

Submitted To



Central University of
Hyderabad

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Administrative Staff
College of India



COMPREHENSIVE ENERGY AUDIT REPORT

PHASE - 1



ABOUT THE REPORT

The project aims to assess the current energy consumption and infrastructure within the university campus to identify efficiency improvement opportunities. Led by University Engineer (UE) Lt Col. C.H. Rao, along with a team of energy engineers and sustainability experts, the initiative focuses on implementing practical solutions rather than just reporting findings. The goal is to optimize energy usage, reduce operational costs by up to 25%, and lower maintenance expenses across the campus. Through data-driven strategies and targeted interventions, the project aims to improve long-term sustainability and resource management.

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1 Executive Summary

The Hyderabad University campus, spanning 2,300 acres, faces challenges in energy efficiency, sustainable mobility, and water management. The campus operates with a load factor of 63.29%, highlighting potential energy optimization opportunities. The electrical consumption pattern indicates inefficiencies in HVAC systems, which contribute significantly to peak demand. Analysing energy bills shows that air conditioning and other electrical loads account for a major portion of the university's expenditure. The replacement of inefficient HVAC systems with energy-efficient alternatives, along with demand-side management strategies such as smart metering and capacitor banks, can improve power factor correction and reduce energy losses. Additionally, upgrading transformers and diesel generator (DG) sets will further enhance system reliability and cost-effectiveness.

The campus's transportation system, currently dependent on six diesel buses, consumes approximately 106.25 Liters of fuel daily, translating to an annual fuel cost of ₹3.3 crores and 104 metric tons of CO₂ emissions

Water conservation remains a priority, with Hyderabad receiving an average annual rainfall of 919 mm. The campus's contour variations (ranging from 583m to 643m) create challenges in stormwater management. The implementation of borewell recharge systems, percolation pits, permeable pavements, and bioswales can significantly enhance groundwater recharge and reduce stormwater runoff. These measures, with recharge efficiencies ranging from 10% to 80%, will contribute to long-term water sustainability.

By integrating HVAC efficiency improvements, electrical system upgrades, and sustainable mobility and water management solutions, the university can reduce operational costs, improve energy reliability, and minimize environmental impact. This report outlines priority actions for immediate savings alongside long-term strategic initiatives to establish a resilient, energy-efficient, and sustainable campus.

Activities based on work plans from Phase 1 of the audit, along with their progression, are detailed in the Table 1 given below.

Table 1 Progression of Activities Based on Phase 1 of Work Plan

S.No	Activity	Status	Share of progress
1	Assess the current electrical infrastructure, including feeders, substations, and distribution grids, to understand their capacity and efficiency.	Completed	100% Completed
2	Implement a weather-proof EMIS for energy demand centers to monitor and manage energy consumption effectively.	Completed	100% Completed
3	Develop a ring main proposal for the campus based on the energy consumption patterns and optimize the load distribution into each feeder/line/grid.	Completed	100% Completed

4	Redesign the entire campus grid based on the usage into Commercial, Residential and Domestic grids to reduce the energy bills.	Completed	100% Completed
5	Evaluate the redundancy-based approach strain leading to electrical failures and suggest remedial measures.	Completed	100% Completed
6	Identify energy demand centers based on consumption, losses, infrastructure criticality, and user type for efficient resource allocation.	Completed	100% Completed
7	Study the potential for alternative and renewable energy generation to include Solar Power, Biomass-based energy and Rooftop solar geysers. Also study, design and recommend implementation strategies in sync with various government schemes.	In Progress	80% Completed
8	Develop a re-aligned design and location of substations to evenly distribute loads catering for future expansion.	Completed	100% Completed

2 Introduction

Hyderabad University, spread across 2,300 acres, accommodates a diverse academic community with over 5,000 students and 400 faculty members. The campus operates a large infrastructure with 85+ buildings, requiring continuous energy supply, water management, and an efficient mobility system. Existing systems face challenges related to high energy consumption, inefficient transportation, and unoptimized resource utilization, leading to increased operational costs and environmental concerns.

This report examines key areas of energy efficiency, water conservation, and sustainable mobility, proposing short-term and long-term solutions. It evaluates current infrastructure limitations and recommends targeted interventions such as solar-powered induction stoves, cool roofs, cycle-sharing, electric buses, transformer upgrades, and stormwater management solutions. The proposed strategies aim to reduce operational inefficiencies, improve resource utilization, and align the campus with national sustainability goals.

By implementing these measures, the university can optimize energy use, minimize its environmental footprint, and serve as a model for sustainable campus development. The report provides a structured roadmap for improving infrastructure resilience and integrating sustainability into campus operations.

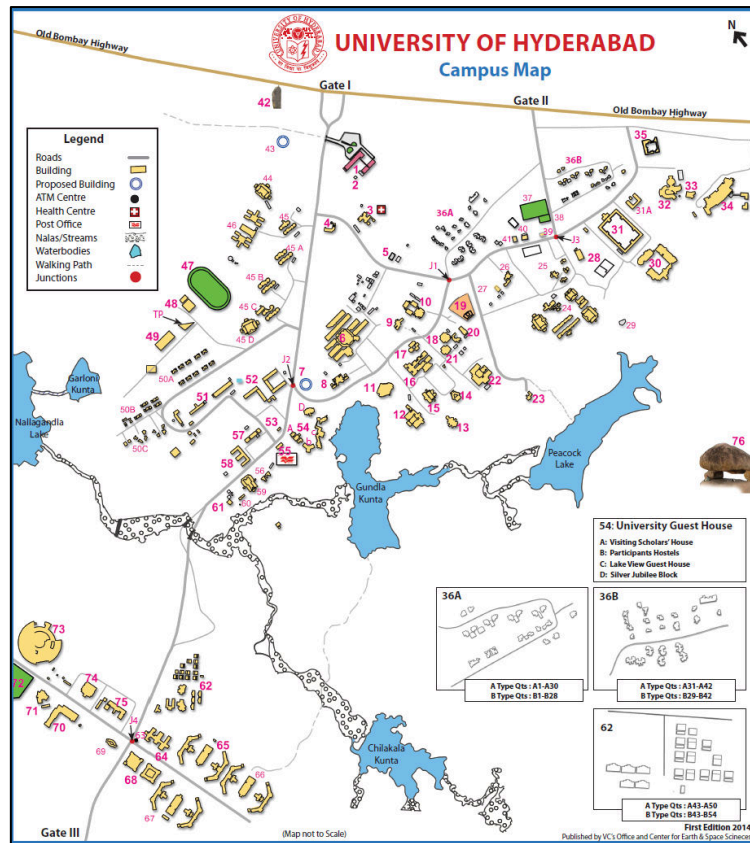


Figure 1 University of Hyderabad Master Plan

2.1 Scope of the Energy Audit

The audit evaluated the university's entire energy ecosystem, focusing on,

- **Electrical Infrastructure:** Capacity and efficiency of feeders, substations, transformers, and capacitors, with emphasis on redundancy gaps and load imbalances.
- **Energy Management Systems:** Implementation of a weather-proof Energy Management Information System (EMIS) for real-time monitoring and predictive load management.
- **Grid Modernization:** Segmentation of the campus grid into Commercial, Residential, and Domestic zones, supported by a ring main system proposal to optimize load distribution.
- **Renewable Energy Feasibility:** Technical and financial viability of solar PV, biomass, and solar water heating systems, including alignment with government incentives.
- **Critical Systems Audit:** Performance assessment of Domestic Hot Water Systems, DG sets, HVAC units, and cooling infrastructure.

2.2 Methodology and Data Collection Framework

A systematic, data-driven approach was used to evaluate the University of Hyderabad's energy infrastructure and propose optimization strategies. Key steps included,

WALKTHROUGH AUDIT & LOAD ASSESSMENT

Conducted room-by-room surveys to document building loads, aggregated for a bottom-up analysis of transformer performance, age, and load imbalances.

EMIS IMPLEMENTATION

Installed energy loggers in high-consumption zones to enable real-time monitoring, automated reporting, and proactive energy management.

RING MAIN SYSTEM PROPOSAL

Analyzed the existing grid using a shortest-path method to design an interconnected ring main system for optimal power routing and balanced transformer loads.

GRID SEGMENTATION

Restructured the electrical grid into Commercial, Residential, and Domestic sectors to improve power allocation and reduce losses.

BACKUP & REDUNDANCY EVALUATION

Assessed DG sets, inverters, and UPS systems to identify failure points and recommend improvements for operational resilience.

ENERGY DEMAND CENTER IDENTIFICATION

Mapped high-consumption zones to target energy conservation measures.

RENEWABLE ENERGY FEASIBILITY

Proposed solar water heating for hostels and initiated feasibility studies for solar PV and biomass integration.

SUBSTATION PLANNING

Evaluated load distribution to propose a redesign and relocation plan for improved scalability and reduced transmission losses.

Figure 2 Methodology and Data Collection Framework

3 Current Electrical Infrastructure Assessment

The University of Hyderabad operates an extensive grid-connected power distribution system, which ensures reliable electricity supply across its campus. The existing infrastructure comprises 14 substations, including a main take-off point that step down power from the grid for distribution. The system is designed to cater to the diverse energy needs of academic buildings, research facilities, administrative offices, hostels, and other campus amenities. Existing grid network of the campus is given in figure 3.



Figure 3 Existing Grid Network

The current system consists of a primary power source, a main receiving station, transformers, and multiple substations. However, with some components exceeding 25 years of operation, there is an urgent need for assessment and possible upgrades to maintain reliability and efficiency.

3.1 Energy Consumption Analysis

The energy consumption analysis of the University of Hyderabad for the years 2020-2024 is presented in Figure 4, highlighting trends and variations over the period.

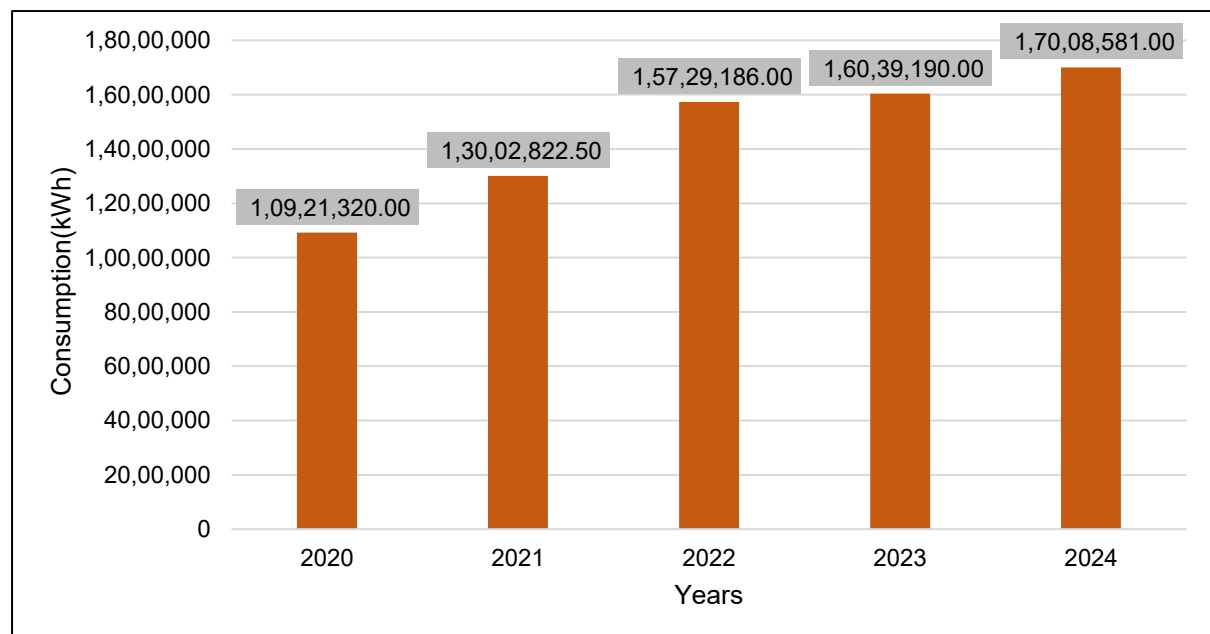


Figure 4 Energy Consumption Analysis from 2020 – 2024

The university's energy consumption shows significant variation over the years, with a general increase in recent years (2020 to 2024). The energy consumption in 2023–24 increased by 55.78% compared to 2020–21, with the highest recorded consumption reaching 17.01 million kWh. This significant rise reflects the university's full-scale operations post-pandemic,

underscoring the critical need for sustained energy efficiency measures and infrastructure modernization to manage growing demand effectively.

3.2 Comparative Study of Seasonal Energy Consumption & Demand (2020–2024)

The seasonal energy consumption and demand analysis (2020–2024) highlights significant variations in energy use across different seasons, directly influencing the university’s operational efficiency, cost management, and sustainability objectives. The comparative seasonal energy consumption & demand analysis is given in figure 5.

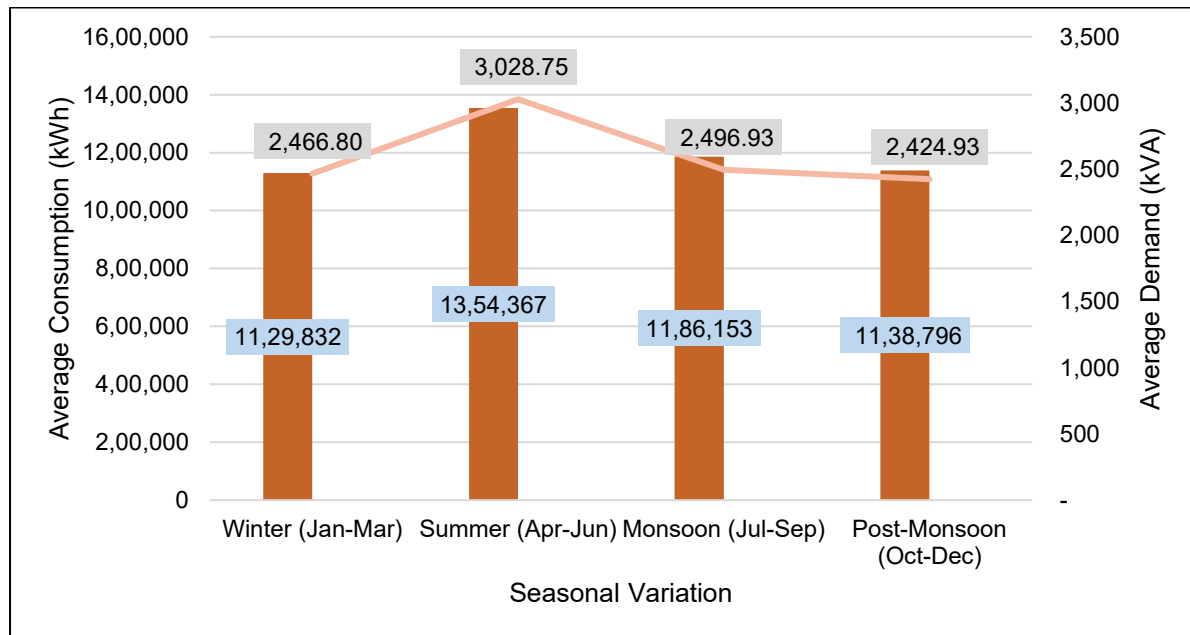


Figure 5 Comparative Study of Seasonal Energy Consumption & Demand (2020–2024)

Summer energy consumption is 16.6% higher than Winter, reflecting increased HVAC demand. In contrast, post-monsoon sees a 15.9% reduction, presenting opportunities for strategic energy savings. Peak demand charges, a major cost driver, surge in Summer, with demand 19.9% higher than post-monsoon, straining campus electrical infrastructure. The kWh/Demand Ratio shows efficiency challenges in Summer, emphasizing the need for demand-side management and system optimizations.

3.3 Load Factor Analysis

The average load factor of the university has been calculated for the years 2020 to 2024, providing insights into the institution's energy utilization efficiency is given in figure 6.

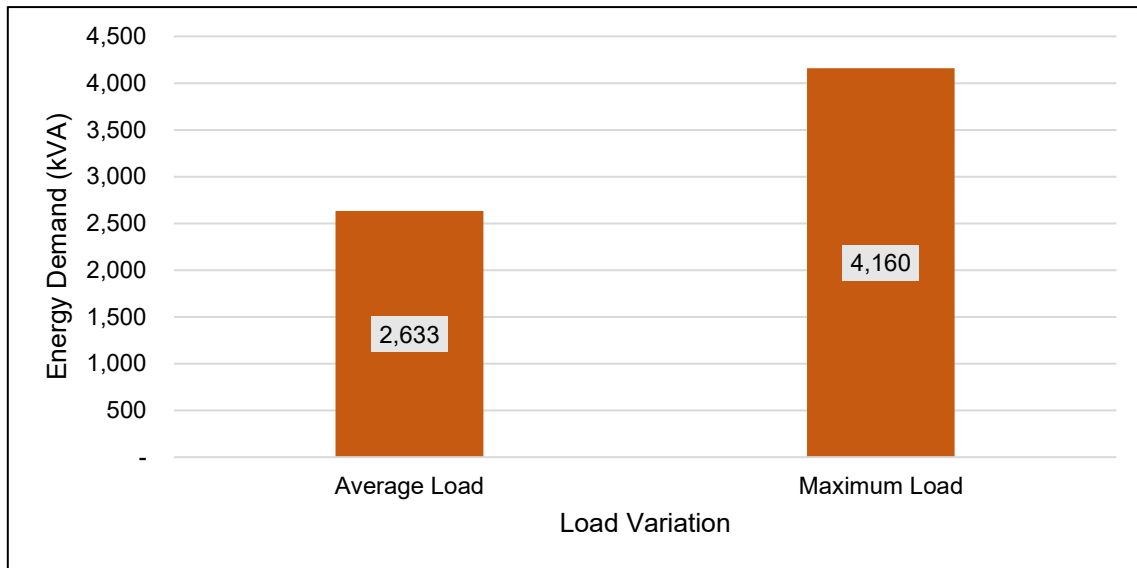


Figure 6 Load Factor Analysis

The university's load factor of **63.29%** highlights opportunities to improve energy efficiency and cost-effectiveness.

Load factor, calculated as the ratio of average load (2,633 kVA) to maximum load (4,160 kVA), indicates how consistently electrical demand is utilized. A lower load factor suggests variations in energy usage, which can impact operational efficiency and cost.

3.4 System Components and Functionality

The primary source of power that feeds the entire distribution network is 33 kV Take-Off Point. It serves as the initial stage of power distribution before it is stepped down for further transmission. Main Receiving Station (MRS) station receives 33 kV power supply and steps it down to 11 kV using two 5 MVA transformers. This step is crucial in preparing the electricity for further distribution across the campus.

A total of 14 substations including MRS are spread across the premises. However, a key issue observed is that most panel designations are not clearly marked, making it difficult to manage and operate efficiently. The infrastructure includes 34 transformers, some of which have exceeded 25 years of operation. This aging equipment poses potential efficiency and reliability concerns, increasing the risk of power failures. Automatic Power Factor Correction (APFC) panels are installed in almost all substations to improve power efficiency, but their condition needs to be evaluated to ensure optimal performance. Different components of electrical network is given in figure 7.

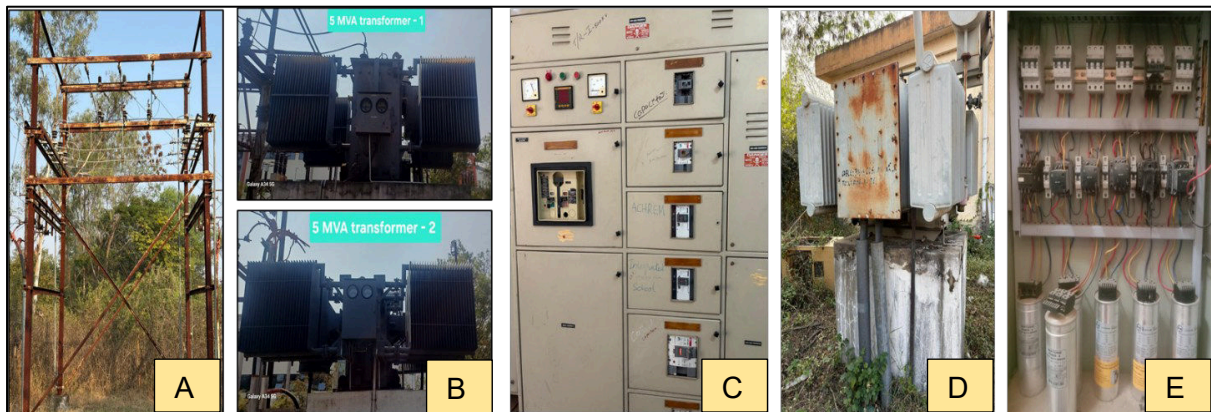


Figure 7 A. 33 kV Take-Off Point. B. Main Receiving Station (MRS). C. Substation. D. Transformers. E. Automatic Power Factor Correction (APFC).

3.5 Solar Vs Grid Energy Comparison

As the university has extensive building infrastructure within the campus, its energy consumption is also significantly high. To offset a portion of the electricity drawn from the grid, the university has integrated rooftop solar power plants across multiple buildings. However, the contribution of solar power remains low compared to the overall grid energy usage. Currently, solar generation accounts for only 16% of the university's total annual electricity consumption of 2024. Monthly energy comparison of solar generation vs grid electricity is given in figure 8.

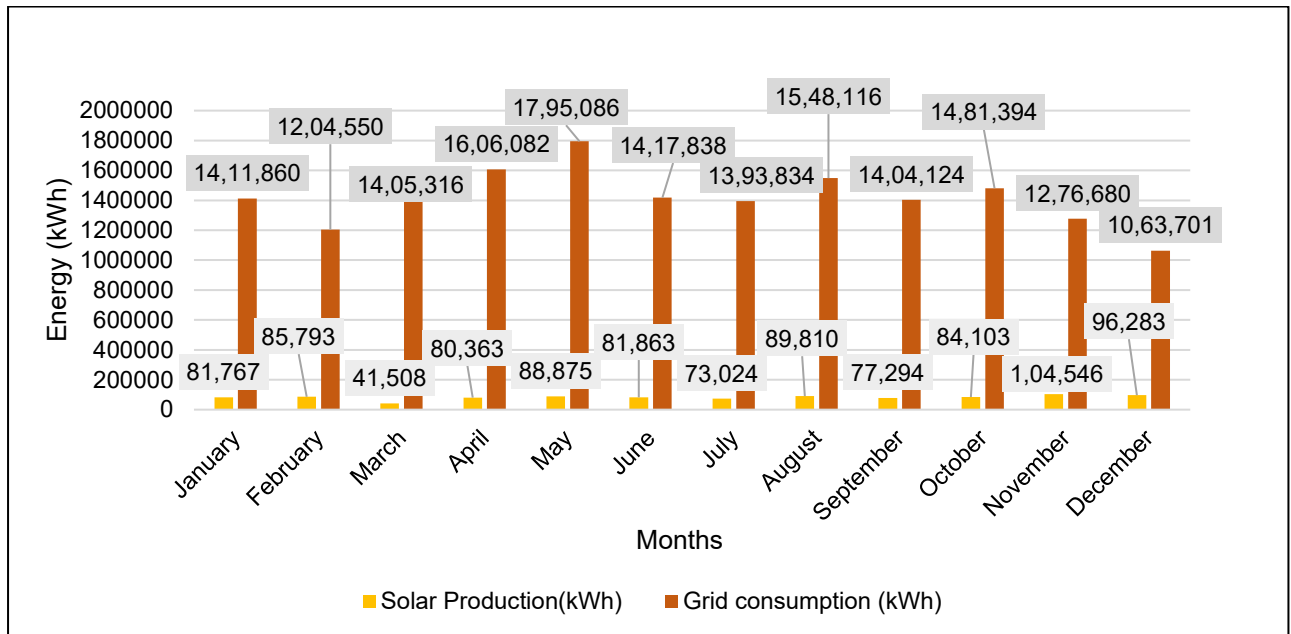


Figure 8 Solar Vs Grid Monthly Energy Comparison for 2024

The data shows a high dependence on grid electricity, as solar production is significantly lower than grid consumption throughout the year. Seasonal variations indicate slightly higher solar generation in summer but still insufficient to meet total energy demands.

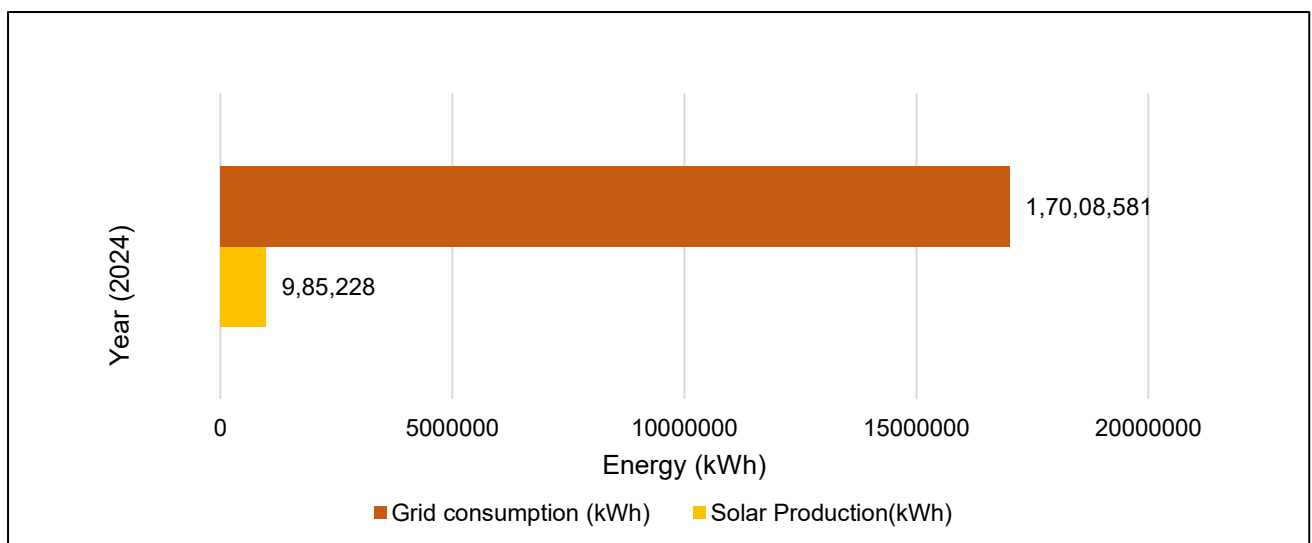


Figure 9 Solar Vs Grid Annual Energy Comparison

The data shows a heavy reliance on grid electricity, with 17,008,581 kWh consumed compared to only 985,228 kWh from solar, meaning solar contributes just 16.26% of total energy usage.

Cost Analysis and Financial Impact

The total energy expenditure for the 2022-23 financial year amounted to ₹165.93 million, representing a significant portion of the university's operational costs. The increase in energy expenses is driven by rising electricity tariffs and higher demand.

3.5.1 Tariff Revisions and Cost Escalation

- Fixed charges increased from ₹390/kVA to ₹475/kVA, impacting the base cost of electricity.
- Energy charges were raised from ₹7/ kVAh to ₹8/ kVAh, contributing to a higher overall electricity bill.
- As a result, the total cost increased by 23.36%, outpacing the rate of consumption growth, highlighting the financial strain caused by tariff hikes.

Rising energy costs highlight the need for sustainable solutions like demand-side management, renewable integration, and efficiency upgrades to optimize the university's power system.

4 Implementation of Energy Monitoring & Management System (EMIS)

An Energy Monitoring & Management System (EMIS) was installed in the School of Life Sciences (SLS) building, focusing on rooms with high energy consumption identified during the inventory audit. The system tracks energy usage to compare actual and rated consumption, enabling optimization. The complete Specifications of Energy Loggers are given in Annexure 1.

4.1 EMIS Implementation Strategy

The EMIS was deployed in the SLS building after identifying it as the facility with the highest energy consumption on campus. Rooms with the highest-rated consumption—determined through equipment inventories and surveys—were selected for sensor installation. Energy loggers (Figure 10) were placed to monitor load patterns and equipment performance, using inventory data and stakeholder feedback.

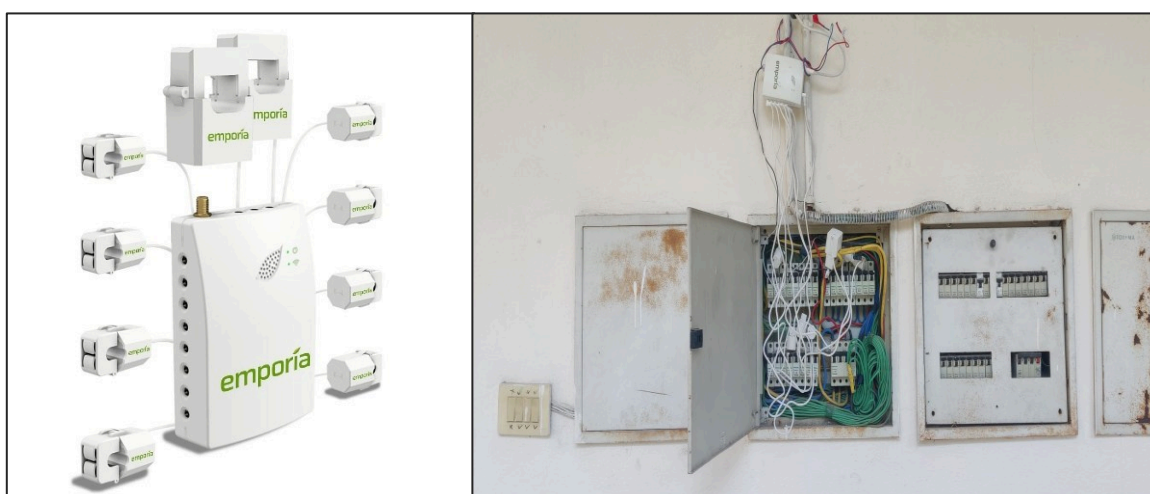


Figure 10: Installed Energy Loggers

A set of three energy loggers are installed in the high consuming buildings of the campus, namely School of Life Sciences (SLS) & Physics. This energy loggers will monitor energy consumption patterns of the selected rooms in the buildings 24/7.

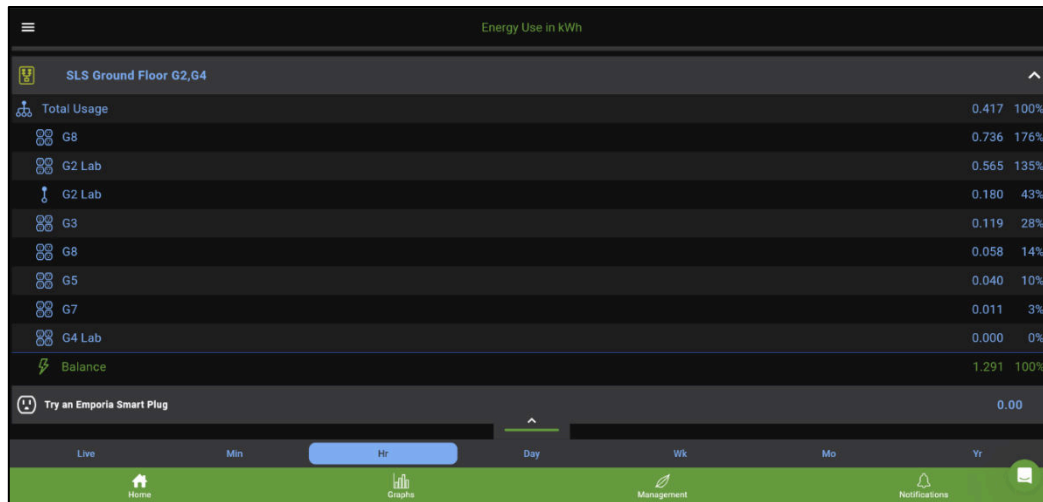


Figure 11 Interface of the Dashboard of Emporia Energy Logger

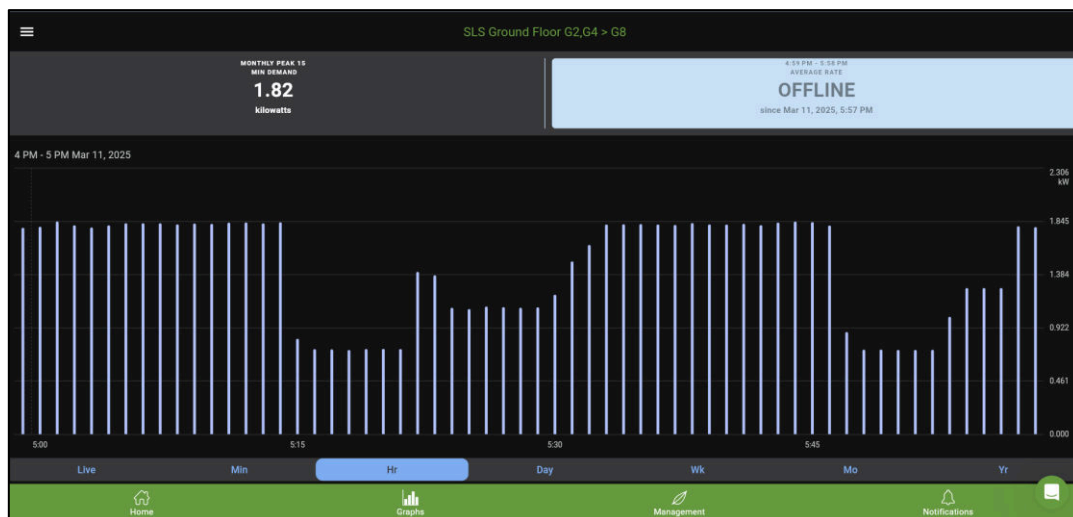


Figure 12 Hourly Graph Generated by Energy Logger

4.2 Real-Time Energy Demand Tracking and Control

The EMIS provides visibility into energy demand across monitored zones, enabling:

- **Load Management:** Identification of peak demand periods and equipment operation.
- **Alerts:** Notifications for abnormal consumption or deviations from benchmarks.
- **Analytics:** Insights to adjust HVAC schedules, lighting controls, and equipment usage.

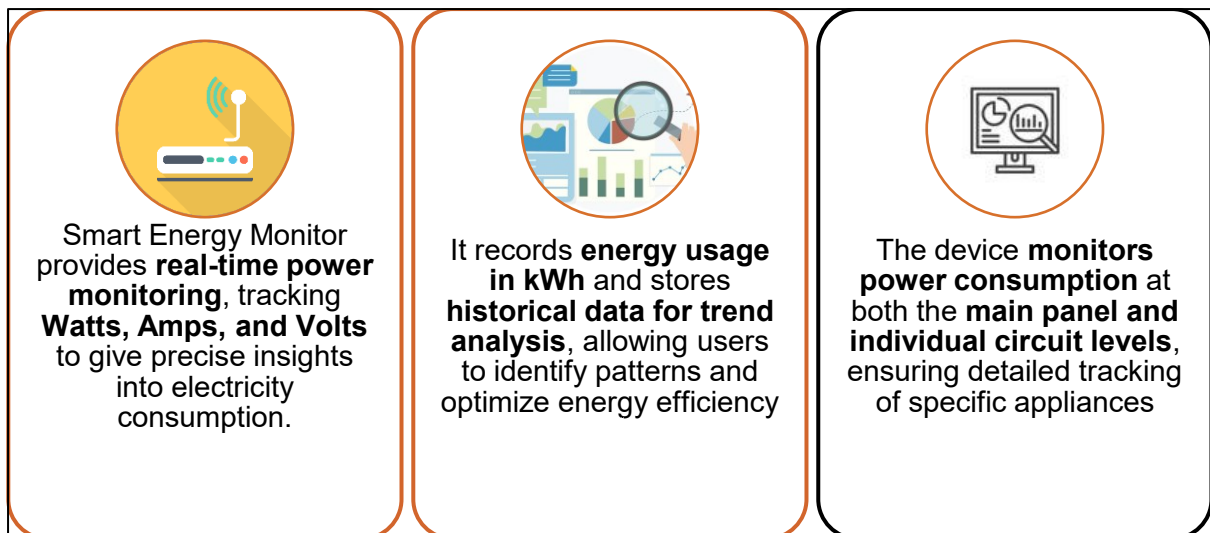


Figure 13 Advantages of EMIS

5 Campus Electrical Network Optimization

The ring main optimization initiative aims to reduce electrical losses and improve the reliability of the university's power distribution network. The proposed optimized ring path forms a closed-loop configuration connecting key substations, with coordinates mapped to minimize power loss and maximize efficiency. The existing electrical network is mapped and given in figure 14.

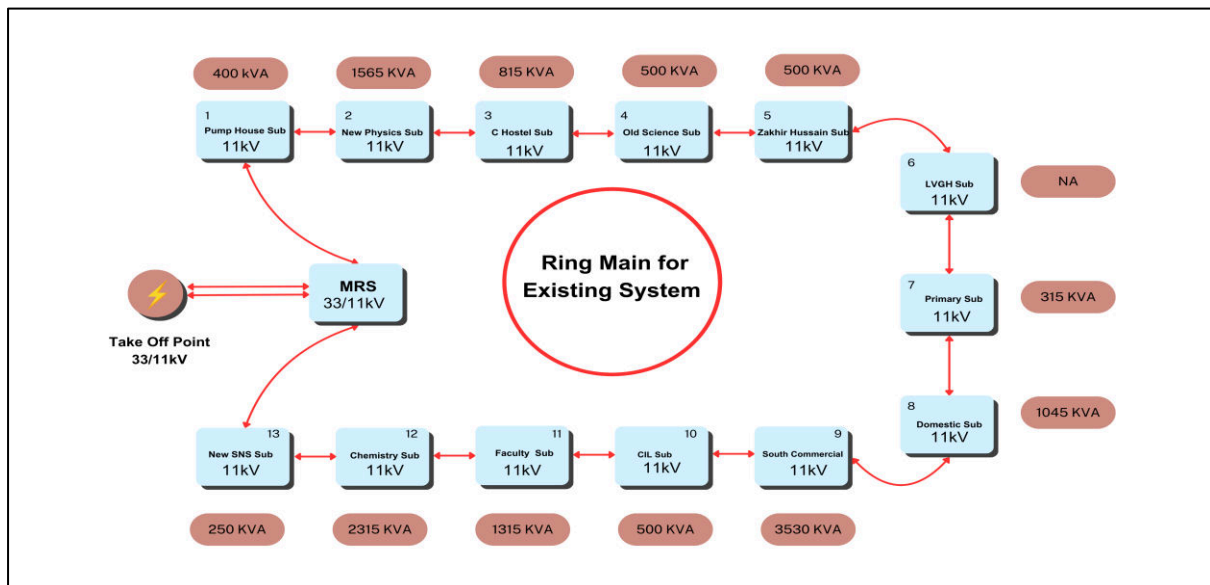


Figure 14 Ring Main for Existing Substations

5.1 Ring Main Proposal and Load Distribution Plan

A ring main system has been proposed to streamline the campus electrical network. The design prioritizes the shortest feasible distribution path, leveraging existing 33kV and 11kV lines to balance load and reduce losses. Key components include:

33kV Main Line: Connects the Take Off Point to the MRS 33/11kV line and critical substations.

11kV Distribution Paths: Supply power to substations (e.g., Domestic, New Physics, CIL, Faculty) to ensure efficient load distribution.

The network is mapped using coordinates defining power line routes, enabling precise analysis of electricity flow and loss reduction opportunities. The proposed ring main systems are shown in Figures 15 and 16, while the remaining ring mains are provided in Annexure 2.

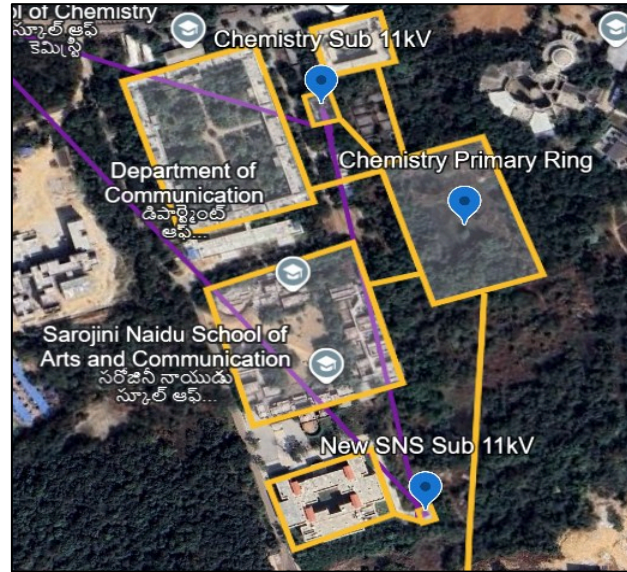


Figure 15 Proposed Ring Main System for Chemistry Substation

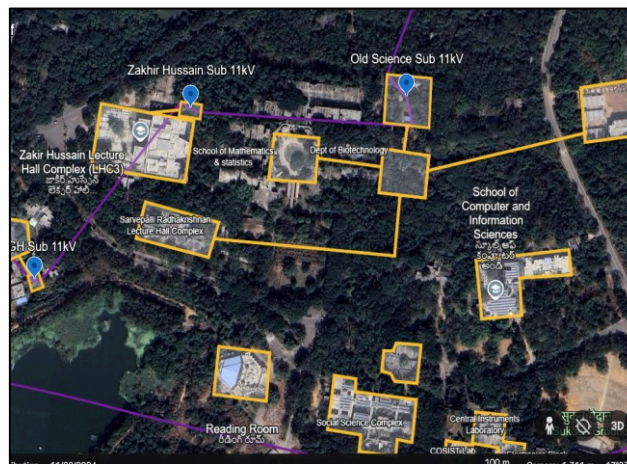


Figure 16 Proposed Ring Main System for Old Science Substation

6 Grid Segmentation into Commercial, Residential, and Domestic Zones

The identified buildings within the university are categorized into commercial, residential, and domestic zones. Commercial buildings, particularly academic and research facilities, likely account for the highest energy consumption due to their operational intensity and occasional 24/7 usage. Residential buildings, such as hostels, show significant energy usage, with seasonal spikes during academic sessions. Domestic buildings have the lowest consumption, attributed to their intermittent or seasonal usage patterns. The Segmented zones are given figures 17, 18 & 19.

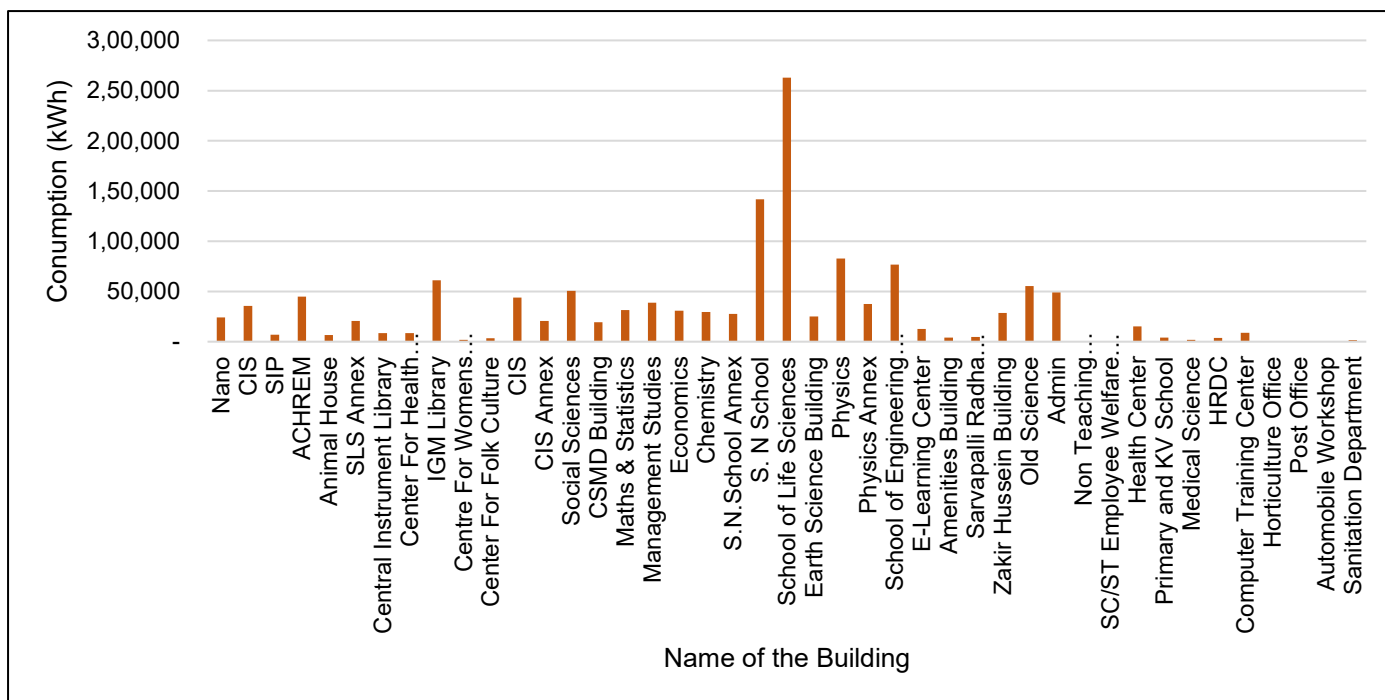


Figure 17 Identified Buildings in Commercial Zone

From the bar chart, Management Studies appears to have the highest electricity consumption (around 150,000 kWh), while Social Sciences is second-highest (around 110,000–120,000 kWh). The difference between these two top consumers is roughly 30,000–40,000 kWh.

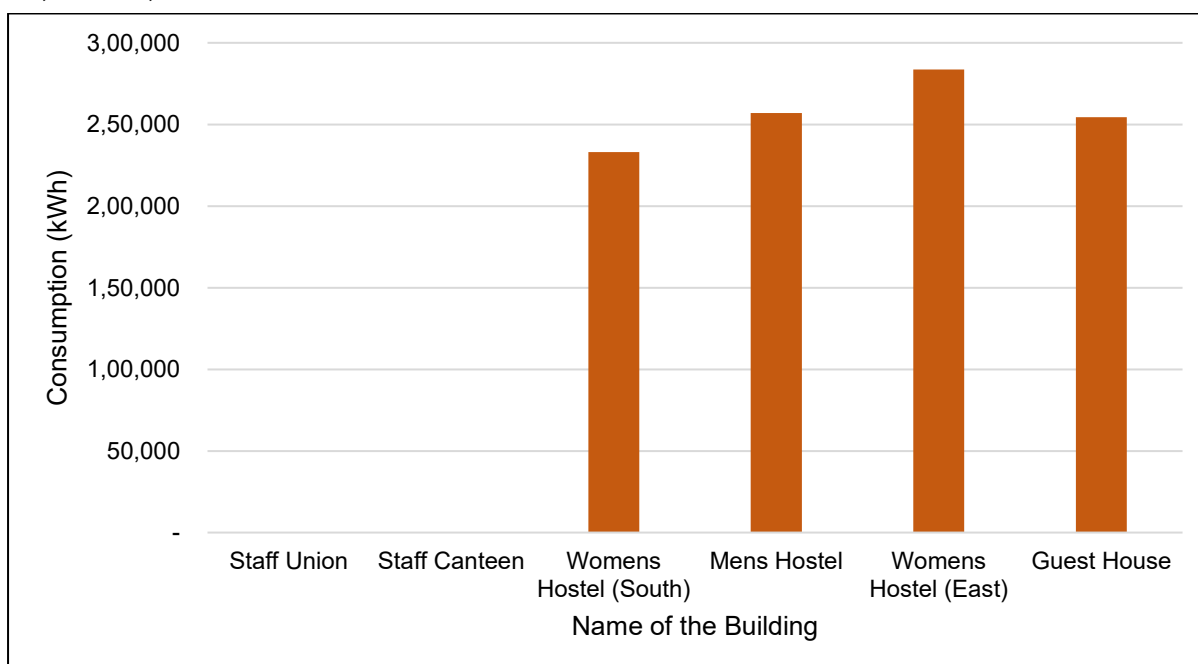


Figure 18 Identified Buildings in Residential Zone

This bar chart shows electricity usage for different campus buildings. The Girls, Boys, and Women's Hostels, along with the Guest House, have the highest consumption, while the separately labelled "Hostel," Staff Union, and Staff Canteen use much less. Factors like occupancy, operating hours, and available services likely influence these differences.

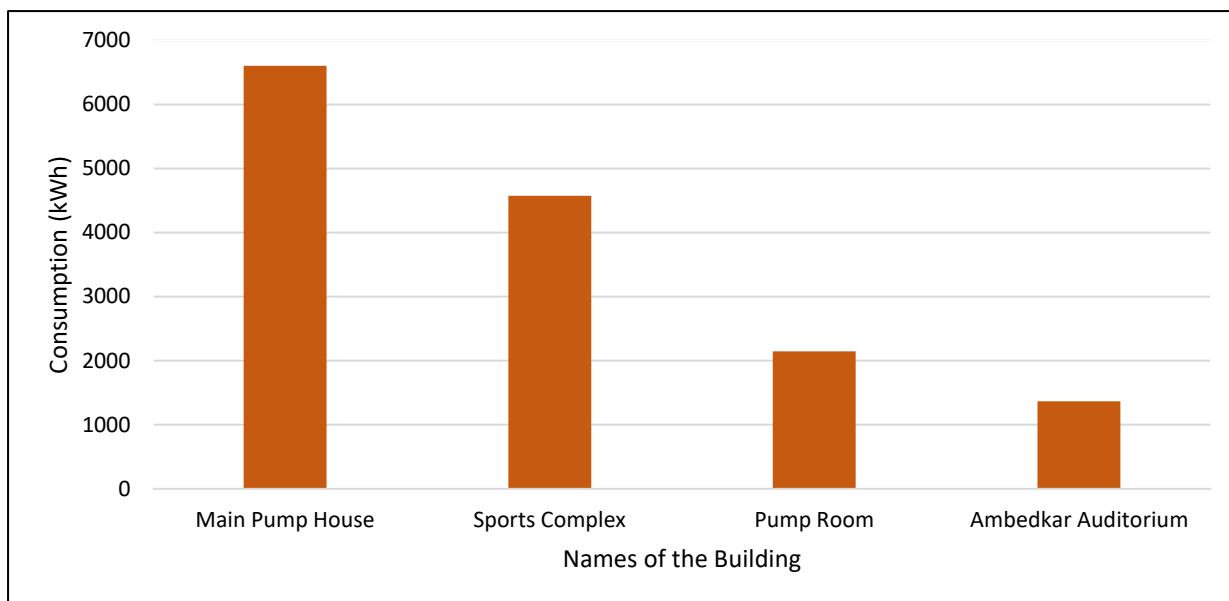


Figure 19 Identified Buildings in Domestic Zone

This bar chart shows electricity consumption for four facilities. The Main Pump House has the highest usage, followed by the Sports Complex. The Pump Room and Ambedkar Auditorium consume notably less energy in comparison.

7 Redundancy & Electrical Failure Analysis

Efficient power distribution is essential for maintaining uninterrupted operations at the university. This section evaluates redundancy-induced stress on electrical systems, identifies failure points, and recommends improvements for reliability and efficiency.

7.1 Identifying Redundancy-Induced Strain and Failure Points

The university's electrical network relies on 34 transformers to manage power distribution across campus buildings. However, the presence of aging transformers and an inefficient redundancy management system has led to:

- Overloading of certain transformers, increasing failure risks.
- Voltage fluctuations and power quality issues, affecting sensitive equipment.
- Higher energy losses due to outdated technology, leading to inefficiencies.
- Increased operational and maintenance costs, impacting long-term sustainability.

The analysis of 8 identified outdated transformers revealed significant strain on the system, contributing to increased downtime risks and energy wastage. These transformers do not comply with IS 1180 & ECBC 2017, making them inefficient and environmentally unsustainable. Table 3 shows the identified transformers that needed to be replaced. Complete list of transformers is given in Annexure 3.

Table 2 List of Transformers Needed to be Replaced

Location	Capacity (kVA)	Year of Installation	Manufacturer
CIL TR-01	500	1978	Indian Transformers Ltd

Old Science Campus -01	500	1986	Hyderabad Power
C, D, E Type Quarter, Primary and KV School	315	1977	Indian Transformers Ltd
Guest House	160	2000	Thana Electric Supply
F-Hostel	100	1994	Thana Electric Supply
CMSD	500	2004	PETE
Shooting Range	315	1977	Kirloskar

Following are the images of existing transformers installed in the university at various locations, given in figure 20, while the remaining transformer images are given in Annexure 3.



Figure 20 CMSD Transformer

7.2 Remedial Measures for System Reliability

To improve the reliability and efficiency of the power distribution system, the following remedial measures are recommended:

Transformer Replacement & Upgrade

- Replace the 8 outdated transformers with BEE 5-star rated transformers, ensuring compliance with IS 1180 and ECBC 2017.

Load Balancing & Smart Redundancy Management

- Implement real-time monitoring systems to distribute loads evenly across transformers.
- Introduce load-sharing mechanisms to prevent overloading of specific units.

Predictive Maintenance & Monitoring

- Deploy IoT-based monitoring solutions for early fault detection and failure prevention.
- Establish a preventive maintenance schedule to extend transformer lifespan.

Backup & Emergency Planning

- Create a redundancy management framework to handle unexpected failures with minimal downtime.
- Maintain backup transformers to prevent disruptions during maintenance or failures.

By replacing outdated transformers, the university can reduce GHG emissions by **5,71,913 kg CO₂e** annually, which is an important step towards efficiency and sustainability, and lead to substantial energy savings of **6,97,455 kWh** annually, which translates to **₹55.8 lakh** in cost savings.

7.3 Electricity Backup System (Inverter) – Existing Status

Reliable backup power is essential for maintaining uninterrupted operations at the university. This section evaluates the current inverter system, its efficiency, and opportunities for improvement to improve reliability and sustainability.

7.3.1 Current Backup Performance

- Total Inverter Capacity: **1,182 kVA**, ensuring extended power backup.
- Annual Backup Energy Supplied: 195,703 kWh during 206.86 hours of power cuts.
- Charging Energy Consumption: 224,059 kWh, resulting in 179.25 metric tons of CO₂ emissions (assuming grid dependency).
- Total Outage Duration: **12,412 minutes per year (207 hours annually)**.

7.3.2 Efficiency Degradation & Cost Implications

Over time, inverter efficiency declines due to aging components and wear. After 10 years, inverter efficiency reduces by 5% (i.e., from 95% to 90% efficiency).

7.3.3 Impact of Upgrading to a 98% Efficient Inverter

- Annual Energy Savings: Reduced consumption with improved efficiency.
- Cost Savings: **₹1.24 lakh per year** in electricity costs.
- CO₂ Emissions Reduction: **14.2 metric tons** annually.

By investing in high-efficiency inverters, the university can significantly reduce energy waste, lower costs, and minimize its carbon footprint while ensuring a more resilient backup power system. Efficiency, energy savings calculations are given in Annexure 4.

7.4 Capacitor Bank Status – Existing Condition

The capacitor bank system is essential for maintaining power factor (PF) correction and voltage stability across the campus. An analysis of the current system reveals inefficiencies due to aging components, lack of Automatic Power Factor Correction (APFC) panels, and degraded capacitor performance in multiple substations. List of capacitors are given in table 6.

7.4.1 Key Findings from Capacitor Bank Analysis

- Several substations including Faculty Substation, SLS-1 Panel, Earth Science, and East Substation lack APFC panels, leading to inefficient power factor management.

- Poor Power Factor at C Hostel Substation, operating at 0.75 PF, requiring urgent correction.
- **Degraded Capacitor Performance:**
 - Old Science Complex-01: 50 kVAr installed, only 0.8 kVAr output.
 - Old Science Complex-03: 80 kVAr installed, only 28 kVAr output.
 - Major concerns observed in Primary Substation, Domestic Substation, SLS-2, and Old Science Complex (01 & 02), where significant output reduction has been recorded.
- Total Replacement Requirement: 24 capacitors need immediate replacement.

Table 4 List of Capacitor Banks

S. No	Location	Total Capacitor (kVAr)	Output (kVAr)	Total no of Capacitors	No of Capacitors to be replaced
1	Primary Substation	60	48.9	6	1
2	Domestic Substation	60	3	6	6
3	SLS-1	60	37.6	-	-
4	SLS-2	60	39.8	6	3
5	SLS-3	60	51.3	9	3
6	Pump House	30	19.5	6	-
7	Zakir Husain	100	95	4	-
8	Old Science Complex-01	50	0.8	5	5
9	Old Science Complex-02	100	74.2	6	2
10	Old Science Complex-03	80	28	8	4
11	Chemistry Capacitor-01	75	0	-	-
12	Chemistry Capacitor-02	75	0	6	-
13	Chemistry Capacitor-03	65	57.1	-	-
14	CIL	40	26.4	3	-
Total		915	478.6		24

7.4.2 Recommendations for Performance Improvement

Following are the recommended actions to improve performance of capacitors,

7.4.2.1 Immediate Replacement of 24 Capacitors

- Priority replacements in Primary Substation, Domestic Substation, SLS-2, and Old Science Complex to restore efficiency and stabilize power factor performance.

7.4.2.2 Upgrade of Substations Without APFC Panels

- Install APFC panels in Faculty Substation, SLS-1, Earth Science, and East Substation to automate power factor correction and improve overall efficiency.
- Optimize C Hostel Substation PF (0.75) to reduce energy losses and improve voltage stability.

7.4.2.3 Maintenance & Fault Diagnosis

- Low output readings in Old Science Complex-01 & 03 suggest aging capacitors or wiring faults.

- Thorough inspections, rewiring, or capacitor replacements to restore optimal performance.

7.4.2.4 Consideration of Harmonic Filtering Systems

- Harmonic distortion reduces capacitor efficiency and lifespan.
- Installing harmonic filters will stabilize voltage levels and improve the overall performance of the capacitor bank.

By implementing these corrective measures, the university can improve power factor correction, reduce energy losses, and improve electrical system reliability across the campus.

8 Energy Demand Centre Identification

Understanding how energy is distributed across the campus is crucial for optimizing efficiency. This section identifies high-consumption zones, analyses loss patterns, and suggests targeted interventions for improved resource allocation. The following heatmap (Figure 21) presents the ten buildings with the highest energy consumption based on actual meter data.

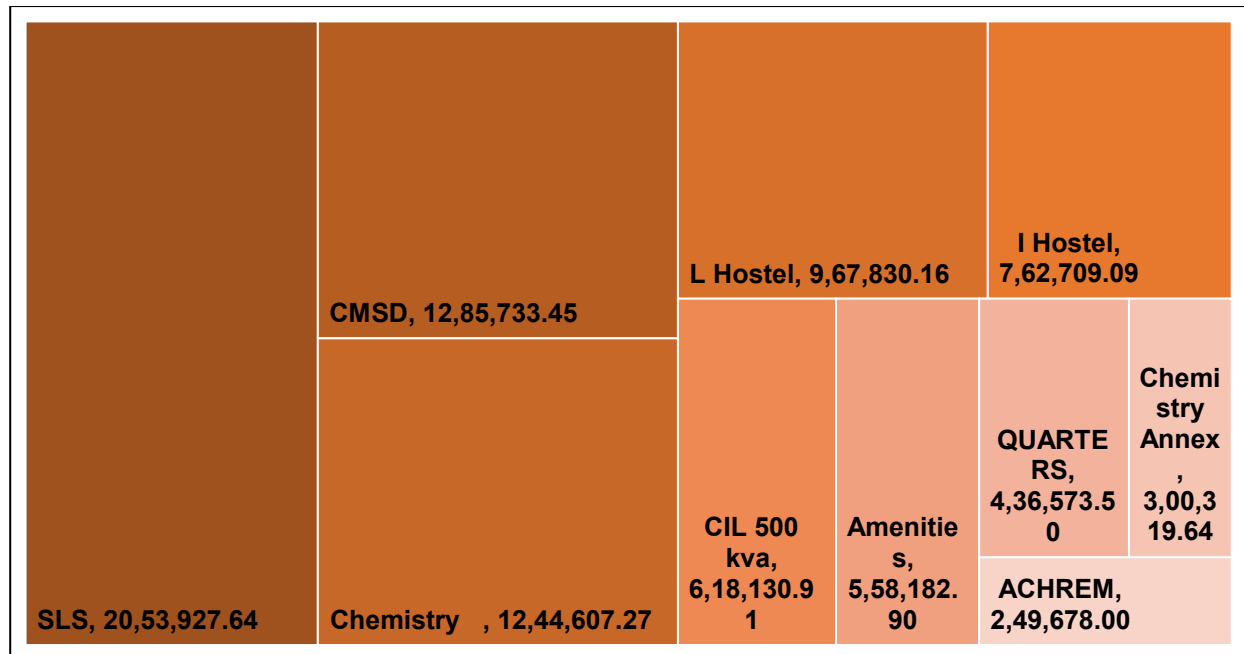


Figure 21 Heatmap of the Top Ten Buildings by Energy Consumption (Meter Data).

8.1 High-Consumption Zones and Loss Analysis

At the University of Hyderabad (HCU), energy demand varies based on building type, function, and operational hours.

- The East Zone has the highest consumption due to dense academic and research buildings, is given as chart in figure 22.
- The North Zone follows with laboratories, administrative offices, and faculty accommodations, graphical representation of north zone is given in figure 23.
- The South Zone sees moderate demand from hostels, commercial spaces, and research centres, graphical representation of north zone is given in figure 24.
- The West Zone has the lowest consumption, primarily from residential and support facilities, graphical representation of north zone is given in figure 25.

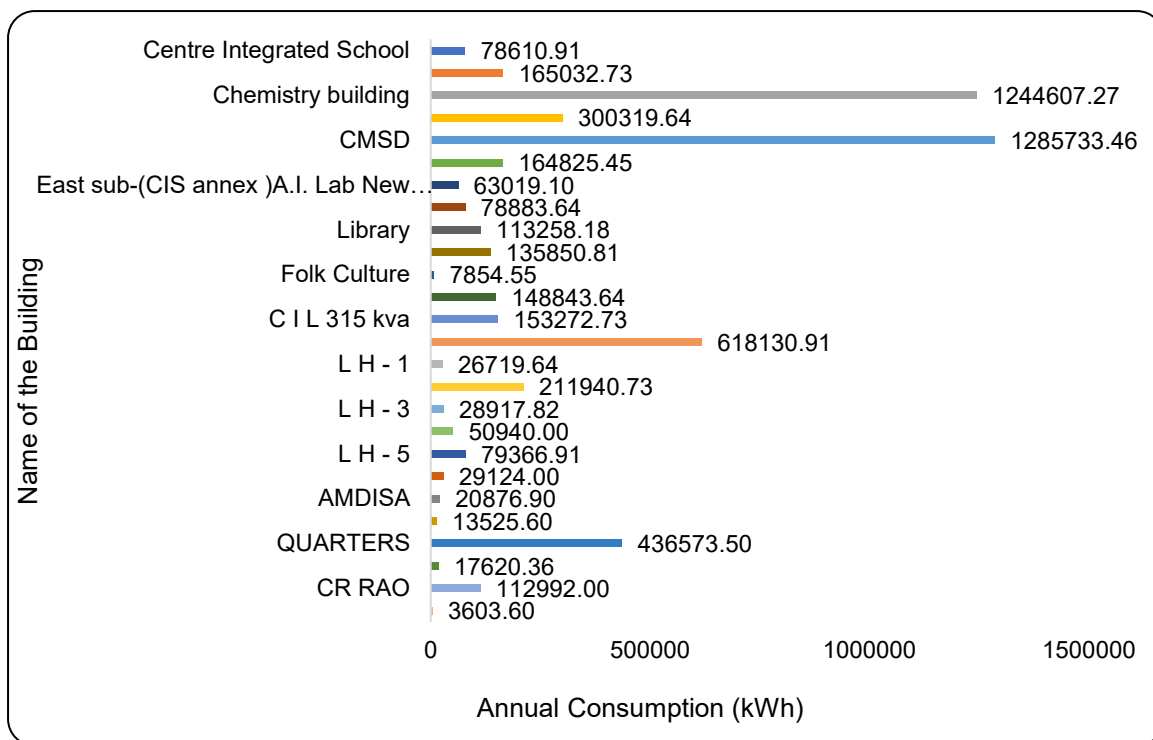


Figure 22 Annual Consumption of East Zone

The above given horizontal bar chart shows the annual consumption at the east zone where CMSD building has the highest annual energy consumption at 1,285,733.46 kWh, followed closely by the Chemistry building at 1,244,607.27 kWh. The CIL 315 kVA facility and Quarters also show significant consumption levels of 618,130.91 kWh and 436,573.50 kWh, respectively. Other buildings, such as the Library and A.I. Lab, have moderate consumption, while Folk Culture records the lowest usage.

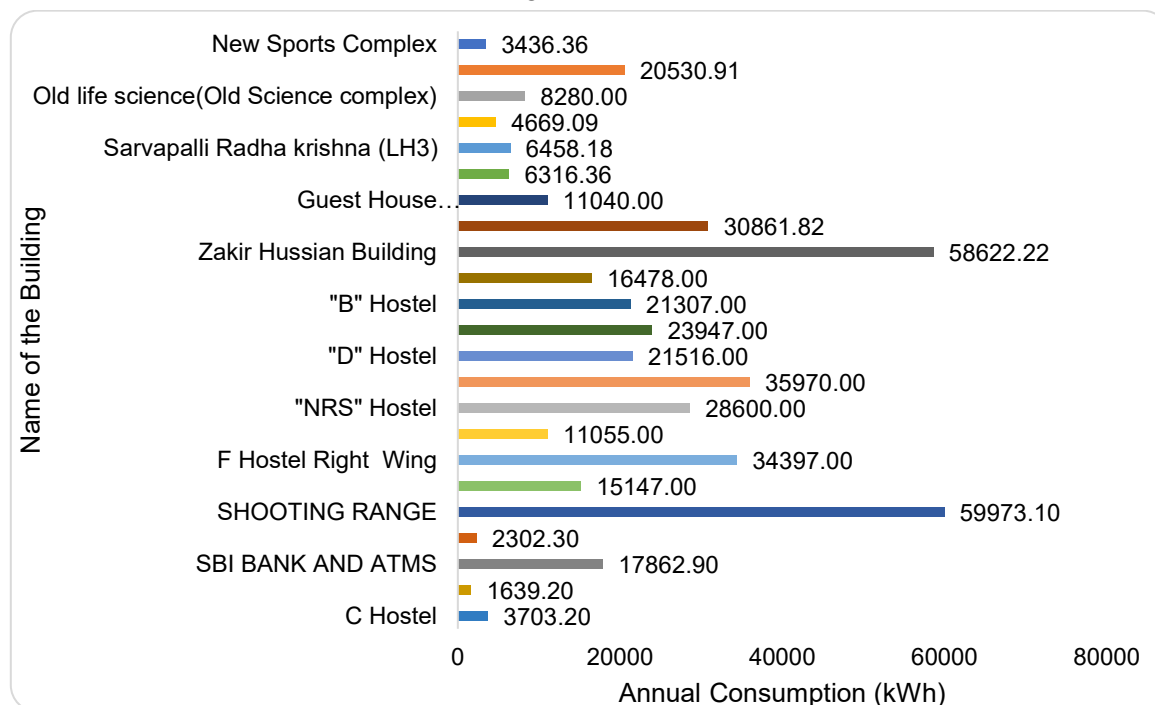


Figure 23 Annual Consumption of North Zone

Figure 25 horizontal bar chart shows the annual consumption of the North zone in which the Shooting Range records the highest annual energy consumption at 59,973.10 kWh, followed

by the Zakir Hussain Building at 58,622.22 kWh. Among the hostels, "C" Hostel has the highest consumption at 23,947.00 kWh, with others such as "D" and "H" Hostels also showing significant usage. Facilities like the SBI Bank and Medical Science consume moderate amounts, whereas buildings like the Post Office and Tomato Genomics have minimal energy use.

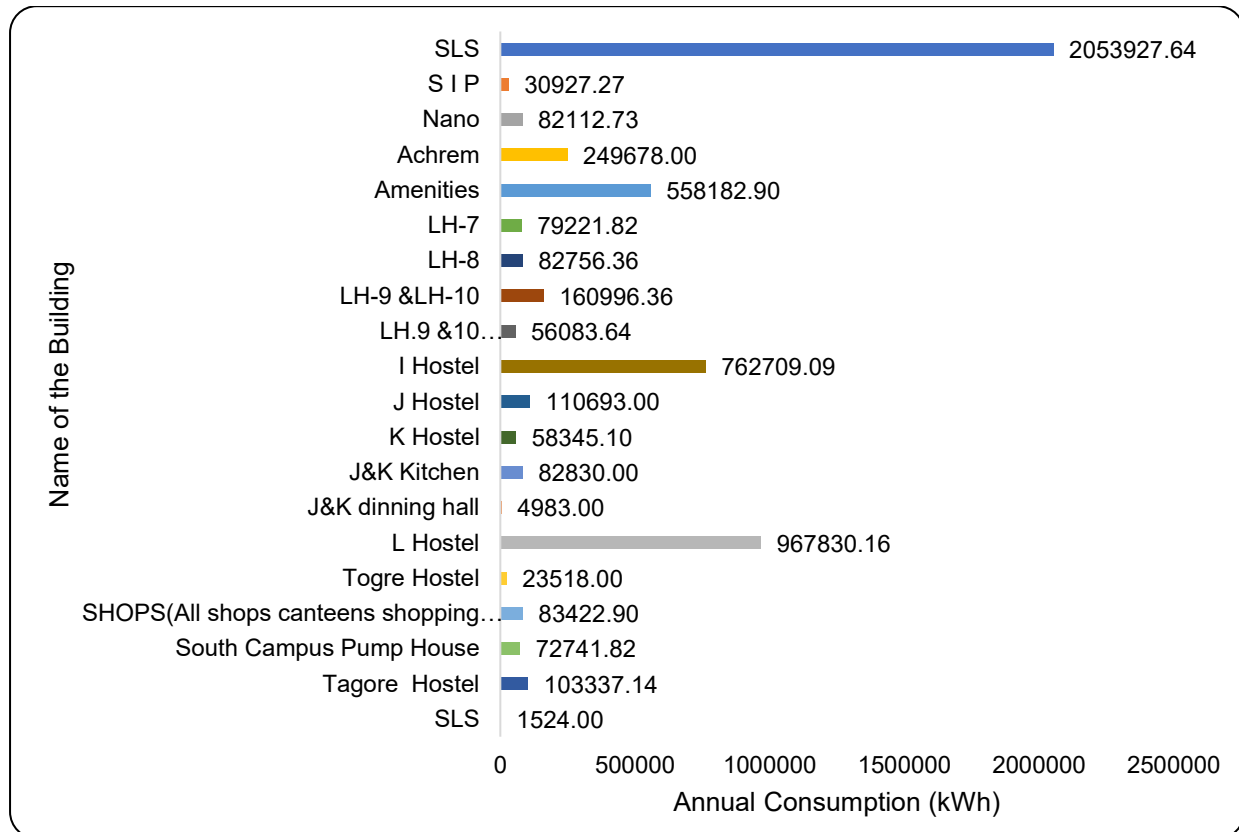


Figure 24 Annual Consumption of South Zone

The above given graph shows the annual consumption of South zone where SLS building exhibits the highest annual energy consumption in the South Zone at 2,053,927.64 kWh, significantly surpassing other buildings. L Hostel and I Hostel also show high energy usage at 967,830.16 kWh and 762,709.09 kWh, respectively, indicating substantial residential demand. Amenities and ACHREM consume 558,182.90 kWh and 249,678.00 kWh, suggesting major operational energy needs. In contrast, smaller facilities such as the J&K Dining Hall (4,983.00 kWh) and SLS (1,524.00 kWh) demonstrate minimal energy consumption.

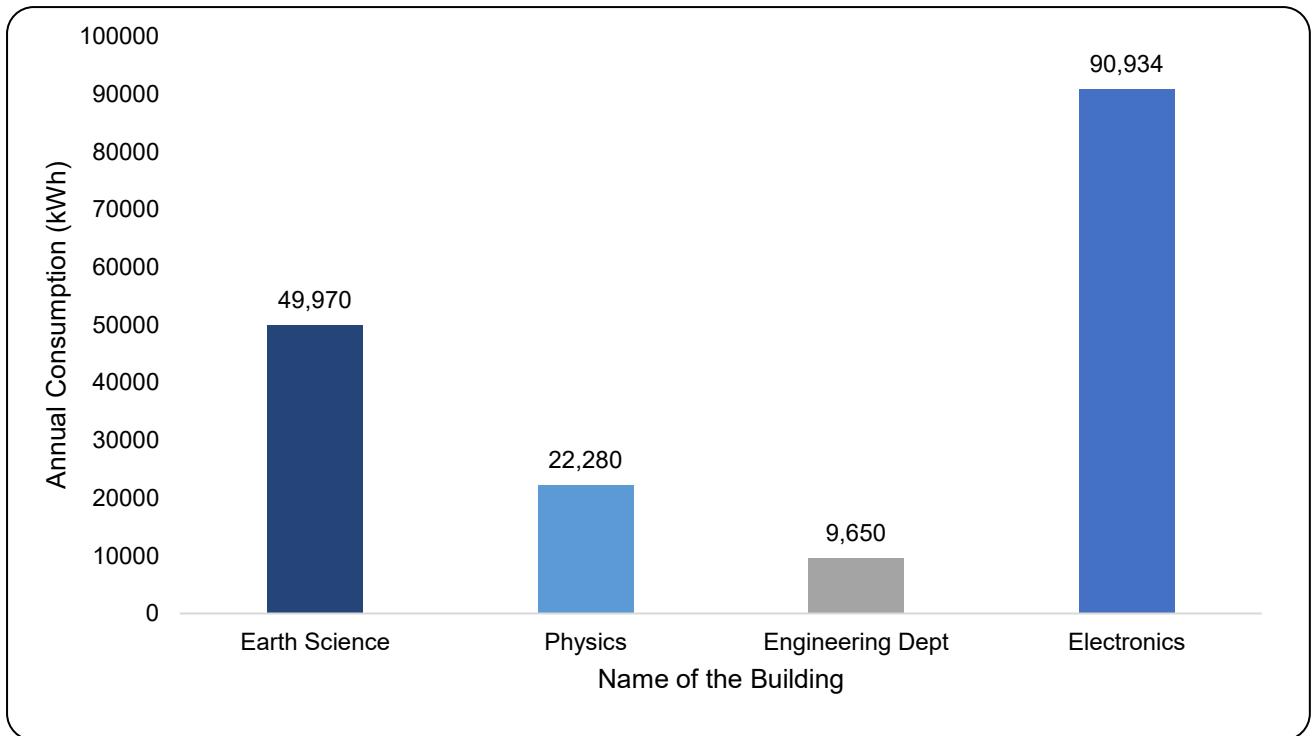


Figure 25 Annual Consumption of West Zone

This horizontal bar graph shows that annual consumption of west zone where Electronics building exhibits the highest annual energy consumption at 90,933.82 kWh, nearly double that of the Earth Science building, which consumes 49,970 kWh. The Physics building follows with 22,280 kWh, while the Engineering Department has the lowest usage at 9,650 kWh. This variation suggests differences in energy-intensive equipment, laboratory operations, or occupancy levels

8.2 Resource Allocation Based on Criticality and User Type

To streamline energy distribution, buildings are categorized based on their usage:

- 24/7 Operational Buildings: Research labs, medical centres.
- Intermittent Use Buildings: Classrooms, auditoriums.
- Seasonal Facilities: Hostels, staff quarters.

8.3 Demand Factor Analysis

- Academic Buildings: 60-90%, with peak loads during working hours.
- Student Hostels: 60-80%, with spikes in the morning and evening.
- Administrative Blocks: 50-70%, depending on office hours and IT usage.
- Commercial Units: 40-60%, with intermittent demand.

Categorization of the Buildings

Academic Buildings: 28 buildings, with most having Intermittent usage, except for Chemistry, Physics, and their annexes, which are 24/7.

Hostels: 5 buildings covering all the sector of hostels, all with Seasonal usage, indicating they are primarily used during post academic sessions.

Research Facilities: 5 buildings, with a mix of 24/7 (e.g., Green House, Animal House) and Seasonal usage (e.g., Central Instrument Library).

Infrastructure and Maintenance: 8 buildings, mostly Seasonal, except for Pump Room, which has a unique usage profile (24/7).

Residential Quarters: 4 buildings, all Seasonal, suggesting they are used during specific times (according to occupancy).

Figure 26 Categorization of Buildings

9 Renewable Energy Integration

To improve sustainability and energy efficiency, the University of Hyderabad (HCU) is actively exploring renewable energy solutions. By integrating solar, biomass, and rooftop solar geyser systems, the university aims to reduce dependence on conventional power sources, lower operational costs, and minimize its environmental footprint. Currently, the campus has an installed solar capacity of 1.05 MWp, with the potential to generate an additional 1.7 MWp.

This section assesses the feasibility of various renewable technologies, including solar water heating systems with heat pump backup, to ensure a stable and sustainable energy supply for the campus.

9.1 Solar Power, Biomass, and Rooftop Solar Geyser Systems

The university has been utilizing solar water heating systems and electric geysers across its 23 men's and women's hostels. However, the existing solar heating units show signs of degradation, with many panels damaged, non-functional, or inefficient, leading to higher energy consumption and maintenance costs. Given these challenges, upgrading the system with advanced solar water heating and heat pump technology is recommended to improve energy efficiency and system reliability.

9.2 Alignment with Government Schemes (e.g., PM-KUSUM, SECI)

The proposed renewable energy upgrades align with government initiatives such as PM-KUSUM and SECI, which promote solar energy adoption and sustainable energy practices in institutions. These schemes offer financial support and incentives, making it feasible for the university to implement cost-effective renewable solutions while reducing dependency on grid electricity.

9.3 Existing Condition of Water Heating System at HCU

The university's Domestic Hot Water System consists of electric geysers and solar water heaters installed in 23 hostels. However, a significant portion of the existing solar water heating units is damaged or operating inefficiently, affecting their overall performance. This results in higher electricity consumption, increased operational costs, and inconsistent hot water availability. Upgrading to a more efficient system is necessary to improve reliability

and energy savings. Existing conditions of water heating systems in hostels is given in figure 29.



Figure 27 Existing Conditions of Water Heating Systems in Hostels

9.4 Solar Water Heater with Heat Pump System

A Solar Water Heater (SWH) with a Heat Pump Backup is an energy-efficient and sustainable alternative to traditional electric geysers. This system leverages solar thermal energy as the primary heating source and uses a heat pump as a backup to ensure a continuous hot water supply, even during low sunlight conditions. A schematic representation of solar water heater with heat pump is given in Figure 30, while the energy savings calculations are given in annexure 5.

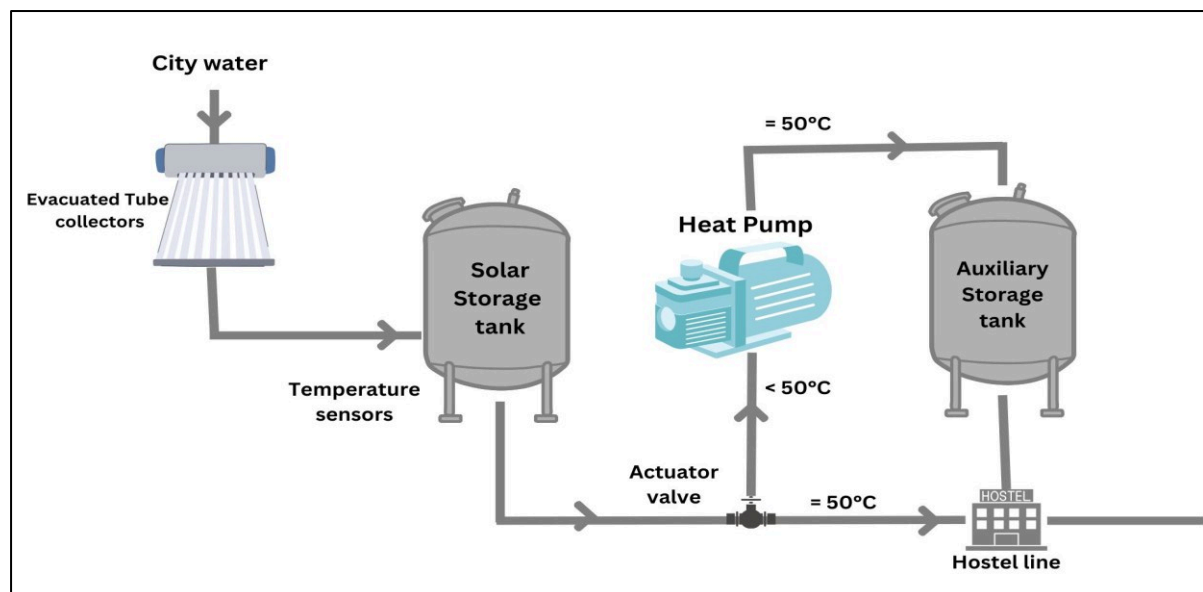


Figure 28 Schematic Representation of Solar Water Heater with Heat Pump

9.5 System Design & Working Principle

This section explores the design and functioning of an integrated water heating and distribution system, incorporating multiple energy-efficient technologies for optimal performance.

9.5.1 City Water Supply & Solar Heating

- Cold water enters the system and is first heated using Evacuated Tube Collectors (ETC), which efficiently absorb solar energy.

- The heated water is stored in a Solar Storage Tank equipped with temperature sensors to monitor and regulate water temperature.

9.5.2 Heat Pump Backup Mechanism

- When the solar-heated water temperature falls below 50°C, the system activates the heat pump to further heat the water.
- An actuator valve directs water through the heat pump only when necessary, optimizing energy consumption and ensuring efficiency.

9.5.3 Auxiliary Storage & Distribution

- Once heated to the desired temperature, the water is transferred to an Auxiliary Storage Tank before being distributed to the hostels.
- This setup ensures a steady and reliable supply of hot water while minimizing electricity use for heating.

*

10 Substation Design and Relocation Plan

A detailed analysis of the 34 existing transformers and 13 substations has been conducted to evaluate geographical proximity and load distribution. The objective is to:

- Optimize transformer utilization
- Reduce redundant infrastructure
- Streamline operations by consolidating substations where feasible

By clubbing substations, maintenance costs can be reduced, load distribution can be balanced, and power reliability can be improved. Redundant substations can be repurposed as dummy or sub-stations to maintain operational flexibility.

10.1 Identified Substations for Clubbing

Substations identified for consolidation based on proximity is given in table 5,

Table 5 List of Identified Substations for Clubbing

Substation	Distance Apart	Total Loading of TR's	Reduced Capacity
F Hostel (100 kVA) & Guest House (160 kVA) to Primary Substation (315 kVA)	480m	Total loading of the corresponding TR's • 100kVA-12.5% • 160kVA-22.75% • 315kVA-19.17%	260 kVA
Zakir Hussain (500 kVA) to Old Science Substation (500 kVA)	360m	Both buildings has a total loading of 38% from two 500kVA TR's	500 kVA

Hostel C (500 kVA) to Shooting Range Substation (315 kVA)	480m	These have 24.34% loading out of 500 & 315 kVA Transformer capacity.	315 kVA
Chemistry (1250 kVA) to New SNS Substation (315 kVA)	320m	The 315 kVA TR at New SNS has a loading of 7 %	815 kVA
North Main Pump House (400 kVA) to New Physics Substation (3130 kVA)	451m	The whole substation has a total loading of 23.55%	NA

Substations identified for clubbing based on proximity is given as images in figure 29.

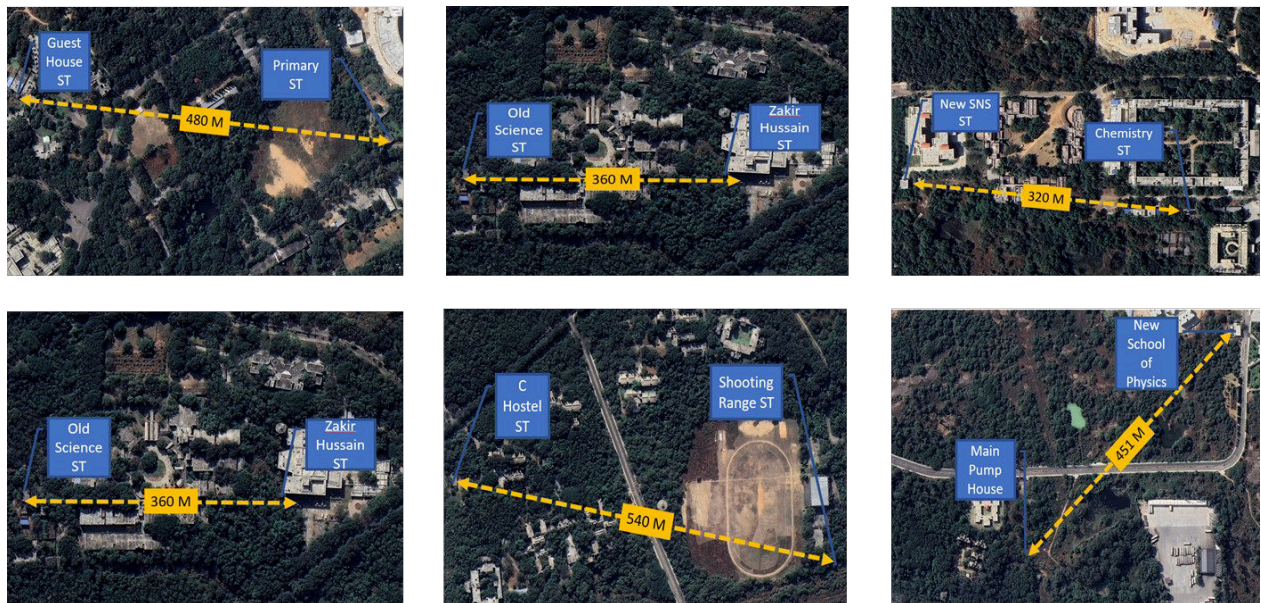


Figure 29 Estimated Distance Between to Be Clubbed Substations

10.1.1 Expected Outcomes of Substation Clubbing

- Reduction in infrastructure redundancy
- Improved load distribution
- Minimization of power losses and voltage drops
- Streamlined maintenance and monitoring

10.1.2 Transformer Load Analysis

A review of total transformer capacity (kVA) across substations indicates variations in load distribution.

- South Commercial Substation & New Physics Substation handle the highest transformer loads.
- Several other substations operate below capacity, indicating potential for consolidation. Shown in figure 30.

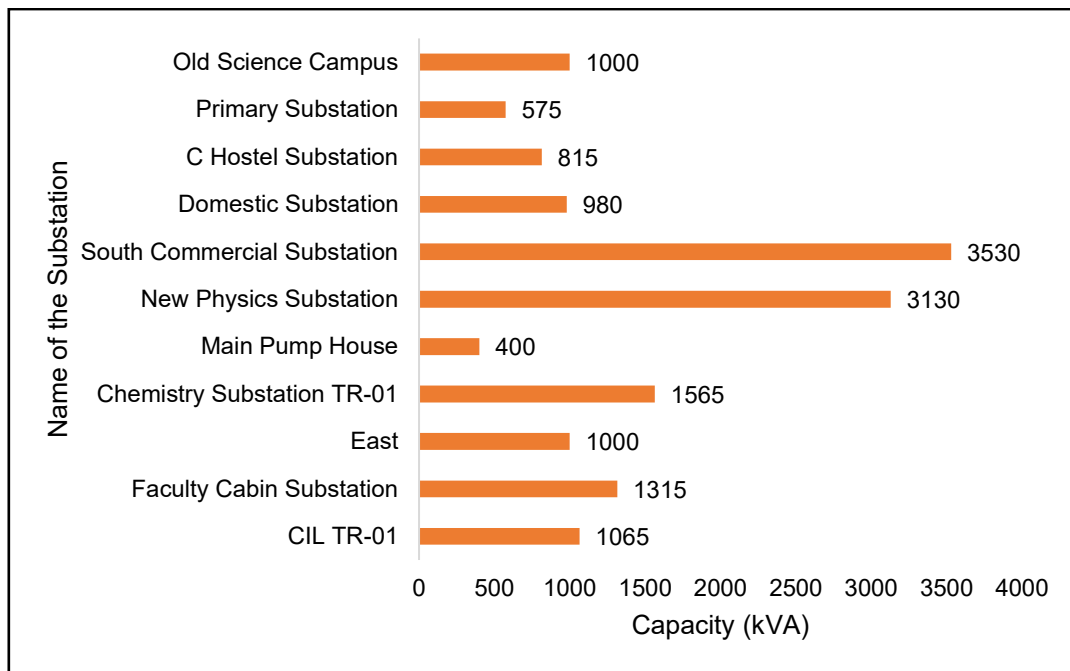


Figure 30 Total Transformer Capacity at Each Substation

10.1.3 Reallocating transformer loads

Reallocating transformer loads will,

- Optimize power distribution
- Balance loads to prevent overloading
- Minimize power delays.

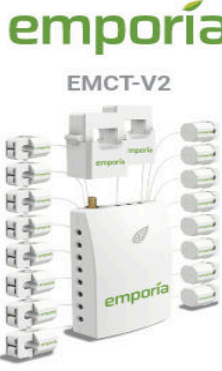
11 Conclusion

The Hyderabad University campus has the potential to become a model for sustainable and energy-efficient infrastructure by implementing the proposed interventions. The current challenges related to high energy consumption, inefficient mobility, unmonitored power usage, and inadequate stormwater management can be effectively addressed through strategic upgrades.

In the short term, initiatives such as solar-based induction cooking, cool roofs, cycle-sharing programs, electric buses, and transformer replacements will provide immediate savings and operational efficiency. Simultaneously, long-term measures, including HVAC optimization, diesel generator replacement with solar-battery systems, power factor improvement through capacitor banks, and stormwater management improvements, will contribute to a resilient and eco-friendly campus.

By integrating smart metering, energy monitoring, and renewable energy solutions, the campus can significantly reduce its carbon footprint, lower operational costs, and improve sustainability. These combined efforts will not only help achieve energy efficiency and cost savings but also align with national and global sustainability goals, making the university a leader in green campus initiatives.

I. Annexure: EMIS - Energy Management Information System



emporia VUE: GEN 2

Smart Home Energy Monitor
for installation in circuit panels

EMCT-V2



Description

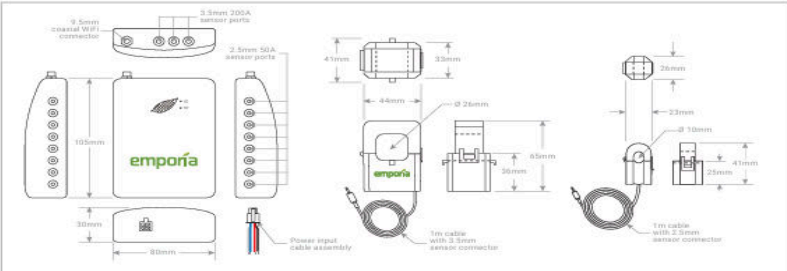
The Emporia Vue Smart Home Energy Monitor installs in the circuit panel of most homes to provide energy monitoring 24/7 of the whole home and can be bundled with 8 or 16 sensors to monitor individual appliances. The Vue connects to your home WiFi network and reports to an app on your phone to help you prevent costly repairs, make your home more energy efficient, and save you money.

Features

- 24/7 real power monitoring
- Real-time data
- Individual circuit monitoring
- Electrician install recommended
- Savings recommendations
- Granular 1 second data
- Connects to cloud over WiFi
- Saves money
- Conserves energy
- Reduces carbon

Specifications

WiFi	2.4 GHz 802.11b/g/n
CT Sensors	2 200A (0.333V) induction sensors (3-phase optional) 0/8/16 50A (0.333V) induction sensors
Power Adapter	100-240VAC 50-60Hz
Power Usage	< 3W
FCC ID	2AS6P-EMPCTV2



Technical drawings showing the dimensions of the EMCT-V2 unit and the CT sensors. The unit is 100mm high and 80mm wide. The CT sensors are 45mm high and 35mm wide. The power input cable assembly is 30mm high and 80mm wide. The 1m cable with 3.5mm sensor connector is 45mm high and 35mm wide. The 1m cable with 2.5mm sensor connector is 45mm high and 35mm wide.

emporia

7901 Shaffer Pkwy
Littleton, CO 80127
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info@emporiaenergy.com
844-EMPORIA (367-6742)







Figure 31 Specifications of Emporia Energy Loggers

II. Annexure: Ring Main Proposal

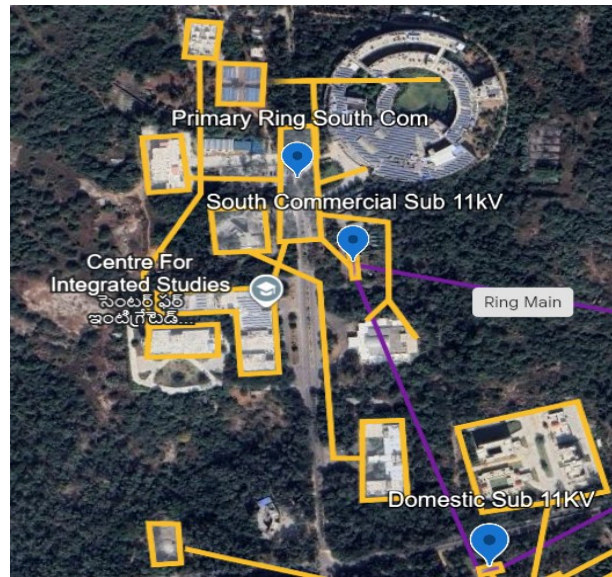


Figure 32 Proposed Ring for South Com Substation(11kV)



Figure 33 Proposed Ring New Physics Substation(11kV)

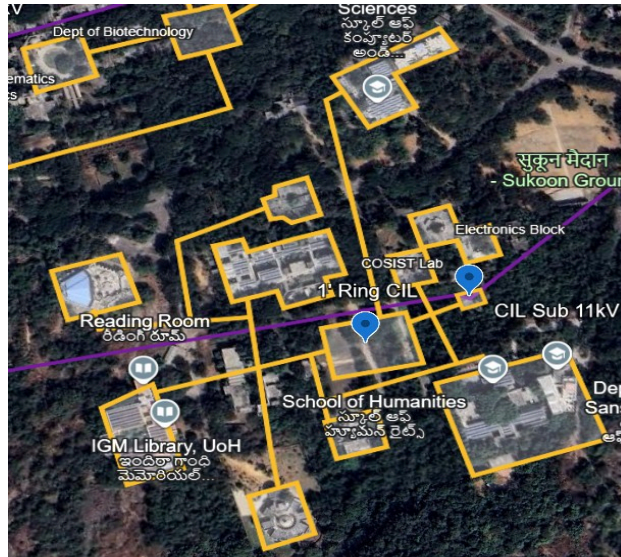


Figure 34 Proposed Ring CIL Substation(11kV)

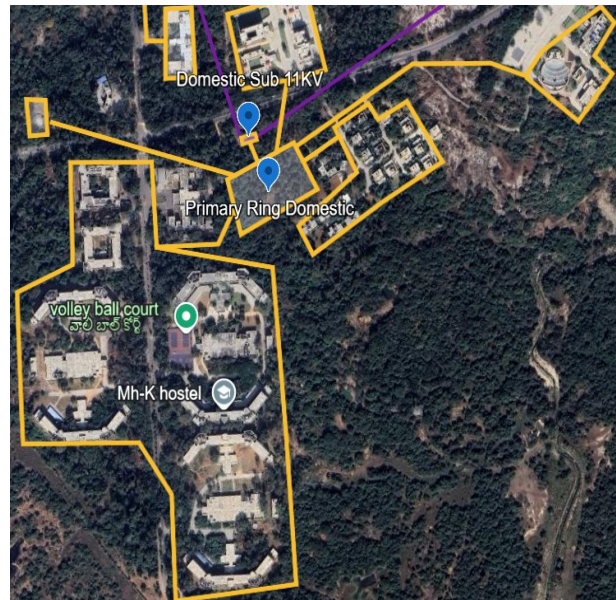


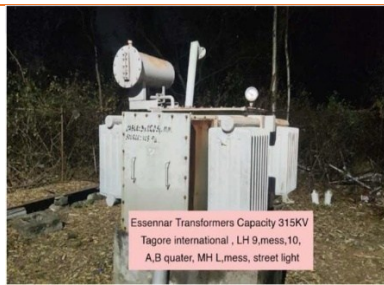
Figure 35 Proposed Ring Domestic Substation(11kV)

III. Annexure: List of Transformers & Images

Table 6 Complete List of Transformers

S.No	Transformer	TR Capacity (kVA)	MFG	Photos
1	Primary	315	1977	
2	Old Science Campus	500	1986	
3	F-Hostel	100	1994	
4	Guest House	160	2000	
5	CIL	500	1978	

6	CMSD	500	2004	
7	South Pump House	100	1976	
8	Shooting Range	315	1977	
9	ACHREM/SIP/CIS	500	2007	
10	Nano Clean Room	500	2007	
11	Nano Building	400	2007	

12	SLS G, 2nd Floor	1000	2012	
13	SLS 1st Floor, Bionest, Green House	500	2007	
14	Animal House, SLS Annex	630	2023	
15	Domestic TR1	315	2007	
16	Domestic TR2	315	2012	
17	Faculty TR1	500	NA	

18	LH TR	315	NA	
19	Chemistry TR1	500	2007	
20	Chemistry TR2	500	2015	
21	SNS	250	2007	
22	New SNS	315	2022	

23	Physics TR 1	1250	2022	
24	Physics TR 2	1250	2022	
25	Earth Science TR 1	315	2022	
26	Earth Science TR 2	315	2022	

27	East TR 1	500	NA	
28	East TR 2	500	NA	
29	C Hostel	500	NA	
30	Zakhir Hussain	500	NA	

31	Students Aminities	250	2020	
32	Main Pump House	400	NA	
33	AI Lab	250	NA	
34	CIL	315	NA	

IV. Annexure: Calculations of Inverters

Calculations for Inverter Performance

Outage Duration Calculation:

- Inverter capacity = 1182 kVA
- Total outage duration = 12,411 minutes

Calculation:

Convert minutes to hours: $12,411 \text{ minutes} / 60 \approx 207 \text{ hours per year}$

Energy consumed for charging = $1182 \text{ kW} \times 206.86 \text{ hours} \approx 244,059 \text{ kWh}$

Inverter Charging Energy and CO₂ Emissions:

Energy consumed for charging = 224,059 kWh

Calculation:

Using an emission factor of approximately 0.8 kg CO₂ per kWh:

- CO₂ Emissions (kg) = $224,059 \text{ kWh} \times 0.8 \text{ kg/kWh} \approx 179,247 \text{ kg CO}_2$
- Converting kg to tons: $179,247 \text{ kg} / 1000 \approx 179.25 \text{ tons CO}_2$

1. Backup Energy Supplied by Inverters:

- At 90% Efficiency (Aged Inverter):
 - a. Loss percentage = $100\% - 90\% = 10\%$
 - b. Annual energy loss = 10% of 193,750 kWh
 $= 0.10 \times 193,750$
 $= 19,375 \text{ kWh}$
- At 98% Efficiency (Upgraded Inverter):
 - c. Loss percentage = $100\% - 98\% = 2\%$
 - d. Annual energy loss = 2% of 193,750 kWh
 $= 0.02 \times 193,750$
 $= 3,875 \text{ kWh}$

To Calculate the Energy Savings from Upgrading

- Energy savings = Loss at 90% – Loss at 98%
 $= 19,375 \text{ kWh} - 3,875 \text{ kWh}$
 $= 15,500 \text{ kWh}$

Calculate the Annual Cost Savings

- Annual cost savings = Energy savings $\times$ Electricity cost
 $= 15,500 \text{ kWh} \times ₹8/\text{kWh}$
 $= ₹124,000 \text{ (or approximately ₹1.24 lakh)}$

V. Annexure: Calculations of Solar Water Heaters

1. Old System Electric Geysers

- **Installed Capacity Calculation (per hostel):**
Number of geysers per hostel = 8

Power rating per geyser = 2 kW

Total installed power = $8 \times 2 \text{ kW} = 16 \text{ kW}$
- **Daily Energy Consumption:**
Operating hours per day = 1.5 hours

Daily energy consumption = $16 \text{ kW} \times 1.5 \text{ hours} = 24 \text{ kWh/day}$
- **Annual Energy Consumption (per hostel):**
Annual operating hours $\approx 1.5 \text{ hours/day} \times 365 \text{ days} \approx 540 \text{ hours/year}$

Annual consumption = $16 \text{ kW} \times 540 \text{ hours} = 8,640 \text{ kWh/year}$

- **Annual Energy Cost (per hostel):**

Cost per unit = 8 INR/kWh

Annual cost = $8,640 \text{ kWh} \times 8 \text{ INR/kWh} = 69,120 \text{ INR/year}$

- **For 23 Hostels:**

Total annual consumption = $8,640 \text{ kWh} \times 23 = 198,720 \text{ kWh/year}$

Total annual cost = $198,720 \text{ kWh} \times 8 \text{ INR/kWh} = 1,589,760 \text{ INR/year}$

2. New System – Solar Water Heater with Heat Pump Backup

- **System Parameters:**

Backup Heat Pump Rating = 12 kW

COP (Coefficient of Performance) = 3.8

(For every 1 kWh of electricity used, 3.8 kWh of thermal energy is produced)

- **Effective Electrical Consumption (per hostel):**

Given effective annual consumption = 1,240 kWh/year

- **Annual Energy Cost (per hostel):**

Cost per unit = 8 INR/kWh

Annual cost = $1,240 \text{ kWh} \times 8 \text{ INR/kWh} = 9,920 \text{ INR/year}$

- **For 23 Hostels:**

Total annual consumption = $1,240 \text{ kWh} \times 23 = 28,520 \text{ kWh/year}$

Total annual cost = $28,520 \text{ kWh} \times 8 \text{ INR/kWh} = 228,160 \text{ INR/year}$

3. Savings Calculation

- **Energy Savings (per hostel):**

Old system consumption = 8,640 kWh/year

New system consumption = 1,240 kWh/year

Energy saved per hostel = $8,640 \text{ kWh} - 1,240 \text{ kWh} = 7,400 \text{ kWh/year}$

- **Total Energy Savings (for 23 hostels):**

Total energy saved = $7,400 \text{ kWh} \times 23 = 170,200 \text{ kWh/year}$

- **Cost Savings (per hostel):**

Old system cost = 69,120 INR/year

New system cost = 9,920 INR/year

Savings per hostel = $69,120 \text{ INR} - 9,920 \text{ INR} = 59,200 \text{ INR/year}$

- **Total Cost Savings (for 23 hostels):**

Total cost saved = $59,200 \text{ INR} \times 23 = 1,361,600 \text{ INR/year}$