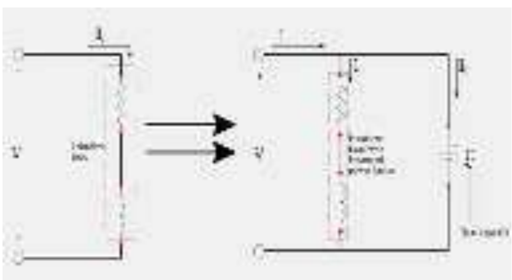
1. Static Capacitor
2. Synchronous Condensor
3. Phase Advancer

9.3.1 Static Capacitor

It is well acknowledged that a significant portion of industries and power system loads exhibit inductive characteristics, resulting in a lagging power factor and a subsequent fall in the overall power factor of the system. In order to enhance power factor, static capacitors are employed in parallel with devices that operate at a low power factor.

The static capacitors in question have the ability to generate a leading current that effectively counteracts the trailing inductive component of the load current. This results in an improvement in the power factor of the load circuit, as the leading component of the current neutralizes or eliminates the lagging component.

These capacitors are typically positioned in close proximity to significant inductive loads, such as induction motors and transformers, with the purpose of enhancing the power factor of the load circuit. This, in turn, leads to an improvement in the overall efficiency of the system or devices.



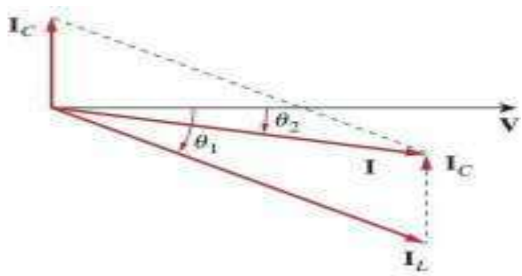


Figure 9. 1: a) Inductive Load b) Capacitive Load

Figure 9. 2: Phasor Diagram

Suppose, here is a single phase inductive load that is taking lagging current (IL) and the load power factor is Cos ϕ as shown in fig 9.2a.

In fig 9.2b, a Capacitor (C) has been connected in parallel with the load. Now a current (IL) is flowing through Capacitor which leads 90° from the supply voltage (Note that Capacitor provides the leading Current i.e., In a purely capacitive circuit, the Current leads 90 deg from the supply Voltage in other words Voltage is 90 deg lagging from Current). The load current is (I_{L}) . The Vectors combination of (I_{L}) and (le) is (I) which is lagging from the voltage at ϕ as shown in fig 9.2.

It can be seen from Fig 2 that angle of ϕ2 < ϕ1 i.e. angle of ϕ2 is less than from angle of ϕ2. Therefore Cosϕ2 is less than Cosoϕ 1(Cosϕ2 > Cos*ϕ1) Hence the load power factor is improved by the capacitor.

Also note that after the power factor improvement, the circuit current would be less than the low power factor circuit current. Also, before and after the power factor improvement, the active component of current would be the same in that circuit because the capacitor eliminates only the reactive component of the current. Also, the Active power (in Watts) would be the same after and before power factor improvement.

9.3.2 Advantages:

Capacitor bank offers several advantages over other methods of power factor improvement.

Losses are low in static capacitors.

There are no moving parts, resulting in low maintenance requirements.

It can function under normal conditions (i.e., ordinary atmospheric conditions).

No foundation is required for installation.

They are lightweight, making installation easy.

9.3.3 Disadvantages:

The age of static capacitor banks is relatively short (8-10 years).

Switching surges occur on the system when the capacitor bank is turned on or off due to changing loads.

Damage can occur if the rated voltage increases.

Repairing capacitors can be expensive once they are spoiled.

9.4 Synchronous Condenser

A synchronous condenser refers to a synchronous motor operating at no-load and over-excited conditions. It behaves like a capacitor by providing a leading current when over-excited.

When a synchronous condenser is connected in parallel across the supply voltage, it draws leading current and partially eliminates the reactive component, resulting in improved power factor. It is commonly used in large industries for power factor improvement.

9.4.1 Advantages:

- Long life (approximately 25 years).
- High reliability.
- Step-less adjustment of power factor.
- No generation of harmonics or maintenance issues.
- Faults can be easily removed.
- Its not effected by harmonics.
- Require low maintenance

9.4.2 Disadvantages:

- It is expensive (maintenance cost is also high) and is therefore primarily used by large power users.
- An auxiliary device has to be used for this operation because a synchronous motor has no self-starting torque.
- It produces noise.

9.5 Phase Advancer

A phase advancer is a straightforward AC exciter connected to the main shaft of a motor, operating with the motor's rotor circuit for power factor enhancement. In industries, phase advancers are employed to improve the power factor of induction motors.

The stator windings of an induction motor draw lagging current 90° out of phase with voltage, resulting in a low power factor. By supplying exciting ampere-turns through an external AC source, the effect of the exciting current on stator windings can be negated, thereby improving the power factor of the induction motor. The phase advancer facilitates this process.

9.5.1 Advantages:

- Lagging KVAR (Reactive component of Power or reactive power) drawn by the motor is significantly reduced as the exciting ampere-turns are supplied at slip frequency (fs).
- The phase advancer can be easily utilized in situations where the use of synchronous motors is unacceptable.

9.5.2 Disadvantage:

- The use of a phase advancer is not economical for motors below 200 H.P. (approximately 150kW).

9.6 Power Factor Improvement in 1ϕ and 3 ϕ Connections:

Power Factor Improvement in three phase system by connecting bank in

1. Delta Connection
2. Star Connection

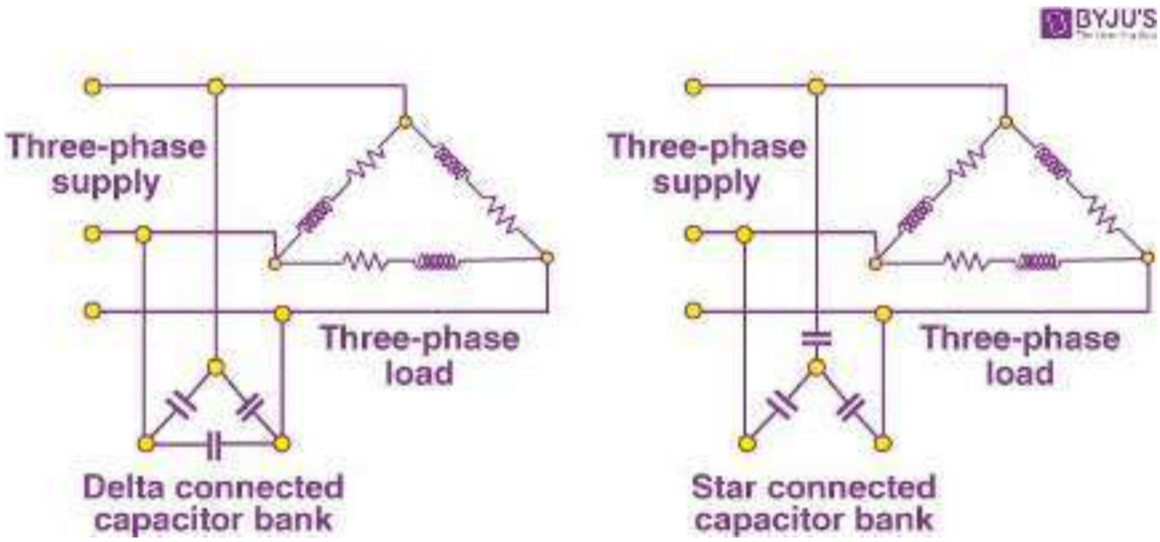


Figure 9. 3: delta and star Connected capacitor bank parallel with three phase load

9.7 Selection Of Capacitor:

The values presented in the table are the multiplication factors that should be applied to the input power (in kilowatts) in order to determine the kilovolt-ampere reactive (KVAR) of capacitance needed to enhance the existing power factor to a desired new power factor.

Table 9. 1: Multipliers to Determine Capacitor KVAR requirements for power factor correction

TABLE 1.2 MULTIPLIERS TO DETERMINE CAPACITOR kVAr REQUIREMENTS FOR POWER FACTOR CORRECTION

Original Power Factor	Desired Power Factor																				
	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.0
0.50	0.982	1.008	1.034	1.060	1.086	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1403	1.440	1.481	1.529	1.589	1.732
0.51	0.937	0.962	0.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
0.52	0.893	0.919	0.945	0.971	0.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
0.53	0.850	0.876	0.902	0.928	0.954	0.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1271	1.308	1.349	1.397	1.457	1.600
0.54	0.809	0.835	0.861	0.887	0.913	0.939	0.966	0.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1230	1.267	1.308	1.356	1.416	1.559
0.55	0.769	0.795	0.821	0.847	0.873	0.899	0.926	0.952	0.979	1.007	1.035	1.063	1.093	1.124	1.156	1190	1.227	1.268	1.316	1.376	1.519
0.56	0.730	0.756	0.782	0.808	0.834	0.860	0.887	0.913	0.940	0.968	0.996	1.024	1.054	1.085	1.117	1.151	1.188	1.229	1.277	1.337	1.480
0.57	0.692	0.718	0.744	0.770	0.796	0.822	0.849	0.875	0.902	0.930	0.958	0.986	1.016	1.047	1.079	1.113	1.150	1.191	1.239	1.299	1.442
0.58	0.655	0.681	0.707	0.733	0.759	0.785	0.812	0.838	0.865	0.893	0.921	0.949	0.979	1.010	1.042	1076	1.113	1.154	1.202	1.262	1.405
0.59	0.619	0.645	0.671	0.697	0.723	0.749	0.776	0.802	0.829	0.857	0.885	0.913	0.943	0.974	1.006	1040	1.077	1.118	1.166	1.226	1.369
0.60	0.583	0.609	0.635	0.661	0.687	0.713	0.740	0.766	0.793	0.821	0.849	0.877	0.907	0.938	0.970	1004	1.041	1.082	1.130	1.190	1.333
0.61	0.549	0.575	0.601	0.627	0.653	0.679	0.706	0.732	0.759	0.787	0.815	0.843	0.873	0.904	0.936	0970	1.007	1.048	1.096	1.156	1.299
0.62	0.516	0.542	0.568	0.594	0.620	0.646	0.673	0.699	0.726	0.754	0.782	0.810	0.840	0.871	0.903	0937	0.974	1.015	1.063	1.123	1.266
0.63	0.483	0.509	0.535	0.561	0.587	0.613	0.640	0.666	0.693	0.721	0.749	0.777	0.807	0.838	0.870	0904	0.941	0.982	1.030	1.090	1.233
0.64	0.451	0.474	0.503	0.529	0.555	0.581	0.608	0.634	0.661	0.689	0.717	0.745	0.775	0.806	0.838	0872	0.909	0.950	0.998	1.068	1.201
0.65	0.419	0.445	0.471	0.497	0.523	0.549	0.576	0.602	0.629	0.657	0.685	0.713	0.743	0.774	0.806	0840	0.877	0.918	0.966	1.026	1.169
0.66	0.388	0.414	0.440	0.466	0.492	0.518	0.545	0.571	0.598	0.626	0.654	0.682	0.712	0.743	0.775	0809	0.846	0.887	0.935	0.995	1.138
0.67	0.358	0.384	0.410	0.436	0.462	0.488	0.515	0.541	0.568	0.596	0.624	0.652	0.682	0.713	0.745	0779	0.816	0.857	0.905	0.965	1.108
0.68	0.328	0.354	0.380	0.406	0.432	0.458	0.485	0.511	0.538	0.566	0.594	0.622	0.652	0.683	0.715	0.749	0.786	0.827	0.875	0.935	1.078
0.69	0.299	0.325	0.351	0.377	0.403	0.429	0.456	0.482	0.509	0.537	0.565	0.593	0.623	0.654	0.686	0720	0.757	0.798	0.846	0.906	1.049
0.70	0.270	0.296	0.322	0.348	0.374	0.400	0.427	0.453	0.480	0.508	0.536	0.564	0.594	0.625	0.657	0691	0.728	0.769	0.817	0.877	1.020
0.71	0.242	0.268	0.294	0.320	0.346	0.372	0.399	0.425	0.452	0.480	0.508	0.536	0.566	0.597	0.629	0663	0.700	0.741	0.789	0.849	0.992
0.72	0.214	0.240	0.266	0.292	0.318	0.344	0.371	0.397	0.424	0.452	0.480	0.508	0.538	0.569	0.601	0635	0.672	0.713	0.761	0.821	0.964
0.73	0.186	0.212	0.238	0.264	0.290	0.316	0.343	0.369	0.396	0.424	0.452	0.480	0.510	0.541	0.573	0607	0.644	0.685	0.733	0.793	0.936
0.74	0.159	0.185	0.211	0.237	0.263	0.289	0.316	0.342	0.369	0.397	0.425	0.453	0.483	0.514	0.546	0580	0.617	0.658	0.706	0.766	0.909
0.75	0.132	0.158	0.184	0.210	0.236	0.262	0.289	0.315	0.342	0.370	0.398	0.426	0.456	0.487	0.519	0553	0.590	0.631	0.679	0.739	0.882
0.76	0.105	0.131	0.157	0.183	0.209	0.235	0.262	0.288	0.315	0.343	0.371	0.399	0.429	0.460	0.492	0526	0.563	0.604	0.652	0.712	0.855
0.77	0.079	0.105	0.131	0.157	0.183	0.209	0.236	0.262	0.289	0.317	0.345	0.373	0.403	0.434	0.466	0500	0.537	0.578	0.626	0.685	0.829
0.78	0.052	0.078	0.104	0.130	0.156	0.182	0.209	0.235	0.262	0.290	0.318	0.346	0.376	0.407	0.439	0473	0.510	0.551	0.599	0.659	0.802
0.79	0.026	0.052	0.078	0.104	0.130	0.156	0.183	0.209	0.236	0.264	0.292	0.320	0.350	0.381	0.413	0447	0.484	0.525	0.573	0.633	0.776
0.80	0.000	0.026	0.052	0.078	0.104	0.130	0.157	0.183	0.210	0.238	0.266	0.294	0.324	0.355	0.387	0421	0.458	0.499	0.547	0.609	0.750
0.81		0.000	0.026	0.052	0.078	0.104	0.131	0.157	0.184	0.212	0.240	0.268	0.298	0.329	0.361	0395	0.432	0.473	0.521	0.581	0.724
0.82			0.000	0.026	0.052	0.078	0.105	0.131	0.158	0.186	0.214	0.242	0.272	0.303	0.335	0369	0.406	0.447	0.495	0.555	0.698
0.83				0.000	0.026	0.052	0.079	0.105	0.132	0.160	0.188	0.216	0.246	0.277	0.309	0343	0.380	0.421	0.469	0.529	0.672
0.84					0.000	0.026	0.053	0.079	0.106	0.134	0.162	0.190	0.220	0.251	0.283	0317	0.354	0.395	0.443	0.503	0.646
0.85						0.000	0.027	0.053	0.080	0.108	0.136	0.164	0.194	0.225	0.257	0291	0.328	0.369	0.417	0.477	0.620
0.86							0.000	0.026	0.053	0.081	0.109	0.137	0.167	0.198	0.230	0264	0.301	0.342	0.390	0.450	0.593
0.87								0.000	0.027	0.055	0.083	0.111	0.141	0.172	0.204	0238	0.275	0.316	0.364	0.424	0.567
0.88									0.000	0.028	0.056	0.084	0.114	0.145	0.177	0211	0.248	0.289	0.337	0.397	0.540
0.89										0.000	0.028	0.056	0.086	0.117	0.149	0.183	0.220	0.261	0.309	0.369	0.512
0.90											0.000	0.028	0.058	0.089	0.121	0.155	0.192	0.233	0.281	0.341	0.484
0.91												0.000	0.030	0.061	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.92													0.000	0.031	0.063	0.097	0.134	0.175	0.223	0.283	0.426
0.93														0.000	0.032	0.066	0.103	0.144	0.192	0.252	0.395
0.94															0.000	0.034	0.071	0.112	0.160	0.220	0.363
0.95																0.000	0.037	0.079	0.126	0.186	0.329
0.96																	0.000	0.041	0.089	0.149	0.292
0.97																		0.000	0.048	0.108	0.251
0.98																			0.000	0.060	0.203
0.99																				0.000	0.143
																					0.000

Chapter 10

Tips for energy conservation opportunities

10.1 Electrical Utilities:

10.1.1 Electricity Distribution System

- Enhance the pricing structure in collaboration with the utility supplier.
- It is advisable to strategically plan and schedule your operations in order to effectively maintain a high load factor.
- If feasible, consider redistributing loads to periods of lower demand.
- One potential approach to reducing the maximum demand is to employ a demand controller that selectively trips loads. By strategically disconnecting some loads during periods of high demand, the overall maximum demand may be minimized.
- To mitigate load peaking, it is advisable to stagger the start-up periods of equipment that exhibit high beginning currents.
- Utilize standby electric generation equipment during periods of high load demand, particularly during on-peak periods.
- Ensure that the power factor is improved to a minimum of 0.90 when operating under rated load circumstances.
- It is recommended to reposition transformers in close proximity to primary loads.
- Configure the transformer taps to get optimal performance.
- Deactivate the primary power supply to transformers that are not currently providing electricity to any operational loads.
- One potential solution to be considered is the implementation of on-site electric generation or cogeneration.
- In the event of an excess in captive generation, it is possible to export electricity to the grid.
- Verify the accuracy of the utility electric meter by comparing it with your own meter.
- It is advisable to power down superfluous computers, printers, and copiers during nighttime hours.

10.1.2 Motors:

- To achieve optimal efficiency, it is important to appropriately scale the load. High-efficiency motors provide a 4-
- It is recommended to utilize energy-efficient motors in situations where it is economically viable, since they have been found to exhibit a 5% increase in efficiency compared to normal motors.
- Synchronous motors can be employed as a means to enhance power factor.
- Please verify the alignment.
- It is important to ensure the provision of adequate ventilation. According to estimates, the lifespan of a motor is projected to be reduced by half for every 10 °C rise in operating temperature over the suggested peak.
- Examine for instances of under-voltage and over-voltage circumstances.

- In order to optimize motor input power, it is necessary to balance the three-phase power supply. An unbalanced voltage has the potential to decrease motor input power by around 3 to 5%.
- Request the restoration of efficiency following the rewinding of the motor. If the process of rewinding is not executed correctly, it may result in a decrease in efficiency ranging from 5% to 8%.

10.1.3 Drives:

- The concept of drives refers to the innate psychological forces that propel individuals to pursue certain goals or
- varying-speed drives should be employed for the purpose of managing big varying loads.
- Utilize gear sets that exhibit excellent efficiency.
- Utilize precise alignment techniques.
- It is advisable to frequently monitor the tightness of the belt.
- The variable-pitch pulleys should be eliminated.
- Flat belts can be employed as viable alternatives to v-belts.
- It is recommended to employ synthetic lubricants while operating big gears.
- The objective is to eliminate the presence of eddy current couplings.
- It is advisable to deactivate or power down electronic devices while they are not in use.

10.1.4 Fans:

- It is recommended to employ streamlined and aerodynamically efficient air inlet cones for the purpose of fan air intakes.
- To prevent inadequate flow distribution at the entrance of the fan, it is important to implement measures that ensure proper and uniform distribution of airflow.
- To optimize the performance of the fan, it is advisable to reduce any blockages present at both the input and exit points.
- It is important to frequently clean screens, filters, and fan blades.
- Utilize fan blades with an aerofoil form.
- Reduce the speed of the fan.
- Utilize low-slip or flat belts for optimal performance.
- It is advisable to periodically monitor and assess the tightness of the belt.
- The variable pitch pulleys should be eliminated.
- varying speed drives should be employed for the purpose of controlling huge varying fan loads.
- It is advisable to employ energy-efficient motors for operations that need constant or near-continuous functionality.
- Minimize the occurrence of air leakage in ducting.
- One should aim to reduce the number of bends in ducting.
- It is advisable to deactivate fans when they are not required.

10.1.5 Blowers:

- Utilize streamlined and aerodynamically optimized air inlet ducts or cones for the purpose of facilitating air intake.
- The objective is to reduce obstacles at the intake and exit of the blower.
- It is important to routinely clean screens and filters.
- Reduce the speed of the blower.
- Utilize low-slip or no-slip belts.
- It is advisable to frequently assess the tightness of the belt.
- The variable pitch pulleys should be eliminated.
- varying speed drives should be employed for controlling big varying blower loads.
- It is recommended to utilize energy-efficient motors for operations that need continuous or near-constant functionality.
- Minimize the occurrence of leaks in ducting.
- It is advisable to deactivate blowers when they are not required.
- The topic of discussion pertains to pumps.
- Optimize pumping operations to operate at or near the optimal efficiency point.
- Optimize the pumping process to reduce the occurrence of throttling.
- To effectively accommodate a broad range of load variations, it is recommended to employ variable speed drives or implement sequenced control of smaller components.
- Cease the operation of both pumps. To address the issue at hand, one potential solution would be to implement an automatic starting mechanism for the online spare. Alternatively, another option would be to incorporate a booster pump in the problematic region.
- Booster pumps are employed to augment the pressure levels for smaller loads necessitating elevated pressures.
- To decrease pumping rates, it is recommended to enhance fluid temperature differentials.
- To mitigate water wastage, it is important to undertake the maintenance of seals and packaging materials.

10.6 Compressors

- One should contemplate the implementation of a variable speed drive in order to accommodate fluctuating loads on positive displacement compressors.
- If the compressor manufacturer grants permission, it is advisable to utilize a synthetic lubricant.
- It is important to ensure that the temperature of the lubricating oil remains within an optimal range, as excessively high temperatures can lead to oil deterioration and a decrease in viscosity, while excessively low temperatures might result in the introduction of condensation and subsequent contamination.
- It is important to adhere to a regular schedule of oil filter replacement.
- It is recommended to conduct regular inspections of compressor intercoolers to ensure their optimal performance.
- Utilize the waste heat generated by a significantly sized compressor for the purpose of operating an absorption chiller or facilitating preheating.
- The concept of process or utility feeds refers to the systems or mechanisms that facilitate the flow of materials, information, or resources inside a particular process or utility network. Developing a comprehensive program to ensure the efficiency and maintenance of compressors. Initiate an energy assessment as

the preliminary step, afterwards incorporating a compressor efficiency-maintenance program into your operational framework.

- A program focused on the ongoing management of energy resources.

10.1.6 Compressed air

- Implement a control system to facilitate the synchronization of various air compressors.

- The objective of this study is to analyze the part-load characteristics and cycling costs associated with the operation of numerous air compressors, with the aim of identifying the most efficient mode of operation.

- It is advisable to refrain from oversizing and instead ensure that the connected load is appropriately matched.

- Utilize modulation-controlled air compressors. At half load, the power consumption is nearly equivalent to that at full load.
- Deactivate the auxiliary air compressor until its utilization becomes necessary.

- Decrease the discharge pressure of the air compressor to the minimum permissible level. A decrease in air pressure of 1 kg/cm2 (from 8 kg/cm2 to 7 kg/cm2) would lead to a reduction in input power consumption by about 9%. Additionally, the implementation of this measure is expected to result in a 10% reduction in compressed air leakage rates.
- It is recommended to utilize dryer dew point settings that are set at the greatest acceptable level.
- It is advisable to deactivate refrigerated and heated air dryers in conjunction with the shutdown of air compressors.
- Utilize a control system for the purpose of minimizing the purging of a heatless desiccant drier.

10.1.7 HVAC (Heating/Ventilation/ Air Conditioning).

- It is advisable to contemplate the installation of a building automation system (BAS) or an energy management system (EMS), or alternatively, the restoration of a non-operational system.
- The objective is to optimize the system by minimizing flow rates and so reducing the power consumption of blowers, fans, or pumps.
- Efforts should be made to minimize or decrease the utilization of reheat wherever feasible.
- Implementing the suitable setback strategy for HVAC thermostats.
- The use of morning pre-cooling during summer and pre-heating during winter, especially before to electricity peak hours, is recommended.
- Utilize the concept of building thermal lag in order to decrease the operational duration of HVAC equipment.
- During the winter season, it is advisable to lower temperatures to the lowest feasible level during periods of inactivity, while ensuring that water lines do not freeze and stored products remain undamaged.

- During the summer season, it is advisable to permit temperatures to increase to their maximum potential during periods of vacancy.
- In order to preserve stored goods, it is imperative to handle them in a manner that minimizes any potential damage.
- Enhance the management and optimization of external air control and use.
- Air-to-air heat exchangers can be employed as a means to mitigate energy demands associated with the heating and cooling of outside air.
- Minimize the operational duration of the HVAC system during non-peak periods, such as nighttime and weekends.
- Maximize the efficiency of ventilation systems.
- Ventilation should only be employed when it is deemed essential. In order to facilitate the shutdown of some sections during periods of non-occupancy, it is recommended to establish specialized HVAC systems specifically designed for continuous loads, such as computer rooms.
- In order to enhance the ventilation system in kitchens, washing rooms, and areas where combustion occurs, it is recommended to allocate a separate and exclusive source of outside air supply.
- The utilization of appropriate equipment and other related measures can be employed to prevent the excessive depletion of conditioned air. Evaporative cooling is a viable method to employ in arid regions.
- Minimize the use of humidification or dehumidification systems during periods of non-occupancy.
- It is advisable to employ atomization as a preferred method of humidification, wherever feasible, instead of relying on steam.
- It is recommended to regularly clean the coils of the HVAC unit and use a comb to straighten any bent fins.
- Enhance the performance of filter banks by implementing modifications aimed at minimizing pressure loss, thus resulting in reduced fan power demands.
- It is advisable to adhere to a regular program for inspecting HVAC filters, with a recommended frequency of at least once a month. Should the need arise, it is essential to undertake the necessary cleaning or replacement of filters.
- Inspect pneumatic controls and air compressors to ensure they are functioning correctly, including assessing their operational efficiency and cycle patterns.
- In order to ensure proper maintenance, it is recommended to employ high-speed doors or clear PVC strip curtains to isolate air-conditioned loading dock areas and cool storage spaces.
- One effective approach to mitigate heat stratification in high-bay spaces is the installation of ceiling fans.
- In places characterized by high ceilings, it is advisable to reposition air diffusers to heights that are considered optimal.
- It is advisable to contemplate the reduction of ceiling heights.
- Remove any obstacles that are blocking the area in front of radiators, baseboard heaters, and other similar heating devices.
- It is advisable to inspect the cleanliness and correct alignment of the reflectors on infrared heaters.
- Utilize industrially-engineered ventilation hoods for the purpose of effectively managing and mitigating the presence of dust and vapor.
- Utilize localized infrared heat for individuals as opposed to uniformly heating the entire space.
- Implement spot cooling and heating techniques, such as employing ceiling fans to provide localized cooling for individuals instead of cooling the entire space.

- It is advisable to exclusively get HVAC window units that are characterized by high-efficiency models.
- Implement timed controls for HVAC window units.
- It is advisable to avoid the installation of excessively large cooling systems. The utilization of oversized units may lead to a phenomenon known as "short cycling," which subsequently leads to inadequate regulation of humidity levels.
- Implementing a multifuel system and operating the system with the most cost-effective fuel option currently accessible.
- One aspect to be taken into consideration is the implementation of separate make-up air systems for exhaust hoods. What is the rationale for utilizing air cooling or heating systems unnecessarily?
- To optimize energy efficiency, it is recommended to reduce the speeds of HVAC fans.
- One potential approach to mitigate cooling demands in humid environments is by the implementation of desiccant drying techniques on outdoor air.
- The topic of discussion pertains to various climatic conditions.
- One topic that warrants consideration is ground source heat pumps.
- One potential solution to address the issue of leaky HVAC ductwork is to implement measures to effectively seal the leaks.
- It is imperative to effectively seal any existing leaks in the vicinity of the coils.
- The task at hand involves the restoration of loose or impaired flexible connections, which encompasses those situated beneath air handling systems.
- It is advisable to avoid the concurrent use of heating and cooling systems during transitional times between seasons.
- The objective is to optimize energy consumption by using zone-based heating, ventilation, and air conditioning (HVAC) systems that utilize both air and water.
- The recommended procedure involves doing an inspection, cleaning, lubrication, and adjustment of the damper blades and linkages.
- Implementing an HVAC efficiency-maintenance program. Commence the energy audit as the initial step, afterwards incorporating an HVAC efficiency-maintenance program into your ongoing energy management program.

10.1.8 Refrigeration

- It is recommended to employ water-cooled condensers as opposed to air-cooled condensers.
- Questioning the Necessity of Refrigeration, Specifically in the Context of Outdated Batch Processes.
- It is advisable to refrain from oversizing the linked load in order to ensure optimal matching.
- One potential strategy to mitigate electricity demand costs is to utilize gas-powered refrigeration equipment.
- The use of "free cooling" can be employed as a means to facilitate the shutdown of chillers during periods of cold weather.
- If feasible, employ a series configuration for chilled water loads.
- One potential use is the conversion of firewater tanks or other types of tanks into thermal storage systems.
- It is advisable to refrain from assuming that traditional methods remain optimal, especially in the context of energy-intensive low temperature systems.
- Addressing improper brine or glycol content that has a detrimental impact on heat transfer and/or pumping energy is essential. In the event of perspiration, it is advisable to provide insulation, and in the case of corrosion, it is recommended to prioritize replacement.

- To optimize the functioning of hot gas bypass, it is necessary to implement changes.
- Conduct an examination of moisture or liquid indicators.
- It is advisable to contemplate the adoption of an alternative refrigerant type in the event that it has the potential to enhance operational efficiency.
- Verify the accuracy of the refrigerant charge level.
- Conduct a thorough examination of the purge system to identify any potential air and water leakage.
- Develop and implement a program aimed at enhancing the efficiency and maintenance of refrigeration systems. Initiate the energy audit as the initial step, followed by a subsequent assessment, and afterwards incorporate a refrigerator efficiency-maintenance program into your ongoing energy management initiative.

10.1.9 Lighting

- One approach to address the issue of high light levels is to employ various strategies such as switching, delamping, and other similar techniques in order to bring the illumination levels down to normal levels. It is essential to have a thorough understanding of the electrical impacts before to engaging in the process of decamping.
- The management of lighting may be effectively achieved by the utilization of clock timers, delay timers, photocells, and/or occupancy sensors, which allow for a proactive and efficient control of lighting conditions. Implementing energy-efficient alternatives to traditional lighting technologies, such as incandescent lighting and mercury vapor lighting, is a recommended course of action.
- The efficiency (measured in lumens per watt) of different technologies can be ranked from highest to lowest as follows: low pressure sodium, high pressure sodium, metal halide.
- The three types of lighting sources often used are fluorescent, mercury vapor, and incandescent. It is advisable to use caution and deliberate consideration while choosing ballasts and bulbs, prioritizing good power factor and long-term efficiency.
- One potential solution for addressing outdated fluorescent systems is to replace them with more modern alternatives, such as Compact Fluorescent Lamps (CFLs) and electronic ballasts.
- It is worth considering the possibility of reducing the number of fixtures in order to minimize their usage.
- The inclusion of daylighting strategies such as skylights should be taken into consideration.One potential recommendation is to choose for a lighter hue when painting the walls, which may contribute to a brighter ambiance. Additionally, reducing the number of lighting fixtures or utilizing lower wattages may also be advantageous.
- Utilize task lighting while minimizing background illumination.
- The objective of this study is to reassess the current approach, selection, and management of outdoor lighting. Implement strict control measures.
- It is recommended to replace incandescent exit signs with LED exit signs.

10.1.10 DG SETS

Diesel generator sets (DG sets) are often used in various industries and applications. These sets consist of a diesel engine and an alternator, which work together to generate Maximize the efficiency of the loading process.

- system that utilizes waste heat to produce steam, and hot water, or generate electricity through the operation of an absorption system.

- The user's query pertains to the choice between using a chiller or preheating in a certain context.
- The concept of process or utility feeds.
- The utilization of jackets and head cooling water is employed to meet the process requirements.
- It is advisable to do regular maintenance on air filters to ensure their cleanliness.
- One effective method for mitigating high temperatures in DG set rooms is to insulate the exhaust pipes.
- It is recommended to utilize heavy fuel oil of lower cost for capacities beyond the threshold of one million watts (IMW).

Chapter 11

Cost Analysis and Pay Back Period Time

11.1 Energy Savings on Ac

i) Energy Saving By Replacing Ac 3 star With 5 Star Ac
Ac with 3-star Rating
Each 2-ton 3 star ac consumes 1950 Watt
The total number of ac is=101
Total Power consumption=101 x 1950=196950watts =196.95 kW
Total Energy consumption per day =196.95 x 7 hours =1378.65 kWh
Energy Cost/day=1378.65 x 6.40= Rs8823.36/-
Total Annual Energy Cost Rs8823.36x100 days=Rs882336……… (1)
2ton 5star Ac power consumption=1113 W
Power consumption by replacing all 3 Star ac with 5 star ac
= 101computers x 1113 watts Each
=112413 w = 112413/1000 = 112.413kw
Energy consumption /day with 7 hours operating = 112.413* 7 = 786.891kWh
Energy cost /day = 786.891 * 6.40 =Rs5036.1024/-
Annual energy cost = 5036.1024*100 =Rs503610.24/............ (2)
Cost Saving (1-2)= Rs 882336-503610.24=Rs 378725.76/------(3)
The cost Of the 3star 2-ton acis Rs42000 /to 47000/-
Cost Of 5 star 2ton ac is = Rs 52000/-to 57000/-
Extra Cost Of Replacement =Rs 5000/
System Replacing All = Rs 5000 X 101 Rs =505000/-------(4)
Payback period (4/3) = 1.3years, 15 months

11.2 Energy savings on lighting For academic building:

a) In the case of fluorescent tubes
Total number of tube lights:703
Wattage:40watt
Lumens: 2400
Cost: 400 per Tube set (including tube) & 50 per tube light
Life: 4000hrs
Usage:5hrs a day for 5 days in a week
Total load: 40*703= 28.12KW
Monthly consumption= 2812KWh
SEB charge Rs 6.40 (approx) per Unit
The charge for monthly consumption is Rs 17996.8.
For a year, energy charges will be Rs 215961.6.
For every 3 years, we have to replace all tube lights because of their life so its cost Rs 35150
Installation cost = 703*400 =Rs 281200.
So for 1 year total cost = Rs 497161.6
So for 2 year total cost = Rs 497161.6+ Rs 215961.6
=Rs 713123.20 (i.e., previous year cost + this year's consumption cost)
So for 3 year total cost Rs 713123.20+Rs 215961.6+Rs 35150 = Rs 964234.8 (i.c. previous year cost + this year consumption cost+ replacement cost)

b) By using LED's for academic building:
Wattage: 20watts
Lumens: 2250
Cost500Rs per led bulb
Life: 50000hrs
Usage: 100hrs per month
Total load: 20*703=14.06KW
Monthly consumption= 1406KWh
Charge for monthly consumption= Rs 8998.4 (Rs 6.40per unit)
Annual consumption charge Rs 107980.8
Installation cost: 500*703 = Rs 351500.
For the 1st year total cost of Rs 459480.8
For 2nd year total cost Rs 459480.8+ Rs107980.8= Rs 597461.6
For 3rd year total cost Rs 597461.6+Rs1079808=Rs 1647269.6
So by replacing tube lights with LEDs, we can reduce the monthly consumption.
We will get back profits after Approx 3.25 Years.

11.3 Automatic Controlled Fans For academic building:

a) Energy Saving by controlled fans and Conventionally controlled fans
=60wx operating hours(per day per fan)
=60wx10 hours/day
= 600wh/day/fan
Energy cost per day per fan =0.6*6.40=3.84
Cost of energy consumption for 260 fnas per day =3.72*260
=967.2
Annual cost of energy consumption by regulated fans
= Rs 2000*288
=Rs 576000….....1
It Can Be Operating Based On User Requirements May Reduce the Operating Time

We found that fans are running if it is not required also, so by automatically controlled fans we can conserve 3hrs a day.
Let us operate the fans on a need basis as a remote control is available, it will reduce the operating hours (Assume that the wattage is the same)= 60W * 7 hr
= 420Wh / day
= 0.42 kWh/day
= 0.42 * 6.4
= RS 2.688/day
Annual Energy consumption by the automatically controlled fan
= 2.688x260x288
= Rs201277.44(2)
Cost saving (1)-(2)= Rs 86261.76/-
The total cost of the additional unit automatic operating switch= Rs.400 x260
= Rs104000
Payback period=104000/86261.76= Approx 1 year 2 month

11.4 Energy Saving on Water Cooler For Academic building:

Energy Saving By Replacing Water Cooler Operating Switch with Solar Operating Switch

Water Cooler: It uses a temperature switch to work on heater Uses the switch working on temperature

Calculation:

If a 1000 W Cooker consumes Electrical Power as long as the power is on then Energy consumed for a full day in the conventional type water cooler:

Energy consumption = Power rating of water cooler x operating hours

= 1000 * 10 = 10000Wh = 10kWh

Energy cost per day =10x 6.40 =Rs64/-

Annual Energy cost = 64 * 365 * days =Rs 23360/ .... (1)

Replaced by Solar Switch Operating Cooler.

It uses an automated operation on solar radiations based on day hot condition

If operating up to the sun hot with a charging facility for 4 more hours during the night between 8

A.M to 8 P.M = 12 hours.

If a 1000 W Cooler consumes electrical power by solar operating automated switch then Energy consumed for only a day in the solar operating automated switch:

=1000 W x 10hrs 10000 Wh = 10 kWh

Energy cost per day =12 x 6.40=Rs76.80/-

Annual Energy cost =76.80x365days = Rs 28032/ ----------(2)

Cost saving due to energy saving (1)-(2)=4672/-

Additional cost for providing solar switch = Rs3000/-

The payback period for providing solar switch = 3000/76.80=39.06days

11.5 Energy Savings on Computers For academic building:

Energy Saving By Replacing Desktop LCD Monitor With Laptop

Computer with desktop LCD monitor

Each LCD monitor consumes 200 Watt

The total number of computers is

Total Power consumption=262 x 200=52400watts =52.40 kW

Total Energy consumption per day =52.40 x 8hours =419.20 kWh

Energy Cost/day=419.20 x 6.40= Rs2682.88/-

Total Annual Energy Cost Rs2682.88x288days= Rs772669.44 (1)

LAPTOP power consumption=150 W

Power consumption by replacing all desktop LCD monitors with laptop

= 262computers x 150 watts Each

=39300 w = 39300/1000 = 39.3kw

Energy consumption /day with 8 hours operating = 39.3* 8 = 314.4kWh

Energy cost /day = 314.4 * 6.40 =Rs 2012.16/-

Energy cost per month = 2012.16 * 24 =Rs48291.84/-

Annual energy cost = 48291.84 * 12 =Rs 579502.08/............ (2)

Cost Saving (1-2)= Rs772669.44-579502.84=Rs 193166.6/ ----- (3)

The cost Of the Computer is Rs 20000/to 23000/-
Cost Of Laptop = Rs 30000/-to 40000/-
Extra Cost Of Replacement =Rs 7000/
System Replacing All = Rs 7000 * 262 Rs =1834000/------ (4)
Payback period (4/3) = 9.49 years, i.c. 114 months
Additional Energy Save by Keeping on All Systems Only When It Is Used or Avoid Using the System in Sleepy Mode
Keep all the systems in sleep mode during non-operating hours.
Let systems be used effectively for 6 hours a day.
The duration of average sleeping mode-2 hours/system
Thus the power consumed by systems during sleeping mode
= 262 * 2 hrs (LCD monitor desktop)=524 hrs
Energy consumed by sleeping mode computer/day=104800Wh
Energy in kWh/day=104800/1000 =104.80 kWh
Cost/day =105 X6.40=Rs672/-
Cost of Energy consumption/month Rs672 x 24 day =Rs16128/-
Annual cost of energy – Rs16128/-x12months =Rs193536/-
Rs 193536 will be lost in a year when we put computers into sleep mode.

As we use the laptop based on the charged facility as well as practice to use only when required by default the energy cost same will be added to the laptop facility.

11.6 Energy Saving on Photocopier for academic building:

Energy saving by operating the photocopier machine only when required or avoiding using machine in the sleepy mode

Which consume energy as follows.
Power Consumption of Xerox M/C in Non-Operating Mode = 1x100W
Energy Saving for Approximate Sleepy Mode Hours For 2 Hours In A Day =100W x 2hr/day
= 200Wh/Day
Energy in kWh =200/1000=0.2kWh/day
Energy for a Month = 0.2kWh x 24days =4.8kWh =4.8
Units Monthly Energy Cost=4.8x 6.40=Rs30.72/-
Annual Energy Cost Saving = Rs30.72x12 =Rs 368.64/-

11.7 Energy savings on lighting for all hostel building:

a) In the case of fluorescent tubes
Total number of tube lights:704
Wattage:40watt
Lumens: 2400
Cost: 400 per Tube set (including tube) & 50 per tube light
Life: 4000hrs
Usage:12hrs a day for 7 days in a week
Total load: 40*704= 28160KW=28.16kw
Monthly consumption= 28.16*384hours=10813.44kwh
SEB charge Rs 6.40 (approx) per Unit
The charge for monthly consumption is=10813.44*6.40= Rs 69206.016.
For a year, energy charges will be monthly consumption*12months=69206.016*12 =830472.192Rs

For every 3 years, we have to replace all tube lights because of their life so its cost Rs 35150.
Instalation cost = 703*400 =Rs 281200
So for 1 year total cost = 830472.192+281200=Rs 1111672.192
So for 2 year total cost = Rs1111672.192+ 830472.192Rs
=Rs 1942144.384(i.e., previous year cost + this year's consumption cost)
So for 3 year total cost Rs1942144.384 +Rs830472.192 +Rs 35150 = Rs 2807767 (i.c. previous year cost + this year consumption cost+ replacement cost)

b) By using LED's for academic building:
Wattage: 20watts
Lumens: 2250
Cost500Rs per led bulb
Life: 50000hrs
Usage: 384hrs per month
Total load: 20*704=14080W=14.08kwh
Monthly consumption= 5406.72KWh
Charge for monthly consumption= Rs 34603.008(Rs 6.40per unit)
Annual consumption charge Rs 415236.096.
Installation cost: 500*704 = Rs 352000.
For the 1st year total cost of Rs 767236.096.
For 2nd year total cost Rs767236.096 +Rs415236.096= Rs 1182472.192.
For 3rd year total cost Rs1182472.192 +Rs415236.096.=Rs 1597708.288
So by replacing tube lights with LEDs, we can reduce the monthly consumption by half.
We will get back profits after Approx 10.08 Months.

Chapter 12

Recommendation And Suggestion

- **Electrical Department:**

Lighting:

Professor's cabin:

- Asst. Prof. S.Sarkar: In this room, the average lux is 40, but the required lux is 200, so one additional 20w led light will be required to achieve the required lux.
- Prof. Dr. S. Majumdar: In this room, the average lux is 40, but the required lux is 200, so an additional one 20w led light will be required to achieve the required lux.
- Asst. Prof. Mafijul Ishlam: In this room, the average lux is 50, but the required lux is 200, so an additional 20w led light will be required to cover the required lux.
- Prof. G.K. Panda: In this room, the average lux is 205, but the minimum required lux is 200, so there is no need to cover the minimum required lux.
- Prof. P. K. Saha: In this room, the average lux is 55.5, but the required lux is 200; therefore, two additional 20w led lights will be required to meet the required lux.
- Prof. Dr. S. Das (H.o.d): In this room, the average lux is 44, but the required lux is 200, so one additional 20w led light will be required to cover the required lux.
- Asst. Prof. T.K.M. Madam: In this room, the average lux is 50, but the required lux is 200; therefore, one additional 20w led light will be required to cover the required lux.

Classrooms:

- Classroom 2: The average lux in this room is 60, but the required lux is 200, so to cover the required lux in room 8, an additional 20w led light will be necessary.
- Classroom 3: The average lux in this room is 60, but the required lux is 200; therefore, to cover the required lux in classroom 9, an additional 20w led light will be necessary.
- Classroom 4: The average lux in this room is 60, but the required lux is 200; therefore, to cover the required lux in classroom 6, an additional 20w led light will be necessary.
- Classroom Tutorial: In this room, the average lux is 45, but the required lux is 200, so four additional 20w led lighting will be needed to achieve the required lux level.
- Classroom for Seniors (1): The average lux in this room is 102.5, but the required lux is 200; thus, four additional 36w FLT lamps will be required to achieve the required lux in this room.
- Final Year Classroom (2): In this room, the average lux is 93, but the required lux is 200, so additional 40w FLT lighting will be required to achieve the required lux.

Departmental Laboratory:

- Electrical Drives: In this room, the average lux is 76, but the required lux is 300, so 4 additional 20w led lighting will be required to meet the required lux.
- Networking Lab: The average lux in this room is 87.25, but the required lux is 300, so three additional 20w led lighting will be required to achieve the required lux.
- Analog Lab: In this room, the average lux is 93, but the required lux is 300, so 6 additional 20w led lighting will be required to achieve the required lux.
- Measurement Lab: In this room, the average lux is 60, but the required lux is 300, so six additional 20w led lamps will be required to achieve the required lux.
- Power system Lab 2: The average lux in this room is 90, but the required lux is 300, so two additional 20w led lamps will be required to achieve the required lux.

- Power Electronics Laboratory: The average lux in this room is 59, but the required lux is 300; thus, eight additional 20w led lighting will be required to achieve the required lux.

Computer Science Department:

Professor's cabin:

- Prof. J. Dutta Mam: The average lux in this room is 92, but the required lux is 200; therefore, you must cover the required lux in the room. Two additional 20w led lights are required.
- Prof Srinibas Sir: In this room, the average lux is 75, but the required lux is 200; therefore, two additional 20w led lights will be required to meet the required lux.
- Professor Chinmoy Ghosh:In this room, the average lux is 82.25, but the required lux is 200, so one additional 20w led light will be required to achieve the required lux.
- Prof. D. Mondal/ D.K. Ksir: The average lux in this room is 141, but the required lux is 200, so the cover the required lux in this room. One additional 20w led light is required.
- Prof A.Hazra sir: In this room, the average lux is 84.25, but the required lux is 200, so the room is adequately lit. Two additional 20w led lamps are required.
- H.O.D. sir: In this room, the average lux is 100, but the required lux is 200, so two additional 20w led lamps will be needed to fulfill the required lux.
- H.O.D. gentlemen (Assist): In this room, the average lux is 90, but the required lux is 200; therefore, two additional 20w led lamps will be required to meet the required lux.

Class rooms:

- Classroom 1: The average lux in this room is 82, but the required lux is 200; therefore, to cover the required lux in classroom 2 additional 20w led light will be required.
- Classroom 2: The average lux is 80, but the required lux is 200, so to cover the required lux in room 3 additional 20w led light is required.
- Classroom3: The average lux in this room is 117, but the required lux is 200. To meet the required lux in room 2 an additional 20w led light will be required.

Departmental Laboratory:

- Multimedia Lab: The average lux in this room is 94, but the required lux is 300, so 5 additional 20w led lighting will be required to achieve the required lux.
- Computer Architecture Lab: In this room, the average lux is 114, but the required lux is 300, so 8 additional 20w led lighting will be required to meet the required lux.
- DBMS lab: The average lux in this room is 110, but the required lux is 300; therefore, six additional 20w led lighting will be required to achieve the required lux.
- Operating System Lab: In this room, the average lux is 93, but the required lux is 300, so 9 additional 40w led lighting will be required to cover the required lux.

Information Technology:

Professor's cabin:

- H.O.D. sir A.k. Samanta: In this room, the average lux is 54, but the required lux is 200; therefore, to cover the required lux in the room, two additional 20w led lights will be needed.
- IT H.O.D. department: The average lux in this room is 38, but the required lux is 200; therefore, the cover the required lux in this room. Two additional 20w led lights are required.
- S.k.Mondal: In this room, the average lux is 58, but the required lux is 200; therefore, 1 additional 20w led light will be required to meet the required lux.

Classrooms:

- classroom 1: The average lux in this room is 70, but the required lux is 200; therefore, an additional 20w led light will be required in room 2 to satisfy the required lux.
- Classroom 2: The average lux in this room is 75, but the required lux is 200; therefore, additional 20w led light will be required to cover the required lux in room 2.

Departmental Laboratory:

- Advanced operating system laboratory: The average lux in this room is 67.25, but the required lux is 300, so six additional 20w led lighting will be required to achieve the necessary lux.
- System Architecture and Organization Laboratory: In this room, the average lux is 36.58, but the required lux is 300, so seven additional 20w led lighting will be required to achieve the required lux.
- Data Base Management System: In this room, the average lux is 88, but the required lux is 300, so two additional 20w led lamps will be required to cover the required lux.
- IT Seminar Room: The average lux in this room is 45, but the required lux is 300, so seven additional 20w led lighting will be required to achieve the required lux.

Civil Engineering Department:

Professor's cabin:

- Asst Prof: The average lux in this room is 35, but the required lux is 200, so two additional 20w led lights will be required to achieve the required lux.
- Asst Prof: In this room, the average lux is 52.91, but the required lux is 200, so one additional 20w led light will be required to achieve the required lux.
- Prof Utpol sir: In this room, the average lux is 50, but the required lux is 200, so two additional 20w led lights will be required to meet the required lux.
- Prof K.Kabiraj sir: In this room, the average lux is 23, but the required lux is 200, so two additional 20w led lights will be required to meet the required lux.
- Asst Prof Mam: In this room, the average lux is 74.83, but the required lux is 200, so one additional 20w led light will be required to meet the required lux.
- In this room, the average lux is 33.16, but the required lux is 200; therefore, 5 additional 20w led lights will be required to fulfill the required lux.
- H.O.D. gentlemen Room: In this room, the average lux is 90, but the required lux is 200, so 2 additional 20w led lights will be required to cover the required lux.

Class rooms:

- Classroom 1: The average lux is 66, but the required lux is 200, so additional 20w led light will be required in room 6 to meet the required lux.

- Classroom 2: The average lux in this room is 28, but the required lux is 200. To cover the required lux in room 13, an additional 20w led light will be necessary.
- Classroom 3: The average lux is 70.66, but the required lux is 200, so additional 20w led light will be required in room 4 to satisfy the required lux.
- Classroom 4: The average lux is 50, but the required lux is 200, so additional 20w led light will be required in room 8 to fulfill the required lux.

Departmental Laboratory:

- Concrete and material lab: The average luminosity in this room is 12.75, but the required lux is 300, so 18 additional 20w led lighting will be needed to achieve the required lux.
- Structures Laboratory: The average luminosity in this room is 46.08, but the required lux is 300, so 31 additional 20w led lighting will be required to achieve the required lux.
- Soil machine lab: The average lux in this room is 54.58, but the required lux is 300, so 32 additional 20w led lighting will be required to achieve the required lux.
- Highway Engineering Lab: The average lux in this room is 46.83, but the required lux is 300, so 26 additional 40w FLT lamps will be required to achieve the required lux.
- Water Resources Laboratory: The average lux in this room is 31.75, but the required lux is 300, so 30 additional 40w FLT lamps will be required to achieve the required lux.
- Lab: The average lux in this room is 36.16, but the required lux is 300; therefore, 10 additional 40w FLT lamps are required to achieve the required lux.

Electronics Communication Engineering Department:

Professor's cabin:

- H.O.D. Department: In this room, the average lux is 32.50, but the required lux is 200; therefore, two additional 20w led lights will be required to meet the required lux.
- Professor Sudip Mondal, sir: In this room, the average lux is 41.08, but the required lux is 200, so two additional 20w led lights will be required to meet the required lux.
- Prof. Alokesh Mondal, sir: The average lux in this room is 55.5, but the required lux is 200, so two additional 20w led lights will be required to meet the required lux.
- Asst Prof: In this room, the average lux is 35, but the required lux is 200, so two additional 20w led lights will be required to achieve the required lux.
- Asst Prof: In this room, the average lux is 45, but the required lux is 200; therefore, two additional 20w led lights will be required to achieve the required lux.

Class rooms:

- Classroom 1: The average lux in this room is 60, but the required lux is 200. To cover the required lux in room 6, an additional 40w led light will be needed.
- Classroom 2: The average lux is 60, but the required lux is 200, so an additional 40w led light will be required in room 6 to satisfy the required lux.
- Classroom 3: The average lux in this room is 45, but the required lux is 200, so an additional 40w FLT light will be required in room 7 to cover the required lux.
- Gallery Room: The average lux in this room is 86.08, but the required lux is 200. To meet the required lux in room 5, an additional 36w FLT light will be needed.

Departmental Laboratory:

- Digital Communication System Lab: The average lux in this room is 46, but the required lux is 300, so 9 additional 40w FLT lamps will be required to achieve the required lux.

- Microwave Lab: The average lux in this room is 54, but the required lux is 300, so 10 additional 40w FLT lamps will be required to achieve the required lux.
- VLSI Lab: In this room, the average lux is 86.83, but the required lux is 300, so one additional 40w FLT light will be required to cover the required lux.
- Design Lab: In this room, the average lux is 36.25, but the required lux is 300, so 10 additional 40w FLT lamps will be required to achieve the required lux.
- Digital Communication Lab: The average lux in this room is 45.91, but the required lux is 300, so 10 additional 20-watt led lighting will be required to achieve the required lux.

Mechanical Department:

Professor's cabin:

- S. Bhatt Sir: The average lux in this room is 79.83, but the required lux is 200. To meet the required lux in this room, two additional 20-watt LED lighting will be required.
- Asst. Prof. S.Mondal: The average lux in this room is 34.91, but the required lux is 200, so three additional 20-watt LED lamps will be required to achieve the required lux.
- H.O.D. Sir, the average lux in this room is 74.75, but the required lux is 200. To meet the required lux in this room, four additional 20-watt LED lighting will be required.
- M.C.Moandal: In this room, the average lux is 70.83, but the required lux is 200, so two additional 20-watt LED lamps will be required to achieve the required lux.
- DR. N. Mukhopadhyay: In this room, the average lux is 71.83, but the required lux is 200, so two additional 20-watt LED lamps will be required to achieve the required lux.
- DR. A. Kundu: In this room, the average lux is 69.83, but the required lux is 200; therefore, two additional LED 20-watt lamps are required to achieve the required lux.
- Dr. S. Mukherjee: In this room, the average lux is 75.83, but the required lux is 200, so two additional 20-watt LED lamps will be required to achieve the required lux.
- Prof. R. Roy: In this room, the average lux is 80.83, but the required lux is 200, so two additional 20-watt LED lamps will be required to achieve the required lux.

Class rooms:

- Classroom 1: The average lux in this room is 58.33, but the required lux is 200, so six additional 20-watt LED lighting will be required to achieve the required lux.
- Classroom 2: The average lux in this room is 36.41, but the required lux is 200, so two additional 20-watt LED lamps will be required to achieve the required lux.
- Classroom 3: The average lux in this room is 41.75, but the required lux is 200. To achieve the required lux in this room, seven additional 20-watt LED lighting will be required.
- Classroom 4: The average lux in this room is 41.83, but the required lux is 200, so seven additional 20-watt LED lighting will be required to achieve the required lux.
- Seminar room: The average lux in this room is 52.16, but the required lux is 200, so seven additional 20-watt LED lamps will be required to achieve the required lux.

Departmental Laboratory:

- Machine dynamics: In this room, the average lux is 23.51, but the required lux is 300; therefore, 10 additional 20-watt led lighting will be required to cover the required lux.
- IC Engines Lab: The average lux in this room is 40.16, but the required lux is 300, so 63 additional 20-watt led lighting will be required to achieve the required lux.
- Heat Transfer Lab: The average lux in this room is 52, but the required lux is 300, so 34 additional 20-watt led lighting will be required to achieve the required lux.
- Hydraulics and Fluids: In this room, the average lux is 32.25, but the required lux is 300, so 53 additional 40-watt led lighting will be needed to achieve the required lux.

- Autocad: In this room, the average lux is 85, but the required lux is 300, so four additional 20-watt led lighting will be required to meet the required lux.
- Anysis Lab: The average lux in this room is 60.75, but the required lux is 300, so seven additional 20-watt led lamps will be required to achieve the required lux.
- Cad – Cam Lab: The average lux in this room is 60.41, but the required lux is 300, so four additional 20-watt led lamps will be required to achieve the required lux.

HU DEPARTMENT:

Professor's cabin:

- H.O.D. DR.N. CHAKROBORTY: In this room, the average lux is 41.83, but the required lux is 200; therefore, one additional LED 20-watt light will be required to meet the required lux.
- Dr. Md Ansur Rahaman: In this room, the average lux is 83, but the required lux is 200, so one additional LED 20-watt light will be required to meet the required lux.
- Dr. Swapan Kumar Ray: In this room, the average lux is 79.50, but the required lux is 200, so one additional LED 20-watt light will be required to meet the required lux.
- Sri R.N.Karjee: In this room, the average lux is 84.50, but the required lux is 200, so one additional LED 20-watt light will be required to meet the required lux.
- Facility room of HU: The average lux in this room is 77, but the required lux is 200; thus, four additional 20-watt LED lamps are required to achieve the required lux.
- Department of Mathematics: The average lux in this room is 69.30, but the required lux is 200; therefore, three additional 20-watt LED lamps will be required to achieve the required lux.
- HU laboratory: the average lux in this chamber is 200, so no additional lighting is required.

OFFICE / ADMENISTRATIVE DEPARTMENT:

- Cash Section: In this room, the average lux is 88, but the required lux is 300, so 6 additional 40-watt FLT lamps will be required to meet the required lux.
- Accounts office: The average lux in this room is 88.50, but the required lux is 300, so one additional 40-watt FLT light will be required to meet the required lux in this room.
- Accounts Section: In this room, the average lux is 102.08, but the required lux is 300, so two additional 36-watt led lamps will be required to meet the required lux.
- Accounts department part 2: The average lux in this room is 37.41, but the required lux is 300, so two additional 40-watt FLT lamps will be required to achieve the required lux.
- Register room: The average lux in this room is 124.41, but the required lux is 300, so seven additional 20-watt led lighting will be required to achieve the required lux.
- Principal Sir Room: The average lux in this room is 64.08, but the required lux is 300, so four additional 36-watt FLT lamps will be required to achieve the required lux.
- Principal Sir AssitRoom: The average lux in this room is 80, but the required lux is 300; therefore, four additional 20-watt led lamps will be required to achieve the required lux.
- AD Section (Ground Floor): In this room, the average lux is 56.50, but the required lux is 300, so one additional 36-watt FLT light will be required to meet the required lux.
- Asst.Proctor: In this room, the average lux is 103.58, but the required lux is 300, so one additional 40-watt FLT light will be required to meet the required lux.
- Placement Assistance: In this room, the average lux is 48.75, but the required lux is 300, so two additional 20-watt led lights will be required to achieve the required lux.
- Conference Room: The average lux in this room is 314, but the minimum required lux is 300, so no additional lighting is required.

- Principle Sir Waiting Room: In this room, the average lux is 49.33, but the required lux is 300, so four additional 40-watt FLT lamps will be required to meet the required lux.
- Deputy registers room: The average luminosity in this room is 73.41, but the required lux is 300, so two additional 20-watt led lamps will be required to achieve the required lux.
- Exam Section: In this room, the average lux is 42.08, but the required lux is 300, so four additional 40-watt FLT lamps will be required to achieve the required lux.
- Controller Sir Room: In this room, the average lux is 218 but the required lux is 300, so two additional 20-watt led lamps will be required to meet the required lux.
- Printing Room: The average lux in this room is 305, but the minimum required lux is 300, so no additional lighting will be required.
- Confidence Cell: In this room, the average lux is 73.25, but the required lux is 300, so one additional 36-watt FLT light will be needed to achieve the required lux.
- Establishment Section: In this room, the average lux is 70, but the required lux is 300, so three additional 36-watt FLT lamps will be required to meet the required lux.
- Office: The average lux in this room is 87.91, but the required lux is 300, so two additional 40-watt FLT lamps will be required to achieve the required lux.
- It Office supper: In this room, the average lux is 99, but the required lux is 300, so two additional 20-watt led lamps will be required to meet the required lux.

Library:

- Central library: In this room, the average lux is 28.5, but the required lux is 300, so 41 additional 40-watt FLT lamps will be required to achieve the required lux.
- First-floor: In this room, the average lux is 31.883, but the required lux is 300, so 15 additional 40-watt FLT lamps will be required to achieve the required lux.
- 2ndFloor: In this room, the average lux is 100.499, but the required lux is 300, so 26 additional 40-watt FLT lamps will be required to meet the required lux.

Server Computer Room

- Computer Room: The average lux in this room is 35.91, but the required lux is 300, so five additional 20-watt led lamps will be required to achieve the required lux.
- Computer Room Lab -1: The average lux in this room is 98.16, but the required lux is 300. To meet the required lux in this room, nine additional 20-watt led lamps are required.
- Computer Lab: The average lux in this room is 79.16, but the required lux is 300, so four additional 40-watt FLT lamps will be required to achieve the required lux.
- Computer Server Room: The average lux in this room is 58, but the required lux is 300, so two additional 20-watt led lamps will be required to meet the required lux.
- Computer Center Lab: The average lux in this room is 49.75, but the required lux is 300, so three additional 40-watt FLT lamps will be required to achieve the required lux level.

BASIC WORK SHOP LABORATORY:

In a rudimentary laboratory, the minimum required lux level is 300, so additional lighting is unnecessary.

HOSTEL:

BOYS HOSTEL 1:

- Common Room: The average lux in this room is 38, but the required lux is 150; therefore, 9 additional 40-watt FLT lamps are required to achieve the required lux.
- Dining Room: The average lux in this room is 52.91, but the required lux is 150. To achieve the required lux in this room, eight additional 40-watt FLT lamps will be required.
- (75) Living Room: The average lux in this room is 71.75, but the minimum required lux is 50; therefore, no additional lighting is required.

BOYS HOSTEL 2:

- Common Room: The average lux in this room is 22.75, but the required lux is 150. To meet the required lux in this room, seven additional 40-watt FLT lamps are required.
- Dining Room: The average lux in this room is 54.33, but the required lux is 150, so 5 additional 40-watt FLT lamps will be required to achieve the required lux.
- (70) Living Room: The average lux in this room is 68.75, but the minimum required lux is 50; therefore, no additional lighting is required.

BOYS HOSTEL 3:

- Common room: The average lux in this room is 52.08, but the required lux is 150. To meet the required lux in this room, six additional 40-watt FLT lamps are required.
- Dining Room: The average lux in this room is 48.41, but the required lux is 150. To meet the required lux in this room, eight additional 40-watt FLT lamps will be required.
- (79) Living Room: The average lux in this room is 87.41, but the minimum required lux is 50; therefore, no additional lighting is required.

BOYS HOSTEL 4:

- Common Room: The average lux in this room is 49.41, but the required lux is 150. To meet the required lux in this room, six additional 36-watt FLT lamps are required.
- Dining Room: The average lux in this room is 61.83, but the required lux is 150. To meet the required lux in this room, seven additional 36-watt FLT lamps will be required.
- Living Room: The average lux in this room is 60, but the minimum required lux is 50; therefore, no additional lighting is required.

GIRLS HOSTEL:

- Common Room: The average lux in this room is 84.75, but the required lux is 150. To meet the required lux in this room, three additional 20-watt LED lighting will be required.
- Dining Room: The average lux in this room is 98.40, but the required lux is 150, so two additional 20-watt LED lamps will be required to achieve the required lux.
- Living Room: The average lux in this room is 67, but the minimum required lux is 50; therefore, no additional lighting is required.

BOYS GYM:

- BOYS GYM: The average lux in this room is 28.41, but the required lux is 200, so 17 additional 40-watt FLT lamps will be required to achieve the required lux.

Fan

Professor’s room:

- Porff. Sarkar: there is already one 60-watt fan in this room, so there is no need to replace it.
- Professor S. Majumdar: we can replace the 100-watt fan in this room with a 60-watt energy-efficient fan.
- Assist Prof. Mafijul Ishlam: there is already one 60-watt fan, so there is no need to replace it.
- Professor G.K. Panda, there is already a 60-watt fan, so there is no need to replace it.
- Prof. P. K. Sahasir, there is already one 60-watt fan, so there is no need to replace it.
- Prof. Dassir: A 60-watt fan is already extant, so there is no need to replace it.
- Assistant Professor T.K.M., there is already one 60-watt fan, so there is no need to replace it.

Classroom:

- Classroom 2: There are six 60-watt fans in this classroom, so no replacement is necessary.
- Classroom 3: This room already has six 60-watt fans, so there is no need to replace them.
- Classroom 4: This room already has six 60-watt fans, so there is no need to replace them.
- Classroom Tutorial: As there is only one 100-watt fan in the room, it must be replaced with a new 60-watt energy-efficient fan.
- Final Year Classroom: Every fan is 60 watts, so there is no need to replace them.
- Final Year Classroom: All fans are 60 watts, so replacement is unnecessary.

Department Laboratory:

- Electrical Drives: Three 100-watt fans must be replaced with new, more energy-efficient 60-watt fans.
- In the Networking Lab, one 100-watt fan must be substituted with a 60-watt fan that is more energy-efficient.
- In the Analog Lab, one 100-watt fan must be substituted with a 60-watt fan that is more energy efficient.
- Measurement Lab: Replace one 100-watt fan with a new 60-watt energy-efficient fan
- Power System Lab 2: Replace four 100-watt fans with new 60-watt energy-efficient fans.
- Power Electronics Laboratory: all fans are 60 watts, so there is no need to replace them.

Computer Science Department:

Professor’s room

- Professor J. Dutta, ma'am, all fans are 60 watts, so there is no need to replace them.

- Prof. Srinibash Sir, please replace one 100-watt fan with a new 60-watt energy-efficient fan.
- Prof. Chinmoy Ghosh, please replace one 100-watt fan with a new 60-watt energy-efficient fan.
- The Prof. D. Mondal/D.K.K. Sirone 100-watt fan must be replaced with a new 60-watt energy-efficient fan.
- Professor A. Hazra, sir: All fans are 60 watts, so there is no need to replace them
- H.O.D. Sir: Since all fans are 60 watts, there is no need to replace them.
- Commander, sir (assist): All fans are 60 watts, so there is no need to replace them.

Classroom:

- Classroom 1: All fans are 60 watts, so they do not require replacement.
- Classroom 2 has air conditioning.
- Classroom 3: Every fan is 80 watts, so we must replace it with a 60 watt energy-efficient fan.

Institutional Laboratory:

- In the Multimedia Laboratory, we must replace three 80-watt fans with new 60-watt energy-efficient fans.
- Computer Architecture Lab: We must replace four 80-watt fans with new 60-watt energy-efficient fans.
- DBMS Lab: We must replace three 80-watt fans with new 60-watt energy-efficient fans.
- Operating System Lab: We must replace four 80-watt fans with new 60-watt, energy-efficient fan

Information Technology

Professor's Room

- The H.O.D., Sir A.K. Samanta, has requested that one 100-watt fan be replaced with a new 60-watt energy-efficient fan.
- IT H.O.D. Department: Replace two 100-watt fans with two new 60-watt energy-efficient fans.
- S.K. Mondal: one 80-watt fan must be replaced with a new 60-watt fan that is more energy efficient.

Class rooms :

- Classroom 1: Replace one 100-watt fan with a new 60-watt energy-efficient fan.
- Classroom 2, a 100-watt fan must be substituted with a 60-watt fan that is more energy efficient.

Departmental Laboratory:

- Advanced Operating System Laboratory: all fans are 60 watts, therefore there is no need to replace them.
- System Architecture and Organization: All fans are 60 watts, so they do not require replacement.

- Data Base Management System: all fans are 60 watts, so there is no requirement to replace them.
- IT seminar room: all fans are 60 watts, so they do not require replacement.

Civil Engineering Division:
professor's room

- Assist Prof.: Replace one 100-watt fan with a new 60-watt energy-efficient fan.
- Assist Prof.: Replace two 100-watt fans with new 60-watt energy-efficient fans.
- Prof. Utpol Sir: Replace one 100-watt fan with a new 60-watt energy-efficient fan.
- Prof. k.Kabiraj: replace one 100-watt fan with a new 60-watt energy-efficient fan
- Assist Prof. Mam: Replace one 100-watt fan with a new 60-watt energy-efficient fan.
- Civil Teachers Room: Replace three 100-watt fans with new 60-watt energy-efficient fans.
- H.O.D. Sir Room: Replace one 100-watt fan with a new 60-watt energy-efficient fan.

Classroom:

- Classroom 1: All fans are 60 watts, so they do not require replacement.
- Classroom 2: Replace four 100-watt fans with an energy-efficient 60-watt fan.
- Classroom 3, eight 80-watt fans will be replaced with more energy-efficient 60-watt fans.
- Classroom 4: All fans are 60 watts, so they do not require replacement.

Departmental Laboratories:

- Concrete and Material Lab: Replace four 100-watt fans with an energy-efficient 60-watt fan.
- Structures Laboratory: Replace four 100-watt fans with an energy-efficient 60-watt fan.
- Soil Machine Lab: Replace two 100-watt fans with an energy-efficient 60-watt fan.
- Highway Engineering Lab: Replace one 100-watt fan with an energy-efficient 60-watt fan.
- Water resources laboratory: all fans are 60 watts, so they do not require replacement.
- Lab: Replace one 100-watt fan with an energy-efficient 60-watt fan.

Electronics and Communication Technology:
Professors Room:

- H.O.D. department: replace one 80-watt fan with an energy-efficient 60-watt fan.
- Professor Sudip Mondal Sir: All fans are 60 watts, so there is no need to replace them with energy-efficient 60watt fans.
- Professor Alokesh Mondal: Replace two 80-watt fans with a 60-watt energy-efficient fan One 100-watt fan will be substituted with two 60-watt energy-efficient fans.
- Assist Prof.: Replace two 80-watt fans with an energy-efficient 60-watt fan.
- Two 100-watt fans will be replaced with an energy-efficient 60-watt fan in Classroom
- Classroom 2: Replace two 100-watt fans with an energy-efficient 60-watt fan.
- Classroom 3: All fans are 60 watts, so they do not require replacement.
- Gallery Room: All ceiling fans are 60 watts, so there is no need to replace them.

ECE Laboratory:

- Digital Communication System Laboratory; b) Microwave Laboratory: Replace 880-watt fans with 60-watt energy-efficient fans.
- In the VLSI laboratory, five 80-watt fans will be substituted with 60-watt energy-efficient fans.
- Design Lab: Replace four 80-watt fans with an energy-efficient 60-watt fan.
- Digital Communication Lab: Replace 680-watt fans with an energy-efficient 60-watt fan

Mechanical Department:

Professors Room:

- S.Bhatt Sir, one 100-watt fan must be replaced with a 60-watt, energy-efficient fan.
- Assistant Professor S. Mondal states that all fans are 60 watts, so there is no need to
- Replace them.
  Two 100-watt fans are to be substituted with an energy-efficient 60-watt fan, mister.
- M.C. Moandal: one 100-watt fan will be substituted with an energy-efficient 60-watt fan.
- Dr. N. Mukhopaddhay : replace one 80-watt fan with one 60-watt energy-efficient fan.
- Dr. A. Kundu: replace one 100-watt fan with a 60-watt energy-efficient fan.
- Dr. S. Mukherjee: replace one 80-watt fan with a 60-watt energy-efficient fan.
- ProffR.Roy: Replace one 100-watt fan with an energy-efficient 60-watt fan.

Classroom

- Classroom 1: Replace four 100-watt fans with energy-efficient 60-watt fans.
- Classroom 2: Replace two 100-watt fans with an energy-efficient 60-watt fan.
- Classroom 3: Replace two 100-watt fans with an energy-efficient 60-watt fan.
- In Classroom 4, one 100-watt fan will be replaced with an energy-efficient 60-watt fan.
- Seminar Room: Replace two 150-watt fans with an energy-efficient 60-watt fan.

Departmental laboratory:

- Machine dynamics: Replace five 100-watt fans with an energy-efficient 60-watt fan.
- Ic Engines Lab: Replace two 80-watt fans with an energy-efficient 60-watt fan.
- Heat Transfer Lab: Replace 5 80-watt fans, 1 100-watt fan, and 1 150-watt fan with new energy-efficient 60-watt fans.
- Hydraulics and Fluids: Replace three 150-watt fans and one 80-watt fan with new energy-efficient fans.
- AutoCAD: This chamber has an air conditioning system.
- In the Analysis Laboratory, two 80-watt fans will be substituted with modern, more energy-efficient 60-watt fans.
- In the Cad-cam lab, all fans are 60 watts, so there is no need to replace them.

HU DEPARTMENT:

Professor's room

- H.O.D. Dr. N. Chakroborty: one 80-watt fan is to be replaced with a 60-watt energy-efficient fan.
- Dr. Ansur Rahaman: Replace one 80-watt fan with an energy-efficient 60-watt fan.

- Dr. Swapan Kumar Dey: replace one 80-watt fan with an energy-efficient 60-watt fan.
- Sri R.N.Karjee: One 80-watt fan will be replaced with an energy-efficient 60-watt fan.
- Replace the 80-watt fan in room HU:2 with new, more energy-efficient 60-watt fans
- The Department of Mathematics is to replace two 100-watt fans with new, more energy-efficient 60-watt fans.
- HU lab: Two 100-watt fans will be substituted with new 60-watt fans that are more energy efficient.

OFFICE/ ADMINISTRATIVE OFFICE:

- A 100-watt fan will be substituted with new 60-watt fans that are more energy efficient.
- Accounts office: Replace two 100-watt fans with new, more energy-efficient 60-watt fans.
- Accounts Section:5 fan replacement with new, more energy-efficient 60-watt fans
- Accounts Department Part 2: The fan does not require replacement.
- register room: one 100-watt fan will be substituted with two 60-watt fans that are more energy-efficient.
- Principal Room: Replace the 780-watt fan with a new 60-watt energy-efficient fan.
- The two 100-watt fans in the principal's assistant's room must be replaced with new, more energy-efficient 60-watt fans.
- An 80-watt fan will be substituted with new 60-watt fans that are more energy-efficient.
- Assistant Inspector: Replace the 180-watt fans with new 60-watt fans that are more energy efficient.
- Placements Assist: Replace the 180-watt fans with new, more energy-efficient 60-watt fans. Two 80-watt fans will be replaced with new, more energy-efficient 60-watt fans in room K.
- In the Sir Principal Waiting Room, one 80-watt fan will be substituted with a new, more energy-efficient 60-watt fan. m)
- Deputy Register Room: all fans are 60 watts, so they do not require replacement. Exam Section 1 requires the replacement of an existing 100-watt fan with a new 60-watt fan that is more energy efficient.
- Room controller, sir: all fans are 60 watts, so there is no need to replace them.
- All printing room fans are 60 watts, so there is no need to replace them.
- Replace the 100-watt fan in Confidence Cell:2 with new 60-watt fans that are more energy-efficient.
- Establishment Section: one 80-watt and one 100-watt fan are to be replaced with a new, more energy-efficient 60-watt fan.
- Office: all fans are 60 watts, so they do not require replacement. There is no need to replace the fans, as they are all 60 watts.

Library

- Central Library: all fans are 60 watts, so they do not require replacement.
- First Floor: All fans are 60 watts, so there is no need to replace them.
- On the second floor, all fans are 60 watts, so there is no need to replace them.

Computer Server Area

- In the computer room, two 80-watt fans will be replaced by two 60-watt, more energy-efficient fans.
- Computer Room Lab: Replace five 80-watt fans with five 60-watt fans that are more energy-efficient.
- Computer Server Chamber: This chamber has an air conditioning system.
- Computer Center Lab: This room has an air conditioning system.

BASIC LABORATORY

- In the Machine Shop, 9 no of150-watt fans will be replaced with new 60-watt fans that are more energy-efficient.
- In the Carpentry Shop, seven 150-watt fans will be replaced with modern, more energy-efficient 60-watt fans.
- Forging Shop: Replace one 150-watt fan with two new, more energy-efficient 60-watt fans.
- In the welding shop, three 150-watt fans and four 100-watt fans will be replaced with new, more energy-efficient 60-watt fans.

Hostel

Boys Hostel 1:

- the is currently using a table fan; if feasible, they should switch to a new, energy-efficient table fan.

Boys Hostel 2:

- They are currently using an inefficient table fan; if feasible, they should switch to a new, energy-efficient table fan.

Boys Hostel 3:

- They are currently using a table fan; if feasible, they should switch to one that is more energy-efficient.

Boys Hostel 4:

- This hostel's 60-watt fans are very ancient and must be replaced with modern, energy-efficient 60-watt fans.

Girls' Hostel :

- They are currently using a table fan; if feasible, they should switch to a new, energy-efficient table fan.

Boys' gymnasium:

- There are 150-watt stand fans, so we must replace them with more energy-efficient alternatives.

Chapter 13
Conclusion

The implementation of energy audits on college campuses represents a crucial and transformative step toward attaining sustainability, cost efficiency, and environmental responsibility. Through meticulous evaluation, strategic planning, and collaborative efforts, energy audits have the potential to generate significant positive effects across multiple dimensions.

Energy audits are potent instruments that enable institutions to acquire a comprehensive understanding of their energy consumption patterns, identify inefficiencies, and devise targeted improvement strategies. Energy assessments provide the basis for well-informed decisions by examining every aspect of campus operations, from building systems and illumination to transportation and waste management.

Energy audits have significance that extends beyond their immediate financial advantages. The reduction in operational expenses through optimized energy consumption is notable, but the environmental benefits are equally compelling. As campuses reduce their carbon footprint and adopt renewable energy sources, they actively contribute to climate change mitigation and the advancement of the global sustainability agenda.

Moreover, energy audits foster a culture of responsibility and awareness within the campus community. They encourage students, faculty, staff, and administrators to share a commitment to energy conservation and environmental stewardship. Through educational initiatives and alterations in behavior, energy audits foster a sense of ownership, allowing each individual to contribute meaningfully to the achievement of larger sustainability goals.

As we turn to the future, energy audits will continue to develop alongside technological advances, data analytics, and innovative methodologies. The incorporation of intelligent technologies, predictive modeling, and inter-disciplinary collaboration will improve the precision and efficacy of energy assessments, allowing institutions to adapt rapidly to shifting conditions and emergent opportunities.

Energy audits on college campuses are fundamentally a dynamic process of continuous improvement. They are continuous endeavors that pave the way for sustained development, not one-time assessments. The results of energy audits have a lasting impact, guiding institutions in their pursuit of energy efficiency, cost savings.

Ultimately, energy audits enable college campuses to serve as models of responsible resource management, influencing not only their immediate communities but also inspiring broader social transformation. By leading the way in sustainable practices and demonstrating the positive results of energy assessments, campuses become beacons of inspiration, pointing the way toward a future in which energy is used prudently, efficiently, and conscientiously.

Chapter 14
Future work

- **Technological Progresses**

The future of energy auditing on college campuses is dependent on technological development. As technology evolves, energy audit techniques will become more precise, effective, and exhaustive. Advanced sensors, Internet of Things (IoT) devices, and artificial intelligence (AI) algorithms will allow for the accumulation, analysis, and predictive modeling of data in real time. Smart meters and building management systems, for instance, can provide granular insights into energy utilization patterns, allowing institutions to optimize their consumption.

Moreover, the integration of Building Information Modeling (BIM) and Geographic Information Systems (GIS) will improve the precision of energy assessments by constructing digital replicas of campus infrastructure. This will allow auditors to simulate and evaluate numerous energy optimization scenarios, such as retrofitting buildings, upgrading lighting systems, and implementing renewable energy.

- **Community Participation**

Energy auditing will transition toward increased community engagement, enabling students, faculty, and staff to participate actively in sustainability initiatives. Campuses can implement energy literacy programs, seminars, and awareness campaigns to educate constituents on the significance of energy conservation. Students from various academic disciplines can contribute creative ideas and solutions, fostering a culture of sustainability.

Moreover, community engagement can extend beyond the confines of the campus. Collaboration with local governments, businesses, and adjacent communities can result in shared energy initiatives and enhanced regional sustainability. By highlighting the benefits of energy audits through public outreach and engagement, colleges and universities can inspire broader social change.

- **Monitoring and Adaptive Strategies over the Long Term:**

Long-term monitoring and adaptive strategies are integral to the future of energy auditing on college campuses. Energy audits should not be limited to a one-time assessment; they should be part of a continuous process to monitor progress and modify strategies in response to changing conditions. Continuous monitoring and data analysis will allow campuses to identify deviations from expected energy performance and promptly implement corrective actions.

The incorporation of machine learning and AI into energy audits will facilitate predictive maintenance, in which equipment failures and energy inefficiencies can be predicted in advance. This proactive strategy will reduce disruptions, optimize energy consumption, and prolong the life of campus infrastructure.

- **Network Electrical System:**

Which would include a comprehensive analysis of all Transformer operations of varying ratings and capacities, their operational pattern, Loading, No Load Losses, Power Factor Measurement on the Main Power Distribution Boards, and, if applicable, potential for improvement. The investigation would also examine potential enhancements to energy metering systems for enhanced control and monitoring.

- **Loading Study of Motors and Pumps:**

Study of motors (greater than 10 kW) in terms of measurement of voltage (V), current (I), power (kW), and power factor, recommending energy-saving measures such as motor capacity reduction or installation of energy-saving devices in existing motors. Study of Pumps and their flow, suggesting energy-saving measures such as reducing the capacity of Motors and Pumps or installing energy-saving devices in existing motors / pump optimization.

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