ENERGY AUDIT REPORT, 2024-2025
DARRANG COLLEGE, TEZPUR, ASSAM

SUBMITTED TO
THE PRINCIPAL
DARRANG COLLEGE
SONITPUR, TEZPUR, ASSAM 784001

SUBMITTED BY
TRCATS LLP
REGISTERED OFFICE: BARUAH CHUBURI, MAZGAON,
SONITPUR, ASSAM, 784001

TRCATS Transitioning Research Consultancy and Training Services LLP
Transition Ideas to Business
An ISO 9001-2015 certified LLP established under the NISP initiative of Tezpur University *GSTIN: 18AAUFT1027A1ZB*

Acknowledgement

We are sincerely thankful to the Management of Darrang College for giving us the opportunity to conduct Energy Audit of the Institute.

We are also grateful to Dr. Palash Moni Saikia, Principal, Darrang College, Assam whose valuable comments / feedback, during various reviews have helped us during the course of the Audit.

We express our sincere gratitude to all other concerned officials for their support and guidance during the conduct of this exercise.

For TRCATS LLP

(Dr. Dipal Baruah)
Director (R&D and Innovation)
TRCATS LLP

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Ref. No. Cert./2026/019 **Date: 18/03/2026**

TO WHOM IT MAY CONCERN

This is to certify that TRCATS LLP, having registered office at Baruah Chuburi, Mazgaon, Tezpur, Sonitpur, Assam -784001, has successfully conducted the Energy Audit of DARRANG COLLEGE, TEZPUR, SONITPUR, ASSAM 784001 for the session 2024-2025.

The college has provided the necessary data and credentials for scrutiny. The activities and measures undertaken by the college have been verified. After collecting and analyzing the required data, the Energy Audit report has been prepared and submitted. The efforts taken by the college towards energy conservation are appreciated.

(Dr. Dipal Baruah)
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Ref. No. Cert./2026/020 **Date: 18/03/2026**

Certificate

This is to certify that Energy Audit was conducted at Darrang College, Tezpur, Assam - 784001 on 29th of December, 2025. The summary of the energy audit report is listed below.

Location of the College

DARRANG COLLEGE
SONITPUR, TEZPUR
ASSAM - 784001

Latitude : 26º38'05" N to 26º38'20"N
Longitude : 92º47'45" E to 92º47'55" E

Sl. No	Description of the Building	Units/ parameter	Values
1	Connected Load	kW	210
2	Contracted Demands	kVA	247
3	Installed capacity of DG set	kVA	275
4	Annual electricity consumption (APRIL 2024 - MARCH 2025)	kWh	139,222.77
	Annual cost of electricity consumption @ ₹ 7.15/ unit	₹	9,95,442.80
	Fixed charges, surcharge, late fee etc. (As per bill details)	₹	6,89,925.20
	Total cost of electricity (as per bill) including all the component	₹	16,85,374.00
	Annual cost of electricity consumption through DG set	₹	1,46,229.00
	Total cost of electricity (Utility+DG set)	₹	18,31,603.00
5	Number of building	No.	22
6	Working hours (Academic and Administration building)	Hrs	8 Hrs (9AM to 5PM)
7	Working hours (Hostel building)	Hrs	24x7
8	Working Days/week of the College	Days	6 days
9	Whether sub-metering of electricity consumption for each building	No.	No sub-meter

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The monthly grid energy consumption and energy bill of Darrang College is as follows.

Sl. No	Description of the Building	Units/parameter	Values
1	Monthly Average consumption	kWh/month	11,601.9
2	Monthly average energy consumption cost @ ₹7.15 per unit and including fixed charges as applicable	₹/month	1,40,447.83
3	Annual energy consumption	kWh/annum	139,222.77
4	Annual energy consumption cost	₹/annum	16,85,374.00
5	Connected load	kW	210
6	Average P.F maintained		91.6

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1. INTRODUCTION

1.1 Background and Rationale

Energy is one of the most critical resources for the functioning of modern institutions. Educational institutions, particularly colleges and universities, are increasingly dependent on electricity for academic, research, administrative, and residential activities. The growing use of digital technologies, laboratory instruments, computing infrastructure, and cooling systems has significantly increased energy demand across campuses.

In India, the electricity sector is still largely dependent on fossil fuel based power generation. As a result, increasing electricity consumption leads to higher operational costs and contributes to greenhouse gas emissions. Efficient energy management has therefore become a priority for institutions that aim to operate sustainably while controlling operational expenditure.

Energy auditing is a systematic process used to analyze energy consumption patterns, identify inefficiencies in energy use, and recommend measures for improving energy performance. Through detailed assessment of energy flows within a facility, an energy audit provides a roadmap for reducing energy consumption without compromising operational efficiency or user comfort.

Darrang College has undertaken this energy audit as part of its commitment to environmental sustainability, energy conservation, and efficient resource management.

1.2 Energy Conservation in Educational Institutions

Educational institutions play a unique role in promoting sustainable development. In addition to reducing operational costs, energy conservation initiatives within educational campuses also contribute to:

- creating awareness among students and staff about responsible energy use
- promoting environmental stewardship
- demonstrating sustainable practices to the community
- integrating sustainability into academic culture

Institutions that implement energy efficiency measures also improve their environmental performance indicators, which are increasingly considered in accreditation processes such as NAAC (National Assessment and Accreditation Council).

Many universities and colleges across India are adopting sustainable campus initiatives that include:

- energy audits
- solar rooftop installations
- energy efficient lighting systems
- green buildings
- waste management programs
- water conservation practices

By conducting periodic energy audits, institutions can monitor their energy performance and implement targeted interventions to improve efficiency.

1.3 Legislative and Policy Framework

Energy efficiency initiatives in India are supported by several national policies and regulatory frameworks.

Energy Conservation Act, 2001

The Government of India enacted the Energy Conservation Act in 2001 to promote efficient use of energy and reduce energy intensity across sectors. The Act established the **Bureau of Energy Efficiency (BEE)**, which is responsible for implementing national energy efficiency programs.

The Act encourages organizations and institutions to adopt energy conservation practices through mechanisms such as:

- energy audits
- energy performance benchmarking
- energy efficiency standards and labeling
- demand side management programs

Although educational institutions are not categorized as designated consumers under the Act, voluntary adoption of energy efficiency practices contributes significantly to national energy conservation goals.

National Action Plan on Climate Change

The Government of India launched the **National Action Plan on Climate Change (NAPCC)** to address climate change challenges through various national missions. One of the key missions is the **National Mission for Enhanced Energy Efficiency (NMEEE)**, which focuses on improving energy efficiency across sectors.

Educational institutions contribute to this mission by adopting energy efficient technologies and reducing their carbon footprint.

Sustainable Campus Initiatives and NAAC

The National Assessment and Accreditation Council (NAAC) encourages institutions to adopt sustainable campus practices as part of their quality assessment criteria.

Energy audits are considered an important component of **Green Campus Initiatives**, which include:

- energy conservation
- renewable energy utilization
- waste management
- water conservation
- environmental awareness programs

Conducting an energy audit helps institutions demonstrate their commitment toward sustainable development and environmental responsibility.

1.4 Objectives of the Energy Audit

The primary objective of this energy audit is to evaluate the energy consumption patterns of Darrang College and identify opportunities for improving energy efficiency.

Specific objectives of the audit include:

Assessment of Energy Consumption

To analyze electricity consumption data for the campus and establish the baseline energy consumption.

Identification of Major Energy Consuming Systems

To identify the systems and equipment that contribute most significantly to energy consumption within the campus.

Evaluation of Operational Practices

To examine operational practices that influence energy use, such as lighting usage patterns, equipment operation schedules, and maintenance practices.

Identification of Energy Conservation Opportunities

To recommend practical and technically feasible energy conservation measures that can reduce energy consumption and operational costs.

Financial Feasibility Analysis

To evaluate the financial viability of proposed energy conservation measures using indicators such as payback period, Net Present Value (NPV), and Internal Rate of Return (IRR).

Environmental Impact Assessment

To estimate the carbon emissions associated with electricity consumption and assess the potential environmental benefits of energy efficiency improvements.

1.5 Scope of the Audit

The energy audit covers the entire campus of Darrang College, including academic buildings, laboratories, administrative facilities, hostels, and other infrastructure.

The following energy consuming systems were included within the scope of the audit:

Electrical Distribution System

Assessment of connected load, electricity consumption, and demand patterns.

Lighting Systems

Evaluation of lighting fixtures, illumination levels, and opportunities for lighting optimization.

Cooling Systems

Assessment of ceiling fans, air conditioning units, and air coolers used for thermal comfort.

Laboratory Equipment

Analysis of energy consumption associated with laboratory instruments and research equipment.

Water Pumping Systems

Assessment of water pumps used for water supply and storage.

Diesel Generator Systems

Evaluation of backup power generation systems and associated fuel consumption.

Renewable Energy Potential

Preliminary assessment of opportunities for integrating solar photovoltaic systems within the campus.

1.6 Limitations of the Study

While conducting the energy audit, certain limitations were encountered due to data availability and monitoring infrastructure.

Absence of Sub-Metering

Energy consumption data for individual buildings was not available because the campus uses a centralized electricity metering system.

As a result, building-wise energy consumption was estimated based on equipment inventory and usage patterns.

Limited DG Operational Data

Detailed records of diesel generator operation, including run hours and electricity generation, were not available. This limited the ability to conduct detailed performance analysis of DG sets.

Lack of Equipment Runtime Logs

Precise operating hours for certain equipment were not recorded. In such cases, operating hours were estimated based on typical institutional schedules.

Despite these limitations, reasonable engineering assumptions were applied to ensure that the analysis remains technically reliable.

1.7 Structure of the Report

This report is organized into several sections that progressively analyze the energy performance of the campus.

The key sections include:

- Baseline energy consumption analysis
- Electrical load distribution
- Equipment inventory and energy consumption
- Diesel generator performance assessment
- Lighting system analysis and lux level study
- Energy conservation measures
- Financial analysis of recommended measures
- Carbon emission analysis
- Implementation roadmap

Each section provides detailed analysis supported by calculations, tables, and observations from the site inspection.

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2. SCOPE OF WORK

The scope of the energy audit for Darrang College was defined to comprehensively assess the energy consumption pattern across the campus and identify opportunities for improving energy efficiency.

The audit focused primarily on **electricity consumption**, which represents the major energy source used by the institution. In addition to grid electricity supplied by the utility, backup power generation through diesel generators was also evaluated.

The scope of work included analysis of energy consumption data, inspection of energy-consuming systems, evaluation of operational practices, and identification of technically feasible energy conservation measures.

The audit was conducted for the **entire campus infrastructure**, including academic buildings, laboratories, hostels, administrative offices, library facilities, and common infrastructure such as pumping systems and lighting installations.

The energy audit examined the following systems and infrastructure components within the campus.

2.1 Electrical Energy Consumption

The primary focus of the audit was analysis of electricity consumption across the campus.

This involved:

- examination of monthly electricity bills
- analysis of power factor values
- calculation of annual electricity consumption
- estimation of average tariff and energy cost

The electricity supply to the campus is provided by **Assam Power Distribution Company Limited (APDCL)** with a contracted demand of approximately **247 kVA** and a connected load of **210 kW**.

The audit assessed the trends in electricity consumption and identified seasonal variations associated with cooling demand and academic activities.

2.2 Electrical Load Inventory

A detailed inventory of electrical appliances and equipment installed in the campus was compiled.

This inventory included:

- lighting fixtures
- ceiling fans
- air conditioners
- computers and printers
- laboratory equipment

- CCTV systems
- water pumps

The purpose of the inventory was to estimate the total connected load and understand the distribution of electricity consumption among different end-use categories.

The equipment inventory also enabled estimation of energy consumption under different operating scenarios.

2.3 Lighting System Assessment

Lighting systems across the campus were evaluated to determine their efficiency and adequacy.

The assessment included:

- identification of lighting technologies used
- estimation of lighting load
- lux level measurement in selected buildings
- comparison with recommended illumination standards

The lighting system consists primarily of **LED bulbs and LED tube lights**, indicating that the institution has already taken steps toward improving lighting efficiency.

However, further improvements can be achieved through lighting control strategies and better utilization of daylight.

2.4 Cooling Systems

Thermal comfort in the campus buildings is primarily maintained using ceiling fans and a limited number of air conditioning units.

The cooling systems assessment included:

- inventory of ceiling fans and AC units
- evaluation of operating schedules
- estimation of cooling load contribution

The audit identified that ceiling fans represent a significant share of energy consumption due to their large number across classrooms, laboratories, and offices.

2.5 Laboratory and Plug Loads

Laboratories and computing facilities contribute significantly to electricity consumption in educational institutions.

The audit assessed energy consumption associated with:

- incubators
- spectrophotometers
- centrifuges
- autoclaves
- refrigerators
- computers and printers

These devices operate for extended periods during academic and research activities and therefore contribute significantly to the plug load category.

2.6 Water Pumping Systems

Water supply within the campus is supported by a network of pumps used for:

- borewell water extraction
- water filtration
- pumping to overhead tanks

The audit examined:

- pump capacities
- number of pumps
- operational practices

Although water pumping contributes a relatively smaller portion of the overall load, energy efficiency improvements can still be achieved through optimized pump operation and maintenance.

2.7 Diesel Generator Systems

Backup power during grid outages is provided through diesel generator (DG) sets installed at the campus and hostel facilities. The audit evaluated the DG system with respect to:

- generator capacities
- fuel consumption
- maintenance practices
- operational records

While DG systems are not used continuously, they contribute to energy cost and carbon emissions when operated.

2.8 Renewable Energy Opportunities

The audit also evaluated the potential for integrating renewable energy systems within the campus.

Particular attention was given to the feasibility of installing **rooftop solar photovoltaic systems** on available building rooftops.

The campus has several buildings with suitable rooftop areas that could support solar PV installations capable of offsetting a significant portion of electricity consumption.

2.9 Measurement Instruments Used

During the audit process, certain measurements were conducted to verify operating conditions of energy consuming systems.

Lux Meter

Lighting levels in selected buildings were measured using a portable lux meter.

Instrument used:

Make: Benetech
Model: GM1351

Lux level measurements were taken in classrooms, laboratories, library spaces, and administrative areas.

The measured values were compared with recommended illumination standards to evaluate adequacy of lighting.

2.10 Data Sources

The energy audit relied on multiple sources of data provided by the institution. These included:

- electricity bills for the audit period
- equipment inventory records
- DG fuel consumption data
- campus building information
- operational practices reported by staff

The data collected during the audit was analyzed using engineering calculations and standard energy audit methodologies.

2.11 Audit Deliverables

The energy audit was designed to produce a comprehensive report that provides actionable recommendations for improving energy efficiency within the campus.

The key deliverables of the audit include:

Baseline Energy Profile

Establishment of the current energy consumption baseline for the campus.

Energy Consumption Analysis

Detailed analysis of electricity consumption trends and load distribution.

Identification of Inefficiencies

Identification of operational and infrastructure factors contributing to inefficient energy use.

Energy Conservation Measures

Recommendation of technically feasible measures to improve energy efficiency.

Financial Analysis

Evaluation of the financial viability of recommended measures through calculation of payback periods and investment requirements.

Environmental Impact Assessment

Estimation of carbon emissions associated with energy consumption and potential emission reductions achievable through recommended measures.

2.12 Expected Outcomes of the Audit

The implementation of recommendations from this energy audit is expected to deliver multiple benefits to the institution.

These include:

- reduction in electricity consumption
- lower energy expenditure
- improved operational efficiency
- reduced environmental impact
- enhanced sustainability profile of the campus

The audit also provides a framework for continuous monitoring and improvement of energy performance.

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3. BENEFITS OF ENERGY AUDIT

An energy audit is a systematic study of energy consumption patterns within a facility with the objective of identifying opportunities for improving energy efficiency. For educational institutions such as Darrang College, energy audits play an important role in promoting sustainable campus operations while reducing operational costs.

Energy audits help institutions understand how energy is consumed within different systems and buildings and provide actionable recommendations for optimizing energy use without compromising functionality or user comfort.

The benefits of an energy audit extend beyond financial savings and include improvements in operational management, environmental performance, and institutional sustainability.

3.1 Financial Benefits

One of the most significant advantages of conducting an energy audit is the potential reduction in electricity expenditure.

Energy costs constitute a major portion of operational expenditure for educational institutions. By identifying inefficient equipment and operational practices, an energy audit enables institutions to reduce unnecessary energy consumption and optimize electricity usage.

Implementation of recommended energy conservation measures can result in:

• reduction in electricity bills
• lower operating costs
• improved financial management of institutional resources

For Darrang College, preliminary analysis indicates that implementation of recommended measures could reduce electricity consumption by **approximately 30–40% through efficiency measures alone**, and even more when renewable energy systems are introduced.

This could translate into substantial annual financial savings that can be redirected toward academic and infrastructure development.

3.2 Operational Benefits

Energy audits provide valuable insights into how different systems within a campus operate and how their performance can be improved.

The audit process helps identify issues such as:

• inefficient equipment
• poor maintenance practices
• improper operating schedules
• lack of monitoring systems

Addressing these issues leads to improved operational efficiency and better utilization of infrastructure.

For example, the audit of Darrang College identified the absence of building-level sub-metering, which makes it difficult to track energy consumption across individual buildings. Installing sub-meters would enable better monitoring and management of electricity usage.

Energy audits also help institutions establish systematic maintenance procedures that ensure equipment operates at optimal efficiency.

3.3 Environmental Benefits

Energy conservation contributes directly to environmental sustainability by reducing greenhouse gas emissions associated with electricity generation.

Electricity in India is largely produced from fossil fuels such as coal, which emit significant quantities of carbon dioxide during power generation.

Reducing electricity consumption therefore helps lower the carbon footprint of an institution.

For Darrang College, the annual electricity consumption corresponds to an estimated **114 tonnes of carbon dioxide emissions per year**.

Implementation of energy efficiency measures combined with renewable energy generation could significantly reduce these emissions and contribute to climate change mitigation.

In addition to reducing carbon emissions, energy conservation helps reduce the overall demand on the national power grid, which improves energy security and reduces environmental impacts associated with power generation.

3.4 Institutional Benefits

Energy audits contribute to improving the overall sustainability profile of an institution.

Many accreditation and ranking systems now consider sustainability initiatives as an important indicator of institutional performance.

By conducting regular energy audits and implementing energy efficiency measures, institutions can demonstrate their commitment to environmental responsibility and sustainable development.

For example, NAAC accreditation criteria encourage institutions to adopt green campus initiatives such as:

- energy audits
- renewable energy systems
- waste management programs
- water conservation initiatives

The results of the energy audit can therefore support institutional efforts to improve sustainability indicators and strengthen accreditation documentation.

3.5 Educational Benefits

Educational institutions have a unique opportunity to integrate sustainability practices into the learning environment.

Energy audits can serve as practical learning tools for students by exposing them to real-world applications of energy management and environmental sustainability.

Energy conservation initiatives on campus can promote awareness among students and staff about responsible energy use and environmental stewardship.

Examples of educational benefits include:

• incorporating energy efficiency concepts into academic programs
• organizing student-led energy conservation campaigns
• conducting workshops and seminars on sustainable practices

Such initiatives help cultivate a culture of sustainability within the campus community.

3.6 Awareness and Behavioral Change

Energy consumption patterns are influenced not only by technology but also by human behavior.

Energy audits often reveal instances where energy is wasted due to simple behavioral factors such as leaving lights or equipment on when not in use.

Awareness programs and behavioral interventions can significantly reduce such unnecessary energy consumption.

For example, measures such as:

• switch-off campaigns
• energy conservation posters
• periodic monitoring of energy use

can encourage students and staff to adopt responsible energy practices.

Even small behavioral changes across a large campus population can result in significant energy savings.

3.7 Long-Term Sustainability Planning

Energy audits provide a foundation for developing long-term energy management strategies.

The findings of the audit can help institutions develop a structured plan for implementing energy efficiency improvements over time.

Such planning may include:

• phased replacement of inefficient equipment
• adoption of smart energy monitoring systems
• integration of renewable energy technologies

By implementing these strategies, institutions can gradually transition toward more sustainable and energy-efficient campus operations.

3.8 Contribution to National Energy Conservation Goals

Energy efficiency initiatives undertaken by individual institutions contribute collectively to national efforts toward energy conservation and environmental protection.

Reducing energy consumption in educational institutions supports broader national goals such as:

• reducing energy intensity of the economy
• lowering greenhouse gas emissions
• promoting renewable energy adoption

Educational institutions can therefore play a meaningful role in supporting the country's sustainable development objectives.

The energy audit of Darrang College provides a valuable opportunity to improve energy management practices and promote sustainability within the campus.

Key benefits include:

• reduction in electricity costs
• improved operational efficiency
• lower environmental impact
• enhanced institutional reputation
• increased awareness about energy conservation

By implementing the recommendations presented in this report, Darrang College can achieve significant improvements in energy performance while reinforcing its commitment to sustainable campus development.

4. METHODOLOGY ADOPTED FOR ENERGY AUDIT

The energy audit of Darrang College was carried out using a structured and systematic approach designed to evaluate the energy consumption patterns of the campus and identify opportunities for improving energy efficiency.

The methodology adopted for this audit follows standard practices used in institutional energy audits. The process included data collection, site inspection, equipment inventory analysis, measurement of operating parameters, and engineering calculations to estimate energy consumption and identify potential energy conservation measures.

The methodology was designed to ensure that the audit results are technically sound, transparent, and reproducible.

4.1 Energy Audit Framework

The audit process consisted of several sequential stages. Each stage contributed to developing a comprehensive understanding of how energy is used across the campus.

The key stages of the audit are described below.

Preliminary Consultation with Facility Personnel

The audit process began with an initial consultation with the college administration and facility personnel. The objective of this consultation was to obtain an overview of the campus infrastructure and energy systems.

During this stage, discussions were held regarding:

- campus buildings and infrastructure
- operating schedules of academic and administrative facilities
- major energy consuming equipment
- existing energy conservation practices

This stage helped the audit team understand the operational characteristics of the campus and identify areas that require detailed investigation.

Review of Available Documentation

The second step involved reviewing all available documentation related to energy consumption and equipment inventory.

Documents reviewed during this stage included:

- monthly electricity bills
- equipment inventory records
- generator fuel consumption data
- building information and usage patterns

The review of electricity bills allowed the audit team to determine the baseline energy consumption of the campus and identify trends in electricity usage over time.

Facility Walkthrough Inspection

A detailed walkthrough inspection of the campus was conducted to observe energy consuming systems and operational practices.

The walkthrough inspection included examination of:

- lighting systems in classrooms, laboratories, and corridors
- cooling equipment such as ceiling fans and air conditioners
- laboratory equipment and computing facilities
- water pumping systems
- diesel generator installations

The purpose of the walkthrough inspection was to verify the information provided in equipment inventories and identify potential inefficiencies in energy use.

During the inspection, the audit team also observed operational practices that influence energy consumption, such as lighting usage during daytime and equipment standby conditions.

Equipment Inventory and Load Assessment

A comprehensive inventory of electrical appliances and equipment installed in the campus was compiled.

The inventory included details such as:

- type of equipment
- rated power consumption
- quantity of units installed
- typical operating hours

The equipment inventory provided the basis for estimating the connected electrical load of the campus and analyzing the distribution of energy consumption among different end-use categories.

The total connected load was estimated by multiplying the rated power of each equipment category by the number of units installed.

Measurement of Lighting Levels

Lighting levels in selected areas of the campus were measured using a portable lux meter. Measurements were taken at representative locations including:

- classrooms
- laboratories
- administrative offices
- library areas
- common spaces

The measured illumination levels were compared with recommended lighting standards for educational institutions. This comparison helped determine whether lighting levels were adequate and whether opportunities exist to optimize lighting energy consumption.

Analysis of Electricity Consumption Data

Monthly electricity consumption data for the period **April 2024 – March 2025** was analyzed to establish the baseline energy consumption of the campus.

The analysis included:

- calculation of total annual electricity consumption
- determination of average monthly consumption
- identification of seasonal variations in electricity use

The analysis also considered power factor values recorded in electricity bills to evaluate the efficiency of electrical power utilization.

Load Distribution Analysis

Using the equipment inventory and operational information, the total electrical load of the campus was categorized into different end-use groups.

These groups included:

• lighting load
• cooling load
• pumping load
• other plug loads (laboratory equipment, computers, etc.)

This categorization allowed the audit team to identify the systems that contribute most significantly to energy consumption and therefore offer the greatest opportunities for energy savings.

Identification of Energy Conservation Measures

Based on the analysis of energy consumption patterns and observations from the site inspection, potential energy conservation measures were identified.

Each measure was evaluated based on:

• technical feasibility
• expected energy savings
• implementation cost
• operational impact

Priority was given to measures that offer high energy savings with relatively low implementation costs.

Financial Evaluation of Energy Conservation Measures

To assess the financial feasibility of recommended measures, a financial analysis was conducted using standard investment evaluation techniques.

The following financial indicators were used:

Simple Payback Period

The payback period indicates the time required for the cost savings generated by an energy conservation measure to recover the initial investment.

Net Present Value (NPV)

NPV evaluates the profitability of an investment by calculating the present value of future cash flows generated by energy savings.

Internal Rate of Return (IRR)

IRR represents the discount rate at which the net present value of an investment becomes zero.

These financial indicators help decision makers prioritize energy conservation measures based on economic viability.

Estimation of Carbon Emissions

To evaluate the environmental impact of electricity consumption, carbon emissions associated with grid electricity were estimated using an emission factor. The emission factor used for the analysis was 0.82 kg CO_2/kWh. This factor represents the average carbon intensity of electricity generated in India.

Using this factor, the total carbon emissions associated with the campus electricity consumption were calculated. The potential emission reductions achievable through energy conservation measures were also estimated.

4.2 Assumptions Used in the Analysis

Certain assumptions were necessary to estimate energy consumption in cases where detailed operational data was not available.

These assumptions include:

- typical operating hours for classrooms and laboratories
- average daily operating hours for lighting systems
- estimated operating hours for equipment based on institutional schedules

These assumptions were based on typical usage patterns observed in educational institutions and discussions with campus personnel.

4.3 Limitations of the Methodology

While the audit methodology provides a reliable assessment of campus energy consumption, certain limitations must be acknowledged.

Lack of Sub-Metering

Since individual buildings are not equipped with sub-meters, building-level energy consumption had to be estimated using equipment inventories and usage patterns.

Limited Operational Data

Detailed runtime logs for certain equipment were not available. Therefore, operating hours were estimated based on typical schedules.

Despite these limitations, the methodology adopted provides a robust framework for evaluating energy consumption and identifying practical energy conservation opportunities.

The methodology adopted for this audit integrates data analysis, field observations, equipment inventory assessment, and engineering calculations.

This systematic approach ensures that the audit findings are based on reliable data and that the recommended energy conservation measures are technically feasible and economically viable.

The next section of the report provides a detailed description of the campus infrastructure and facilities that influence energy consumption patterns.

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5. DESCRIPTION OF THE COLLEGE CAMPUS

5.1 Overview of the Institution

Darrang College is one of the oldest and most prominent higher educational institutions in the Sonitpur district of Assam. Established in **1945**, the college has played a significant role in promoting higher education in the region.

The campus is located in **Tezpur town**, situated on the northern bank of the Brahmaputra River. The college serves a large number of students across multiple academic disciplines and provides infrastructure for teaching, research, and student development.

Over the years, the institution has expanded its academic programs, infrastructure, and student facilities. This expansion has also led to increased demand for electricity due to the installation of additional laboratories, computing facilities, and other modern educational infrastructure.

As a result, efficient energy management has become increasingly important for ensuring sustainable operation of the campus.

Darrang College is located in **Tezpur, Sonitpur District, Assam**, within a region characterized by a humid subtropical climate (Fig. 1).

Fig. 1 Google Earth Map of Darrang College

The approximate geographical coordinates of the campus are:

Latitude: **26°38'05" N to 26°38'20" N**
Longitude: **92°47'45" E to 92°47'55" E**

The climate of the region has a significant influence on energy consumption patterns, particularly with respect to cooling requirements.

Climatic Characteristics of the Region

The region experiences three major climatic seasons:

Winter Season (November – February)

Cool and relatively dry weather conditions prevail during this period. Energy consumption is generally lower due to reduced cooling requirements.

Pre-Monsoon and Summer Season (March – May)

Temperatures begin to rise, increasing the demand for cooling systems such as fans and air conditioners.

Monsoon Season (June – October)

This period is characterized by high humidity and moderate temperatures. Although temperatures may not be extremely high, humidity increases the need for mechanical ventilation and air circulation.

These climatic conditions contribute to seasonal variations in electricity consumption within the campus.

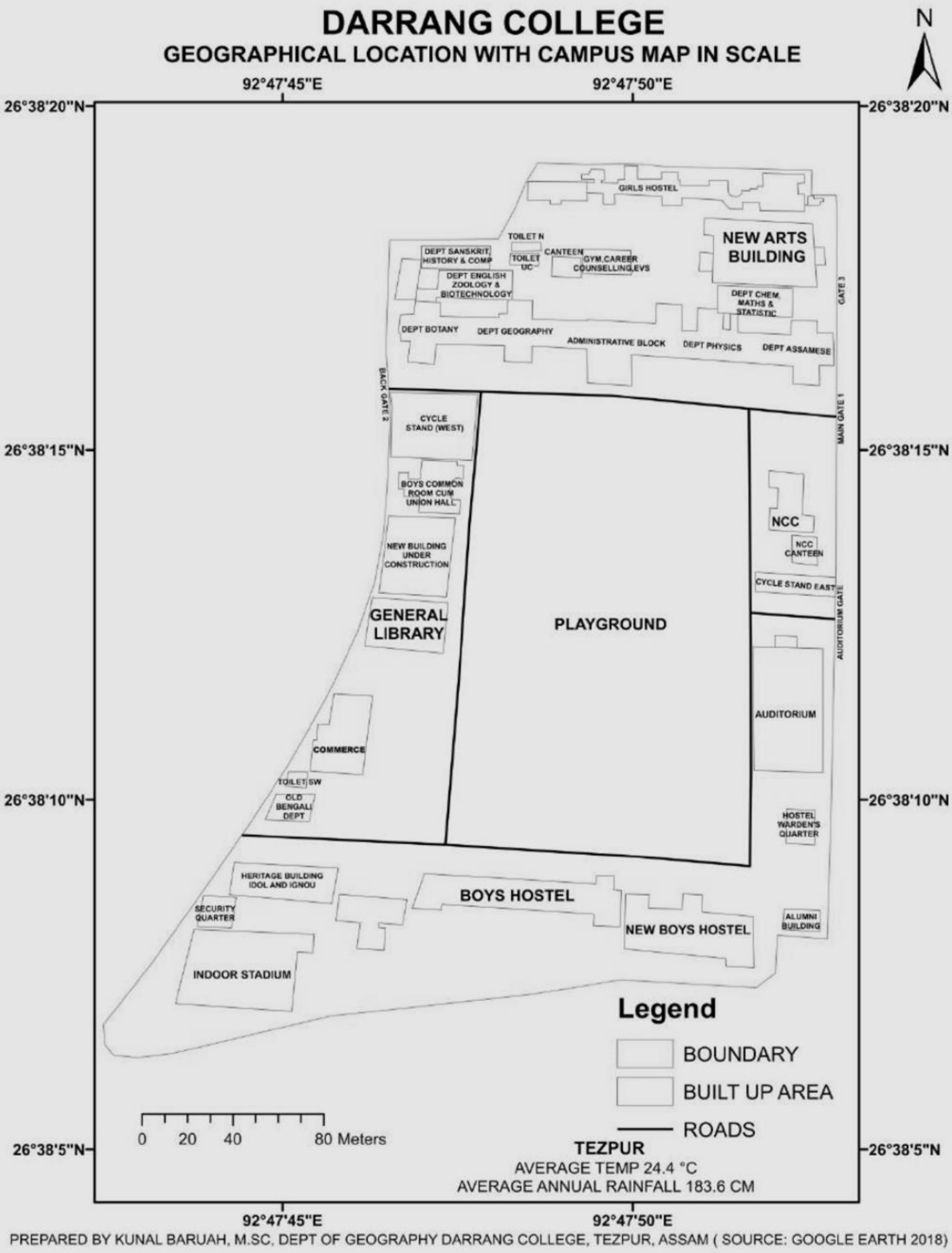

Fig. 2 Layout of Darrang College

Table 1 Land Use Distribution

Category	Area (sq. m)
Built-up area	20,782.53
Playground	18,162.42
Open space and plantation	31,120.74
Hollows / trenches	452.98

The relatively large open space and plantation area contributes to a greener campus environment and provides opportunities for implementing sustainability initiatives (Table 1).

The built-up area consists of multiple academic and administrative buildings distributed across the campus (Fig. 2).

5.4 Campus Infrastructure

The campus consists of a mix of building types constructed over several decades.

Building Types

The infrastructure includes:

- RCC (Reinforced Cement Concrete) buildings
- Assam-type buildings with sloping roofs
- multi-storey academic buildings
- single-storey laboratory structures

The Assam-type buildings, which are common in the region, typically feature sloped roofs and wooden structural elements. These buildings have good natural ventilation but sometimes have limited natural lighting depending on orientation.

Modern RCC buildings house most of the laboratories, classrooms, and administrative facilities.

5.5 Academic Departments

Darrang College hosts a wide range of academic departments that provide undergraduate and postgraduate education.

The college currently accommodates **27 academic departments** distributed across different buildings within the campus (Table 2).

Table 2 Distribution of Departments

Discipline	Number of Departments
Arts	16
Science	8
Commerce	1
Environmental Science	1
Home Science	1

These departments occupy classrooms, laboratories, faculty rooms, and research facilities across the campus buildings.

Science departments, in particular, operate specialized laboratory equipment that contributes to higher energy consumption compared to conventional classroom spaces.

5.6 Major Campus Buildings

The campus consists of several important buildings that support academic and administrative activities.

Academic Buildings

• Main Academic Building
• New Academic Building
• NEC Building
• Science Laboratory Blocks
• Commerce Building

These buildings accommodate classrooms, laboratories, faculty offices, and departmental facilities.

Administrative Buildings

Administrative operations are conducted from dedicated office buildings that include:

• Principal's Office
• Administrative Offices
• Accounts Section
• Examination Branch

These buildings house computers, printers, and office equipment that contribute to plug loads.

Library Facilities

The campus has a central library that serves as an important academic resource for students and faculty.

The library building contains:

• reading rooms
• reference sections
• computer facilities
• digital library resources

Library spaces require adequate lighting and cooling systems to ensure comfortable study environments.

Hostels

The campus includes residential facilities for students.

• Boys Hostel
• Girls Hostel

Hostels operate continuously throughout the day and night and therefore contribute to round-the-clock electricity consumption.

Hostel energy use includes:

• lighting
• fans
• water heating
• charging of electronic devices

Auditorium and Indoor Stadium

The campus also includes large multipurpose facilities such as:

• Auditorium
• Indoor stadium / gymnasium

These facilities are used for academic events, cultural programs, sports activities, and student gatherings.

Lighting and sound systems installed in these facilities contribute to occasional peak electricity demand during events.

5.7 Water Supply Infrastructure

Water supply within the campus is supported by borewell systems and pumping infrastructure.

Water extracted from borewells is first directed to filtration systems and then pumped to overhead storage tanks for distribution across campus buildings.

The water supply system includes several electric pumps with different capacities.

Although pumping loads constitute a relatively small portion of total electricity consumption, their continuous operation during certain periods contributes to the campus energy demand.

5.8 Campus Energy Infrastructure

Electricity for the campus is supplied by **Assam Power Distribution Company Limited (APDCL)** (Table 3).

Table 3 Key Electrical Parameters

Parameter	Value
Connected Load	210 kW
Contract Demand	247 kVA
Power Supply Source	APDCL Grid
Backup Power	Diesel Generators

In addition to grid electricity, the campus also maintains diesel generator sets for backup power during outages.

These generators ensure uninterrupted electricity supply for critical facilities such as laboratories and administrative offices.

5.9 Working Schedule of the Institution

Understanding the operating schedule of the institution is important for estimating energy consumption patterns.

Academic Buildings

Operating hours: **9:00 AM – 5:00 PM**; Working days: **6 days per week**

During these hours, most classrooms, laboratories, and administrative facilities are active.

Hostel Buildings

Hostels operate **24 hours per day** since they accommodate resident students.

Electricity consumption in hostels therefore continues even outside academic working hours.

5.10 Natural Lighting and Ventilation

Many buildings within the campus are designed to allow natural ventilation through large windows and open corridors.

This architectural feature helps reduce the dependence on mechanical cooling systems during moderate weather conditions.

However, some classrooms and laboratories have limited daylight penetration due to building orientation and structural layout.

In such cases, artificial lighting is required even during daytime.

Optimizing daylight usage through architectural modifications and better lighting control could further reduce electricity consumption.

5.11 Green Campus Features

The campus includes significant green spaces with trees and plantations.

These green areas provide several environmental benefits such as:

- reduction in heat island effects
- improvement of microclimatic conditions
- enhanced campus aesthetics

The presence of large open spaces also creates opportunities for implementing additional sustainability initiatives such as renewable energy installations.

The infrastructure and operational characteristics of Darrang College influence the overall energy consumption pattern of the campus.

Key factors affecting energy demand include:

- number of buildings and laboratories
- presence of hostel facilities
- operation of laboratory equipment
- climatic conditions requiring cooling systems

Understanding these factors is essential for analyzing energy consumption and identifying opportunities for improving energy efficiency.

The next section of the report examines the **baseline energy consumption of the campus in detail**, including monthly electricity usage and cost analysis.

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6. PRESENT ENERGY CONSUMPTION SCENARIO

The present energy consumption scenario of Darrang College was evaluated by analyzing the electricity consumption data for the fiscal year **April 2024 – March 2025**.

The objective of this analysis is to establish a **baseline energy profile** of the campus, which represents the current level of energy consumption under normal operating conditions.

The baseline analysis helps in:

- identifying seasonal trends in electricity consumption
- understanding the distribution of electrical loads
- evaluating electricity costs and tariffs
- estimating energy intensity indicators

This baseline will serve as the reference point for evaluating the effectiveness of recommended energy conservation measures.

6.1 Electricity Supply to the Campus

Electricity for the campus is supplied by **Assam Power Distribution Company Limited (APDCL)**.

The college is connected to the state electricity grid through a high-capacity electrical connection that supports the energy requirements of all campus buildings.

The connected load represents the total rated capacity of electrical equipment installed in the campus. The contract demand indicates the maximum power demand agreed with the utility.

6.2 Monthly Electricity Consumption

Monthly electricity consumption for the fiscal year **April 2024 – March 2025** was obtained from the electricity bills provided by the institution (Fig. 3, Table).

Monthly Electricity Consumption Data

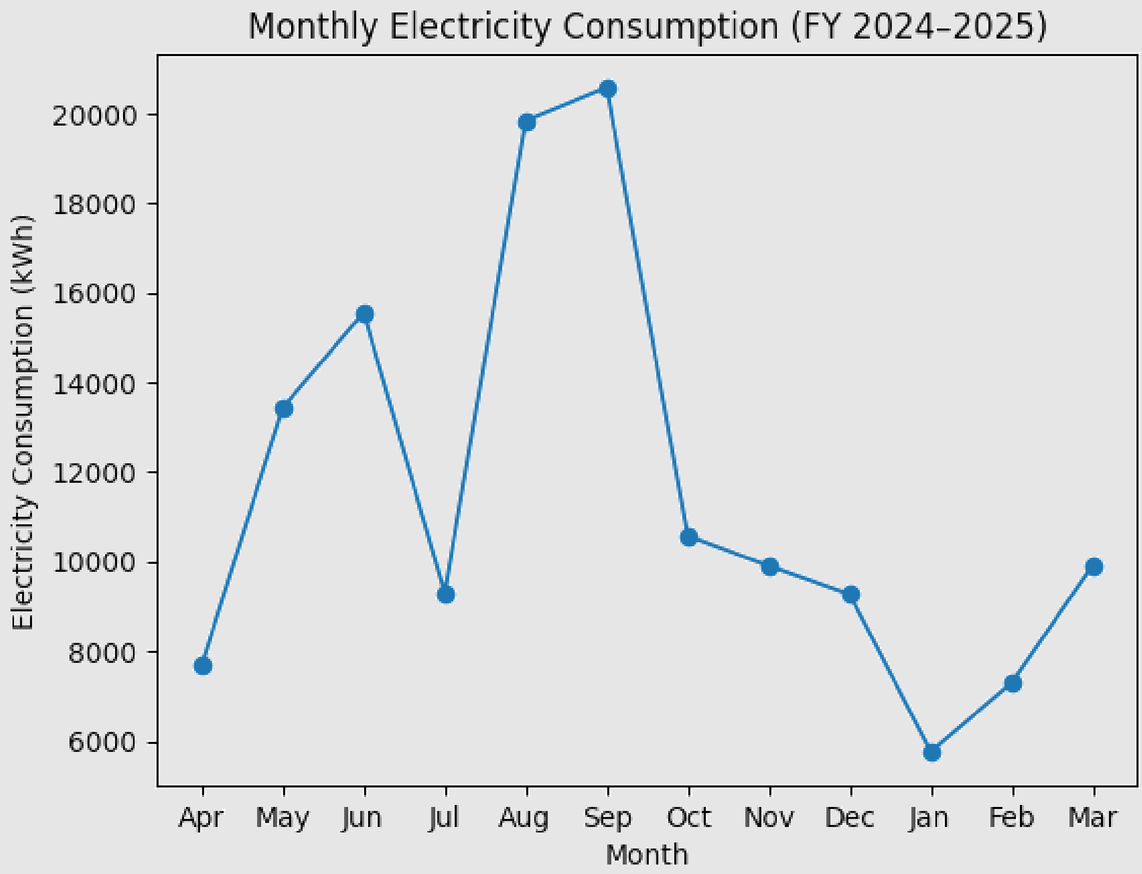

Fig. 3 Electricity consumption of Darrang College

Table 5 Monthly electricity consumption of Darrang College

Month	Units Consumed (kWh)	Billed Amount (₹)
April 2024	7,683.39	107,659
May 2024	13,436.28	157,854
June 2024	15,556.86	175,231
July 2024	9,303.66	112,748
August 2024	19,839.60	215,477
September 2024	20,574.12	223,939

Month	Units Consumed (kWh)	Billed Amount (₹)
October 2024	10,573.20	133,358
November 2024	9,904.95	126,157
December 2024	9,271.67	112,486
January 2025	5,761.95	92,408
February 2025	7,294.32	100,463
March 2025	9,922.77	127,594

6.3 Annual Electricity Consumption

The total annual electricity consumption was calculated by summing the monthly electricity usage values.

$$\text{Annual Consumption} = \sum_{i=1}^{12} Monthly\ Consumption\ = 139{,}222.77\ \text{kWh}$$

Thus, the campus consumed approximately **139,223 kWh of electricity during FY 2024–2025.**

6.4 Average Monthly Electricity Consumption

Average monthly electricity consumption is calculated as:

$$\text{Average Monthly Consumption} = \frac{\text{Annual Consumption}}{12} \approx 11{,}601.9\ \text{kWh}$$

6.5 Annual Electricity Cost

The total electricity cost was obtained by summing the monthly billed amounts.

Annual Electricity Cost = ₹1,685,374

Average Electricity Tariff

Average Tariff ≈ ₹12.1/kWh which includes:

- energy charges
- fixed charges
- electricity duty
- other applicable surcharges

6.6 Power Factor Analysis

Power factor values recorded in electricity bills indicate the efficiency with which electrical power is utilized.

Table 5 Monthly Power Factor Values

Month	Power Factor
April	0.92
May	0.94
June	0.93
July	0.92
August	0.95
September	0.97
October	0.90
November	0.93
December	0.92
January	0.78
February	0.88
March	0.92

Average Power Factor

Average PF ≈ 0.916

A power factor above **0.9** is generally considered acceptable.

However, the power factor in **January dropped to 0.78**, which indicates poor reactive power management during that period.

Improving power factor can reduce system losses and improve electrical efficiency.

6.7 Seasonal Variation in Energy Consumption

Electricity consumption shows noticeable seasonal variation throughout the year.

High Consumption Months

The highest electricity consumption occurred during:

• August 2024 – 19,839 kWh
• September 2024 – 20,574 kWh

These months correspond to periods of high humidity and academic activity, which increase the use of cooling systems and laboratory equipment.

Low Consumption Months

The lowest consumption occurred during January 2025 – 5,762 kWh

This reduction is mainly due to:

- winter weather conditions
- reduced cooling requirements
- partial academic breaks

6.8 Electricity Consumption Trend

The monthly electricity consumption trend indicates that energy demand is strongly influenced by:

- climatic conditions
- academic schedules
- laboratory activities

The peak consumption observed in late monsoon months suggests that cooling loads and humidity control contribute significantly to energy demand.

This trend analysis helps identify periods when energy conservation efforts could have the greatest impact.

6.9 Comparison with Previous Audit Baseline

The previous energy audit reported an annual electricity consumption of approximately 115,757 kWh. The current consumption of **139,223 kWh** indicates an increase of approximately ≈20.3%.

Possible reasons for this increase include:

- expansion of academic infrastructure
- increased use of laboratory equipment
- growth in computing facilities
- increased student population

Understanding this trend is important for planning future energy management strategies.

6.10 Contribution of Backup Power Systems

The campus also uses diesel generator sets during power outages. The recorded annual diesel consumption was approximately: **1,640 litres.** Although generator operation is intermittent, the electricity generated through DG sets contributes to the overall energy supply of the campus. However, detailed generator runtime data was not available, which limits the ability to accurately estimate energy generated from DG systems. Maintaining proper generator logs would improve monitoring and performance evaluation.

6.11 Energy Intensity Indicators

Energy intensity indicators help evaluate how efficiently energy is used relative to campus infrastructure or population.

Although complete demographic data was not available, preliminary indicators can still be estimated.

Energy Consumption per Building

Energy per Building ≈ 6,328 kWh/building/year

Such indicators can be refined further once detailed occupancy data becomes available.

6.12 Key Observations from Baseline Analysis

The baseline analysis reveals several important characteristics of campus energy consumption.

1. Electricity consumption is moderately high during humid months due to cooling requirements.
2. Plug loads from laboratory equipment and computing infrastructure contribute significantly to electricity demand.
3. The campus power factor is generally acceptable but shows occasional deterioration.
4. Energy consumption has increased compared to the previous audit period.
5. Lack of building-level monitoring makes it difficult to identify energy-intensive buildings.

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7. BUILDING-WISE ENERGY LOAD ASSESSMENT

A building-wise assessment of electrical load was carried out to understand how electricity demand is distributed across different buildings and functional areas within the campus.

Since the campus currently operates with **a single main electricity meter**, building-level energy consumption data is not directly available. Therefore, the building-wise load analysis was performed using the following approach:

• equipment inventory located within each building
• functional use of the building
• typical operating hours
• density of electrical appliances

This analysis helps identify buildings that contribute significantly to campus energy consumption and therefore should be prioritized for energy efficiency interventions.

7.1 Campus Buildings Considered for Analysis

The campus consists of multiple buildings serving different purposes including teaching, research, administration, student accommodation, and recreational activities.

For the purpose of load assessment, the buildings were grouped into the following categories:

Academic Buildings

These buildings primarily contain classrooms and teaching spaces.

Examples include:

• Main Academic Building
• New Academic Building
• NEC Building
• Commerce Building

These buildings generally contain lighting systems, ceiling fans, projectors, and occasional computing equipment.

Laboratory Buildings

Science departments operate specialized laboratories equipped with energy-intensive instruments.

Major laboratory facilities include:

- Zoology Laboratory Block
- Chemistry Laboratory Block
- Physics Laboratory Block
- Biotechnology Laboratories

These laboratories contain equipment such as:

- incubators
- ovens
- spectrophotometers
- centrifuges
- microscopes
- refrigerators

Such equipment often operates continuously or for extended periods, resulting in higher electricity consumption.

Administrative Buildings

Administrative buildings house offices responsible for institutional management and support services.

Major spaces include:

- Principal's office
- administrative offices
- examination branch
- accounts section

Electrical loads in these areas primarily consist of:

- computers
- printers
- photocopiers
- lighting and fans

Although individual equipment power ratings are relatively small, their continuous use during working hours contributes to electricity consumption.

Library Building

The central library is one of the major facilities on campus and includes several functional areas.

These include:

- reading rooms
- reference sections
- computer terminals
- digital resource facilities

The library requires:

- continuous lighting
- adequate ventilation and cooling
- operation of computing infrastructure

As a result, the library contributes moderately to overall electricity consumption.

Hostel Buildings

The campus includes residential hostels for students.

These include:

- Boys Hostel
- Girls Hostel

Unlike academic buildings, hostel buildings operate **24 hours per day**, resulting in continuous electricity demand.

Hostel energy consumption includes:

- lighting in rooms and corridors
- ceiling fans
- charging of electronic devices
- water pumping for bathrooms

Although individual room loads are small, the cumulative demand across multiple rooms contributes significantly to electricity consumption.

Recreational and Event Facilities

The campus also contains facilities used for events and sports activities.

These include:

- auditorium
- indoor stadium / gymnasium

These facilities are used intermittently but may create temporary peak loads due to lighting systems and sound equipment during events.

7.2 Methodology for Building-Wise Load Estimation

In the absence of sub-metering, building-wise loads were estimated using the following methodology:

1. Identify electrical appliances located within each building.
2. Determine the rated power of each appliance.
3. Estimate the quantity of each appliance installed in the building.
4. Calculate connected load using the formula:
   $$\text{Connected Load} = \text{Number of Appliances} \times \text{Rated Power}$$
5. Aggregate the loads to estimate the total electrical load of each building.

This method provides a reasonable estimate of the load distribution across buildings.

7.3 Major Energy Consuming Buildings

Based on equipment density and functional usage, several buildings were identified as major contributors to electricity consumption.

Zoology Block

The Zoology department houses multiple laboratories containing research equipment and specialized instruments.

Energy consumption in this building is driven by:

- powered microscopes
- incubators

• refrigeration equipment
• laboratory lighting
• computing equipment

Due to the presence of such equipment, the Zoology block is estimated to account for approximately **19% of the peak campus load**.

Administrative Block

The administrative building houses office facilities that operate throughout the working day.

Major electrical loads include:

• computers and printers
• lighting and fans
• photocopy machines

Although individual appliances have modest power ratings, continuous operation throughout the day results in steady electricity consumption.

Main Academic Building

The main academic building contains numerous classrooms and faculty rooms.

Electrical loads in this building primarily consist of:

• lighting fixtures
• ceiling fans
• projectors
• occasional computing equipment

Electricity demand varies depending on class schedules and occupancy.

Library Building

The library contains multiple reading rooms and computing facilities.

The major loads include:

• lighting systems
• fans

• computer terminals
• networking equipment

Since the library operates for extended hours, it contributes to continuous electricity consumption during academic sessions.

New Academic Building

The new academic building contains modern classrooms equipped with digital teaching aids.

Electrical loads include:

• lighting systems
• ceiling fans
• digital projectors
• computing equipment

These loads contribute to moderate electricity demand during academic hours.

7.4 Hostel Energy Consumption

Hostel buildings contribute to electricity consumption through residential energy use.

Typical loads include:

• lighting inside rooms
• ceiling fans
• charging of electronic devices
• bathroom lighting
• water pumps

Because hostels operate continuously throughout the day and night, they contribute to the **base electrical load of the campus**.

Although individual room loads are relatively small, the cumulative demand across many rooms leads to significant electricity consumption.

7.5 Load Characteristics of Different Building Types

Different building categories exhibit distinct load characteristics.

Academic Buildings

- energy demand primarily during daytime
- demand depends on classroom occupancy

Laboratory Buildings

- energy demand from specialized equipment
- certain instruments operate continuously

Administrative Buildings

- moderate energy demand during office hours

Hostel Buildings

- continuous energy demand throughout the day

Understanding these load characteristics is important for designing targeted energy conservation strategies.

7.6 Importance of Building-Level Energy Monitoring

One of the major findings of this assessment is the absence of building-level electricity monitoring.

Without sub-metering, it is difficult to:

- accurately track energy consumption of individual buildings
- identify inefficient buildings
- evaluate the impact of energy conservation measures

Installing sub-meters in major buildings would allow the institution to develop a more detailed understanding of energy consumption patterns.

Building-level monitoring also enables benchmarking and performance tracking over time.

7.7 Key Observations

The building-wise load assessment revealed several important observations:

1. Laboratory buildings are among the largest energy consumers due to the presence of specialized equipment.
2. Administrative buildings contribute steady electricity demand during office hours.
3. Hostel buildings contribute to continuous base load due to 24-hour occupancy.
4. Lack of building-level energy monitoring limits the ability to identify inefficient buildings.

The building-wise load assessment highlights the importance of focusing energy conservation efforts on buildings with high equipment density and long operating hours.

Laboratory buildings and hostels represent the most significant contributors to campus energy demand.

Improving the energy efficiency of these buildings could significantly reduce overall electricity consumption.

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8. EQUIPMENT INVENTORY AND ENERGY CONSUMPTION ANALYSIS

A comprehensive inventory of electrical appliances and equipment installed within the campus was analyzed as part of the energy audit process. The objective of this analysis is to estimate the energy consumption associated with different categories of equipment and identify opportunities for improving energy efficiency.

Electrical equipment installed in educational institutions can broadly be categorized into the following groups:

- cooling equipment (fans and air conditioning units)
- lighting systems
- office and computing equipment
- laboratory instruments
- utility systems such as pumps

Each category of equipment contributes differently to the overall electricity consumption of the campus depending on its power rating and operating hours.

The energy consumption of each equipment category was estimated using the following relationship:

$$\text{Energy Consumption} = \text{Power Rating} \times \text{Operating Hours}$$

Where:

Power Rating is expressed in kilowatts (kW) and Operating Hours represent the total hours of operation during a given period.

8.1 Cooling Equipment

Cooling equipment is essential for maintaining thermal comfort within classrooms, laboratories, offices, and hostel rooms. The cooling load of the campus is primarily served by ceiling fans and a limited number of air conditioning units.

Cooling systems account for a significant portion of electricity consumption because they operate for several hours each day.

Ceiling Fans

Ceiling fans represent the largest category of cooling equipment within the campus.

Inventory

Equipment	Quantity	Power Rating
Ceiling Fans	845	70 W

Total Installed Fan Load

Total Load = 59.15 kW

Estimated Operating Hours

Typical operating schedule for fans in classrooms and offices:

- 6 hours per day
- 150 working days per year

Annual Energy Consumption

Energy ≈ 53,235 kWh/year

This indicates that ceiling fans contribute significantly to electricity consumption.

Air Conditioners

Air conditioners are installed in selected offices and laboratories where temperature control is required.

Inventory

Equipment	Quantity	Power Rating
Air Conditioners	17	1.1 kW

Total Installed AC Load

Total Load = 18.7 kW

Estimated Operating Hours

Typical usage:

- 5 hours per day
- 100 working days per year

Annual Energy Consumption

Energy ≈ 9,350 kWh/year

Although the number of AC units is limited, their high power ratings result in considerable energy consumption.

8.2 Lighting Systems

Lighting systems provide illumination for classrooms, laboratories, corridors, offices, and outdoor areas.

The campus lighting system has largely been upgraded to **energy-efficient LED lighting**, which reduces electricity consumption compared to conventional fluorescent lamps.

Tube Lights

Inventory

Equipment	Quantity	Power Rating
LED Tube Lights	926	20 W

Total Installed Load

Load = 18.52 kW

Operating Hours

Typical lighting usage:

- 6 hours per day
- 300 days per year

Annual Energy Consumption

Energy ≈ 33,336 kWh/year

LED Bulbs

Inventory

Equipment	Quantity	Power Rating
LED Bulbs	362	9 W

Total Installed Load

Load ≈ 3.26 kW

Annual Energy Consumption

Energy ≈ 5,868 kWh/year

8.3 Office and Computing Equipment

Administrative operations rely on several electrical devices including computers, printers, and networking equipment.

These devices contribute to plug loads within administrative buildings and computer laboratories.

Computers

Inventory

Equipment	Quantity	Power Rating
Computers	75	100 W

Total Load

Load = 7.5 kW

Operating Hours

Estimated usage:

• 6 hours per day
• 300 days per year

Annual Energy Consumption

Energy ≈ 13,500 kWh/year

Printers

Inventory

Equipment	Quantity	Power Rating
Printers	25	200 W

Total Load

Load = 5 kW

Operating Hours

Estimated usage:

• 0.5 hours per day
• 300 days per year

Annual Energy Consumption

Energy ≈ 750 kWh/year

8.4 Laboratory Equipment

Science laboratories contain several specialized instruments that consume significant electricity.

Examples include:

• autoclaves
• centrifuges
• ovens
• incubators

• spectrophotometers
• refrigerators

Because these instruments operate for extended periods during laboratory sessions and research activities, their combined electricity consumption is substantial.

Based on equipment ratings and operating schedules, the total laboratory equipment load is estimated to be approximately ≈ 60 kW

Estimated annual energy consumption ≈ 35,000 kWh/year

8.5 CCTV and Security Systems

The campus has an installed network of CCTV cameras for security monitoring.

Inventory

Equipment	Quantity	Power Rating
CCTV Cameras	32	30 W
CCTV DVR	2	30 W

These systems operate continuously throughout the day.

Estimated annual energy consumption ≈ 9,000 kWh/year

8.6 Water Pumping Systems

Water pumps are used for extracting groundwater and supplying water to overhead storage tanks.

Pump Inventory

Pump Capacity	Quantity
1 kW	1
2 kW	3
5 kW	2

Total Pump Load

Total Load = 17 kW

Estimated Operating Hours

• 2 hours per day
• 365 days per year

Annual Energy Consumption

Energy ≈ 12,410 kWh/year

The estimated annual electricity consumption of major equipment categories is summarized below.

Equipment Category	Annual Consumption (kWh)
Cooling Systems	127,000
Lighting Systems	52,000
Office Equipment	22,500
Laboratory Equipment	35,000
Water Pumps	12,410

These values represent approximate energy consumption based on equipment ratings and operating schedules.

The equipment-level analysis reveals several important insights:

1. Cooling equipment, particularly ceiling fans, contributes significantly to electricity consumption.
2. Lighting energy consumption has been reduced through the adoption of LED lighting technology.
3. Laboratory equipment contributes a substantial portion of electricity demand due to high power ratings.
4. Water pumping and security systems contribute relatively smaller portions of energy consumption.

Based on the equipment inventory analysis, several opportunities for improving energy efficiency were identified:

• replacing conventional ceiling fans with BLDC fans
• installing occupancy sensors for lighting control
• implementing better operational practices for laboratory equipment
• improving pump efficiency through maintenance and optimization

Implementing these measures could significantly reduce the electricity consumption of the campus. The equipment inventory analysis provides a detailed understanding of how electricity is consumed across different systems within the campus.

The analysis highlights that cooling systems, lighting systems, and laboratory equipment represent the most significant contributors to electricity consumption. Targeted improvements in these areas can result in substantial energy savings.

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9. DIESEL GENERATOR SYSTEM ANALYSIS

Darrang College relies primarily on electricity supplied by the state utility (APDCL) for its power requirements. However, to ensure continuity of operations during power outages, the campus maintains diesel generator (DG) sets that provide backup electricity.

Diesel generators are commonly used in institutional campuses where uninterrupted power supply is essential for maintaining the operation of laboratories, administrative offices, and hostel facilities.

Although DG sets operate only during power outages, they contribute to energy costs and carbon emissions because diesel fuel is significantly more expensive than grid electricity.

The objective of this section is to evaluate:

- the installed capacity of DG sets
- fuel consumption patterns
- operational practices
- opportunities for improving generator performance and monitoring

9.1 Installed Generator Capacity

The campus operates multiple diesel generators located in different parts of the campus. These include generators for the main academic campus and additional units for hostel facilities.

Table 6: Diesel Generator Set Specification

	College Campus		Boys Hostel	Girls Hostel
Make	Kirloskar Oil Engines Ltd.	Kirloskar Electric Co. Ltd.	Kirloskar	Kohler Power India Pvt. Ltd.
Model	KG 254 S0	4AB225S1	NA	KES 15II
Rated kVA	140	100	20	15

	College Campus		Boys Hostel	Girls Hostel
Rated kW	112	85	16	12
Voltage	415	415	415	230
Frequency	50	50	50	50
Specific Fuel Consumption (SFC)	At 100% load-37.1 ltr/hr	At 100% load-28.0 ltr/hr	At 100% load-6.0 ltr/hr	At 100% load-4.0 ltr/hr
	At 75% load-28.8 ltr/hr	At 75% load-21.9 ltr/hr	At 75% load-4.9 ltr/hr	At 75% load-3.0 ltr/hr
	At 50% load- 20.4 ltr/hr	At 50% load- 15.5 ltr/hr	At 50% load- 3.4 ltr/hr	At 50% load- 2.2 ltr/hr
Photograph				

Total Installed Generator Capacity

Total Capacity = 225 kW

The installed generator capacity is therefore sufficient to support critical campus loads during grid outages.

9.2 Operating Characteristics of DG Sets

Diesel generators are typically operated during:

- grid power outages
- maintenance shutdowns of utility supply
- emergency situations

The operating schedule of the generators depends on the frequency and duration of power outages.

Unlike grid electricity, generator operation is intermittent and usually limited to a few hours per day during outages.

Because generator fuel cost is high, institutions generally try to minimize generator operation wherever possible.

9.3 Diesel Fuel Consumption

The diesel consumption records provided by the institution indicate the following approximate fuel usage during the audit period.

Annual Diesel Consumption

Generator Location	Fuel Consumption
Main Campus DG	1500 litres
Boys Hostel DG	60 litres
Girls Hostel DG	80 litres

Total Annual Diesel Consumption

Total Fuel = 1640 litres/year

This indicates that generator operation during the audit period was relatively limited.

9.4 Diesel Generator Operating Cost

The annual cost of diesel fuel used for generator operation was approximately ₹1,46,229. Diesel-based electricity generation is significantly more expensive than grid electricity due to the high cost of diesel fuel. For example, the cost of electricity generated from diesel generators typically ranges between ₹18 – ₹25 per kWh compared to grid electricity cost of approximately ₹12 per kWh.

Therefore, reducing generator operation through improved grid reliability or renewable energy integration can reduce energy costs.

9.5 Specific Fuel Consumption (SFC)

Specific Fuel Consumption (SFC) is a measure used to evaluate the efficiency of diesel generators.

It represents the amount of fuel consumed per unit of electricity generated.

$$SFC = \frac{Fuel\ Consumed}{Energy\ Generated}$$

Typical SFC values for diesel generators range between 0.25–0.30 litres/kWh

The generator manufacturer specifications indicate the following approximate fuel consumption rates:

Load Level	Fuel Consumption
100% Load	37.1 litres/hour
75% Load	28.8 litres/hour
50% Load	20.4 litres/hour

These values correspond to the rated operating conditions of the generator.

9.6 Estimated Electricity Generation from Diesel

Based on typical generator efficiency and fuel consumption values, the approximate electricity generated from diesel fuel can be estimated.

Assuming 1 litre diesel ≈ 3.6 kWh electricity

Estimated annual electricity generation ≈5904 kWh/year

Thus, the diesel generators likely produced approximately **5900 kWh of electricity during the audit period**.

This represents a relatively small portion of the campus electricity supply compared to grid electricity.

9.7 Operational Issues Observed

During the audit, certain operational issues related to generator management were observed.

Lack of Detailed Generator Logs

The institution currently records fuel purchase data but does not maintain detailed logs of:

- generator runtime hours
- electricity generated
- load levels during operation

Without such data, it is difficult to evaluate generator performance and efficiency.

Maintenance Records

Although the generators are reported to undergo periodic maintenance, detailed maintenance logs were not readily available during the audit.

Proper maintenance documentation helps ensure reliable operation and extend generator lifespan.

To improve generator performance monitoring, it is recommended that the institution implement a structured data recording system.

The following parameters should be recorded regularly:

- generator start and stop times
- total operating hours
- fuel added
- load conditions
- maintenance activities

Maintaining such records will allow the institution to evaluate generator efficiency and plan maintenance schedules more effectively.

Diesel generators produce emissions that contribute to air pollution and greenhouse gas emissions.

Typical emissions from diesel combustion include:

- carbon dioxide (CO_2)
- nitrogen oxides (NO_x)
- particulate matter

Reducing reliance on diesel generators can therefore contribute to improved environmental performance.

Integrating renewable energy systems such as solar PV can reduce generator usage and associated emissions.

9.8 Opportunities for Improvement

Several opportunities exist for improving the efficiency and management of generator systems.

Improved Monitoring

Installing energy meters on generator output circuits would allow accurate measurement of electricity generated during generator operation.

Scheduled Maintenance

Regular preventive maintenance should be conducted to ensure optimal generator performance.

Renewable Energy Integration

Solar photovoltaic systems can reduce generator usage by supplying electricity during daytime outages.

The diesel generators installed at Darrang College provide essential backup power during electricity outages.

The total installed generator capacity of approximately **225 kW** is sufficient to support critical loads within the campus.

However, the audit revealed that generator operation monitoring can be improved through better record keeping and performance tracking.

Improved monitoring and integration of renewable energy systems could further reduce generator usage and associated operational costs.

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10. LUX LEVEL STUDY

Lighting is a fundamental requirement in educational institutions, ensuring adequate illumination for classrooms, laboratories, offices, libraries, and other functional spaces.

An efficient lighting system should provide:

- adequate illumination for visual tasks
- uniform distribution of light
- minimal glare
- optimal energy consumption

The lighting audit conducted at Darrang College focused on evaluating the existing lighting infrastructure and determining whether the illumination levels meet recommended standards.

The objectives of the lighting analysis were to:

- assess the existing lighting technologies
- measure illumination levels in different areas
- compare measured values with recommended standards
- identify opportunities for reducing lighting energy consumption

10.1 Existing Lighting Infrastructure

The campus lighting system has largely transitioned to energy-efficient technologies.

The lighting fixtures installed across campus include:

• LED tube lights
• LED bulbs
• metal halide lamps (in limited locations)
• halogen lamps (few installations)

The widespread adoption of LED lighting indicates that the institution has already taken significant steps toward improving lighting efficiency.

LED lighting systems offer several advantages compared to conventional lighting technologies such as fluorescent or incandescent lamps.

Advantages of LED Lighting

• lower electricity consumption
• longer operating life
• reduced maintenance requirements
• better lighting quality

Because LED lighting consumes significantly less power, it contributes to reducing electricity costs and environmental impact.

10.2 Lighting Inventory

A detailed inventory of lighting fixtures installed across campus was reviewed during the audit.

Lighting Fixture Inventory

Lighting Fixture	Quantity	Power Rating
LED Tube Lights	926	20 W
LED Bulbs	362	9 W
Halogen Lamps	3	250 W
Metal Halide Lamps	10	600 W

10.3 Lux Level Measurement

Lux level measurements were conducted in representative buildings using a portable lux meter. Measurements were taken at typical working height (approximately 0.8 meters above floor level).

The measured illumination levels in selected campus buildings are shown below.

Table 7 Measured illumination levels

Building	Average Lux Level
Administrative Block	125 lux
Main Building	162 lux
Sanskrit Block	87 lux
Zoology Block	75 lux
Commerce Block	226 lux
Chemistry Block	98 lux
Heritage Block	137 lux
Auditorium	146 lux
Indoor Stadium	338 lux
Boys Common Room	156 lux
Union Office	133 lux
Library	96 lux
NEC Building	113 lux
New Academic Building	112 lux

The recommended illumination levels for educational buildings are provided by international lighting standards such as those of the Illuminating Engineering Society (IES).

Recommended Illumination Levels

Area	Recommended Lux
Classrooms	300 lux
Laboratories	500 lux
Library reading areas	300 lux
Library shelves	150 lux
Staff rooms	300 lux
Assembly halls	300 lux
Indoor sports areas	300–700 lux

Comparison of measured lux levels with recommended standards indicates the following observations.

Areas with Adequate Lighting

Certain areas such as the indoor stadium and commerce block exhibit relatively higher illumination levels.

Areas with Moderate Lighting

Most academic buildings show illumination levels between **100–200 lux**, which is moderately adequate for general use.

Areas with Lower Illumination

Some laboratory buildings recorded illumination levels below recommended standards.

This suggests that additional lighting may be required in certain locations, particularly where detailed visual tasks are performed.

One positive observation during the audit was the availability of natural daylight in several buildings. Large windows and open corridors allow natural light to enter classrooms and offices during daytime. This provides an opportunity to reduce artificial lighting during daylight hours. However, in some classrooms with unfavorable orientation, daylight penetration is limited. Improving daylight utilization through architectural modifications could further reduce lighting energy consumption.

Several measures can be implemented to further improve the efficiency of the lighting system.

Lighting Control Zoning

Installing separate switches for different lighting zones allows occupants to turn off unnecessary lights when not required.

Occupancy Sensors

Occupancy sensors automatically switch off lights in unoccupied rooms, reducing energy waste.

Daylight Sensors

Daylight sensors adjust artificial lighting levels depending on available natural light.

Transparent Roofing Panels

In Assam-type buildings, replacing portions of roofing with translucent materials can improve natural lighting.

The lighting audit revealed several important findings.

1. Most lighting fixtures have already been converted to LED technology, improving efficiency.
2. Artificial lighting is sometimes used during daytime even when adequate natural light is available.
3. Certain areas have illumination levels below recommended standards.
4. Lighting control systems are currently manual and not optimized for energy savings.

The lighting system at Darrang College is relatively energy-efficient due to the widespread adoption of LED lighting.

However, further improvements can be achieved through better utilization of daylight and implementation of automated lighting controls.

Lighting energy consumption can be reduced while maintaining adequate illumination levels through proper design and operational practices.

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11. OBSERVATIONS AND RECOMMENDATIONS

We now present the final section of the Energy Audit Report, which summarizes the key findings of the audit and outlines the strategic recommendations for improving energy efficiency and sustainability within the campus.

The comprehensive energy audit conducted for Darrang College for the fiscal year 2024–2025 has provided valuable insights into the energy consumption patterns of the campus. The audit involved analysis of electricity consumption records, equipment inventories, operational practices, and infrastructure systems.

The primary objective of the audit was to identify opportunities for reducing energy consumption while maintaining the operational efficiency and comfort levels required for academic and administrative activities.

The findings of the audit indicate that the institution has already taken several positive steps toward energy efficiency, particularly through the adoption of LED lighting systems. However, significant opportunities remain for further improving energy performance through equipment upgrades, operational improvements, and renewable energy integration.

11.1 Summary of Campus Energy Consumption

The analysis of electricity bills for the audit period revealed that the campus consumed approximately 139,223 kWh/year. The total annual electricity expenditure for this consumption was approximately ₹16.85. Electricity consumption varies throughout the year due to seasonal climatic variations and academic activity schedules.

The highest electricity consumption was observed during the humid monsoon months, while the lowest consumption occurred during winter months when cooling requirements were minimal.

11.2 Major Energy Consuming Systems

The energy consumption of the campus is distributed among several end-use systems.

Based on the load distribution analysis conducted during the audit, the approximate contribution of each system is as follows:

Energy Use Category	Contribution
Cooling Systems	40 %
Plug Loads and Laboratory Equipment	41 %
Lighting Systems	11 %
Water Pumping Systems	8 %

Cooling systems and plug loads together account for more than 80% of total electricity consumption, indicating that these systems offer the greatest opportunities for energy savings.

11.3 Key Findings of the Energy Audit

The audit identified several important observations related to energy consumption and management practices within the campus.

Absence of Building-Level Monitoring: Electricity consumption is currently monitored only at the campus level through a single utility meter. This makes it difficult to identify energy-intensive buildings or departments.

High Number of Conventional Ceiling Fans: The campus operates a large number of conventional ceiling fans, which contribute significantly to electricity consumption.

Efficient Lighting Infrastructure: Most lighting fixtures across the campus have already been upgraded to LED technology, which is a positive development.

Limited Monitoring of Diesel Generators: Although diesel generators provide essential backup power, detailed monitoring of generator performance is currently limited.

Opportunities for Renewable Energy: The campus has several buildings with rooftops suitable for installing solar photovoltaic systems.

11.4 Energy Saving Potential

The energy conservation measures identified during the audit have the potential to significantly reduce electricity consumption.

The most impactful measures include:

• replacement of conventional fans with BLDC fans
• installation of rooftop solar photovoltaic systems
• improved lighting controls
• occupancy sensors in classrooms and offices
• enhanced energy monitoring systems

Implementation of these measures could reduce electricity consumption by more than 50% when solar generation is considered.

11.5 Financial Benefits

The financial analysis conducted for the recommended energy conservation measures indicates that most of the proposed investments are economically viable.

The estimated total investment required for implementing major measures is approximately ₹56 lakh. The total annual financial savings achievable through these measures are estimated to be approximately ₹16 lakh/year. This results in an average payback period of approximately 3–4 years, making the proposed measures financially attractive.

11.6 Environmental Benefits

Electricity consumption and diesel generator operation contribute to greenhouse gas emissions. The annual carbon footprint associated with campus energy use is estimated to be approximately 118 tonnes CO_2/year. Implementation of energy efficiency measures and renewable energy systems could reduce emissions by approximately 116 CO_2/year. This would significantly reduce the environmental impact of campus operations.

11.7 Strategic Recommendations

Based on the findings of the energy audit, the following strategic actions are recommended for Darrang College.

Establish an Energy Management Committee: An institutional energy management committee should be formed to oversee the implementation of energy efficiency initiatives.

Implement Building-Level Sub-Metering: Installing sub-meters for major buildings will enable more detailed monitoring of energy consumption.

Replace Conventional Fans with BLDC Fans: Gradual replacement of existing ceiling fans with energy-efficient BLDC fans should be prioritized.

Install Rooftop Solar PV Systems: Solar photovoltaic systems should be installed on suitable campus buildings to reduce grid electricity consumption.

Promote Energy Awareness: Regular awareness programs should be conducted to encourage students and staff to adopt energy conservation practices.

11.8 Long-Term Vision

The findings of this audit provide a foundation for developing a long-term energy management strategy for the institution.

With sustained implementation of energy efficiency measures and renewable energy systems, Darrang College has the potential to evolve into a model green campus that demonstrates sustainable energy practices.

Such initiatives not only reduce operational costs but also strengthen the institution’s commitment to environmental responsibility and sustainable development.

11.9 Final Remarks

The energy audit conducted for Darrang College highlights both the current energy consumption profile and the significant opportunities available for improving energy efficiency. By implementing the recommendations presented in this report, the institution can achieve substantial reductions in electricity consumption, operational costs, and carbon emissions. Furthermore, these initiatives will enhance the sustainability profile of the campus and support the institution's long-term environmental and educational objectives.
