ENERGY AUDIT REPORT

for

SWAMI RAMA HIMALAYAN UNIVERSITY

Swami Ram Nagar, Doiwala, Dehradun, 248140, Uttarakhand, India

(Session 2021-2022)

Prepared & Submitted By

M/s ECOSCIENCE CONSULTANCY

An ISO 9001, ISO 14001, ISO 45001, ISO 17020 and ISO 50001 certified Company
Registered Office: Lakshmi Vihar Colony, Bahadrabad, Haridwar, Uttarakhand, 209402
Corporate Office: Rajpura, Uttarakhand
Contact details: 9045728562, 9041733378
Email: ecoscience.consultancy@gmail.com
Website: www.ecoscienceconsultacy.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

Abbreviation	Full Form
A	Ampere
AC	Alternating Current
APFC	Automatic Power factor Controller
Avg.	Average
BEE	Bureau of Energy Efficiency
CEA	Certified Energy Auditor
CFL	Compact florescent lamp
SRHU	Swami Rama Himalayan University
EER	Energy Efficiency Ratio
FTL	Florescent Tube Light
Kcal	Kilo Calories
Kg.	Kilogram
KL	Kilo Liter
KV	Kilo Volt
kVA	Kilo Volt Ampere
KVAr	Kilo Volt Ampere Reactive
kW	Kilo Watts
kWh	Kilo Watt Hour
M or m	Meter
Mm	Millimeters
Max.	Maximum
Min.	Minimum
MT	Metric Ton
No.	Number
PF	Power Factor
TR	Tons of Refrigeration
Urms	Under root mean square
V	Voltage
W	Wattage (Watt)

DECLARATION – MANAGEMENT SRHU

I, ………………………….,…………………….. on behalf of Swami Rama Himalayan University (SRHU), do declare & testify that all the data provided are on factual basis as per the available records and the data has been shared in good faith and is not intended for any other purpose other than Energy audit.

We would like to express our heartfelt gratitude to the team at Ecoscience Consultancy for taking on this important task. We are confident that the upcoming audit will be conducted with the utmost excellence. Thank you for your dedication and expertise!

Sincerely,

Name:
Designation:
Swami Rama Himalayan University (SRHU)

Declaration by Ecoscience Consultancy

Ecoscience Consultancy hereby declare that the energy audit report prepared for the "Swami Rama Himalayan University (SRHU)" located at Swami Ram Nagar, Doiwala, Dehradun, Uttarakhand (India) by our team has been reviewed and approved. The expertise and methodologies used for preparing this audit report are of the highest quality and the experts used their know-how to the optimum level. The recommendations and findings in this report can be considered and implemented where feasible to improve the facility's energy efficiency and sustainability.

I affirm that this report has been prepared in good faith and with the intent of achieving significant energy savings and operational improvements. We are committed to making informed decisions based on the expert analysis provided and to continuously enhancing our energy management practices.

Dr. Gurpreet Singh
(Managing Director)
Ecoscience Consultancy

Declaration by Experts/Auditors

We, the undersigned, hereby certify that the energy audit for (SRHU) has been conducted with utmost diligence and professionalism. The data and findings presented in this report are accurate to the best of our knowledge and are based on standard industry practices and methodologies. We further certify that the audit complies with all relevant regulations and standards, and the Recommendations provided are aimed at improving the energy efficiency of the building

Team of Experts for the Study

S. No.	Name of Expert	Area of Expertise	Sign.
1.	Dr. Gurpreet Singh (Ph. D. & M. Tech. Env. Sc.)	Technical & Environment • Lead Auditor for Green and Environment • Air Quality Expert • Environment Sustainability • Carbon Footprint Expert	
2.	Dr. Avinash Kumar (Ph.D., M. Tech., M.Sc. in Env. Sc.)	Environment Management System • Water Quality Expert. • Pollution Load Assessor. • Carbon Footprint Expert. • Environment Audit Expert.	
3.	Mr. Navjot Singh (BE Electrical & specialization in MEP)	Energy & Environment • Energy Auditor • MEP Expert • Engineering Design Expert	

EXECUTIVE SUMMARY

The premises encompass a vast campus with multiple buildings that cater to students, faculty, and support staff. For the institution's successful operations, a reliable power supply is essential to meet various needs, including lighting, air conditioning, heaters, fans, electric motors, electronic equipment, laboratories, and computer networking. In summary, power is a fundamental necessity required in every aspect of the institution.

1. Power Requirement

As the power is the primary requirement for almost all the day-to-day activities, the total load of the university is 4100KVA. The power is chiefly derived/procured from the UPCL Grid with standby mode in the form of 9 DG's of 500 KVA. As an environment friendly step and energy conservation measure, power is also procured from the solar power plant installed in the premises. The power procurement from the solar power sector is 1.5 MW.

The Energy Audit

The fundamental objectives of the Energy Audit are as below: -

- Assessment of power/energy requirement on minimum basis.
- Identification of "grey areas" in the field of energy consumption.
- Scope for improvements with financial aspects
- Assessment of Infrastructure/installation-oriented changes/0improvements.
- Assessment of operation-oriented possible changes/improvements.
- Assessment/identification of best practices.
- Intend measures for power conservation

2. Energy Audit Domain

The Energy Audit primarily encompasses all the above-mentioned aspects. It was conducted at Swami Rama Himalayan University (SRHU) by Ecoscience Consultancy Pvt. Ltd. to assess current energy consumption patterns, identify opportunities for energy conservation, and recommend strategies to enhance environmental sustainability on the campus. This comprehensive audit included a detailed analysis of energy usage, an evaluation of infrastructure, and feasibility studies for renewable energy solutions.

3. Key Findings with major financial benefits

Key findings revealed significant opportunities for energy efficiency improvements across various sectors of the campus. The Assessment of current scenario viz-a-viz power consumption would lead us to potential energy conservation in following major areas.

- Lighting (Interior/Exterior)
- AC
- Heaters
- Fans
- electric motors
- electronic equipment's
- laboratories and computer networking

Table 1-1 Investment and benefits

By adopting these recommended measures there is a substantial energy savings, improved sustainability, and reduced operational costs for SRHU. With the above improvements the capital cost will be recoverable in 3- 4 years' span & thereafter and there on the savings will be adding to the overall financial health of the institute.

The audit underscores the importance of a proactive approach to energy management and sustainability in educational institutions. In this way, SRHU can significantly reduce its environmental impact, enhance the campus's learning environment, and position itself as a leader in energy management within the educational sector.

S. No.	Sectors of Improvement	Total Investment (in Rs.)	Monetary savings (in Rs.)
2	Fans (replacement with BLDC FANS)	1875000	360871.8/year
3	Street lights (Integration with solar panel)	1203000	184938.5/month
4	AC system	4,80,000	2,86,920
6	Use of motion sensors	20,000	5000

4. Recommendations

To maximize the benefits and uphold the true intent of this Energy Audit, it is essential for the institute's management to implement key improvements at the ground level. Without translating these recommendations into practical actions, the core purpose of the Energy Audit would remain unfulfilled. Based on the analysis, calculations, and data gathered, the following suggestions and recommendations are outlined: Installations of 150KW solar plant.

- Replacement of existing street lights with solar lights.
- Replacement of old inefficient ACs with 5-star inverter ACs.
- Replacement of normal fans with BLDC fans.
- Replacement of old pumps with IE4 power efficient pumps
- Increase the capacity of APFC up to 100KVAr.
- Awareness programs cum seminars on energy saving scenarios.

This comprehensive approach not only aligns with global sustainability goals but also ensures long-term financial health and operational excellence for SRHU.

CHAPTER 1

INTRODUCTION

1.1 ABOUT SRHU

SRHU, with its 25+ years of legacy, has established itself as one of the leading higher education institutes in the region. The institution is focused on providing affordable, high-quality education and ensuring academic excellence for its students.

In addition to its academic programs, the institution has formed partnerships with over 50 international universities. These collaborations offer students valuable opportunities to participate in exchange programs and gain exposure to global perspectives and experiences. The university also collaborates with leading organizations in various industries to provide students with practical training and an inside look into the real-world operations of these organizations. Overall, SRHU, Uttarakhand is committed to equipping students with the knowledge, skills, and experiences necessary for successful career development and personal growth.

SRHU, Uniqueness

- First to introduce Ph.D. program in medical sciences in Uttarakhand
- First Private University in India to launch EDP-Homestay Program for the village youth.
- First in the state to offer Health / Actuarial Sciences specialization in M.Sc. Statistics.
- First in the State and Largest in Northern India 1200 bed super-specialty Post Graduate Teaching Hospital.
- First and only NABH accredited hospital in Uttarakhand.
- First and only Private Hospital in India to receive Ayushman Gold Certificate for providing quality services to patients under the scheme
- First and only Cadaver Lab in the state
- First and only Comprehensive Cardiac Care Centre in the state.
- First to introduce Bone Marrow Transplant Program in Uttarakhand.
- Instill a sense of pride and belongingness in students and alumni towards the institution.
- To create facilities& ambience for advance level of pharmaceutical teaching & practical skills.

- To constantly strive for research, development & innovation in pharmaceutical sciences, thereby providing the faculty & students the right platform to showcase their talents & achieve laurels.
- To collaborate with industry, academia & healthcare organizations that ensures the best placement opportunities, promote entrepreneurial development activities & also provide international exposure.
- To make students socially vibrant &committed pharmaceutical professionals.

Figure 1-1 Photograph of University Interiors

1.2 ABOUT ENERGY AUDIT

An energy audit is a systematic process aimed at evaluating energy consumption patterns, identifying inefficiencies, and proposing measures to improve energy efficiency and reduce costs. It plays a significant role in promoting sustainability by helping institutions understand their energy usage and implement strategies for conservation. The components of an energy audit typically include data collection, analysis of energy consumption, evaluation of the efficiency of existing systems, and Recommendations for energy-saving measures.

The significance of conducting an energy audit at an educational institution like Swami Rama Himalayan University (SRHU) lies in its potential to promote environmental sustainability, reduce operational costs, and enhance the overall efficiency of campus facilities. By systematically assessing energy usage, the audit helps identify key areas where improvements can be made, leading to long-term benefits for both the institution and the environment.

Objectives

The energy audit practices can vary from one facility to another. However, an energy audit is usually conducted to understand how energy is used within the plant and to find opportunities for improvement and energy saving. Sometimes, energy audits are conducted to evaluate the effectiveness of an energy efficiency project or program.

Types of energy audits

The type of facility energy audit conducted depends on the function, size, and type of the facility, the depth to which the audit is needed, and the potential and magnitude of energy savings and cost reduction desired. Based on these criteria, a facility energy audit can be classified into two types: a preliminary audit (walk-through audit) and a detailed audit (diagnostic audit).

Preliminary audit (Walk-through audit)

In a preliminary energy audit, readily available data are mostly used for a simple analysis of energy use and performance of the plant. This type of audit does not require a lot of measurement and data collection. These audits take a relatively short time and the results are more general, providing common opportunities for energy efficiency. The economic analysis is typically limited to calculation of the simple payback period, or the time required paying back the initial capital investment through realized energy savings.

Detailed audit (Diagnostic audit)

For detailed (or diagnostic) energy audits, more detailed data and information are required. Measurements and a data inventory are usually conducted and different energy systems (pump, fan, compressed air, steam, process heating, etc.) are assessed in detail. Hence, the time required for this type of audit is longer than that of preliminary audits. The results of these audits are more comprehensive and useful since they give a more accurate picture of the energy performance of the plant and more specific recommendation for improvements. The economic analysis conducted for the efficiency measures recommended typically go beyond 3 the simple payback period and usually include the calculation of an internal rate of return (IRR), net present value (NPV), and often also life cycle cost (LCC)

1.3 PURPOSE OF THE REPORT

The primary objective of this energy audit report for Swami Rama Himalayan University (SRHU), Uttarakhand, conducted by Ecoscience Consultancy, is to provide an in-depth analysis of the current energy consumption patterns and identify opportunities for energy efficiency improvements. This audit aims to:

- Establish a baseline of the present energy consumption pattern
- Identify Energy Efficiency Measures (EEMs) that can lead to sustained energy savings on the campus
- Prepare a comprehensive action plan for implementing these measures.

CHAPTER 2

PROJECT DESCRIPTION

2.1 PROJECT LOCATION

Swami Rama Himalayan University (SRHU), Uttarakhand, is a prominent educational institution situated in the city of Uttarakhand. The campus is strategically located in a region that experiences a typical Hill area climate characterized by hot summers, winters, and moderate monsoon seasons. The facility spans a substantial ground-covered area and is well-equipped with modern infrastructure to support its diverse academic programs and extracurricular activities.

Table 2-1 Location details of the project

S. No.	Particulars	Details
a)	Location	Swami Rama Nagar, Doiwala
b)	District	Dehradun
c)	State	Uttarakhand
d)	Coordinates	Lat.: 30°11’26.98’’N; Long.: 78°10’03.03’’E
e)	Elevation	554 m amsl

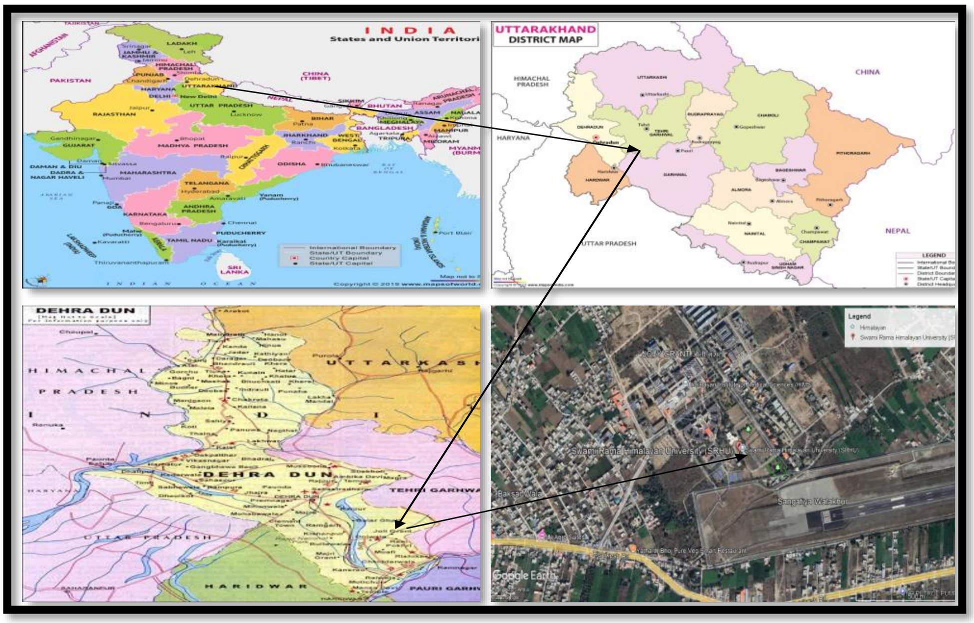


Figure 2-1 Location of the project

2.2 METEOROLOGICAL DATA

The climate data for SRHU, Uttarakhand, provides insights into the solar radiation and wind speed experienced throughout the year. This information is crucial for optimizing the energy efficiency and sustainability measures implemented on the campus.

Climate Details

The region experiences:

- Summers: Moderate hot & humidity, with temperatures often exceeding 29.6°C.
- Winters: Mild and pleasant, with temperatures ranging between 7.7°C to 16°C.
- Monsoon: Moderate rainfall, primarily occurring from July to September.

	Unit	Climate data location	Facility location	Source
Latitude		30.3	30.2	
Longitude		78.1	78.2	
Climate zone		2A - Hot - Humid		NASA
Elevation	m	1131	537	NASA – Map
Heating design temperature	°C	-3.1		NASA
Cooling design temperature	°C	21.8		NASA
Earth temperature amplitude	°C	19.6		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	10.2	42.8%	25.11	3.75	89.2	2.1	7.7	242	6
February	12.4	42.5%	36.40	4.50	89.0	2.5	10.8	157	67
March	17.5	34.9%	23.56	5.64	88.9	2.8	16.6	16	233
April	23.1	26.8%	20.40	6.76	88.7	3.1	23.1	0	393
May	27.5	24.8%	36.58	7.42	88.4	3.3	28.3	0	543
June	28.5	40.5%	138.30	6.73	88.1	2.9	29.6	0	555
July	25.8	71.5%	317.44	5.36	88.1	2.3	26.4	0	490
August	24.1	81.5%	332.32	4.83	88.2	2.0	24.2	0	437
September	22.4	75.9%	170.40	5.25	88.6	1.9	21.9	0	372
October	18.8	56.5%	21.70	5.42	89.0	2.1	17.1	0	273
November	15.0	44.4%	4.50	4.49	89.2	2.0	12.2	90	150
December	11.7	41.2%	9.92	3.69	89.2	2.0	8.6	195	53
Annual	**19.8**	**48.7%**	**1,136.63**	**5.32**	**88.7**	**2.4**	**18.9**	**699**	**3,571**
Source	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA
Measured at					m	10	0		

Figure 2-2 Monthly representation of the climatic conditions

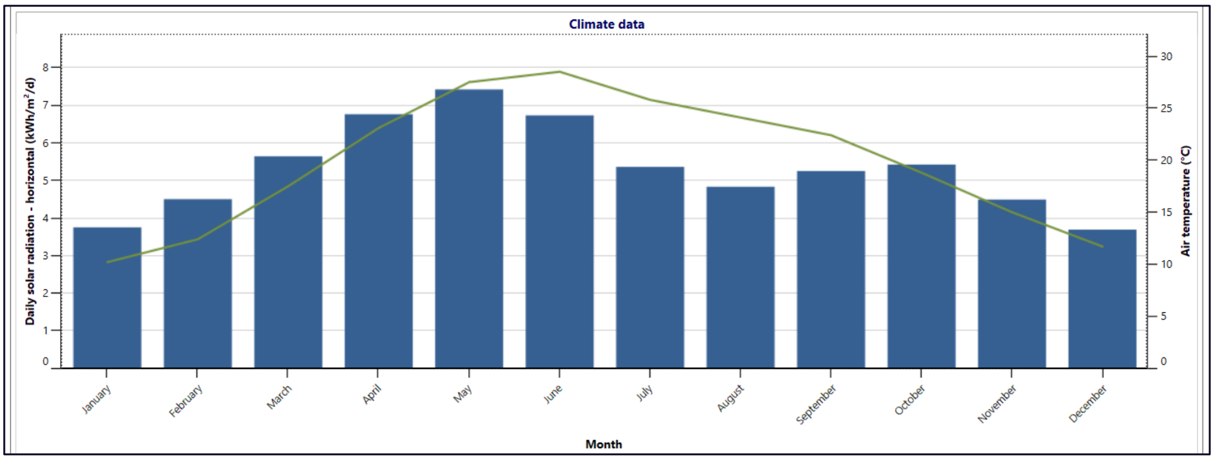


Figure 2-3 Graphical Representation of Solar Radiation & Wind Speed Month Wise

Wind Energy

Operating a wind power plant involves more than just installing turbines; it requires careful planning and analysis of wind patterns. Ideal locations for wind turbines typically have an annual average wind speed of at least 9 mph (4 m/s) for small turbines and 13 mph (5.8 m/s) for utility-scale turbines. Unfortunately, the wind speed in the region is below 2 m/s, making it unsuitable for wind energy generation. The following Fig 2.4 shows the wind speed data in various states of India.

In Uttarakhand, the wind energy potential is low due to these inadequate wind speeds, which is why detailed studies on wind energy have not been included in the audit report. However, solar energy remains a promising and effective renewable energy option for the campus, offering a viable alternative in the region.

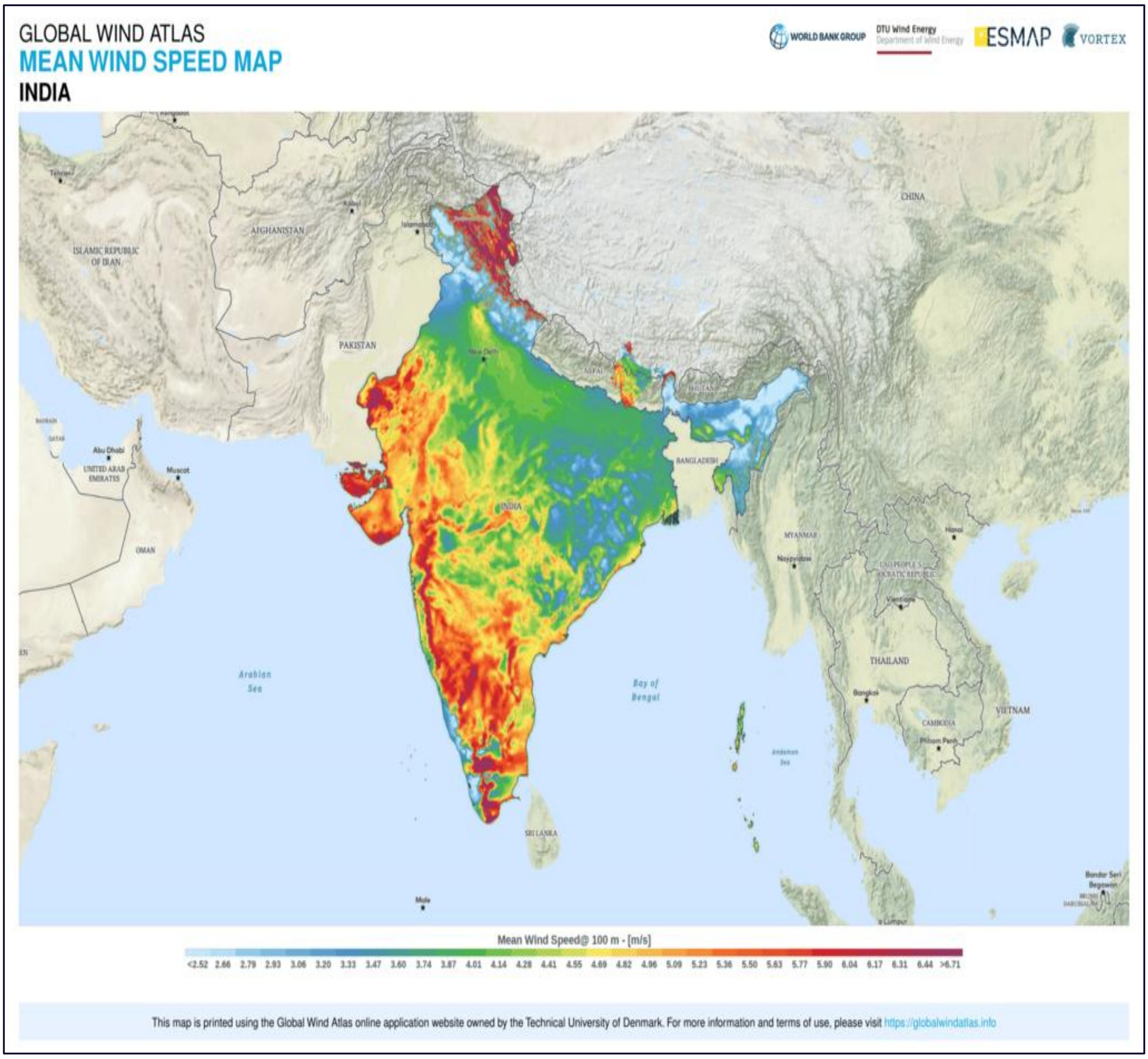


Figure 2-4 wind speed data in various states of India

2.3 POWER/LOAD DETAILS

The energy audit conducted at Swami Rama Himalayan University (SRHU), Uttarakhand, aimed to evaluate the current energy consumption patterns and identify opportunities for energy efficiency improvement. The details of the project are listed below in Table 2.2.

Table 2-2 Power Details

S.No.	Particulars	Details
1.	**Project Details**	
a.	**Name of the Institution**	**Swami Rama Himalayan University**
b.	**Building Covered Area**	**2,44,820 sqm**
c.	**Connected load/ contract demand of the university**	**4100KVA**
d.	**Alternate source of energy (Solar/ Wind) in institute (Type and capacity)**	**1.5 MW Solar**
2.	**Components contributing power Load in the Campus**	
a.	**Type/ No. of Florescent Lights**	**525**
b.	**Type/ No. of LED Lights**	**8949**
c.	**Type/ No. of Air Conditioner**	**900 No's, 3 star**
d.	**Type/ No Fans**	**2500 normal &2200 BLDC fans installed.**
e.	**Type/ No DG**	**9 (500 KVA)**
f.	**Type/ No -Other equipment and electrical appliances**	**Exhaust Fan- 850 No's (40w Each)**
g.	**Type/ No E-vehicles**	**5**

2.3.1 Importance of the study

The energy audit and subsequent implementation of energy efficiency measures at Swami Rama Himalayan University (SRHU), Uttarakhand, hold significant importance for several reasons:

1. Energy Efficiency and Cost Savings:
    - Conducting a comprehensive energy audit helps identify areas where energy consumption can be reduced. This leads to significant cost savings on utility

bills, which can be redirected towards other essential academic and operational activities.

2. Environmental Sustainability:
    - By implementing energy-efficient technologies and renewable energy solutions, SRHU can significantly reduce its carbon footprint. This aligns with global sustainability goals and demonstrates the institution's commitment to environmental stewardship.
3. Enhanced Learning Environment:
    - Improving energy efficiency ensures a more comfortable and conducive learning environment for students and staff. Better lighting, climate control, and reliable power sources contribute to overall well-being and productivity.
4. Compliance with Regulations:
    - The project ensures that the institution complies with national and local energy regulations and standards. This not only avoids potential legal issues but also positions SRHU as a leader in energy management in the educational sector.
5. Educational Impact:
    - The project serves as a live case study for students, particularly those studying environmental science, engineering, and related fields. It provides practical insights into energy management, sustainability practices, and the implementation of green technologies.
6. Community Leadership:
    - By undertaking such a project, SRHU sets an example for other educational institutions and organizations in the region. It showcases how proactive measures can lead to substantial benefits, encouraging others to follow suit.
7. Long-term Benefits:
    - The long-term benefits of reduced energy consumption and lower operational costs contribute to the financial health of the institution. This ensures that SRHU can continue to invest in quality education and infrastructure improvements.

In summary, the energy audit and implementation project at SRHU, Uttarakhand, is crucial for promoting energy efficiency, sustainability, and overall institutional excellence. It reflects a forward-thinking approach that balances economic, environmental, and educational benefits.

CHAPTER 3

METHODOLOGY

3.1 METHODOLOGY

This section outlines the methodology used to conduct the energy audit at Swami Rama Himalayan University (SRHU), Uttarakhand. The methodology includes systematic data collection, analysis, and identification of energy efficiency measures aimed at reducing energy consumption and enhancing sustainability on the campus.

3.2 DATA COLLECTION

A team of engineers/Experts visited the SRHU campus to conduct thorough on-site inspections. These inspections focused on evaluating the current state of energy consumption and environmental practices across various facilities, including classrooms, laboratories, administrative buildings, hostels, and common areas. The inspections involved visual observations, measurements, and discussions with the concerned officials and supervisors to gather detailed information on operations and load distribution.

Energy Consumption Data:

Data on historical and current energy consumption was collected through:

- **Electricity Bills:** Analysis of electricity bills from the Uttarakhand Electricity Board to establish a baseline of energy usage.
- **Generator Usage:** Monitoring the performance and fuel consumption of diesel generators (DG sets) on campus.
- **Renewable Energy Contributions:** Evaluating the contribution of solar energy installations in meeting the campus's energy demands.

3.3 ANALYSIS

3.3.1 Energy Efficiency Assessment

The efficiency of existing energy systems was evaluated, including:

- Lighting Systems: Assessment of lighting fixtures and identification of energy-saving opportunities through retrofitting with LED lights.

- AC Systems: Evaluation of heating, ventilation, and air conditioning systems for potential improvements.
- Electrical Equipment: Analysis of the performance of electrical equipment and identification of inefficiencies.

3.3.2 Environmental Impact Assessment

The environmental impact of current practices was analyzed, focusing on:

- Carbon Footprint: Estimation of the carbon footprint of the campus.
- Resource Utilization: Evaluation of resource utilization and potential areas for improvement in sustainability practices.

3.3.3 Benchmarking

SRHU's energy and environmental performance were compared against industry standards and best practices. This involved:

- Performance Metrics: Establishing performance metrics and identifying gaps.
- Opportunities for Improvement: Highlighting areas with significant potential for energy savings and environmental impact reduction.

3.4 IDENTIFICATION OF ENERGY EFFICIENCY MEASURES (EEMS)

Potential energy efficiency measures were identified based on the data collected and analyzed. These measures focus on improving the efficiency of lighting systems, HVAC systems, and other electrical equipment, as well as enhancing waste management and water conservation practices.

3.5 IMPLEMENTATION PLAN

An actionable implementation plan was developed, detailing the steps required to implement the recommended energy efficiency measures. The plan includes timelines, responsible parties, and estimated costs for each measure.

CHAPTER 4

OBSERVATION AND FINDINGS

4.1 INTRODUCTION

This chapter presents the key findings from the energy audit conducted at Swami Rama Himalayan University (SRHU), Uttarakhand. The findings are categorized into various aspects of energy consumption, environmental impact, and sustainability practices. Each section highlights the current state, potential areas for improvement, and recommendations for achieving energy efficiency and sustainability goals.

4.2 ENERGY CONSUMPTION ANALYSIS

The total energy consumption for the SRHU campus is primarily met through electricity supplied by the Uttarakhand Power Corporation Limited and supplemented by solar energy installations and diesel generators.

Major energy-consuming areas include lighting, AC systems, and electrical equipment used in classrooms, laboratories, and administrative buildings.

There are three sources of electricity source in the facility

1. Main electricity with tariff rate of Rs. 5.82 Kw/h
2. Electricity from Generators
3. Electricity from Solar

4.2.1 Electricity Bill for The Year 2021-2022 for meter 1 & 2

Table 3 Monthly electrical bill

S. No.	Bill Month /year	Rate KWh	Total Energy Cost-M1	Bill No.-M1	Total Energy Cost- M2	Bill No.-M2
1	04/2022	5.82	5,25,139	38980220512000001	4,814,640	28980220506000003
2	05/2022	5.82	7,08,523	38980220607000020	4,777,920	38980220607000021
3	06/2022	5.82	9,10,828	38980220707000039	5,490,720	38980220706000005

4	07/2022	5.82	8,86,464	29980220806000003	5,980,500	38980220806000001
5	08/2022	5.82	8,42,270	29980220908000027	6,475,140	29980220908000024
6	09/2022	5.82	4,74,465	28980881010000002	5,708,340	38980221008000001
7	10/2022	5.82	3,04,819	28980221109000016	3,939,300	28980221109000015
8	11/2022	5.82	4,72,003	29980221205000016	3,385,260	29980221205000014
9	12/2022	5.82	9,04,996	28980230108000002	3,934,980	28980230106000001

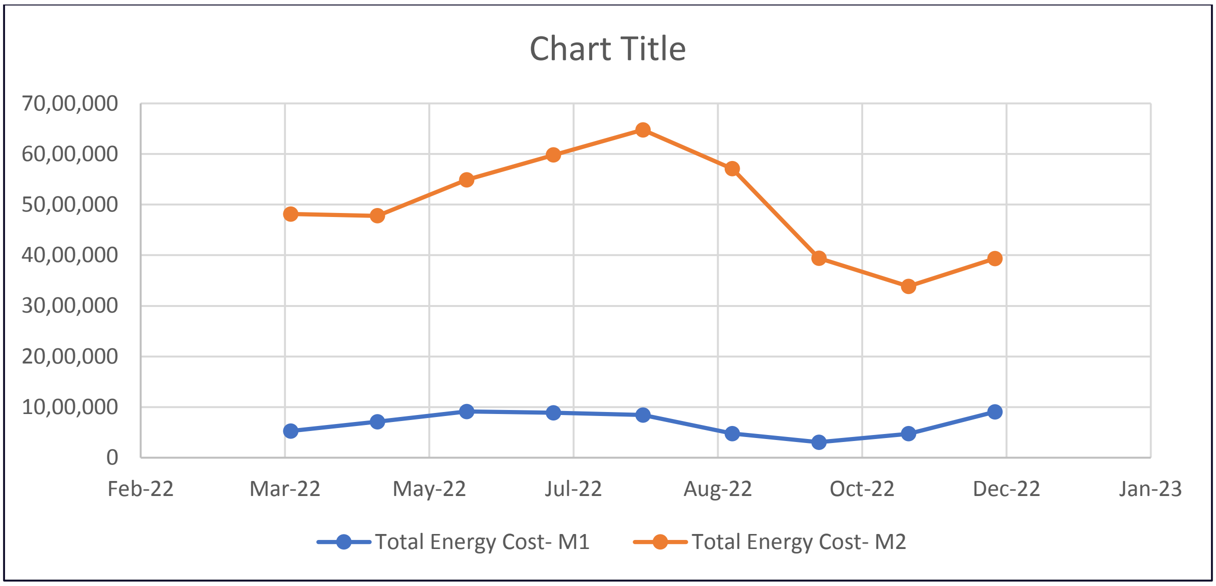
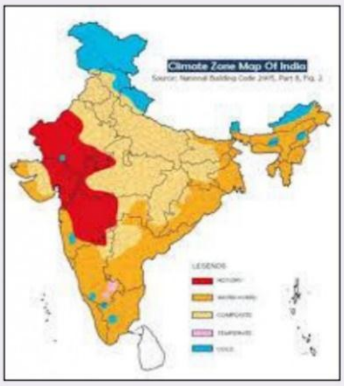


Figure 4-1 Graphical representation of monthly bill

4.2.2 Energy Performance Index (EPI)

The Energy Performance Index (EPI) is a key metric used to evaluate the energy efficiency of a campus. It represents the total energy consumed over a year divided by the total built-up area, measured in kWh/sqm/year. This index provides a straightforward and relevant indicator of whether a campus is energy efficient. For educational institutes like SRHU, benchmarking the EPI helps in comparing the energy performance against established standards and identifying areas for improvement.

The benchmarking for EPI is presented in figure 4.1, which illustrates the energy benchmarks for commercial buildings. This comparison allows SRHU to assess its energy efficiency relative to similar institutions and set targets for energy conservation.



Based on the data collected from different categories of commercial buildings, the following tables show the indicative EPI benchmarks.

EPI benchmarks for Office Buildings

Climate Zone	Less than 50% AC	More than 50% AC
	EPI (kWh/m²/yr)	
Warm & Humid	101	182
Composite	86	179
Hot & Dry	90	173
Moderate	94	179

EPI benchmarks for Shopping Malls

Climate Zone	EPI (kWh/m²/yr)
Warm & Humid	428
Composite	327
Hot & Dry	273
Moderate	257

EPI benchmarks for Hospitals

Climate Zone	EPI (kWh/m²/yr)
Warm & Humid	275
Composite	264
Hot & Dry	261
Moderate	247

EPI benchmarks for Hotels

Climate Zone	Upto 3 star	Above 3 star
	EPI (kWh/m²/yr)	
Warm & Humid	215	333
Composite	201	290
Hot & Dry	167	250
Moderate	107	313

EPI benchmarks for Institutes

Climate Zone	EPI (kWh/m²/yr)
Warm & Humid	150
Composite	117
Hot & Dry	106
Moderate	129

EPI benchmarks for BPOs

Climate Zone	EPI (kWh/m²/yr)
Warm & Humid	452
Composite	437
Hot & Dry	-
Moderate	433

Disclaimer : The EPI benchmarks should be considered as an Indicative figure as it largely depends upon the operating hours, energy efficiency measures, sample size, climatic zone and lack of detailed information by building owners.

Energy benchmarks for Commercial Buildings

Bureau of Energy Efficiency
4th Floor, Sewa Bhawan, R.K. Puram, New Delhi – 110066
Website : www.beenet.in

Figure 4-2 Energy benchmarks for commercial buildings

4.2.2.1 Calculations of EPI

To understand the energy performance of SRHU, we calculate the Energy Performance Index (EPI) based on the annual energy consumption and the total built-up area of the campus. According to figure 4.2, the required EPI for an educational institution is 150 kWh/sq m/year. The calculations for SRHU's EPI for the year 2021-22 are as follows:

Annual energy consumption during year 2021-22 = 9974391 kWh

Total build up area of the campus = 2,44,820 sqm

EPI = 9974391/244820

EPI = 40.74kWh/sqm/year

The calculated EPI for SRHU is 40.74 kWh/sq m/year, which is within the desired limit of 150 kWh/sq m/year. This indicates that the institution is operating within an acceptable range of energy efficiency for its climate zone, which is classified as composite. Maintaining or further improving this EPI will help SRHU in achieving its sustainability goals.

4.2.3 Energy source derived from fuel

SRHU utilizes diesel generators (DG sets) as a backup energy source to ensure uninterrupted power supply during grid outages. SRHU's campus has nine DG set with a capacity of 500 KVA. This generator is installed in acoustic covers to minimize noise and is primarily used during power cuts

to provide in-house power generation. The following figure 4.2 illustrates the DG set installed at the university.

Figure 4-3: DG set at SRHU

4.2.3.1 HSD Consumption of DG Sets

The diesel consumption of the DG set was monitored to evaluate its efficiency. The details for the fiscal year 2021-22 are presented below:

Table 4-4 Diesel Consumption Details

Diesel consumption details	**FY 21-22**	**Units Generated KWH**
Annual- Lts	7100	112.5
Average cost per liter (Rs /lts)	82	
Total Amount (Rs)	5,82,200	

4.2.3.2 Technical details of DG set of 500 KVA

The technical specifications of the 500 KVA DG set are detailed in the table below:

Table 4-5 Rated parameters of DG Sets

S.No.	Description	Details
1.	Make	JAKSON
2.	Capacity-KVA	500
3.	Volts	415
4.	Amps	696
5.	Power factor	0.8
6.	Rpm	1500
7.	Connection	STAR
8.	Frequency-HZ	50

The voltage profile of the 500 KVA DG set during the one-hour test run is summarized below:

Table 4-6 Voltage Profile DG-1

VOLTS	DATE	TIME	AVG	MINI	MAX	UNITS
U12 rms	05-03-2022	14:00:00.0	415.855	406.5	424.6	V
U23 rms	05-03-2022	14:00:00.0	419.177	409.7	427.2	V
U31 rms	05-03-2022	14:00:00.0	418.002	409.7	425.6	V
	Average		**422.53**	**VOLTS**		

The current profile of the 500 KVA DG set during the test run is detailed below:

Table 4-7 Current Profile DG-1

AMPS	DATE	TIME	AVG	MINI	MAX	UNITS
A1 rms	05-03-2022	14:00:00.0	81.995	67	103.5	A
A2 rms	05-03-2022	14:00:00.0	110.424	89.5	140	A
A3 rms	05-03-2022	14:00:00.0	83.125	66	108	A
	Average	14:00:00.0	**98.3**	**AMPS**		

The power factor profile of the 500 KVA DG set during the one-hour test run is as follows:

Table 4-8 Power Factor Profile DG-1

PF	DATE	TIME	AVG	MINI	MAX
PF1	05-03-2022	14:00:00.0	0.977	0.972	0.98
PF2	05-03-2022	14:00:00.0	0.97	0.964	0.979
PF3	05-03-2022	14:00:00.0	0.977	0.973	0.981
Average	05-03-2022	14:00:00.0	**0.974**		

4.2.3.3 Details of energy generated by 500 KVA generator during trial: -

The performance of the 500 KVA DG set was analyzed during a trial run. The following data was collected and represented graphically in Figure 4.3.

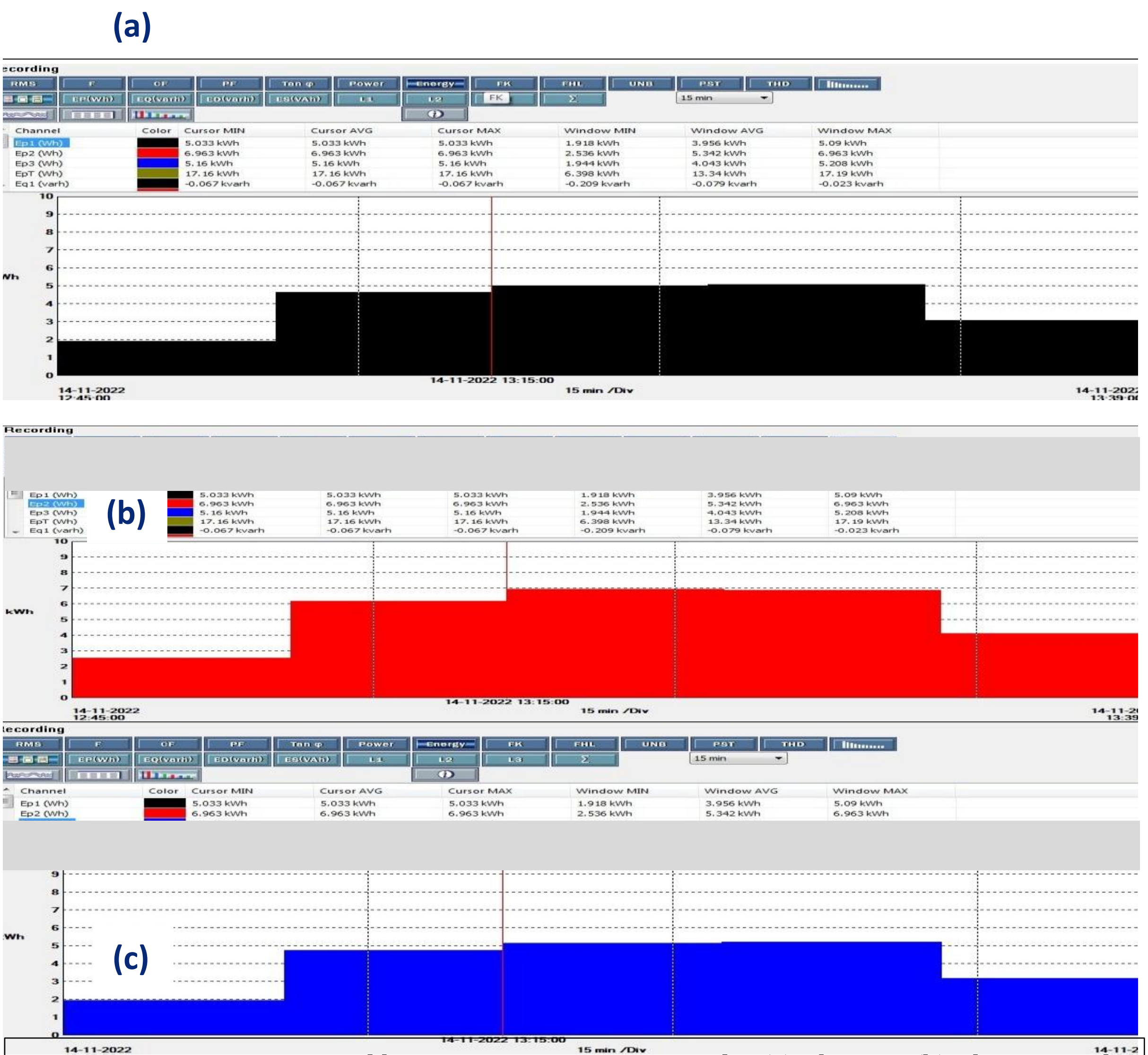


Figure 4 4 Energy Generated by 500 KVA DG Set on trial – (a) Phase-1, (b) Phase-2, and (c) Phase-3.

During the trial, the energy generation and efficiency metrics of the DG set were monitored and recorded. The complete data has been graphically represented to provide a clear view of the generator's performance under operational conditions.

4.2.2.4 Analysis of DG Set Performance

All the measurement data from the DG set trial has been analyzed to supplement management's efforts in further reducing energy costs. The following aspects were evaluated:

1. Specific Energy Consumption: It is crucial to monitor the specific energy consumption of the DG set. Energy meters installed on the set provide real-time data, and a logbook is maintained to record hours of operation and diesel consumption.
2. Effect of Temperature & Suction Pressure: For every 3.5°C increase in inlet air temperature, fuel consumption increases by 1%. The DG set is designed for an ambient temperature of 25 to 30°C. Higher temperatures and lower suction pressures decrease efficiency. The current status of the set is as follows:

    - Exhaust Pipes: Insulated to prevent heat loss.
    - Expansion Joint & Bend: Insulated to maintain efficiency.
    - Oil Pressure: Varied from 4.9 to 5.1 kg/sq cm, found satisfactory.
    - Water Temperature: Ranged from 40 to 48°C, found on the lower side.
    - Load Handling: With a balanced load, the set can be loaded up to 75% of its capacity. With power factor control, it can be loaded up to 85%.
    - Supply Voltage: The average voltage of the DG set is 422.5V.
    - Power Factor: The DG set operates at a power factor of 0.973, which is higher than the standard 0.8.

The load power factor is dependent on the load, and the AC generator is designed for a power factor of 0.8 lag as specified by standards. Regular monitoring and maintenance of these parameters are essential to ensure optimal performance and efficiency of the DG set.

4.2.3.4 Test report of DG Set

A test report for a Diesel Generator (DG) set is a formal document that records and evaluates the performance, functionality, and compliance of the generator under various operating conditions. It is a critical tool to ensure that the DG set meets required standards and operates reliably.

DELHI ANALYTICAL RESEARCH LABORATORY
Plot No. 2 (A-2) Timber Block , Jhilmil Industrial Area, Delhi- 110095
E- mail: darltesting@gmail.com , www.darltesting.in
Ph.: 011-43545890 ,09717324010 , 9971520106 , 8595224665.
Recognition/Approval : MoEF/FSSAI/BIS/ISO 9001, 45001 Certified Laboratory

TEST REPORT

REPORT NO.	820220905EV018	DATE OF RECEIPT	05/09/2022
ISSUED TO.	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	TEST STARTED ON	05/09/2022
		DATE OF REPORTING	12/09/2022
		ISSUE OF TEST REPORT	12/09/2022
SUBMITTED BY	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	BATCH SIZE	N.S
		SAMPLE QTY.	1
SAMPLE NAME.	DG Noise (500 KVA) (at SRHU Campus No-09)	BATCH NO.	N.S

Name of the Instrument	Noise Level Meter	
Used Description	Noise level monitoring of **(DG Noise)** was carried out by Us on dated – 03/09/2022 and following average values were observed.	
Time Duration	06:30 PM to 07:00 PM	
Location	D.G set area (at SRHU Campus)	permissible Limit
1. Inside the Acoustic Enclosure	98 dB(A)	
2. Outside the Acoustic Enclosure & at A Distance of		Minimum of 25dB (A) Insertion loss
0.5 M	70.2	dB(A)
1.0 M	68.4	dB(A)
2.0 M	65.2	dB(A)
3.0 M	63.2	dB(A)
4.0 M	61.8	dB(A)
5.0 M	59.6	dB(A)

REPORT REMARK : - PARTY ASKED FOR ABOVE TEST ONLY

Authorised Signatory
Mr. Deependra Tiwari

Note : 1. The results are related to the test items only. 2. Sample will be destroyed after one month from the date of issue of test report 3. This report is not be reproduced wholly or in part and cannot as an evidence in the court of law and should Not be used in any Advertisement media without written consent. 4. Laboratory is not responsible for customer provided details.

DELHI ANALYTICAL RESEARCH LABORATORY
Plot No. 2 (A-2) Timber Block , Jhilmil Industrial Area, Delhi- 110095
E- mail: darltesting@gmail.com , www.darltesting.in
Ph.: 011-43545890 ,09717324010 , 9971520106 , 8595224665.
Recognition/Approval : MoEF/FSSAI/BIS/ISO 9001, 45001 Certified Laboratory

TEST REPORT

REPORT NO.	820220905EV015	DATE OF RECEIPT	05/09/2022
ISSUED TO.	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	TEST STARTED ON	05/09/2022
		DATE OF REPORTING	12/09/2022
		ISSUE OF TEST REPORT	12/09/2022
SUBMITTED BY	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	BATCH SIZE	N.S
		SAMPLE QTY.	1
SAMPLE NAME.	DG Noise (500 KVA) (at SRHU Campus No -06)	BATCH NO.	N.S

Name of the Instrument	Noise Level Meter	
Used Description	Noise level monitoring of **(DG Noise)** was carried out by Us on dated – 03/09/2022 and following average values were observed.	
Time Duration	03:00 PM to 03:30 PM	
Location	D.G set area (at SRHU Campus)	permissible Limit
1. Inside the Acoustic Enclosure	98 dB(A)	
2. Outside the Acoustic Enclosure & at A Distance of		Minimum of 25dB (A) Insertion loss
0.5 M	69.9	dB(A)
1.0 M	65.4	dB(A)
2.0 M	62.8	dB(A)
3.0 M	60.7	dB(A)
4.0 M	54.4	dB(A)
5.0 M	56.4	dB(A)

REPORT REMARK : - PARTY ASKED FOR ABOVE TEST ONLY

Authorised Signatory
Mr. Deependra Tiwari

Note : 1. The results are related to the test items only. 2. Sample will be destroyed after one month from the date of issue of test report 3. This report is not be reproduced wholly or in part and cannot as an evidence in the court of law and should Not be used in any Advertisement media without written consent. 4. Laboratory is not responsible for customer provided details.

DELHI ANALYTICAL RESEARCH LABORATORY
Plot No. 2 (A-2) Timber Block , Jhilmil Industrial Area, Delhi- 110095
E- mail: darltesting@gmail.com , www.darltesting.in
Ph.: 011-43545890 ,09717324010 , 9971520106 , 8595224665.
Recognition/Approval : MoEF/FSSAI/BIS/ISO 9001, 45001 Certified Laboratory

TEST REPORT

REPORT NO.	820220905EV016	DATE OF RECEIPT	05/09/2022
ISSUED TO.	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	TEST STARTED ON	05/09/2022
		DATE OF REPORTING	12/09/2022
		ISSUE OF TEST REPORT	12/09/2022
SUBMITTED BY	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	BATCH SIZE	N.S
		SAMPLE QTY.	1
SAMPLE NAME.	DG Noise (500 KVA) (at SRHU Campus No -07)	BATCH NO.	N.S

Name of the Instrument	Noise Level Meter	
Used Description	Noise level monitoring of **(DG Noise)** was carried out by Us on dated – 03/09/2022 and following average values were observed.	
Time Duration	04:00 PM to 04:30 PM	
Location	D.G set area (at SRHU Campus)	permissible Limit
1. Inside the Acoustic Enclosure	98 dB(A)	
2. Outside the Acoustic Enclosure & at A Distance of		Minimum of 25dB (A) Insertion loss
0.5 M	70.4	dB(A)
1.0 M	68.4	dB(A)
2.0 M	66.1	dB(A)
3.0 M	64.2	dB(A)
4.0 M	61.3	dB(A)
5.0 M	59.2	dB(A)

REPORT REMARK : - PARTY ASKED FOR ABOVE TEST ONLY

Authorised Signatory
Mr. Deependra Tiwari

Note : 1. The results are related to the test items only. 2. Sample will be destroyed after one month from the date of issue of test report 3. This report is not be reproduced wholly or in part and cannot as an evidence in the court of law and should Not be used in any Advertisement media without written consent. 4. Laboratory is not responsible for customer provided details.

DELHI ANALYTICAL RESEARCH LABORATORY
Plot No. 2 (A-2) Timber Block , Jhilmil Industrial Area, Delhi- 110095
E- mail: darltesting@gmail.com , www.darltesting.in
Ph.: 011-43545890 ,09717324010 , 9971520106 , 8595224665.
Recognition/Approval : MoEF/FSSAI/BIS/ISO 9001, 45001 Certified Laboratory

TEST REPORT

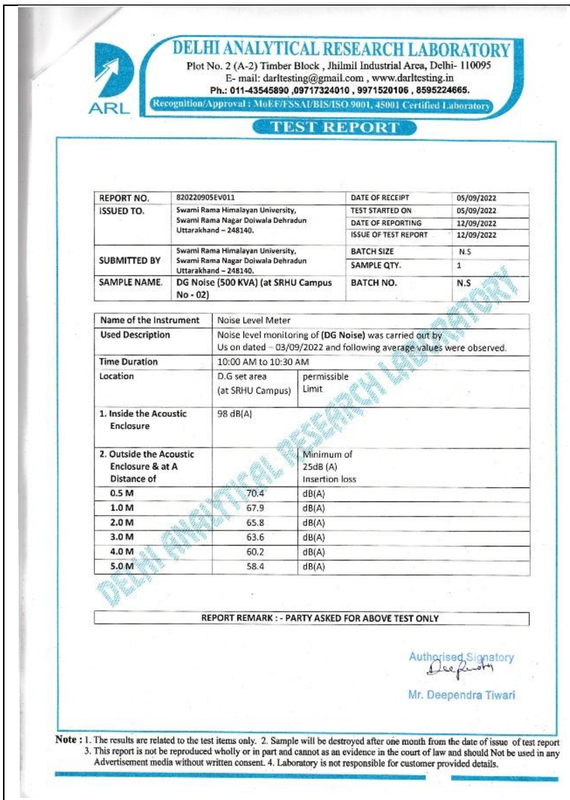
REPORT NO.	820220905EV017	DATE OF RECEIPT	05/09/2022
ISSUED TO.	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	TEST STARTED ON	05/09/2022
		DATE OF REPORTING	12/09/2022
		ISSUE OF TEST REPORT	12/09/2022
SUBMITTED BY	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	BATCH SIZE	N.S
		SAMPLE QTY.	1
SAMPLE NAME.	DG Noise (500 KVA) (at SRHU Campus No -08)	BATCH NO.	N.S

Name of the Instrument	Noise Level Meter	
Used Description	Noise level monitoring of **(DG Noise)** was carried out by Us on dated – 03/09/2022 and following average values were observed.	
Time Duration	05:30 PM to 06:00 PM	
Location	D.G set area (at SRHU Campus)	permissible Limit
1. Inside the Acoustic Enclosure	98 dB(A)	
2. Outside the Acoustic Enclosure & at A Distance of		Minimum of 25dB (A) Insertion loss
0.5 M	71.2	dB(A)
1.0 M	69.8	dB(A)
2.0 M	67.2	dB(A)
3.0 M	64.1	dB(A)
4.0 M	62.9	dB(A)
5.0 M	58.4	dB(A)

REPORT REMARK : - PARTY ASKED FOR ABOVE TEST ONLY

Authorised Signatory
Mr. Deependra Tiwari

Note : 1. The results are related to the test items only. 2. Sample will be destroyed after one month from the date of issue of test report 3. This report is not be reproduced wholly or in part and cannot as an evidence in the court of law and should Not be used in any Advertisement media without written consent. 4. Laboratory is not responsible for customer provided details.



DELHI ANALYTICAL RESEARCH LABORATORY
Plot No. 2 (A-2) Timber Block, Jhilmil Industrial Area, Delhi- 110095
E- mail: darltesting@gmail.com , www.darltesting.in
Ph.: 011-43545890 ,09717324010 , 9971520106 , 8595224665.
Recognition/Approval : MoEF/FSSAI/BIS/ISO 9001, 45001 Certified Laboratory

TEST REPORT

REPORT NO.	820220905EV011	DATE OF RECEIPT	05/09/2022
ISSUED TO.	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	TEST STARTED ON	05/09/2022
		DATE OF REPORTING	12/09/2022
		ISSUE OF TEST REPORT	12/09/2022
SUBMITTED BY	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	BATCH SIZE	N.S
		SAMPLE QTY.	1
SAMPLE NAME.	DG Noise (500 KVA) (at SRHU Campus No - 02)	BATCH NO.	N.S

Name of the Instrument	Noise Level Meter	
Used Description	Noise level monitoring of **(DG Noise)** was carried out by Us on dated – 03/09/2022 and following average values were observed.	
Time Duration	10:00 AM to 10:30 AM	
Location	D.G set area (at SRHU Campus)	permissible Limit
1. Inside the Acoustic Enclosure	98 dB(A)	
2. Outside the Acoustic Enclosure & at A Distance of		Minimum of 25dB (A) Insertion loss
0.5 M	70.4	dB(A)
1.0 M	67.9	dB(A)
2.0 M	65.8	dB(A)
3.0 M	63.6	dB(A)
4.0 M	60.2	dB(A)
5.0 M	58.4	dB(A)

REPORT REMARK : - PARTY ASKED FOR ABOVE TEST ONLY

Authorised Signatory
Mr. Deependra Tiwari

Note : 1. The results are related to the test items only. 2. Sample will be destroyed after one month from the date of issue of test report 3. This report is not be reproduced wholly or in part and cannot as an evidence in the court of law and should Not be used in any Advertisement media without written consent. 4. Laboratory is not responsible for customer provided details.

DELHI ANALYTICAL RESEARCH LABORATORY
Plot No. 2 (A-2) Timber Block, Jhilmil Industrial Area, Delhi- 110095
E- mail: darltesting@gmail.com , www.darltesting.in
Ph.: 011-43545890 ,09717324010 , 9971520106 , 8595224665.
Recognition/Approval : MoEF/FSSAI/BIS/ISO 9001, 45001 Certified Laboratory

TEST REPORT

REPORT NO.	820220905EV012	DATE OF RECEIPT	05/09/2022
ISSUED TO.	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	TEST STARTED ON	05/09/2022
		DATE OF REPORTING	12/09/2022
		ISSUE OF TEST REPORT	12/09/2022
SUBMITTED BY	Swami Rama Himalayan University, Swami Rama Nagar Doiwala Dehradun Uttarakhand – 248140.	BATCH SIZE	N.S
		SAMPLE QTY.	1
SAMPLE NAME.	DG Noise (500 KVA) (at SRHU Campus No - 03)	BATCH NO.	N.S

Name of the Instrument	Noise Level Meter	
Used Description	Noise level monitoring of **(DG Noise)** was carried out by Us on dated – 03/09/2022 and following average values were observed.	
Time Duration	11:15 AM to 11:45 AM	
Location	D.G set area (at SRHU Campus)	permissible Limit
1. Inside the Acoustic Enclosure	98 dB(A)	
2. Outside the Acoustic Enclosure & at A Distance of		Minimum of 25dB (A) Insertion loss
0.5 M	70.7	dB(A)
1.0 M	68.2	dB(A)
2.0 M	64.2	dB(A)
3.0 M	61.2	dB(A)
4.0 M	59.6	dB(A)
5.0 M	57.2	dB(A)

REPORT REMARK : - PARTY ASKED FOR ABOVE TEST ONLY

Authorised Signatory
Mr. Deependra Tiwari

Note : 1. The results are related to the test items only. 2. Sample will be destroyed after one month from the date of issue of test report 3. This report is not be reproduced wholly or in part and cannot as an evidence in the court of law and should Not be used in any Advertisement media without written consent. 4. Laboratory is not responsible for customer provided details.

Figure 4-4 Test report of DG set

Purpose of the Report:

To validate the performance of the DG set against its specifications.

To ensure compliance with local and international standards (e.g., ISO, IEC, CPCB norms).

To identify any potential issues and recommend corrective actions.

Test Conditions:

The report includes environmental factors like ambient temperature, humidity, and barometric pressure, which can influence performance.

It also outlines the load conditions under which the tests were performed (e.g., 25%, 50%, 75%, 100%, and 110% of rated load).

Parameters Tested:

Electrical parameters: Voltage, current, frequency, power output.

Mechanical parameters: Fuel consumption, noise levels, vibrations.

Efficiency and stability under varying loads.

Emissions compliance (e.g., NOx, CO, particulate matter).

Importance of the Test Report:

Ensures operational safety and reliability of the DG set.

Provides a benchmark for maintenance and troubleshooting.

Serves as a compliance document for regulatory authorities.

Structure of the Report:

General information about the DG set and the test environment.

Detailed test procedure and methodology.

Tabulated results showing performance metrics under different load conditions.

Observations and comments about performance anomalies, if any.

Recommendations for maintenance or upgrades.

Certification:

The report is usually certified by a qualified technician or testing authority, ensuring its authenticity and accuracy.

Conclusion:

A well-documented test report of a DG set is essential for ensuring the equipment's efficient and safe operation. It not only verifies performance but also provides critical insights for preventive maintenance and operational improvements.

4.2.4 Renewable energy options

4.2.4.1 Solar Panels

At present, power is sourced from the UPCL, which is subsequently stepped down to 433 V using 18 nos. transformer of 4MVA, 750 KVA, 1200KVA, 2000KVA, 500KVA, 250KVA, 200KVA & 315KVA. Metering is done at the 11 kV level. Power is also generated using 9 DG sets of 500KVA. The university have installed the solar power plant of 2.5 MW. The university building has ample space i.e. Roof top area on hostels auditorium buildings. The average power generation from a 1 KW SPV System is around 4-5 kWh per day. Since the proposed SPV system does not have a battery backup grid connection would be required to meet the power requirements during night. Also, the SPV power generation varies with time of day, the balance power requirements are automatically met by the grid supply during this period.

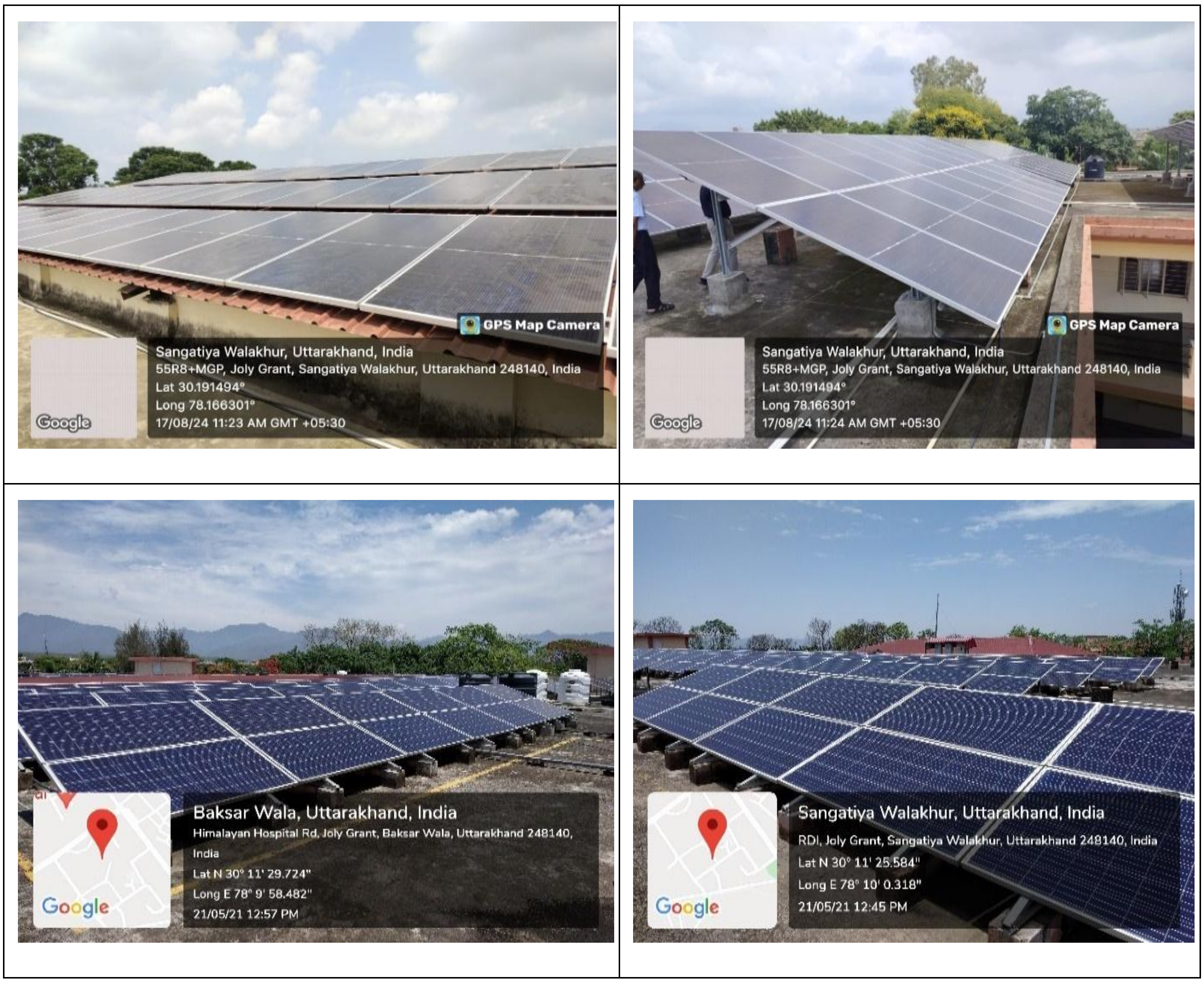


Figure 4-5: Picture showing the installed solar panel

4.2.4.2 Operation and Maintenance

Regular operation and maintenance of the SPV power plant after commissioning is essential. This includes the supply of consumable items as necessary and the submission of daily analysis and evaluation of operational plant data through remote monitoring. Key activities include:

- Visual inspections.
- Data recording using a robust data-logger and related sensors to measure irradiation, ambient and module temperature, and energy output of the power plant. Information is accessible through a web interface from any location.
- Monthly/yearly energy and performance reporting.
- Plant health monitoring and troubleshooting measures.
- Module cleaning, preventive and scheduled maintenance, and replacement work as required.
- Emergency response.
- Refurbishments & warranty claim management and redressal system.

Preventive inspection and maintenance of system components according to manufacturer's specifications, documentation of events and measures, and provision of small parts and operating material are also included. Fault detection and analysis involve function checks after fault messages are received, immediate start of fault removal measures, and long-term trend analysis. Analysis of interruptions and incidents, and supply chain management for spare parts such as modules, inverters, cabling, and mechanical components are essential.

4.2.4.3 Solar water heating system

Solar water heaters, also known as solar domestic hot water systems, provide a cost-effective method for generating hot water. They can be utilized in any climate, and their fuel—sunshine—is free. The facility is equipped with solar water boilers. Below is a comparison between solar water heaters and electric water heaters.

From the data given by the university, we observe that the facility has installed 450 numbers of solar water heater of capacity 2.5 KW which is sufficient as shown in Fig 4.6 but Solar heater details are given in fig 4.7 and the data for the installed solar heating system for all the hostels is given in Table 4-8.

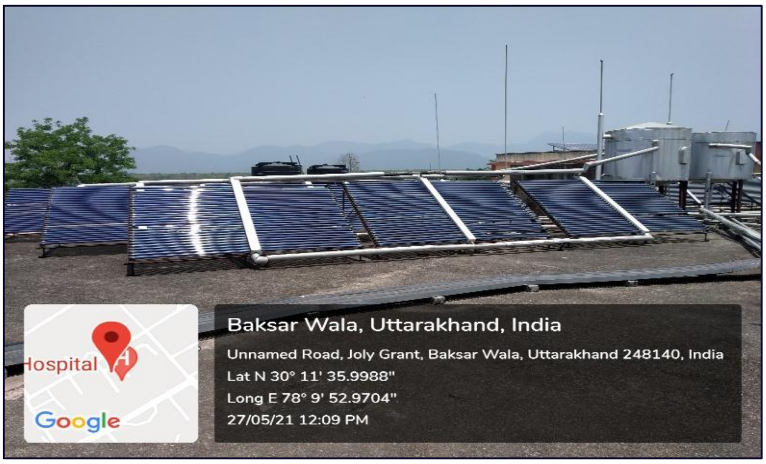
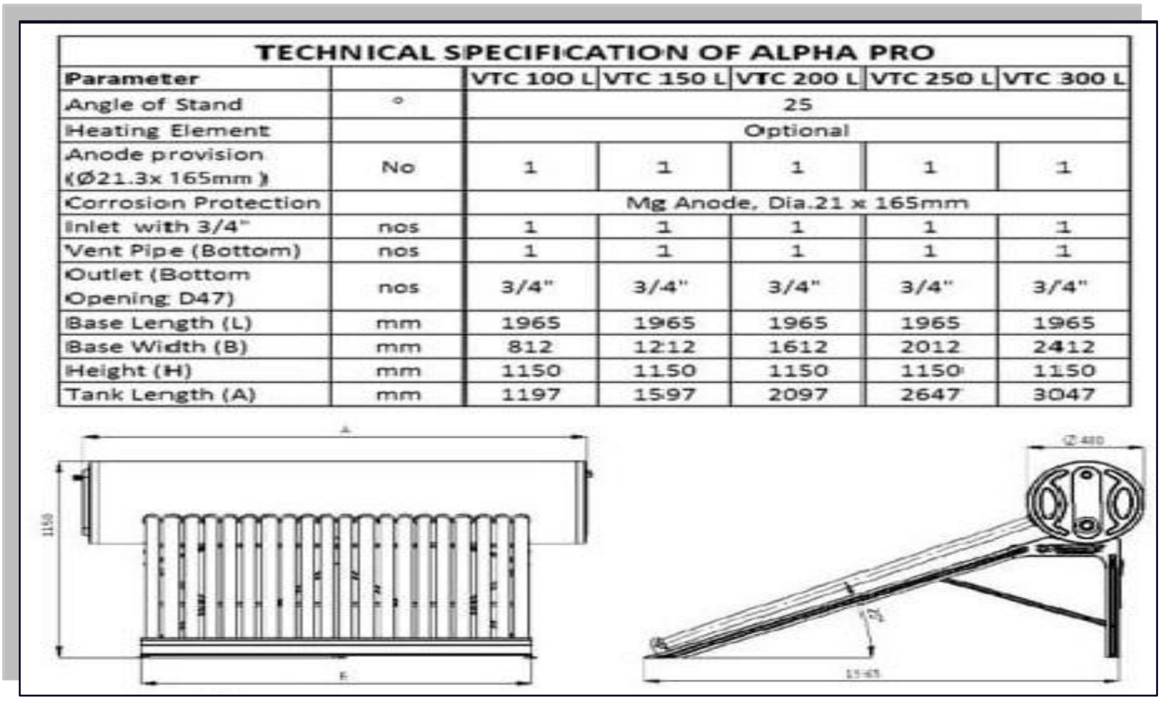


Figure 4-6 Solar water heating system



TECHNICAL SPECIFICATION OF ALPHA PRO

Parameter		VTC 100 L	VTC 150 L	VTC 200 L	VTC 250 L	VTC 300 L
Angle of Stand	°	25				
Heating Element		Optional				
Anode provision (Ø21.3x 165mm)	No	1	1	1	1	1
Corrosion Protection		Mg Anode, Dia.21 x 165mm				
Inlet with 3/4"	nos	1	1	1	1	1
Vent Pipe (Bottom)	nos	1	1	1	1	1
Outlet (Bottom Opening D47)	nos	3/4"	3/4"	3/4"	3/4"	3/4"
Base Length (L)	mm	1965	1965	1965	1965	1965
Base Width (B)	mm	812	1212	1612	2012	2412
Height (H)	mm	1150	1150	1150	1150	1150
Tank Length (A)	mm	1197	1597	2097	2647	3047

Figure 4-7 Technical specifications of solar water boiler

4.3 INFRASTRUCTURE AND EQUIPMENT ASSESSMENT

The Campus has total of 18 transformers the list is as follows

S.No	Location	Equipment	Qty
1	33 KVA Sub Station	4 MVA Transformer	2
		33 KV Brekar	1
2	DG House Hospital	500 KVA DG sets With AMF panels	9
3	Hospital Sub Station	750 KVA Transformer	3
		1250 KVA Transformer	2
		2000 KVA Transformer	1

		11 KVA Breker	1
		LT Elect Panel Room	1
4	Residence Sub Station	11 KV breker	2
		500 KVA Transformer	1
		250 KVA Transformer	2
		500 KVA Transformer	1
		750 KVA Transformer	1
5	Medical University Sub Station	500 KVA Transformer	1
		LT Panel	2
		315 KVA Transformer	1
		11 KV Oil Circuit Breker	1
6	Tube-well	250 KVA Transformer	1
7	MBBS Hostel	750 KVA Transformer	1
		315 KVA Transformer	1

4.3.1 Transformer 1-2000kva

Voltage profile – in commer t/f 1

During the audit, quality of in-coming power is measured through 3 Phase Power Analyzer in order to measure the power quality parameters at incomer panel of T/F 1 Thus, various parameters were recorded which included Voltage, Current, Power Factor, Total Harmonic Distortion (THD), and Unbalancing of Load:

4.3.1.1 Voltage profile

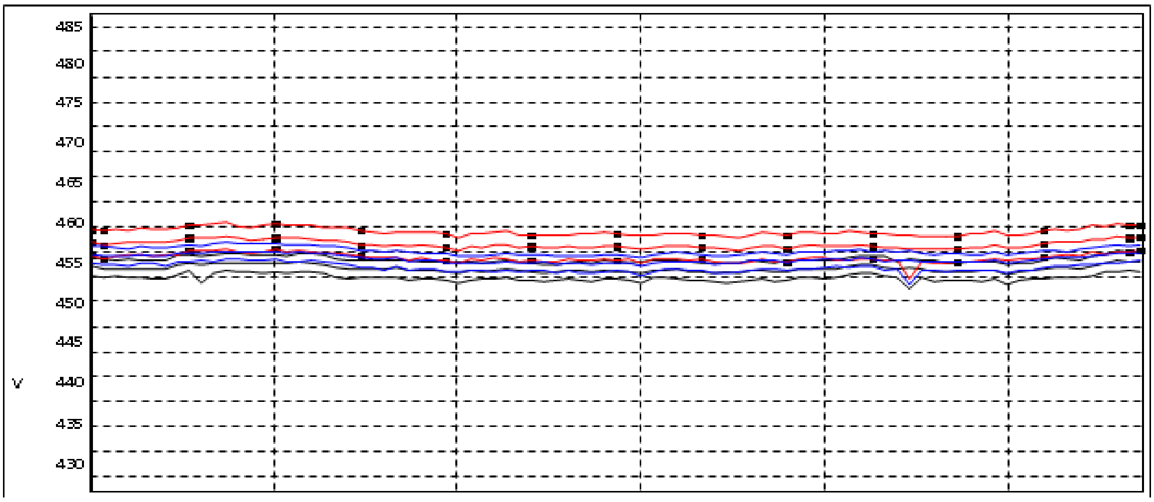


Figure 4-8 Voltage graph of 2000 KVA Transformer 1

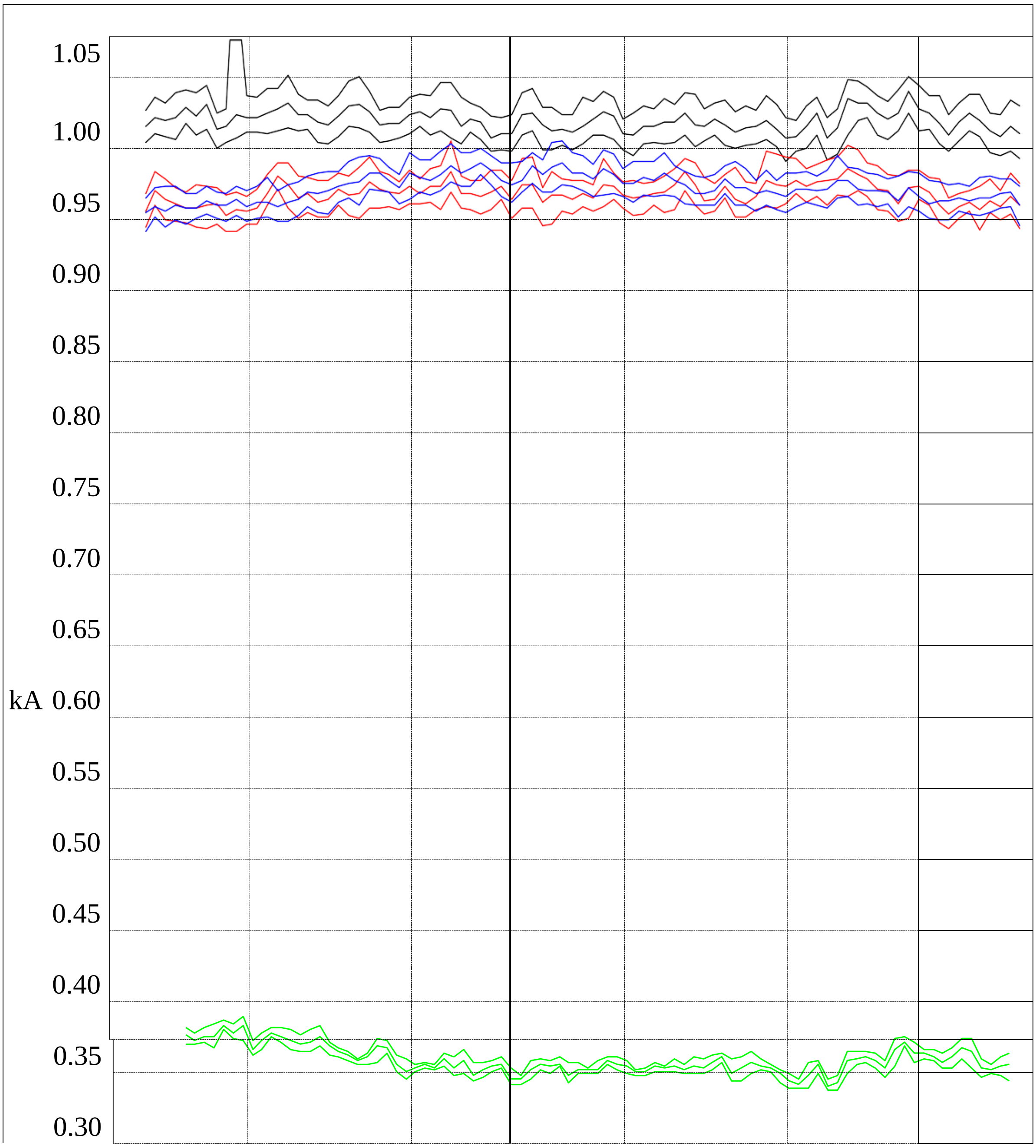
Table 4-9 Voltage profile of Transformer – 1,600 KVA 1

Urms Line 1	Urms Line 2	Urms Line 3	Average	%age im-balance
436.653	441.416	438.539	438.9	1.09

4.3.1.2 Imbalance voltage

The unbalanced voltage is 1.09 % which is under the prescribed limit as per IEEE standards. Imbalance of 2% is acceptable as it doesn't affect the cable.

4.3.1.3 Current profile



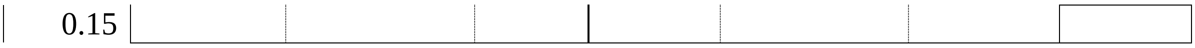


Figure 4-9 Current graph of 2000KVA transformer 1

Table 4-10 Current profile of 2000KVA transformer 1

Arms	Arms	Arms	Average	%age
Line 1	Line 2	Line 3	833.0	im- balance
923	782.674	793.188		16.85

4.3.1.4 Imbalance current

The unbalance current was observed to be 16.85 %. Being the load on the transformer is very less. The large current unbalance at no load/low load is quite common and does not indicate any fault. Any large single-phase load, or a number of small loads connected to only one phase cause more current to flow from that particular phase causing voltage drop on line. All the single-phase loads should be distributed on the three-phase system such that they put equal load on three phases.

4.3.2 Transformer 2-1250 KVA

4.3.2.1 Voltage profile – in commer t/f 1

During the audit, quality of in-coming power is measured through 3 Phase Power Analyzer in order to measure the power quality parameters at incomer panel of T/F 1 Thus, various parameters were recorded which included Voltage, Current, Power Factor, Total Harmonic Distortion (THD), and Unbalancing of Load:

VOLTAGE PROFILE

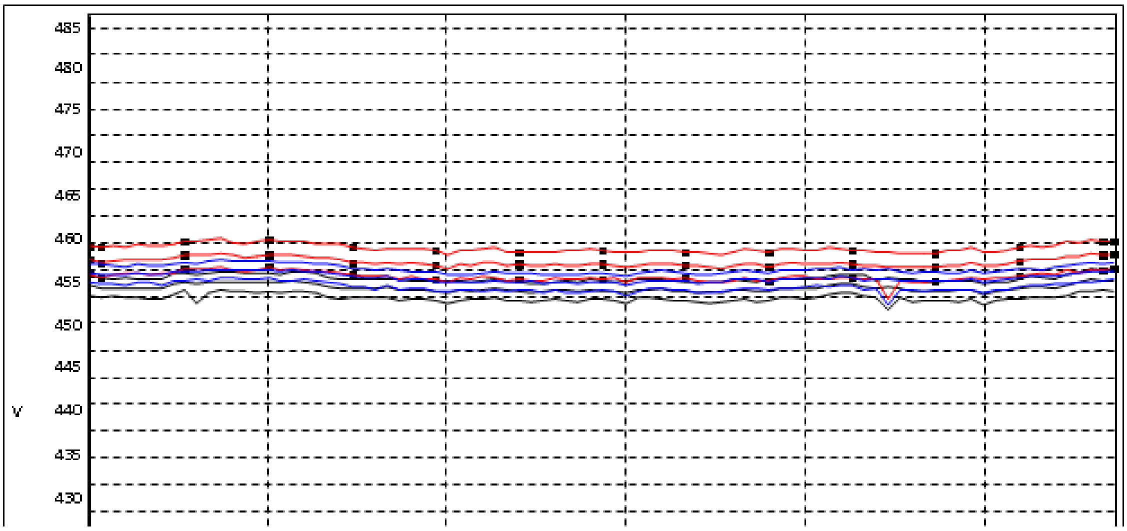


Figure 4-10 voltage graph of 1250KVA transformer 2

Table 4-11 Voltage profile of Transformer - 1250 KVA 2

Urms	Urms	Urms	Average	%age
Line 1	Line 2	Line 3		im-balance
436.653	441.416	438.539	438.9	1.09

Imbalance voltage

The unbalanced voltage is 1.09 % which is under the prescribed limit as per IEEE standards. An unbalance of 2% is acceptable as it doesn't affect the cable.

4.3.2.2 Current profile

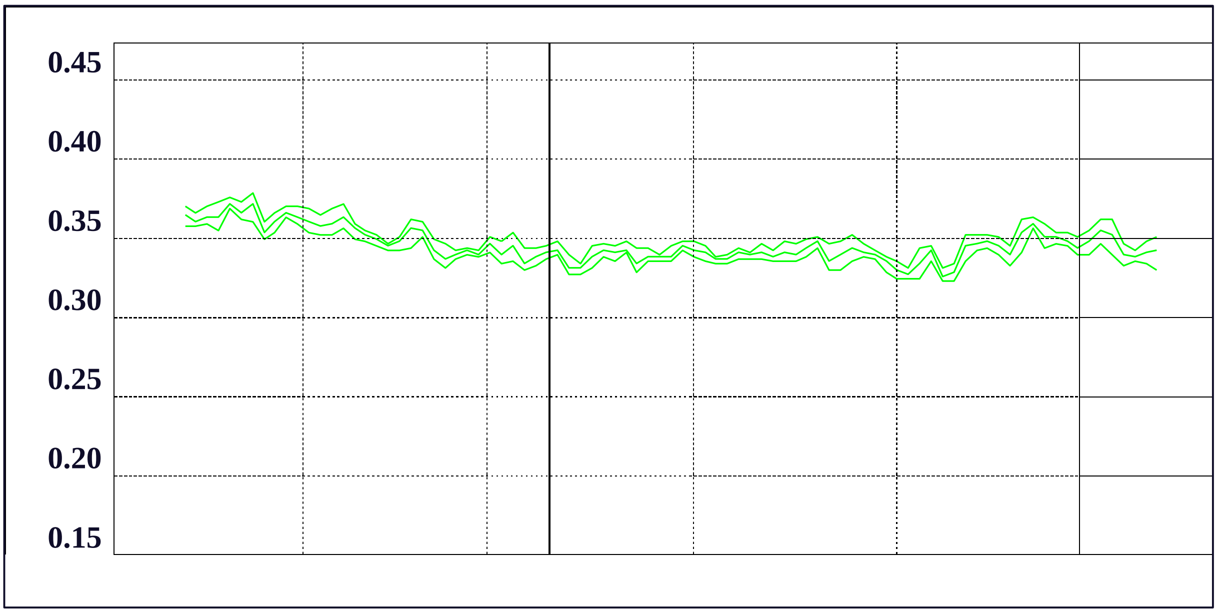


Figure 4-11 Current graph of 1250KVA transformer 2

Table 4-12 Current profile of 1250KVA transformer 2

Arms	**Arms**	**Arms**	**Average**	**%age**
Line 1	**Line 2**	**Line 3**	**833.0**	**im- balance**
923	**782.674**	**793.188**		**16.85**

Imbalance current

The unbalance current was observed to be 16.85 %. Being the load on the transformer is very less. The large current unbalance at no load/low load is quite common and does not indicate any fault. Any large single-phase load, or a number of small loads connected to only one phase cause more current to flow from that particular phase causing voltage drop on line. All the single-phase loads should be distributed on the three-phase system such that they put equal load on three phases.

4.3.2.3 Voltage profile of transformer 2&3- 750 KVA

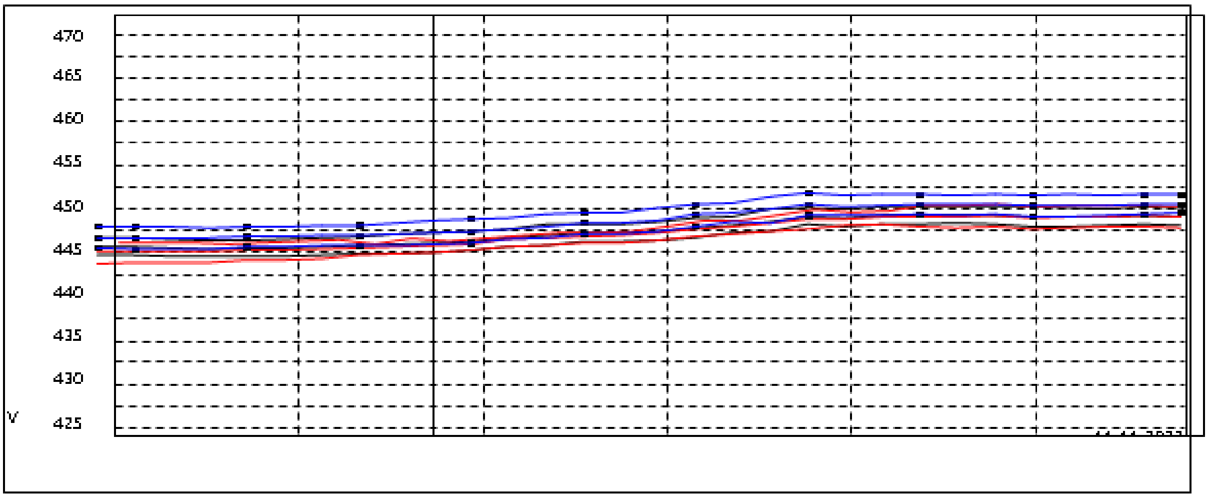


Table 4-13 Voltage profile of 750KVA transformer 3

Urms	Urms	Urms	Average	%age
Line 1	Line 2	Line 3	440.6	im- balance
439.03	442.72	439.956		0.84

Figure 4-12 Voltage graph of 750KVA transformer 3

Imbalance voltage

The unbalanced voltage is 0.84% which is under the prescribed limit as per IEEE standards. An unbalance of 2% is acceptable as it doesn't affect the cable.

4.3.2.4 Current profile

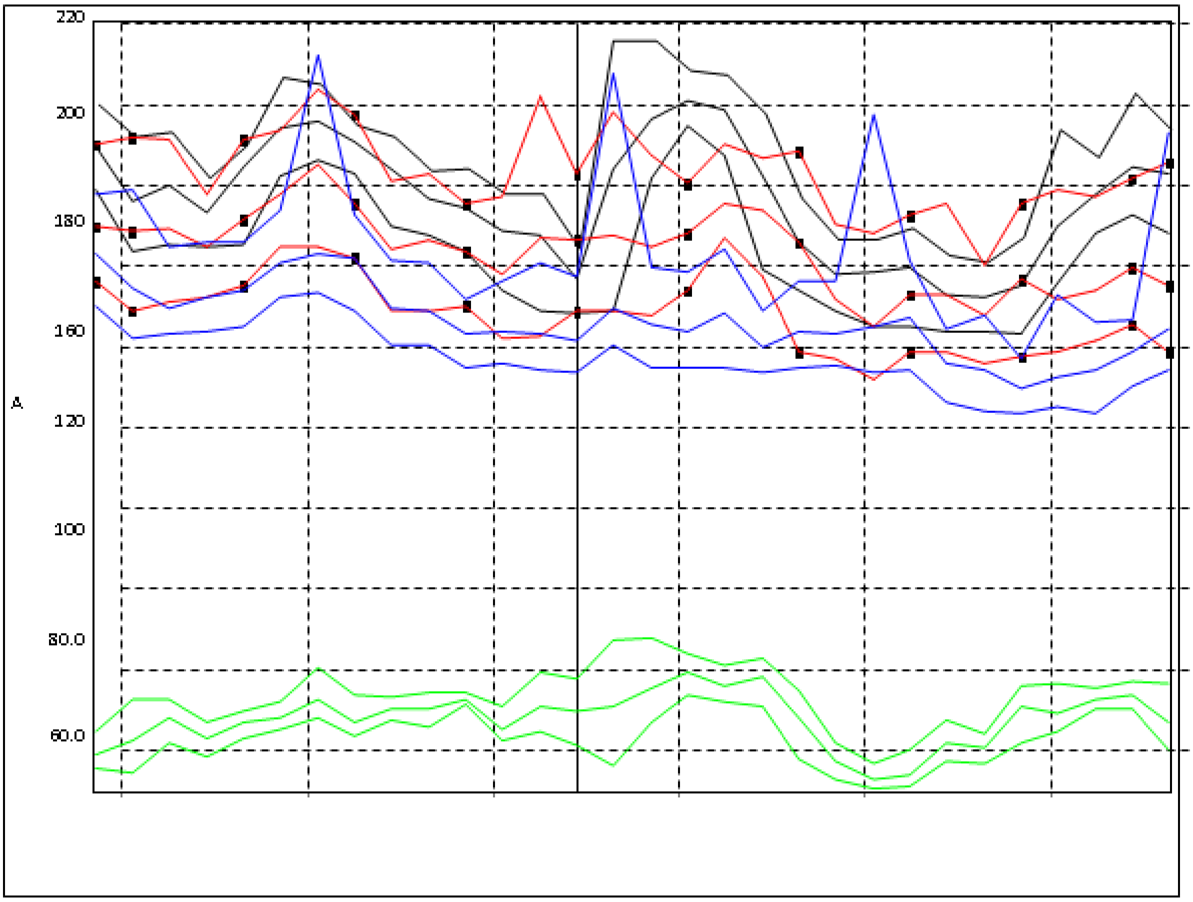


Figure 4-13 Current graph of 750kva Transformer 3

Table 4-14 Current profile of 750kva Transformer 3

Arms	Arms	Arms	Average	%age
Line 1	Line 2	Line 3		im-balance
195.817	308.223	206.022	236.7	47.49

Imbalance current

An unbalanced load occurs when there is significantly more power drawn. This can lead to the overheating of the electrical components and possibly over loading the panel.

The unbalance current was observed to be 8.6%. It does not indicate any fault. Any large single-phase load, or a number of small loads connected to only one phase cause more current to flow from that particular phase causing voltage drop on line. All the single-phase loads should be distributed on the three-phase system such that they put equal load on the transformer**.**

4.3.3 Mechanical systems

The assessment included evaluating mechanical systems such as water pumps, compressors, and ventilation fans. These systems were found to be in good condition. However, periodic maintenance is essential to maintain their efficiency and ensure optimal performance.

4.3.4 Building envelope

The inspection of the building envelope, which includes walls, roofs, windows, and doors, revealed that the insulation and sealing are generally adequate. However, there are opportunities to improve energy efficiency by enhancing insulation in certain areas. Improving insulation and sealing can significantly reduce energy loss and improve overall energy efficiency.

4.3.5 Office/classroom equipment

The review of energy consumption by office equipment (computers, printers, etc.) and classroom equipment (projectors, smart boards, etc.) indicated that most devices are relatively energy-efficient. However, upgrading to more energy-efficient models and implementing policies for turning off equipment when not in use can further reduce energy consumption.

By implementing these measures, SRHU can significantly enhance its energy efficiency, reduce operational costs, and minimize its environmental impact. Regular monitoring and maintenance will ensure sustained improvements and help maintain the efficiency of infrastructure and equipment.

4.3.6 Water pumping system

The building has made the provision for storage of 359000 L. of water per day in PVC tanks placed on the roof top of the buildings for the facility of the staff and students in the university and hostels by pumping with two submersible pumps of 33HP each installed near stage area Each pump runs 7-8 hour a day.

4.3.6.1 Sewage treatment plant

In a sewage treatment plant, the initial step involves passing sewage water through screens or a grit chamber to remove large solids. The effluent from this primary treatment contains about 45-50% unstable organic matter. This effluent then undergoes secondary treatment, where fine solids are removed through bacterial action, followed by secondary sedimentation. For tertiary treatment or disinfection, processes such as sand filters and reverse osmosis are employed. During sludge digestion in a tank, combustible gases like methane (CH4) and carbon dioxide (CO2) are released, which can be utilized as fuel. The digested sludge can either be incinerated or repurposed as fertilizer. Additionally, the plant has installed two 18 hp blowers, with one serving as a standby. Auditors have inspected and measured various motors and pumps within the facility.

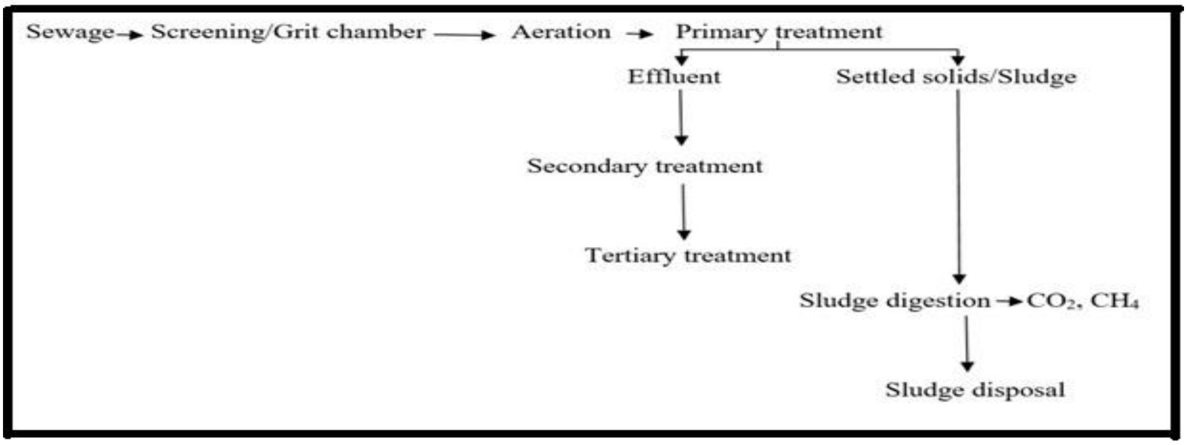


Figure 4-14 Process flow of sewage treatment plant

Power consumption of submersible pump and STP pump set

During the audit power consumption of 33 hp submersible pump installed near stage area was measured the auditors measured the power consumption of the motor pump and measured details are shown below: -

Table 4-15 PUMP-33HP Measured Data

Volts	Amps.	PF	KW
420.63	56.81	0.565	23.38
414.30	50.34	0.568	20.52
414.99	56.66	0.6	24.45
416.64	**54.61**	**0.578**	**22.78**

Table 4-16 Blower -18 hp measured data

VOLTS	AMPS	PF	POWER
443	27.3	0.62	12.99
449	23	0.62	11.09
395	27.2	0.74	13.77
429	**25.83**	**0.66**	**12.62**

Table 4-17 Filter water pump- 15 hp measured data

VOLTS	AMPS	PF	POWER
414	9.7	0.9	6.26
439	12	0.98	8.94

409	11	0.9	7.01
420	**10.90**	**0.926667**	**7.40**

Table 4-18 Sludge recirculation pump

VOLTS	AMPS	PF	POWER
449	2.2	0.84	1.44
447	2.2	0.76	1.29
454	1.9	0.75	1.12
450	**2.10**	**0.783**	**1.28**

Load of pump and efficiency of water pump & STP:

Based upon head, measured flow and measured load, the auditors calculated efficiency/ power of motor pumps as follows

Table 4-19 Performance monitoring of sewage treatment plant

Description	W/Pump	STP-Filter water pump
Head-M	40	10
Measured flow-M3/hr	60	55
Measured power-KW	19.5	7.4
Hydraulic power-KW	6.54	1.498
Overall efficiency-%	33.54	20.25
Pump efficiency-%	42	25

Figure 4-15 STP plant in the campus

Overall efficiency of 33 hp water pump sets is satisfactory. The efficiency of STP Filter water pump of 15 hp is found low it is recommended to replace the said existing pump set with BEE star rated energy efficient pump set. Replacement of existing inefficient STP filter water pump set with energy efficient BEE 5star rated pump set.

4.3.6.2 Energy saving calculations

Table 4-20 Energy saving calculations for STP plant

Energy Saving Calculation		Units	water Pump
STP filter water pump set	=	Nos.	1
Annual Energy consumption of pump set for STP as (19000x4.2x250)/1000=19950	=	kWh	19950
Saving Potential after replacing existing motor pump setswith BEE star rated energy efficient pump set of three phase 15hp @ 25 %	=	KWh	4806
Cost Benefit Analysis			
Per Unit cost		Rs.	6.66
Annual Monetary Savings (4806x6.6)	=	Rs.	32009
Investment for replacing with BEE star rated energy efficient 3 phase 11 kw with flow 65 m3/hr. motor pump sets complete in all respect.	=	Rs.	75000
Simple payback period (75000/32009)	=	Years	2.3

The payback period is would be 75000/32000=2.3 years. Since the product life is much more than that, the move is economically beneficial.

4.3.7 Lift system

17 No.s. Passenger lifts have been provided for comfort of students and staff.

13 Nos lifts of make Schindler ,3 No.s of Johnson make and 1 No.s of North star make lifts provided in Block-3, 4,5,6,8, and 9. Table 4.15 shows the rated parameters of the lift

Table 4-21 Rated parameters of lift

Make	**JOHNSON**
Motor	3 phase squirrel cage induction
Motor voltage	380 V ±5%
Motor - Nominal current	17.5A
Motor capacity	7.7 kW
Car speed	1.25m/s


Figure 4-16 Jhonson lift & motor.

Power measurement data

Table 4-22 Summary of all the measurement data

v	A	PF	KW	REMARKS
435.2	11.3	0.762	6.490	lift on load moving down ward
432	10	0.668	4.998	lift on load moving upward
431	0.512	0.65	0.248	lift on no load

The lift is operating very efficiently. The auditors do not find any saving in it. Therefore, Energy saving potential –Nil.

Data analysis for lift:

The lift is operating very efficiently. The auditors do not find any saving in it. Therefore, Energy saving potential –Nil.

4.4 LIGHTING SYSTEMS & OTHER POWER CONSUMPTIONS

4.4.1 Street lights & flood lights

Streets lights are the important part of in energy management. It is absorbed that the institution has adopted 20% of solar street lights of their total need.

4.4.2 Calculations for street lights

The following table details the calculations for energy consumption and potential savings associated with street lights and flood lights on campus

Table 4-23Calculation of Street Lights

Description	Quantity	Wattage (W)	Total Wattage (W)
30w street light	250	30	7500
45w street light	51	45	2295
50w flood light	70	50	3500
150w flood light	30	150	4500

Total street lights used in the campus	401		17795w
One unit of electricity		1000 W/h	
Operating hours per day		12 hours	213540WH
Units consumed in one day			213.5
Units consumed in one month			18435
Electrical charges for one month			Rs. 18435(@5.85/unit)
Cost of installing 401 solar street lights (220W each)			Rs. 1,07,844
Total cost of replacement			**Rs. 1203000**

From the above calculations, it is observed that there is significant potential for cost savings by installing solar street lights. Replacing the normal street lights and flood lights with solar-powered, ones would cost about Rs. 1203000, with a monthly saving of Rs. 1,07,844. Thus, the payback period would be approximately 11 months i.e. within 01 year itself.

4.4.3 Benefits of using solar street lights

- **Automatic Operation**: Solar LED flood lights are powered by sunlight, turning on at dusk and off at dawn automatically. Equipped with a built-in 12000mAh LifePO4 battery, they can provide continuous lighting for up to 15 hours once fully charged.
- **High Efficiency**: The 200W solar flood light comes with 918SMD 5730 chipset LEDs, offering up to 15 hours of continuous and bright lighting. The automatic sensor switch ensures it turns on at night and off in the morning, making it an economical and innovative lighting solution.
- **Energy Saving**: These lights can convert up to 19% of sunlight into electricity, sustaining ample battery life even under rainy weather. Using solar flood lights is a smart, eco-friendly choice.
- **Easy Installation**: Solar flood lights for home outdoor use are wireless and can be self-installed. They can be easily mounted on walls or poles using the included screws.
- **Durability and Weather Resistance**: Solar rechargeable flood lights are extremely durable, constructed with ABS material, and designed to be IP65 waterproof. They can withstand extreme weather conditions, making them suitable for patios, lawns, gardens, decks, yards, driveways, and fences.
- **Maintenance free**: Solar lights are relatively maintenance free with almost zero finance involvement. Only regular cleaning of solar panel with de-ionized water is required which is a low-cost affair.

By implementing these recommendations, SRHU can significantly enhance its energy efficiency, reduce operational costs, and minimize its environmental impact. Regular monitoring and maintenance will ensure sustained improvements and help maintain the efficiency of lighting systems and other power consumptions.

4.5 INDOOR LUX LEVEL

A high-quality DIGITAL LUX METER was used to measure the illumination levels at various locations of SRHU University. The recommended lighting levels for these areas are provided in the table below

Table 4-24The recommended light level as per standard

Location	Recommended LUX
Normal work station space, open or closed office	500
Conference Rooms	300
Training Rooms	500
Internal Corridors	200
Auditorium	150-200
Entrance Lobbies, Atria`	200
Stairwells	200
Toilets	200
Dining Area	150-200

4.5.1 Lux level of different indoor locations in the campus

The university authorities provided details of luminaries installed within their building premises. The auditors surveyed the area and compared the type of fittings, their height, and type of reflectors. During Audit, it was observed that university is LED lights.

- Lack of proper cleaning of lighting fixtures was observed resulting in lower ILER and Lux Levels.
- As per study findings of Lux, it is recommended for converting the existing installation to use more efficient lighting equipment.

4.5.2 Lighting details & motion sensors

Lighting is the biggest energy consuming area. The lights installed in the campus is given as follows:

Table 25 Lighting details of campus

Sl. No.	Location	2x16 W LED	16 W D.L	20 watt LED	18 Watt LED	12 w LED Bulb	(2'x2') 36 W	Surface Light-12 W LED	2'x2' 48 Watt	30 watt Street Light	45 Watt Street Light	Flood Light 50 watt	Flood Light 150 watt
					Corridor		Recessed						
1	Himalayan School of Scienece & Technology (HSST)	299	274		148		32						
2	Himalayan School of Management Studies (HSMS)	299	274		148		32						
3	Himalyan Hospital_New OPD Building				1746(4' long)								
4	Activity center (Creche / Shoping Mall)		270		37			110					
5	Himalayan Hospital, Laboratory, Central Library building		600		310		100		934				
6	Cancer Research Institure (CRI)						183						
7	Himalayan Institute of Medical Sciences (HIMS)				127	49	42		49				
8	Himalayan University of Nursing (HCN)				25		49		32				
9	Himalayan school of Yoga Sciences (HSYS)				101								
10	Himalayan School of Bio sciences (HSBS)				154	33							

11	Trauma Center Hospital		195		20		100						
12	Campus Lighting									250	51	70	30
13	WWR			209									
14	WMR			150									
15	New PG Hostel (Boys & Girls)			258									
16	Old PG hostel			109									
17	MBBS Hostel			700									
18	Residence			350									
	Total Qty	**598**	**1613**	**1776**	**2816**	**82**	**538**	**110**	**1015**	**250**	**51**	**70**	**30**
	Total Watt	19136	25808	35520	50728	984	19368	1320	48720	7500	2295	3500	4500
					Total KW		**219.4**						

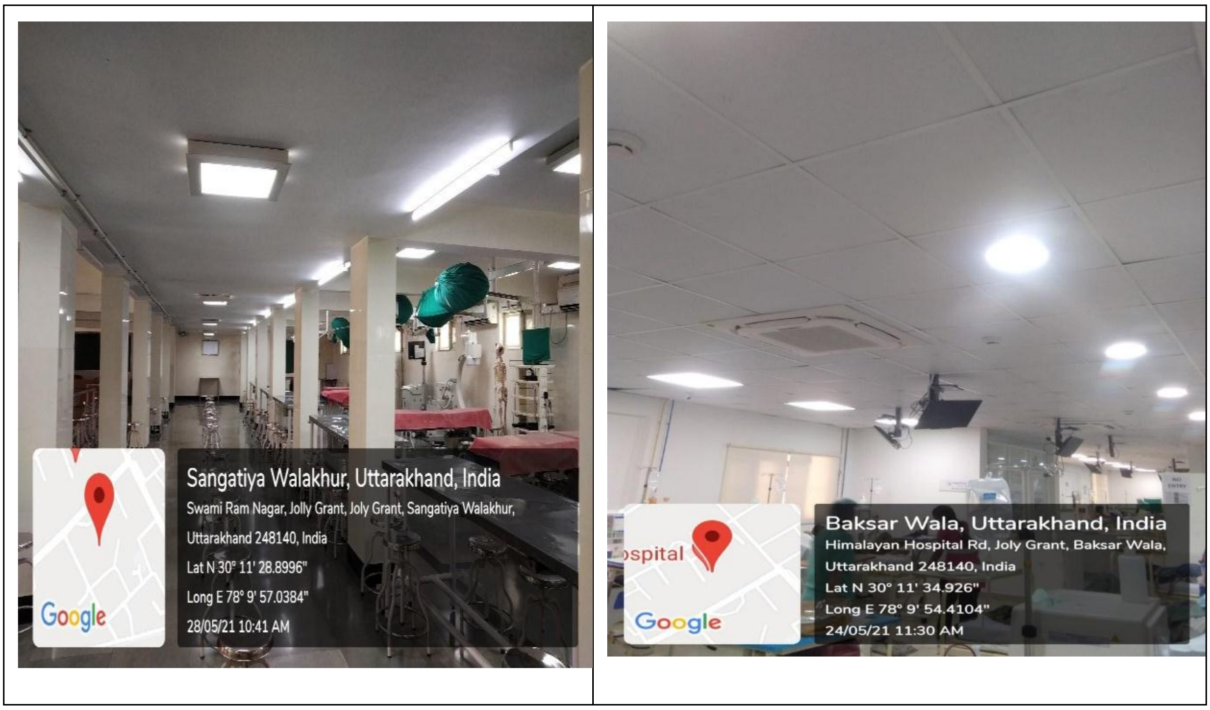


Figure 4-17 LED lights used in campus

The Occupancy sensor detects presence of people in the target monitored area. They provide convenience by turning lights on automatically when someone enters a room, and save energy by turning lights off room or reducing light output when a space is unoccupied.

The motion sensor responds to moving objects only. The difference between them is occupancy sensor produce signals whenever an object is stationary or not while motion sensor is sensitive to only moving objects. These types of sensors utilize some kind of a human body's property or body's actions. For instance, a sensor may be sensitive to body weight, heat, sounds, dielectric constant and so on. Occupancy sensors differ from motion sensors in that they don't require significant motion in order to work. Their purpose is not to detect motion, but to detect whether people are present, even if they're not moving around. Many occupancy sensors will use a combination of sensors and various technologies.

The study shows that there are cases, where lights are on even when there's no occupancy in the room, thus un necessary wastage of electricity as such it becomes necessary to use occupancy sensors to overcome this loss. PIR (passive infrared) motion sensor switches are energy saving devices which detects movement-based occupancy and keep the connected load like lights, fan air conditioner etc. ON, it shuts of the appliances, when its detection area is vacant. It is useful for energy saving. The university have increased its motion sensors capacity by 5%. So, the university have overall 57% of motion sensors installed in the building. However, it is recommended to install 100% of motion sensor in the building. The power saving calculations are given below.

Let lights in the operate motion sensor. = 288

Power consumed by single light = 18W

Total power consumed by all the lights during the day (18Wx288x8Hx0.9) = 29030WH

If all the lights are connected to the motion sensors the operation time of the lights are reduced to 4Hr

So, total energy consumed by the university (18Wx290x4Hx0.9) = 19000WH

Total energy saved per day = 20000 WH (approx.)

Total energy saved per month = 62 KWH

Total energy saved per year = 744 KWH

Total monetary saving per year = Rs. 5000 (approx.)

Cost of installation of remaining 100 motion sensors = Rs. 20000

So, the payback time would be 4 years

4.6 USE OF BLDC FANS

During the audit, it was observed that the university have installed 2200 numbers of BLDC fans & 2500 numbers of normal fans. It is recommended to replace 50% with BLDC fans for better energy efficiency. The energy saving calculation for BLDC fans is provided below:

Table 4-26: Energy Saving Calculation of BLDC fans

Energy Saving Calculation		**Units**	**Value**
Total Number of fittings	=	Nos.	1250
Annual electricity Consumption of 75-watt normal fan (1250nox75wx7hrx200daysx0.75LF/1000=82.5Kwh)	=	KWh	98437.5
Annual electricity Consumption of proposed 28W BLDC Fans (1250nox28wx7hrx200daysx0.75LF/1000=82.5Kwh)	=	kWh	36750
Cost Benefit Analysis			
Proposed Annual Energy Savings potential	=	kWh	61687.5
Per Unit cost	=	Rs.	5.85
Proposed Annual Monetary Savings	=	Rs.	360871.8
Investment/ fixture (including replacement cost)	=	Rs.	1500
Total Investment	=	Rs.	1875000
Simple Payback Period	=	Years	5.1

From the above data, it is seen that the university has 2500 normal fans. According to our recommendation, the university should replace at least 50% of these normal fans with BLDC fans. The cost of replacement would be Rs. 1875000. The annual monetary savings would be Rs.360871.8. The payback time would be 5.1 years.

Implementing these changes will not only lead to significant energy savings but also improve the overall efficiency and sustainability of the university’s operations.

4.6.1 AC Systems

The evaluation of heating, ventilation, and air conditioning (AC) systems at SRHU revealed several inefficiencies in energy consumption. The AC systems are critical for maintaining a comfortable environment within the campus buildings but are also significant energy consumers. The audit indicated that the existing AC units are not operating at optimal efficiency. Many of the units are older models that lack modern energy-saving features. During peak usage times, the AC systems were found to consume a substantial portion of the campus's total energy, contributing to high energy bills and increased operational costs. Temperature control across different areas of the campus was inconsistent, with some areas experiencing overcooling or overheating, indicating potential issues with the HVAC system's zoning and control mechanisms. During audit it is found that the campus has installed total 900 numbers of 3-star AC

4.6.1.1 Benefits of 5-star rating inverter type air conditioners

Every air conditioner comes with a BEE star rating label that indicates its efficiency. ACs are rated on a scale of 1-5, with 5-star ACs being the most energy-efficient. Investing in 5-star air conditioners, though more expensive initially, can lead to significant energy savings over time. The BEE star rating is determined by the Indian Seasonal Energy Efficiency Ratio (ISEER) or Energy Efficiency Ratio (EER). Higher values of these ratios correspond to higher star ratings and greater energy savings.

Figure 4-18 Air conditioner used in the campus

The government mandates BEE star ratings for most home appliances, including air conditioners, washing machines, refrigerators, and microwave ovens. Over the years, BEE has made the star ratings more stringent. For example, an AC with a 5-star rating in 2018 may not even qualify for a 1-star rating in 2023 due to updated efficiency standards.

Table 4-27 Consumption table of different star rating AC

AC type Non-Inverter/Inverter	0.75 Ton	1 Ton	1.5 Ton	2 Ton
3 Star Non-inverters	627	828	1235	1548
3 Star Inverter	550	726	1077	1344
5 Star Non-inverters	576	760	1130	1412
5 Star Inverter	421	557	815	1005

. It is recommended to replace these with more efficient 5-star inverter ACs.

By implementing these recommendations, SRHU can improve its energy efficiency, reduce operational costs, and minimize its environmental impact. Regular monitoring and maintenance will ensure sustained improvements and help maintain the efficiency of infrastructure and equipment.

4.7 POWER FACTOR

Apart from safety and reliability, several other goals, including efficiency, should be pursued in the design and implementation of electrical systems. One of the measures of efficiency in an electrical system is the efficiency with which the system transforms the energy it receives into useful work. This efficiency is indicated by a component of electrical systems known as the Power Factor. The power factor indicates how much power is actually being used to perform useful work by a load and how much power it is “wasting”. As trivial as its name sounds, it is one of the major factors behind high electricity bills, power failures, and sometimes the imbalance in electrical networks.

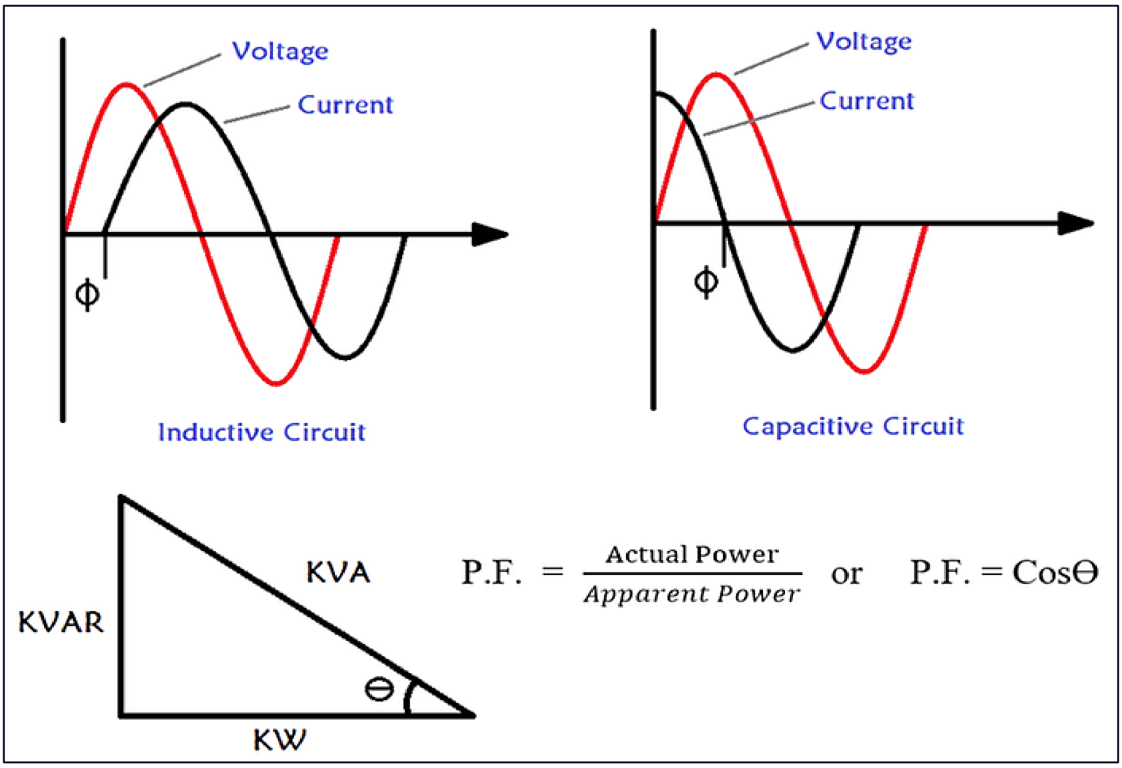


Figure 4-19 Power Factor Waveform

To properly describe power factor and its practical significance, it is important to understand the different types of electrical loads and components of power that exist.

From basic electricity classes, electrical loads are essentially of two types:

1. **Resistive Loads**
2. **Reactive Loads**

Resistive Loads

Resistive loads, as the name implies, are made up of purely resistive elements. For these loads (considering ideal conditions), all the power supplied to them is dissipated for useful work because the current is usually in phase with the voltage. Examples of resistive loads include incandescent light bulbs and batteries.

Reactive Loads

Reactive loads, on the other hand, are more complex. While they cause a drop in voltage and draw current from the source like resistive loads, they dissipate no useful power (no work is done). Reactive loads can either be capacitive or inductive. In inductive loads, the power drawn is used to set up magnetic flux without any direct work performed, while in capacitive loads, the power is used in charging the capacitor and not directly producing work. The power dissipated in reactive loads is referred to as reactive power. Reactive loads are characterized by the current leading (capacitive loads) or lagging (inductive loads) behind the voltage, resulting in a phase difference between the current and the voltage.

Relationship between Voltage and Current for an Inductive Load

The variations in these two types of loads lead to three power components in electrical systems:

1. **Actual Power**
2. **Reactive Power**
3. **Apparent Power**

i. **Actual Power** This is the power associated with resistive loads. It is the power component dissipated for performing actual work in electrical systems, such as heating and lighting. It is expressed in Watts (W) and symbolically represented by the letter P.

ii. **Reactive Power** This is the power associated with reactive loads. Due to the delay between voltage and current in reactive loads (either capacitive or inductive), the energy dissipated produces no work. It is referred to as reactive power and its unit is Volt-Ampere Reactive (VAR).

iii. **Apparent Power** Typical electrical systems comprise both resistive and inductive loads. Thus, the total power in an electrical system is a combination of the actual and reactive power components, known as Apparent Power. Its unit is volt-amps (VA) and it is represented mathematically by the equation:

Apparent Power=Actual Power +Reactive Power

This combination leading to the apparent power is what brings about the power factor. In ideal situations, the actual power dissipated in an electrical system is usually greater than the reactive power.

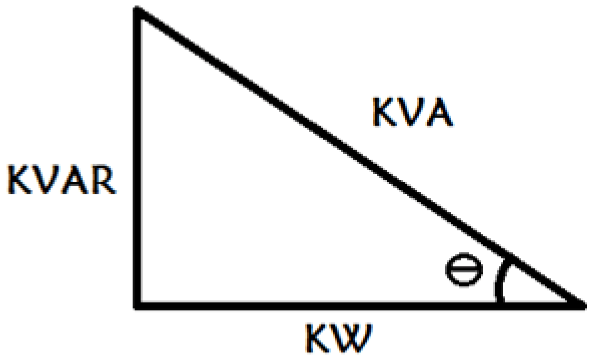


Figure 4-20 Power Triangle

By obtaining the cosine of the angle theta, we can determine the efficiency of the system in using the power it receives for work. This efficiency, evaluated as the ratio of the actual power to the apparent power, is referred to as the power factor, with values between 0 and 1. From the power triangle, according to the cosine rule (Adjacent over Hypotenuse), the power factor can be estimated as the ratio of actual power to the apparent power:

P.F. = Actual Power / Apparent Power or P.F. =Cosϴ

An increase in reactive power (presence of a high number of reactive loads) leads to an increase in apparent power and a larger value for angle theta, resulting in a low power factor. Conversely, a reduction in reactive loads leads to an increased power factor, indicating high efficiency in systems with fewer reactive loads.

4.7.1 Power Factor According to Uttarakhand State Electricity Regulatory Commission (UPCL)

- The power factor of electricity consumers is monitored to ensure efficient energy usage. A power factor below the optimal level can lead to increased losses in the electrical system. To address this, the Uttarakhand Power Corporation Limited (UPCL) implements surcharges for low power factors and offers incentives for maintaining higher power factors.
- Surcharges for Low Power Factor:
- Consumers without Electronic Tri Vector Meters: If such consumers have not installed shunt capacitors of appropriate ratings and specifications, a surcharge is levied on the current energy charges.
- Consumers with Electronic Tri Vector Meters:

- A surcharge of 5% on current energy charges is applied for a power factor below 0.90 and up to 0.85.
- A surcharge of 10% on current energy charges is applied for a power factor below 0.85.
- Incentives for High Power Factor:
- While specific incentives for maintaining a high-power factor are not detailed in the provided sources, consumers are encouraged to maintain an optimal power factor to avoid surcharges and potentially benefit from lower energy losses and improved efficiency.
- It's important to note that these regulations are subject to change. For the most current information, consumers should refer to the latest tariff orders and notifications issued by UPCL and the Uttarakhand Electricity Regulatory Commission (UERC).

4.7.2 Solution to the Power Factor Problem

To improve the power factor, it is recommended to install an Automatic Power Factor Control (APFC) panel that can maintain the power factor above 0.9 and help generate power factor incentives, reducing the electricity bill. The university has already installed an APFC panel with a capacity of 500 KVAR, but it is recommended to increase the capacity to 100 KVAR.

Example Calculation

Let the bill amount	=	Rs. 20000
From load list avg. PF	=	0.75
Desired power factor	=	0.9
For 0.9 to 0.8 % cap. Charge	=	10 x 1% = 10%
For 0.8 to 0.75 % cap. Charge	=	5 x 2% = 10%
So, total cap. Charge would be	=	10+10% = 20%
If power factor is 0.9 then reduction in bill would be		
20% of total bill amount	=	16000
So reduced bill amount	=	331980-265584= Rs. 4000
After using the APFC panel the average power factor will be 0.97.		
So, total hike in power factor	=	7%
According to para SXI. 6.2 Power Factor Incentive will be 0.25% for increase of 0.01		
So, 7% of Rs. 16000 rebates will be	=	Rs. 1400
Total bill amount	=	Rs. 14600
Total saving after installing APFC panel	=	Rs. 6000
Cost of installing APFC panel	=	Rs. 32000 approx.

4.7.1 Calculations of APFC for the university

During the Audit process the power factor of the university comes out to be 0.98 which is quite which is quite good as there are 6 APFC installed of following capacity

S.No.	Capacity of APFC (in KVAR)	QTY.
1.	450	1
2.	350	1
3.	200	1
4.	250	3

4.8 DIRECT DEMAND MONITORING & CONTROL SYSTEM

Maximum demand tends to reach present limit, shedding some of non-essential loads temporarily can help to reduce it. It is possible to install direct demand monitoring & control system, which will switch off non-essential loads when a present demand is reached. Simple system gives an alarm, and the loads are shed manually. Sophisticated microprocessor-controlled system is also available, which will provide a wide variety of control options like:

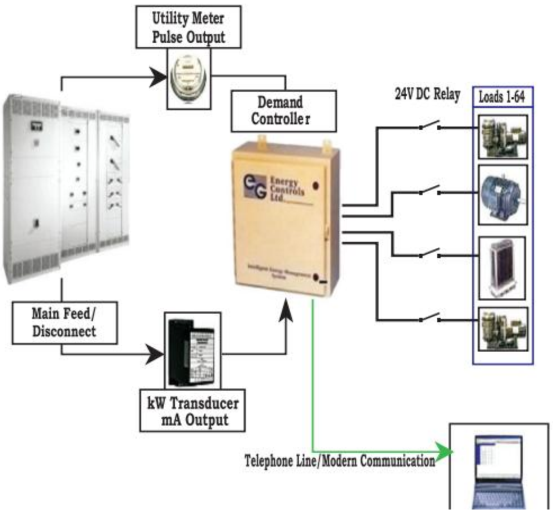


Figure 4-21 Direct demand monitoring

- Accurate prediction of demand
- Graphical display of present load, available load, demand limit.
- Visual and audible alarm
- Automatic load shedding in predetermined sequence.
- Automatic restoration of load

4.9 SUGGESTIONS FOR POWER SAVING

Following the comprehensive Swami Rama Himalayan University (SRHU), several key recommendations have been identified to enhance energy efficiency and sustainability across the campus. Implementing these recommendations will lead to significant energy savings, reduced operational costs, and a minimized environmental footprint.

1. Lighting Systems (Indoor & Outdoor)

The existing indoor lighting systems in campus are LED and some Florescent It is recommended to replace these with the LED lights and all the exterior street lights with the solar lights.

2. Fans

The evaluation of fans on the campus highlighted the potential for energy savings through the replacement of 50% of 1250 normal fans with energy-efficient BLDC fans. This replacement would cause in the significant reduction in the energy bills.

3. AC Systems

The AC systems at SRHU are critical for maintaining a comfortable environment but are significant energy consumers. The audit revealed inefficiencies in the current systems, many of which are older models and less star rating, lacking modern energy-saving features. It is recommended to:

- Replace older AC units with more efficient 5-star inverter ac.
- Install programmable thermostats to optimize operations and reduce unnecessary energy use.
- Conduct regular maintenance to ensure optimal performance and longevity of AC systems.

4. Power factor

The current power factor of the SRHU is 0.98 which is quite good, and no further change is needed.

5. Direct demand monitoring & control system

Installation of direct demand monitoring & control system for maintaining the contract demand by shredding of the non-essential loads when the present demand limits are reached.

6. Electricity Consumption

To optimize electricity consumption, the following measures are recommended:

- Optimize the tariff structure with utility supplier.
- Schedule your operations to maintain a high load factor.

- Shift load to off peak time if possible.
- Minimize maximum demand by tripping loads through a demand controller.
- Stagger start up times for equipment with large starting currents to minimize load peaking.
- Use standby electric generation equipment for on peak high load periods.
- Correct power factor to at least 0.90 under rated load condition.
- Relocate transformers close to main loads.
- Set transformer taps to optimum settings.
- Disconnect primary power to transformers that do not serve any active loads.
- Consider on site electric generation or cogeneration.
- Export power to grid if you have any surplus in your captive generation.
- Check utility electric meter with your own meter.
- Shut off unnecessary computers, printers & copiers at night.

7. Motors

To improve motor efficiency and lifespan, the following actions are recommended:

- Properly size to the load for optimum efficiency.
- High efficiency motors offer of 4-5% higher efficiency than standard motors.
- Use energy efficient motors were economical.
- Use synchronous motors to improve power factor.
- Check alignment.
- Provide proper ventilation.
- For every 10 ℃ increase in motor operating temperature over recommended peak, the motor life is estimated to be halved.
- Check for under voltage and over voltage conditions.
- Balance three phase power supply.
- An imbalance voltage can reduce 3-5% in motor input power.
- Demand efficiency restoration after motor rewinding.

8. Pumps

To optimize pump performance and energy efficiency, the following recommendations are made:

- Operate pumping near best efficiency point.
- Modify pumping to minimize throttling.

- Adapt to wide load variation with variable with variable speed drives or sequenced control of smaller units.
- Stop running both pumps, add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressure.
- Increasing fluid temperature differentials to reduce pumping rates.
- Repair seals and packing to minimize flow and reduce pump power requirements

Implementing these recommendations will help SRHUs achieve significant energy savings, reduce operational costs, and minimize their environmental footprint, fostering a more sustainable campus environment.

4.10 CONCLUSIONS

The energy audit conducted at SRHU revealed several key findings and recommendations that, if implemented, can significantly enhance the institution's energy efficiency and sustainability. This detailed analysis has identified major energy-consuming areas, inefficiencies in current practices, and potential areas for significant savings.

The audit revealed that lighting, AC systems, and electrical equipment are the primary energy consumers on the campus. The current AC systems are not operating at optimal efficiency. Upgrading to modern, energy-efficient units, along with regular maintenance and the use of programmable thermostats, can greatly enhance performance and reduce energy use.

SRHU has already made strides in integrating renewable energy by utilizing solar power. Solar energy is one of the most widely used renewable source of energy one can use renewable energy technologies to convert solar energy in to electricity, it is very reliable source of energy and can significantly reduce the electricity bills as such university have already installed the solar power plant of 2.5MW and 450 numbers of solar water heaters of 2KW capacity each.

There shall be considerable amount of energy saving by retrofitting of some conventional ceiling fan with the energy efficient BLDC ceiling fan of new technology. It is seen that university has 2200 numbers of BLDS fan installed and 2500 number of normal fans. The evaluation of fans on the campus highlighted the potential for energy savings through the replacement of 1250 normal fans with energy-efficient BLDC fans.

Additionally, the audit identified opportunities to enhance the energy management system on campus. Implementing a robust system for real-time monitoring and control of energy usage will ensure sustained efficiency improvements. This system should include practices such as regular energy audits, continuous performance tracking, and the adoption of energy-efficient practices across all campus operations.

4.11 ENVIRONMENTAL IMPACT ASSESSMENT ASSOCIATED WITH ENERGY RESOURCES

The environmental impact assessment of Swami Rama Himalayan University (SRHU) aims to evaluate the campus's environmental footprint and identify opportunities for enhancing sustainability. This assessment focuses on several key areas, including carbon footprint, air quality, water usage, waste management, and biodiversity. By understanding and addressing the environmental impacts associated with its operations, SRHU can implement effective strategies to promote a greener and more sustainable campus.

4.11.1 Carbon footprint

The energy audit conducted at SRHU highlighted the campus's carbon footprint, which is influenced by its energy consumption patterns. The use of grid electricity, diesel generators, and other fossil fuel-based energy sources contributes to greenhouse gas (GHG) emissions. The integration of renewable energy sources, particularly solar panels, has significantly mitigated the carbon footprint. The current solar installations have reduced the reliance on grid electricity and diesel generators, thereby lowering GHG emissions. Continued investment in renewable energy and energy efficiency measures will further decrease GHG emissions.

4.11.2 Air quality

The operation of diesel generators has an impact on local air quality, releasing pollutants such as nitrogen oxides (NOx) and particulate matter (PM). Although the generators are essential for backup power, their use should be minimized to reduce air pollution. Solar energy systems do not produce air pollutants, making them a cleaner alternative to traditional energy sources. Regular maintenance of generators and the adoption of cleaner technologies are essential for reducing air pollutants.

CHAPTER 5

DISCLOSURE OF CONSULTANT ENGAGED

5.1 INTRODUCTION ABOUT CONSULTANT

Ecoscience Consultancy is a reputed business house working in the field of environment in North India since 2022 with Vision & Mission of "Preventing pollution with Purpose-Bringing profit and goodwill in equal measure". The organization aims that the customers achieve effective compliance with legislation including a better public image and earn from waste. The company comprises of Ecoscience Consultancy - engaged in consultancy & analytical services; Ecoscience Consultancy - engaged in providing engineering solutions and Environment Matters – undertaking capacity building programs in the field of environment**.**

Ecoscience Consultancy - is a certified ISO 9001:2015 organization providing engineering & turnkey solutions for overall pollution abatement. Committed to a green planet, we strive to use our world-class resources to give environmentally safe solutions to our customers. We provide engineering and turnkey solutions for pollution control and recycling including:

- Sewage Treatment Plants.
- Effluent Treatment Plants.
- Ultra Filtration-RO Combination Systems for Effluent recycling.
- Wastewater Treatment Equipment's & Components- Aeration Systems.
- Disinfection Systems-Ozone/UV based.
- Sludge Handling Systems-Filter Press/Bags.
- Air Pollution Control Systems.
- Noise Attenuation.
- Solid Waste Management Systems- Ecoster.

KEY RECOGNITIONS/ACCREDITATIONS OF CONSULTANT

- ISO 9000:2015, ISO 14001:2015, ISO 45001:2018. ISO 50001:2015, ISO/IEC 17020:2012 certified.

QUALITY RESEARCH ORGANIZATION

Certificate of Registration

This is to certify that

ECOSCIENCE CONSULTANCY

LAKSHMI VIHAR COLONY, BAHADRABAD, HARIDWAR
UTTARAKHAND STATE -249402, INDIA.

has been independently assessed by QRO
and is compliant with the requirement of:

ISO 9001:2015

Quality Management System

For the following scope of activities:

PROVIDING EXPERT SOLUTION IN THE FIELD OF ENVIRONMENT MONITORING, WASTEWATER MANAGEMENT (ETP/STP INSTALLATION AND MAINTENANCE), THIRD PARTY AUDITS (FOR WASTE MANAGEMENT), GREEN AUDITS, ENERGY AUDITS, CARBON FOOTPRINT.

Date of Certification: 14th January 2025
1st Surveillance Audit Due: 13th January 2026
2nd Surveillance Audit Due: 13th January 2027
Certificate Expiry: 13th January 2028

Certificate Number: 305025011408Q

QUALITY RESEARCH ORGANIZATION

المجلس الوطني للاعتماد
EGAC
CAB # 011905

MEMBER OF MULTILATERAL RECOGNITION ARRANGEMENT IAF

Head of Certification

India Office : QRO Certification LLP
142, IInd Floor, Avtar Enclave, Near Paschim Vihar West Metro Station, Delhi-110063, (INDIA)
Website : www.qrocert.org, E-mail : info@qrocert.org

QRO
QUALITY RESEARCH ORGANIZATION

Certificate of Registration

This is to certify that

ECOSCIENCE CONSULTANCY

LAKSHMI VIHAR COLONY, BAHADRABAD, HARIDWAR
UTTARAKHAND STATE -249402, INDIA.

has been independently assessed by QRO
and is compliant with the requirement of:

ISO 14001:2015

Environmental Management System

For the following scope of activities:

PROVIDING EXPERT SOLUTION IN THE FIELD OF ENVIRONMENT MONITORING, WASTEWATER MANAGEMENT (ETP/STP INSTALLATION AND MAINTENANCE), THIRD PARTY AUDITS (FOR WASTE MANAGEMENT), GREEN AUDITS, ENERGY AUDITS, CARBON FOOTPRINT.

Date of Certification: 14th January 2025
1st Surveillance Audit Due: 13th January 2026
2nd Surveillance Audit Due: 13th January 2027
Certificate Expiry: 13th January 2028

Certificate Number: 305025011409E

EGAC
CAB # 011905

MEMBER OF MULTILATERAL RECOGNITION ARRANGEMENT IAF

Head of Certification

Validity of this certificate is subject to annual surveillance audits to be done successfully on or before 365 days from date of the audit.
(In case surveillance audit is not allowed to be conducted; this certificate shall be suspended / withdrawn).
The Validity of this certificate can be verified at www.qrocert.org
This certificate of registration remains the property of QRO Certification LLP, and shall be returned immediately upon request.

India Office : QRO Certification LLP
142, IInd Floor, Avtar Enclave, Near Paschim Vihar West Metro Station, Delhi-110063, (INDIA)
Website : www.qrocert.org, E-mail : info@qrocert.org

Certificate of Registration

This is to certify that

ECOSCIENCE CONSULTANCY

LAKSHMI VIHAR COLONY, BAHADRABAD, HARIDWAR
UTTARAKHAND STATE -249402, INDIA.

has been independently assessed by QRO
and is compliant with the requirement of:

ISO 45001:2018

Occupational Health and Safety Management System

For the following scope of activities:

PROVIDING EXPERT SOLUTION IN THE FIELD OF ENVIRONMENT MONITORING, WASTEWATER MANAGEMENT (ETP/STP INSTALLATION AND MAINTENANCE), THIRD PARTY AUDITS (FOR WASTE MANAGEMENT), GREEN AUDITS, ENERGY AUDITS, CARBON FOOTPRINT.

Date of Certification: 14th January 2025
1st Surveillance Audit Due: 13th January 2026
2nd Surveillance Audit Due: 13th January 2027
Certificate Expiry: 13th January 2028

Certificate Number: 305025011410HS

EGAC CAB # 011905

Head of Certification

Validity of this certificate is subject to annual surveillance audits to be done successfully on or before 365 days from date of the audit.
(In case surveillance audit is not allowed to be conducted; this certificate shall be suspended / withdrawn).
The Validity of this certificate can be verified at www.qrocert.org
This certificate of registration remains the property of QRO Certification LLP, and shall be returned immediately upon request.

India Office : QRO Certification LLP
142, IInd Floor, Avtar Enclave, Near Paschim Vihar West Metro Station, Delhi-110063, (INDIA)
Website : www.qrocert.org, E-mail : info@qrocert.org

Certificate

UK cert
Certification & Inspection

Certificate of Compliance

This is to certify that the

Conformity Assessment Certification

of

ECOSCIENCE CONSULTANCY

at

LAKSHMI VIHAR COLONY, BAHADRABAD, HARIDWAR
UTTARAKHAND STATE -249402, INDIA.

has been independently assessed and is compliant with the requirements of:

ISO/IEC 17020:2012

For the following scope of activities:

PROVIDING EXPERT SOLUTION IN THE FIELD OF ENVIRONMENT MONITORING, WASTEWATER MANAGEMENT (ETP/STP INSTALLATION AND MAINTENANCE), THIRD PARTY AUDITS (FOR WASTE MANAGEMENT), GREEN AUDITS, ENERGY AUDITS, CARBON FOOTPRINT.

Certificate Number: UQ - 2025011405

Validity of this certificate can be verified at www.ukcertifications.org.uk/verify

Date of Certification	14th January 2025
1st Surveillance Audit Due	13th January 2026
2nd Surveillance Audit Due	13th January 2027
Certificate Expiry	13th January 2028

Authorised Signatory

UKAF

UK Certification & Inspection Ltd.
UK cert
Certification & Inspection

Certificate of Registration

This is to certify that

ECOSCIENCE CONSULTANCY

LAKSHMI VIHAR COLONY, BAHADRABAD, HARIDWAR
UTTARAKHAND STATE -249402, INDIA.

has been independently assessed by QRO
and is compliant with the requirement of:

ISO 50001:2018

Energy Management Systems

For the following scope of activities:

PROVIDING EXPERT SOLUTION IN THE FIELD OF ENVIRONMENT MONITORING, WASTEWATER MANAGEMENT (ETP/STP INSTALLATION AND MAINTENANCE), THIRD PARTY AUDITS (FOR WASTE MANAGEMENT), GREEN AUDITS, ENERGY AUDITS, CARBON FOOTPRINT.

Date of Certification: 14th January 2025
1st Surveillance Audit Due: 13th January 2026
2nd Surveillance Audit Due: 13th January 2027
Certificate Expiry: 13th January 2028

Certificate Number: 305025011411EN

EGAC CAB # 011905

Head of Certification

Validity of this certificate is subject to annual surveillance audits to be done successfully on or before 365 days from date of the audit. (In case surveillance audit is not allowed to be conducted; this certificate shall be suspended / withdrawn).
The Validity of this certificate can be verified at www.qrocert.org
This certificate of registration remains the property of QRO Certification LLP, and shall be returned immediately upon request.

India Office : QRO Certification LLP
142, IInd Floor, Avtar Enclave, Near Paschim Vihar West Metro Station, Delhi-110063, (INDIA)
Website : www.qrocert.org, E-mail : info@qrocert.org