ENERGY AUDIT – 2022 -23

KRISTU JYOTI COLLEGE OF MANAGEMENT & TECHNOLOGY

CHETHIPUZHA, CHANGANACHERRY

KOTTAYAM

EXECUTED BY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

Every institution should be imparting knowledge about the campus environment and its surroundings through activities that follows the principles of sustainability. An energy audit is essential first step to reduce energy cost and greenhouse emissions. Audit is defined as a systematic and implement examination of data statements, records, operations and performance of an enterprise for a purpose. Energy audits is a systematic study or survey to identify how energy used in its own facility. And identifying the energy savings opportunities in the building Behavioural Change through the student education can provide greatest benefit at least cost. Even small savings in each households make dramatic change in the society and for nation. The idea of energy conservation and sustainability will be percolated to society through students will have long standing effect and successful too.

This report compiled by the BEE certified energy auditor along with the project engineers who are experienced in the field of energy, environment and management.

ACKNOWLEDGEMENTS

We express our sincere gratitude to Kristu Jyoti College of Management and Technology for giving us an opportunity to carry out the project of Energy Audit. We are extremely thankful to management and all the staffs for their support to carry out the studies and for input data, and measurements related to the project of Energy Audit.

Kristu Jyoti College – TEAM

Rev. Fr. Joshy Cheeramkuzhy CMI	***Principal***
Rev. Fr. Chacko Manackal CMI	**Bursar, Kristu Jyoti Group**
Dr. Anu Antony	**IQAC Coordinator**

Also mentioning our Energy audit team members for successfully completing the assignment in time and making their best efforts to add value.

ENERGY AUDIT TEAM

1. **Mr. Santhosh A**
   Registered Energy Auditor of Bureau of Energy Efficiency (BEE – Govt. of India)
   Accredited Energy Auditor No – EA 7597

2. **Mr. Jaideep P P**
   Senior Project engineer

Yours faithfully

ATHUL ENERGY CONSULTANTS PVT LTD THRISSUR 680 020

Managing Director
Athul Energy Consultants Pvt Ltd

EXECUTIVE SUMMARY

I. ENERGY SAVING PROPOSALS

TABLE 1: ENERGY SAVING PROPOSALS

Sl.	Energy conservation measures	Annual Energy Savings	Annual Financial Savings	Investment	Simple payback period
		kWh	Rs	Rs	Months
1	Changing the leading power factor to lagging power factor (College)	-	89,820	10,000	02
2	Replacement of Ceiling fans(60W) with BLDC fans 5 star rated(28W) – 40 nos	2,150	16,773	1,40,000	100
3	Replacement of Fluorescent tubes (T8-50 nos) with LED lights	1,344	10,483	17,500	20
Total Savings		**3,494**	**1,17,076**	**1,67,500**	
1	Changing the leading power factor to lagging power factor (Hostel)	-	25,789	5,000	03
Total Savings		**-**	**25,789**	**5,000**	

II. ENERGY AUDIT SUMMARY & RECOMMENDATIONS

The summary of the report with respect to each section is as follows.

1. **Baseline energy performance:**

Electricity consumption analysis

- **Demand analysis:** The recorded maximum demand found to be 190kVA, which is 76% of the contract demand.
- **Power factor**: The PF for past year is unity. Provide small divisions of capacitors (1, 2 kVAr) to the MSB for maintain the PF in low load conditions.

2. Water Conservation

Sub-metering: Sub metering of water in the major usage areas are to provide for better control. Also records shall be kept for all the sub meter to understood the variation in the consumption pattern in each section.

- Use advanced taps in washbasins in canteen, toilet and department, rooms etc. for reducing and controlling water usage.
- Change flesh system in departments (Dual flesh) for reduction in water consumption.

3. Equipment and utility description

- **Voltage:** The maximum and minimum supply voltage were during the normal operational period, excluding the power failure, is 404.1 V and 384.7 V respectively with an average voltage of 392.95 V.
- **Current imbalance**: The maximum current occurred during the normal period was measured at 172.9 A. The current imbalance varies from 4.8 to 20.8 which is not within standards (<8%).

Capacitors: All Power factor can be improved to unity to increase the incentives received by the college. Provide small rating capacitors to the APFC panel.

- **Harmonics:** The present Harmonics values (THDv = 2% & THDi = 20.90%), current harmonics are not within the limits.
- **Ceiling fan loads:** Ceiling fans are installed in majority of the areas by replacing it with Brushless DC fans which consumes in the range of 25 to 30W at full speed, instead of 70W in normal fans, will reduce the power consumption considerably. Also, while purchasing new fans priority should be given for BLDC

2. **Behavioral Changes**

- Use of student volunteers for reducing electricity consumption in hostels and other college areas.

- Encourage student projects in connection with energy conservation areas such as in renewable energy area, use of terrain advantage of college buildings, automatic system for control the light, fan and air conditioning requirements
- Proper recording of log books, consumption of fuel (Electricity, LPG) to maintain by facility manager. Along with this a facility management to be formed and the committee headed by Principal or any deputed person and the committee members include the persons from academics, students, PTA, Administration, kitchen, Hostel warden and facility engineer for verification
- Celebrate energy conservation month (November 14 to December 14) and energy conservation day December 14 with energy conservation programmes among college for creating awareness about importance of energy conservation.

III. ENERGY PERFORMANCE INDEX (EPI)

EPI based on the energy consumption in Mar 2022 - Mar 2023. The projected energy consumption after the implementation of energy saving proposal given in the table below.

TABLE 2: ENERGY PERFORMANCE INDEX

Sl. No:	Energy Performance and climate impact	Unit	Baseline	Projection
1	Annual Electricity Consumption	kWh	502,560	499,066
2	Annual electricity consumption	TOE	43.22	42.92
3	Annual Energy Cost	Rs in lakhs	53.91	52.74
4	Annual Specific Electricity Consumption	kWh/Student	291.17	289.15
5	Annual Specific Electricity Consumption	TOE/Student	0.0250	0.0249
6	Annual Carbon Footprint- Electricity	Ton CO_2	397.02	394.26

Note: Unit conversions:

TOE = 10 million kCal (BEE energy audit manual)

MWh of electricity = 0.79 Ton of CO_2 (www.cea.gov.in)

kWh of electricity = 860 kCal (BEE energy audit manual)

Liters of Diesel = 9500 kCal (BEE energy audit manual)

IV. CARBON FOOT PRINT

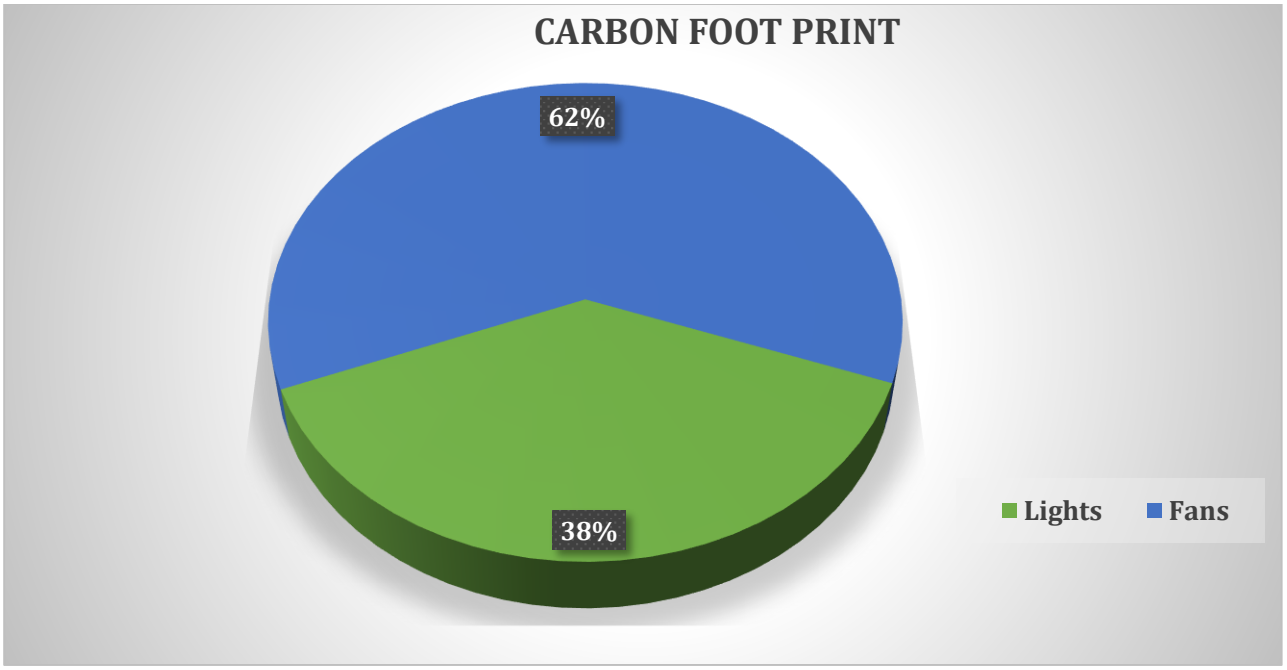
Carbon foot print is often used as short hand for the amount of carbon emission (usually in Tones) being emitted by an activity or by organization this is an important component in ecological foot print or the depicting the biological space reduction in the earth. Various environment protection and energy conservation connected with carbon footprint. Institution took its accountability to protect nature and taken few steps for the carbon neutral campus.

1. Replacement of fluorescent lights with LED
2. Replacement of old ceiling fans with energy efficient BLDC fans

TABLE 3 CARBON FOOT PRINT

Particulars	Energy consumption reduction (kWh)	Carbon Emission reduction (Ton CO_2)	% of total
Replacement of Fluorescent tubes (50 nos) with LED lights	1,344	0.94	38.37
Replacement of 40 numbers of Ceiling fans with BLDC Fans	2,150	1.51	61.63
Total	***3,494***	***2.45***	***100***

FIGURE 1: CARBON FOOT PRINT



INTRODUCTION

I. ENERGY AUDIT

An energy audit is a key to assessing the energy performance of an energy consuming facility and for developing an energy management program. The typical steps of an energy audit are:

- Preparation and planning
- Data collection and review
- Plant surveys and system measurements
- Observation and review of operating practices
- Data documentation and analysis
- Reporting of the results and recommendations

1.1. Definition of energy auditing

In the Indian Energy Conservation Act of 2001 **(BEE 2008)**, an energy audit is defined as: **"The verification, monitoring and analysis of the use of energy and submission of technical report containing recommendations for improving energy efficiency with cost-benefit analysis and an action plan to reduce energy consumption."**

1.2. Objectives of Energy Auditing

The objectives of an energy audit can vary from one plant to another. However, an energy audit is usually conducted to understand how energy issued within the plant and to find opportunities for improvement and energy saving. Sometimes, energy audits conducted to evaluate the effectiveness of an energy efficiency project or program. In Kristu Jyoti College of Management and technology as per the request from the institution, we have assessed the energy consumption and saving opportunities at present scenario.

Methodology for the study

The methodology adopted for energy audit starts from historical energy data analysis, power quality analysis, monitoring of operational practices, system evaluation, cost benefit analysis of the energy conservation opportunities, and prepare plan for implementation. The proposals given in the report includes economical energy efficiency measures to reduce facilities unnecessary energy consumption and cost. The energy conservation options, recommendations and cost benefit ratio, indicating payback period are included in this report.

Scope of Work

The Scope of Work includes:

1. Historical energy data analysis.
2. Electrical, Mechanical and Thermal energy analysis.
3. Power Quality Analysis.
4. Identification of Energy saving opportunities.
5. Cost Benefit Analysis.

II. KRISTU JYOTI COLLEGE OF MANAGEMENT & TECHNOLOGY

The Kristu Jyoti Group of educational institutions came into fruition with the Monastic Council of CMI Fathers of Chethipuzha led by rev. Fr. James Kozhimattom CMI having setup the Kristu Jyoti School linked to Sacred Heart Monastery in the year 1982. In the month of June 1982 marked the coming into being of KristuJyoti English Medium School as well. In order to cater to the needs of the students and the parents, Placid Vidya Vihar Seniour Secondary School of CBSE mode got formed in 1988. In 2002 Kristu Jyoti College of Management and Technology was put into operation along with the novel institutions such as KristuJyoti Kindergarten and Play School. The ICSE oriented school, the Kristu Jyoti, Vidyaniketan commenced functioning in the academic year 2005-2006 onwards.

Kristu Jyoti College of Management & Technology was established in the year 2002 at Chethipuzha, Changanacherry, Kottayam, Kerala, India. Since its inception, it has been affiliated to Mahatma Gandhi University and also does have the approval of All India Council for Technical Education, New Delhi (AICTE). The first course, that was provided by the college was MCA in the year 2002. The college also extended courses such as M.Sc Bioinformatics and B.Com Computer Applications in the year 2004. The year 2010 paved the way for the college inducting into its scheme of things two more courses viz BCA and BBA. In the subsequent year 2011, the college introduced the courses such as BCom (Finance and Taxation) and MCom Finance. The other courses, the college incorporated into its fold are BSc Psychology in 2014, BSc Geology and BA English in 2015, MHRM and MSc Psychology in 2020.

VISION

Empowering students to meet needs of the society by focusing on academic, technological and professional excellence.

MISSION

To provide quality education through an effective teaching –learning process, skill development and integrated personnel progression.

III. GENERAL DETAILS

The general details of the College given below in table.

TABLE 4: GENERAL DETAILS

Sl. No:	Particulars	Details
1	Name of the College	Kristu Jyoti College of Management and Technology, Changanacherry
2	Address	Kristu Jyoti College of Management and Technology Chethipuzha, Changanacherry Kottayam
3	Contact Person	Rev. Fr. Joshy Cheeramkuzhy CMI (Principal) Ph: 9496101681
4	Contact Number & E mail of the college	0481-2720696/62351011681 kjcmt@kjcmt.ac.in, kjc@kjcmt.ac.in
5	Web site	www.kjcmt.ac.in
6	Type of Building	Educational Institution
7	Annual Working Days	210
8	No: of Shifts	Day Shift (One) (9:00 AM -4:00 PM)
9	No: of students enrolled	1727
10	No: of teaching & non-teaching staff	Teaching - 81 non-teaching - 24
11	No: of departments	06
12	Total Land Area	05 Acres
13	No: of Programmes	UG – 07 and PG -04
14	Average power consumption per month. (kWh/month)	12771
15	Average electricity charges per month. (Rs. /month)	113544

IV. LOAD BALANCE- ELECTRICAL

The details of the loads in the college at the audit time given below:

TABLE 5: LOAD BALANCE

Sl. No:	Particulars	Total Power
		kW
1	Light & Fan Loads	40.15
2	AC Loads	13.136
3	PC & Other Loads	35.81
4	Miscellaneous Loads	10
Total		**99.096**

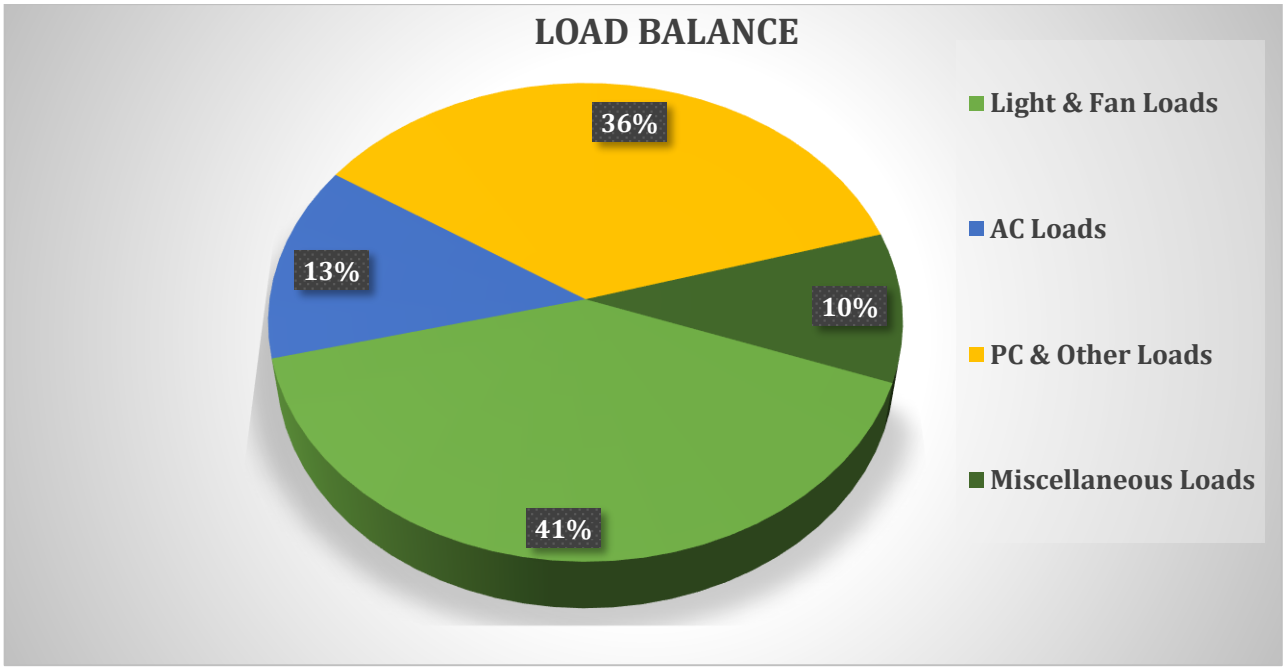


FIGURE 2: LOAD BALANCE – ELECTRICAL

ENERGY & UTILITY DESCRIPTION

In this section, the single line diagrams of electricity and water given which provides an overview of the energy flow in the building.

I. SINGLE LINE DIAGRAM – ELECTRICAL

The electrical single line diagram of the college given below:

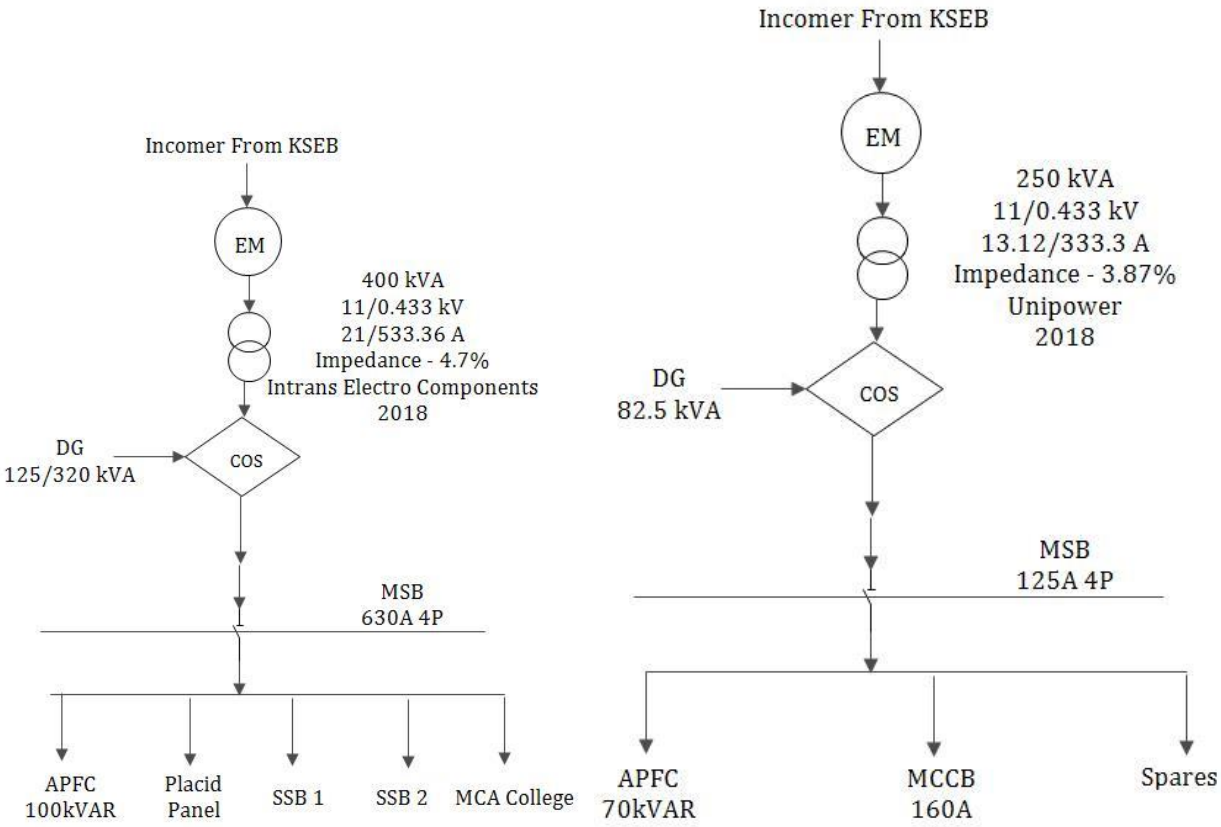


FIGURE 3: SINGLE LINE DIAGRAM – COLLEGE & HOSTEL

II. SINGLE LINE DIAGRAM – WATER

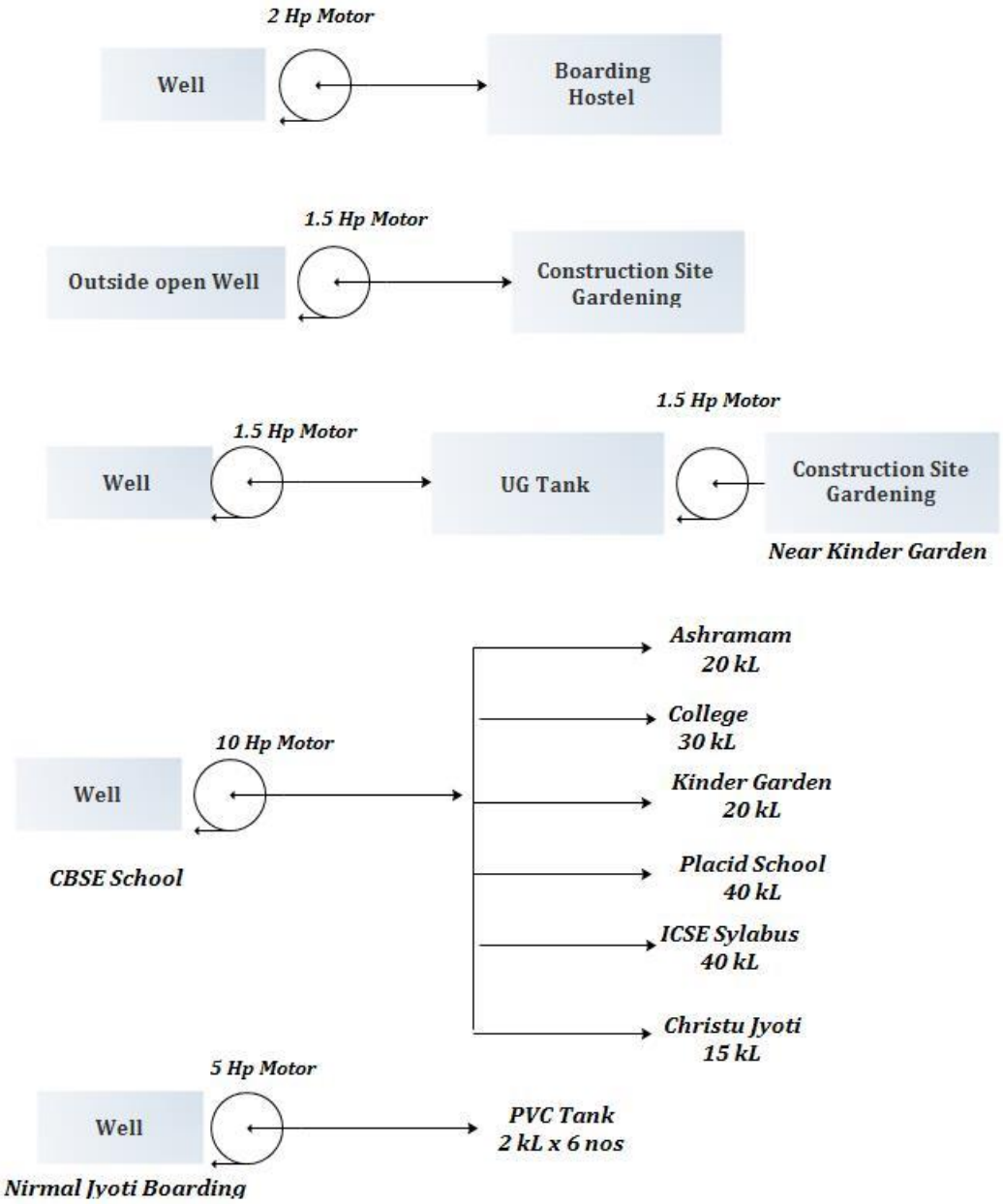


FIGURE 4: WATER LINE DIAGRAM – COLLEGE & HOSTEL

ENERGY ANALYSIS

The different type's energy usage given in this section. The major source of energy to the college is electricity. Other forms come in the form of diesel.

ELECTRICITY CONSUMPTION ANALYSIS - COLLEGE

The major source of electricity to the college is the electrical connection from the KSEBL. Diesel generators provided in the college, but it only used during the power failures in critical days like examinations or college events.

I. DESCRIPTION OF ELECTRICITY BILL

Base line data given below based on the Electricity bill provided by the supplier of electricity to the College. Details obtained from the KSEBL bill for the month of Mar 2022-Mar 2023 is as follows in the Table.

TABLE 6: KSEBL BILL ANALYSIS

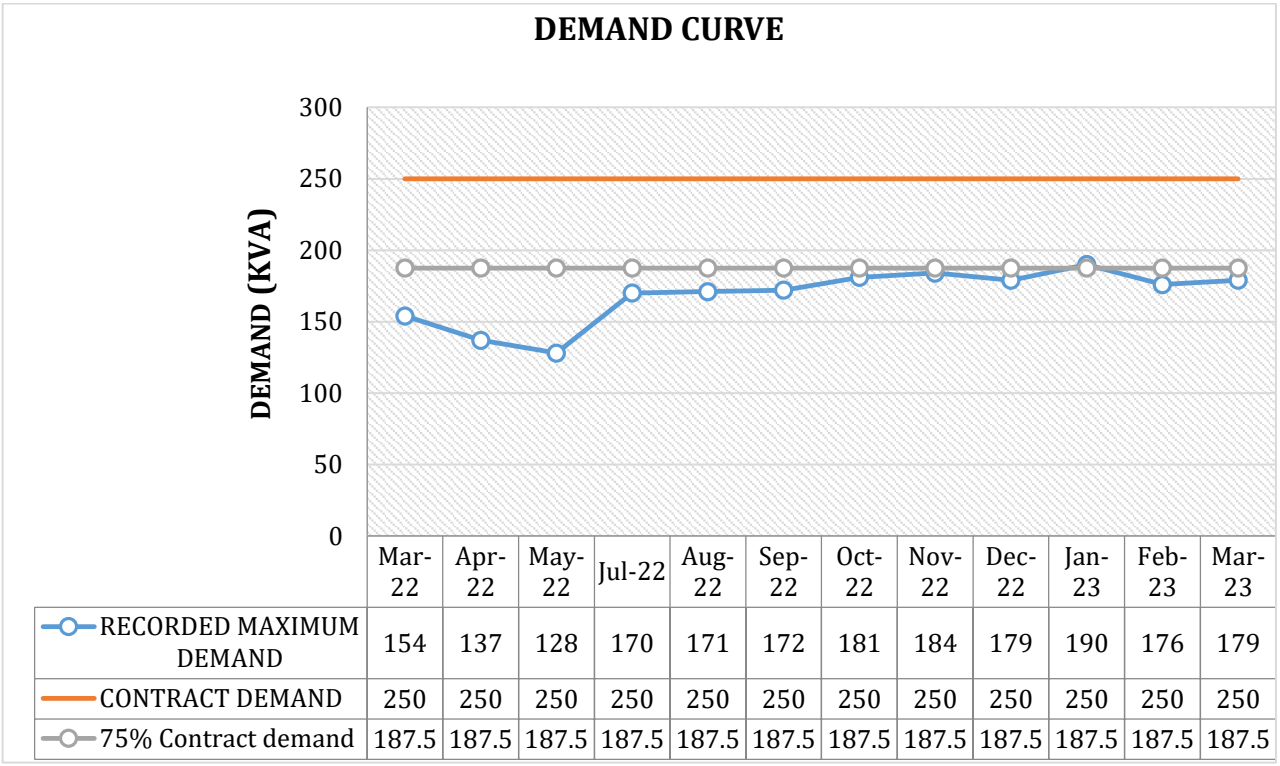
Particulars		Details
Consumer No		1346380059061
Contract Demand (kVA)		250
Connected Load (kW)		475
Tariff		HT II (B) General
Recorded maximum demand (kVA)		190
Average monthly electricity consumption (kWh/month)		41880
Average Power factor		1
Average Demand charges (Rs/month)		91263
Annual power factor penalty & Incentive (Rs/year)		Incentives - 7,504/-
Demand charge (Rs / kVA)		500
Energy charge (Rs/kWh)	Normal Period	7.8
	Peak Period	11.7
	Off – Peak Period	5.85
Average electricity cost (Rs/month)		4,49,250/-

Inference & Suggestions

- Average Power factor is found to be 1. Leading of power factor in many months and there are no incentives for power factor when it is leading
- By avoiding the leading conditions, the college will get incentives for the power factor.
- Recorded maximum demand (RMD) during past 12 month was 190 kVA. It recorded during the month of Jan 2023, which is 76% of contract demand.

II. DEMAND ANALYSIS

This section analyses the trend for the maximum demand versus the Contract Demand (CD) over 12-month period (Mar 2022-Mar 2023).



	Mar-22	Apr-22	May-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23
RECORDED MAXIMUM DEMAND	154	137	128	170	171	172	181	184	179	190	176	179
CONTRACT DEMAND	250	250	250	250	250	250	250	250	250	250	250	250
75% Contract demand	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5

FIGURE 5: DEMAND IN VARIOUS TIME ZONE

Inference

- Annual demand charges came as Rs. 10,95,160 /- for the college.
- The recorded maximum demand was found to be 190 kVA which is 76% of the contract demand.
- RMD came as almost less than billing demand in last 12 months.

Suggestion

- Maintaining the power factor to near unity in lagging mode yields the incentives for the power factor.
- Remove the direct connected capacitors from the APFC panel and provide small rated capacitors to the panel.

III. ELECTRICITY DEMAND IN VARIOUS TIME ZONES

The variations of demands in the time zones are given below in figure.

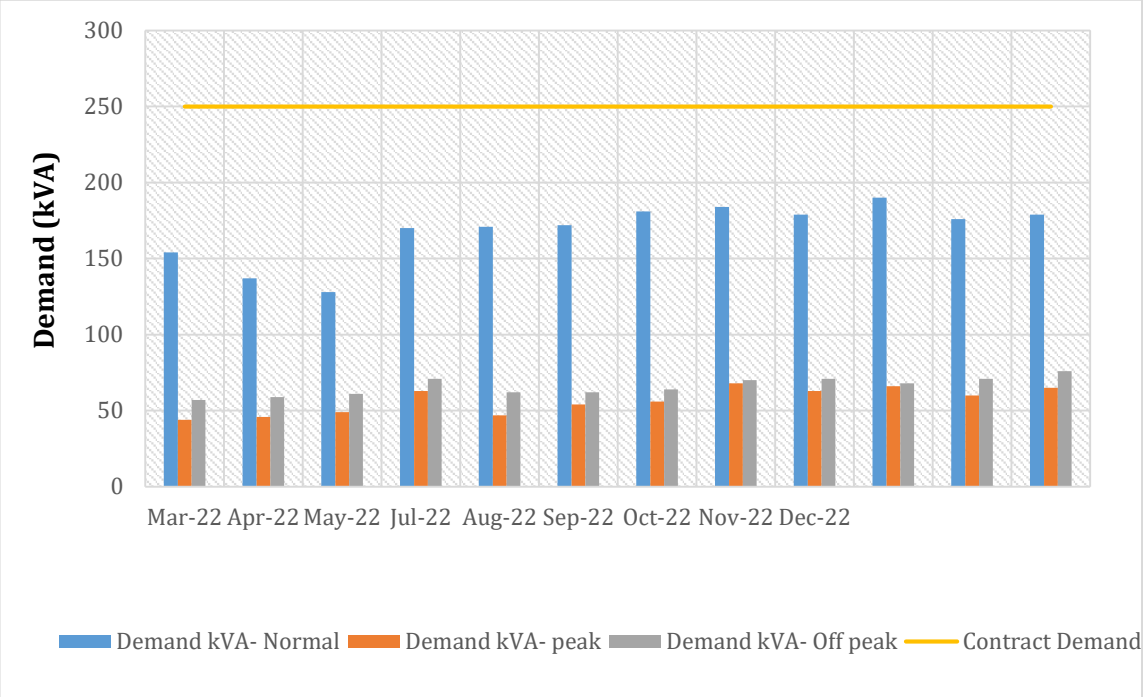


FIGURE 6: ELECTRICITY DEMAND IN VARIOUS TIME ZONE

Inference

- The average demand registered during the normal, Peak and off-peak period with respect to the contract demand (250 kVA) were 67.37%, 22.7% and 26.4% respectively.
- The maximum demand registered during the normal, Peak and off-peak period with respect to the contract demand (250 kVA) were 76%, 27.2% and 30.4% respectively.

IV. POWER FACTOR ANALYSIS IN KSEBL BILL

The Power factor is the ratio of Active power (kW) and apparent power (kVA).

$$PF = Active\ energy kWh / Apparent energy\ (kVAh)$$

The power factor variations in past one year is given below in figure.

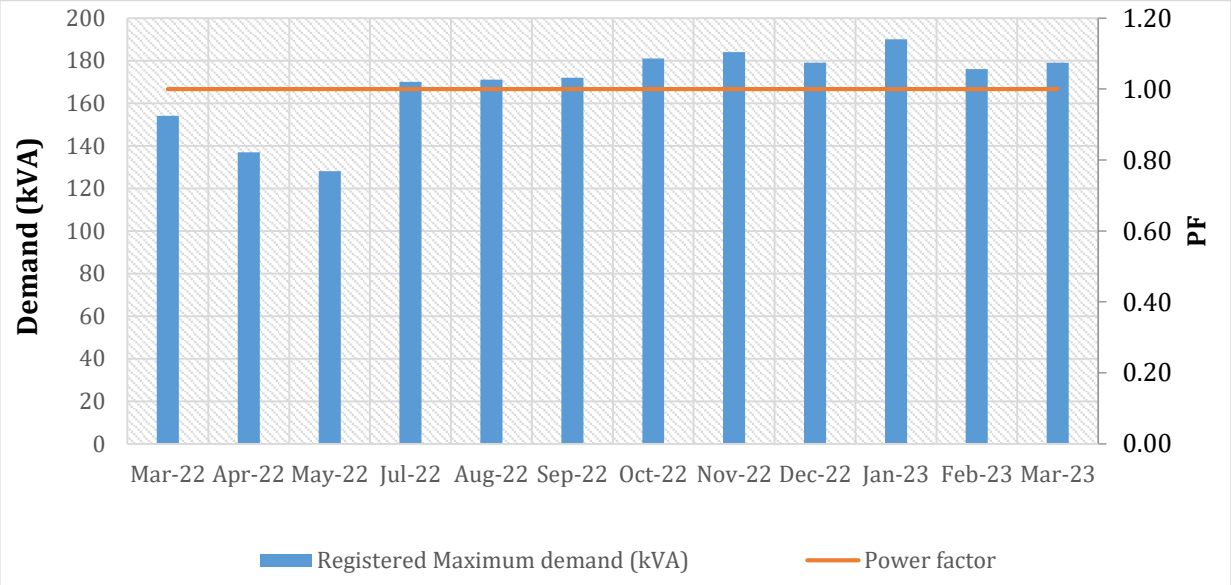


FIGURE 7: POWER FACTOR ANALYSIS

Inference

- The PF for past year is unity.
- In all month PF was recorded as 1.

Suggestion

- College has not getting any incentives due to leading of power factor
- Provide small divisions of capacitors (1, 2 kVAr) to the MSB for maintain the PF in low load conditions.

V. TARIFF RATES ANALYSIS

The average monthly energy and demand charges for the period Mar 2022-Mar 2023 is represented in Fig.

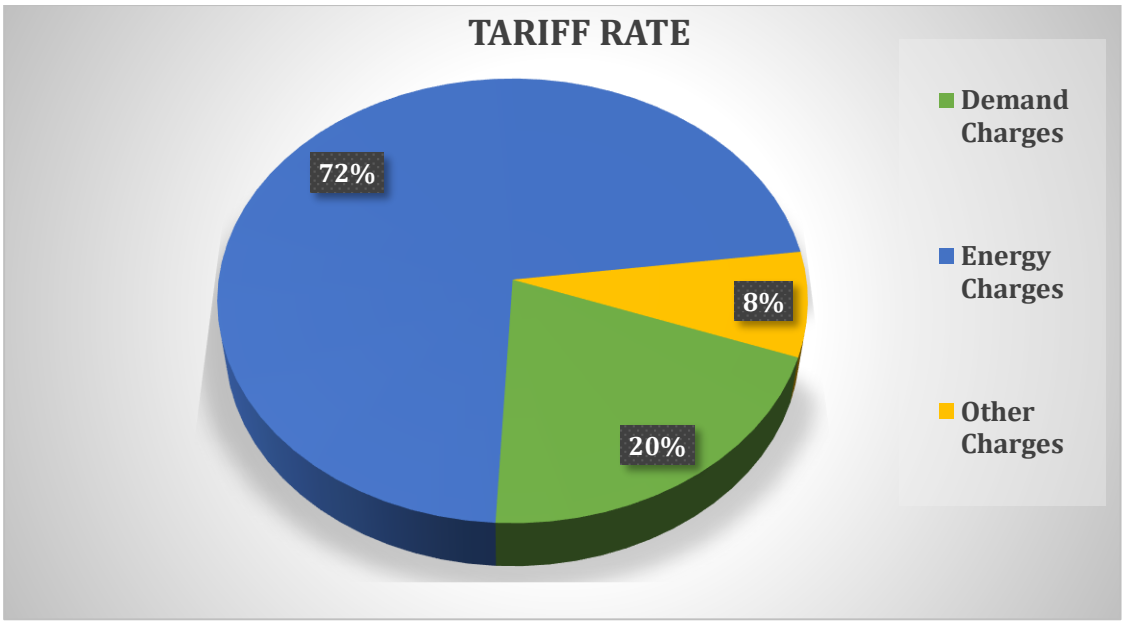


FIGURE 8: TARIFF RATE ANALYSIS

Inference

- Average demand charges for the past one year were Rs 91,263/-per month and energy charges was Rs. 3,24,415/- per month.
- The energy charges come about 72% of the total bill for the college.

VI. SPECIFIC ELECTRICITY CONSUMPTION

The electricity consumption from the Mar 2022-Mar 2023 has been taken for the benchmarking. Here the comparison is done with electricity consumption and the number of students. The below table shows the specific electricity consumption of the college.

TABLE 7: SPECIFIC ELECTRICITY CONSUMPTION

Month	Electricity Consumption	Number of Students	SEC
	kWh	Number	kWh/Student
Mar-22	38160	1726	22.11
Apr-22	32283	1726	18.70
May-22	33522	1726	19.42
Jul-22	45417	1726	26.31
Aug-22	38229	1726	22.15
Sep-22	38070	1726	22.06
Oct-22	44298	1726	25.67
Nov-22	46179	1726	26.75
Dec-22	43137	1726	24.99
Jan-23	49173	1726	28.49
Feb-23	43815	1726	25.39
Mar-23	50277	1726	29.13
Average	**24.26**	**24.26**	**24.26**
Annual Specific Electricity consumption			**291.2**
Annual Electricity Consumption(kWh)			**502560**

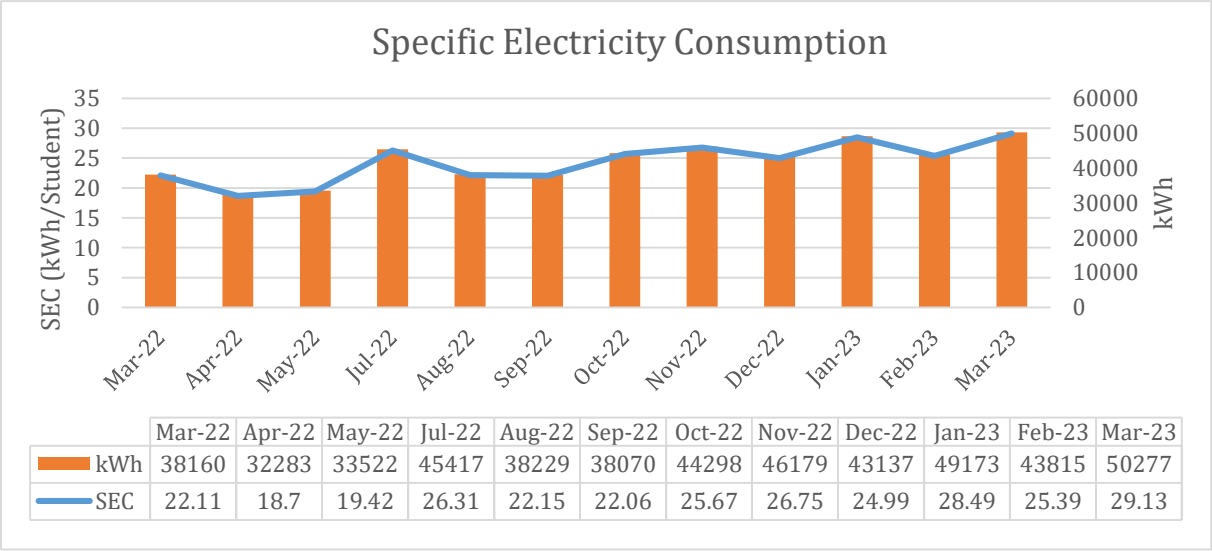


FIGURE 9: SPECIFIC ELECTRICITY CONSUMPTION (KWH/STUDENTS)

ELECTRICITY CONSUMPTION ANALYSIS – NIRMAL JYOTHI BOARDING HOUSE

The major source of electricity to the hostel is the electrical connection from the KSEBL. Diesel generators are provided in the college, but it is only used during the power failures in critical days like examinations or college events.

I. DESCRIPTION OF ELECTRICITY BILL

Base line data given below is based on the Electricity bill provided by the supplier of electricity to the College. Details obtained from the KSEBL bill for the month of Mar 2022-Feb 2023 is as follows in the Table.

TABLE 8: KSEBL BILL ANALYSIS

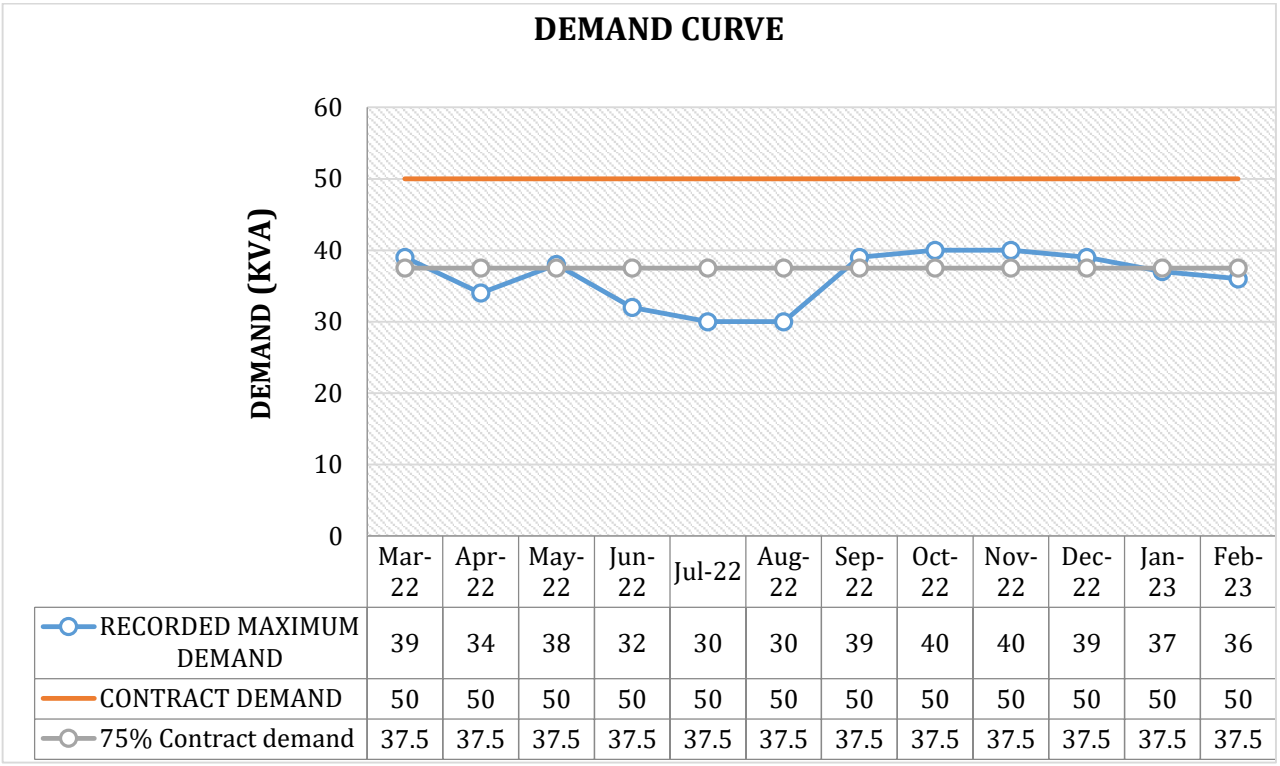
Particulars		Details
Consumer No		1346360062381
Contract Demand (kVA)		50
Tariff		HT II (B) General
Recorded maximum demand (kVA)		40
Average monthly electricity consumption (kWh/month)		12771
Average Power factor		1
Average Demand charges (Rs/month)		18558
Annual power factor penalty & Incentive (Rs/year)		Nil
Demand charge (Rs / kVA)		500
Energy charge (Rs/kWh)	Normal Period	6.8
	Peak Period	10.2
	Off – Peak Period	5.1
Average electricity cost (Rs/month)		1,13,544/-

Inference & Suggestions

- Average Power factor is found to be 1. Leading of power factor in so many months and there are no incentives for power factor.
- By avoiding the leading conditions, the hostel will get incentives for the power factor.
- Recorded maximum demand (RMD) during past 12 month was 40 kVA. It was recorded during the month of Oct 2022, which is 80% of contract demand.

II. DEMAND ANALYSIS

This section analyses the trend for the maximum demand versus the Contract Demand (CD) over a 12-month period (Mar 2022-Feb 2023).



	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23
RECORDED MAXIMUM DEMAND	39	34	38	32	30	30	39	40	40	39	37	36
CONTRACT DEMAND	50	50	50	50	50	50	50	50	50	50	50	50
75% Contract demand	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5

FIGURE 10: DEMAND IN VARIOUS TIME ZONE

Inference

- Annual demand charges came as Rs. 18,558 /- for the college.
- The recorded maximum demand was found to be 40 kVA which is 80% of the contract demand.
- RMD came as almost less than contract demand in last 12 months.

Suggestion

- Maintaining the power factor to near unity in lagging mode yields the incentives for the power factor.

III. ELECTRICITY DEMAND IN VARIOUS TIME ZONES

The variations of demands in the time zones are given below in figure.

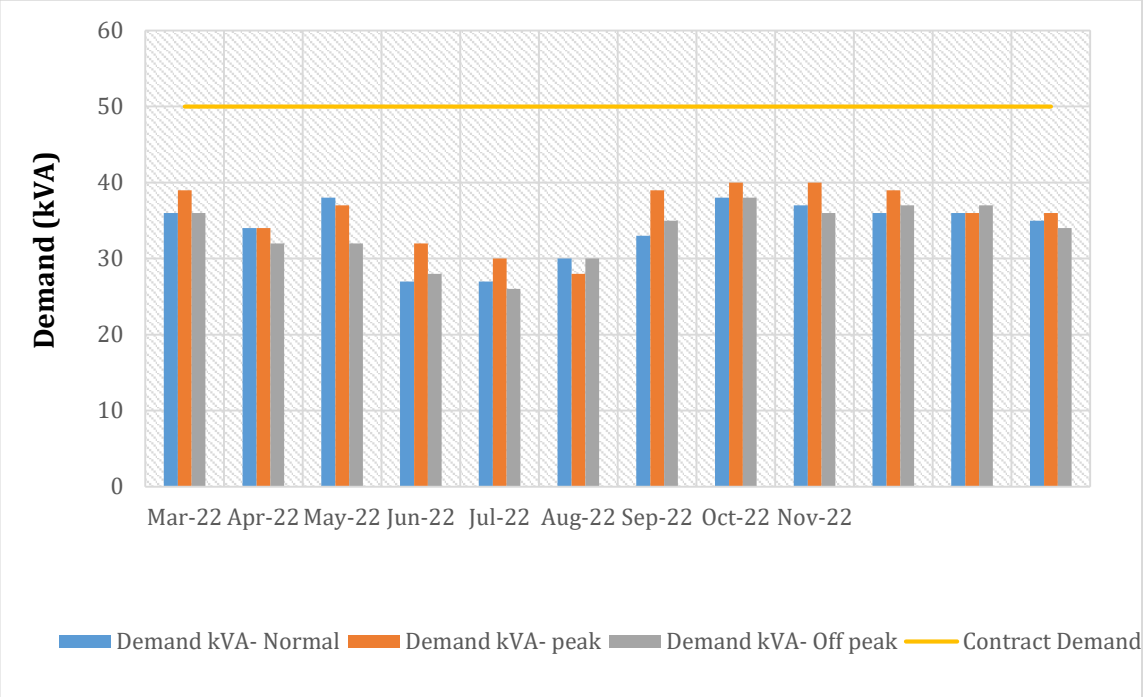


FIGURE 11: ELECTRICITY DEMAND IN VARIOUS TIME ZONE

Inference

- The average demand registered during the normal, Peak and off-peak period with respect to the contract demand (50 kVA) were 67.83%, 71.67% and 66.83% respectively.
- The maximum demand registered during the normal, Peak and off-peak period with respect to the contract demand (50 kVA) were 76%, 80% and 76% respectively.

IV. POWER FACTOR ANALYSIS IN KSEBL BILL

The Power factor is the ratio of Active power (kW) and apparent power (kVA).

$$PF = Active\ energy kWh / Apparent energy\ (kVAh)$$

The power factor variations in past one year is given below in figure.

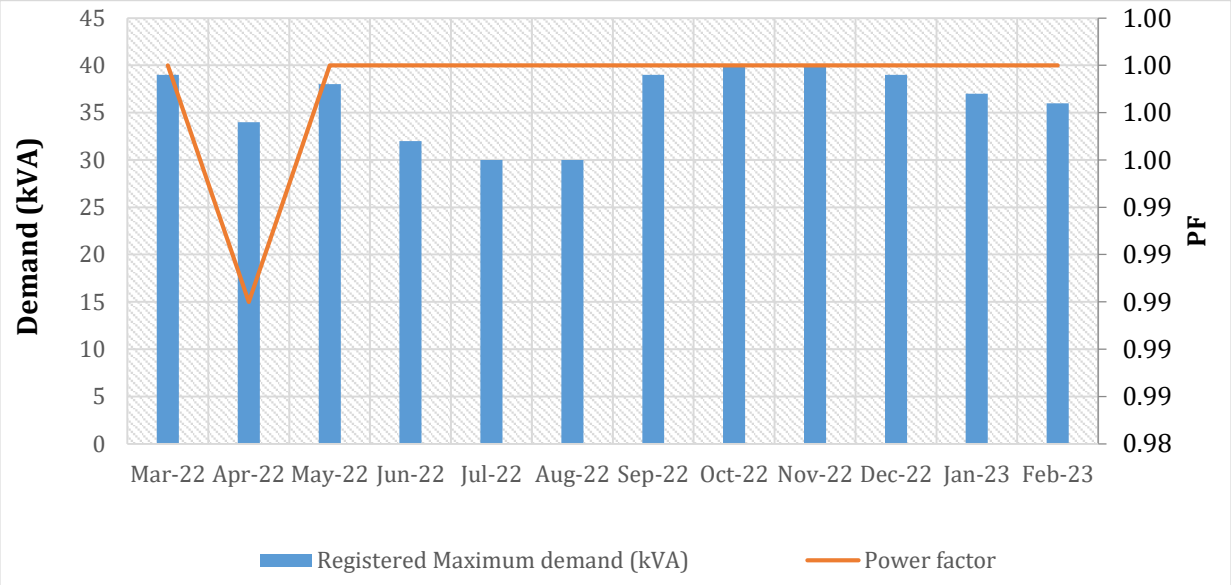


FIGURE 12: POWER FACTOR ANALYSIS

Inference

- The PF for past year varies from 0.99 to 1.

Suggestion

- Hostel has not getting any incentives due to leading of power factor
- Provide small divisions of capacitors (1, 2 kVAr) to the MSB for maintain the PF in low load conditions.

V. TARIFF RATES ANALYSIS

The average monthly energy and demand charges for the period Mar 2022-Feb 2023 is represented in Fig.

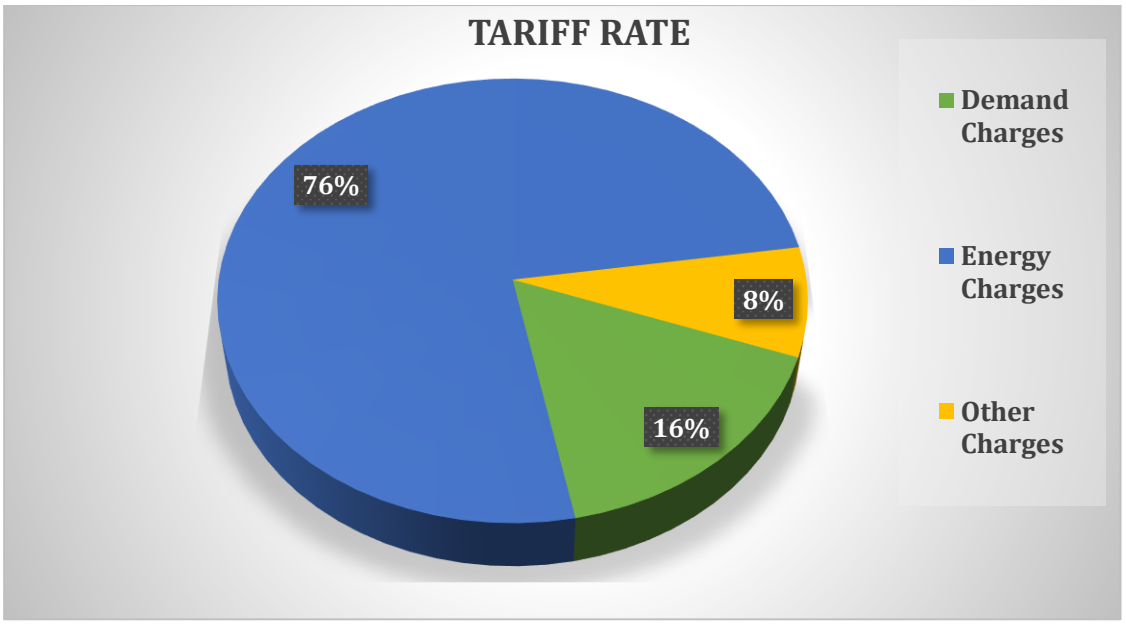


FIGURE 13: TARIFF RATE ANALYSIS

Inference

- Average demand charges for the past one year were Rs 18,558/-per month and energy charges was Rs. 85,962/- per month.
- The energy charges come about 76% of the total bill for the hostel

UNINTERRUPTIBLE POWER SUPPLY (UPS)

TABLE 9: UPS DETAILS

Location	Rated Capacity	Make	Battery Details		
	kVA		Rating	Nos	Make
Computer Lab 2	20	APC	12V 40Ah	32	Exide
Computer Lab - Server	6	Emerson	12V 60Ah	16	Exide
Chavara Block	6	APC	12V 40Ah	16	Exide
Lab	20	APC	12V 40Ah	32	Exide

Suggestions

i. Proper ventilation should provide for UPS and batteries.
ii. UPS room should be kept neat and clean.
iii. Petroleum jelly should applied to the battery terminals for better life.

ELECTRICITY SUPPLY & DISTRIBUTION PERFORMANCE

The objective of this section is to establish how the facility is performing in terms of energy consumption.

MAIN LOGGING – TRANSFORMER– MEASUREMENT EVALUATION

The main logging of transformers conducted using the Krykard power quality analyser. The Secondary side of the transformers logged for 02 hours and measured data given in following table. The measurement-averaging period was 20 seconds.

The summary of measured parameters of the transformer given in the table below

TABLE 10: TRANSFORMERS LOGGING

Particulars		**Details**
Make		Intro Electro Components Ltd
Rating (kVA)		400
Voltage ratings (kV)		11/0.433
Current ratings (A)		21/533.36
Volt impedance - %		4.70
Year		2018
Parameters		**Value**
Voltage line (V)	Min	384.7
	Avg	392.95
	Max	404.1
Current (A)	Min	97
	Avg	138.98
	Max	172.9
Frequency (Hz)	Min	49.79
	Avg	49.98
	Max	50.23
Energy consumed (kWh)	Total	170
Energy received (kVAh)	Total	172
Power factor		0.988
Active power (kW)	Min	80.22
	Avg	93.32
	Max	104.72
Parameters		**Value**
Apparent power (kVA)	Min	80.67
	Avg	94.62
	Max	106.31
Reactive power (kVAr)	Min	1.56
	Avg	8.27

	Max	16.61
Voltage imbalance %	Min	0.3
	Avg	0.5
	Max	0.7
Current imbalance %	Min	4.8
	Avg	10.57
	Max	20.8
THDv %	Min	1.2
	Avg	1.63
	Max	1.9
THDa %	Min	2.70
	Avg	12.11
	Max	20.90

INFERENCE & OBSERVATION – TRANSFORMER EVALUATION

TABLE 11: TRANSFORMER ANALYSIS – INFERENCE & OBSERVATION

<table>
<tr><th colspan="2">TRANSFORMER - ANALYSIS</th></tr>
<tr><th>Inference</th><th>Observation</th></tr>
<tr><td>

The maximum and average loading of each transformer during the period of audit is:

<table>
<tr><th></th><th>Max load %</th><th>Avg load %</th></tr>
<tr><td>TR (400 kVA)</td><td>26.58</td><td>23.33</td></tr>
</table>
</td><td>

The present loading pattern of the transformer is not good.

</td></tr>
<tr><td>

The load factor [(Load factor (%) =Energy used during the period (kWh) × 100 ÷ {Maximum demand (kW) × Time under consideration (hr)}] of the transformer during the audit period is:

<table>
<tr><th></th><th>Load factor %</th></tr>
<tr><td>TR (400 kVA)</td><td>81.17</td></tr>
</table>
</td><td>

Load factor of transformer is ok.

</td></tr>
<tr><td>

The power factor variations among the transformer are tabulated below;

<table>
<tr><th></th><th>PF – Avg</th></tr>
<tr><td>TR (400 kVA)</td><td>0.986 lagging</td></tr>
</table>
</td><td>

The present PF in the hostel is good at the time of audit.
PF should be improved to unity to receive incentives.

</td></tr>
</table>

I. ANALYSIS: VOLTAGE VARIATION IN MEASUREMENT PERIOD

The Voltage profile at the LT side is plotted below in figure.

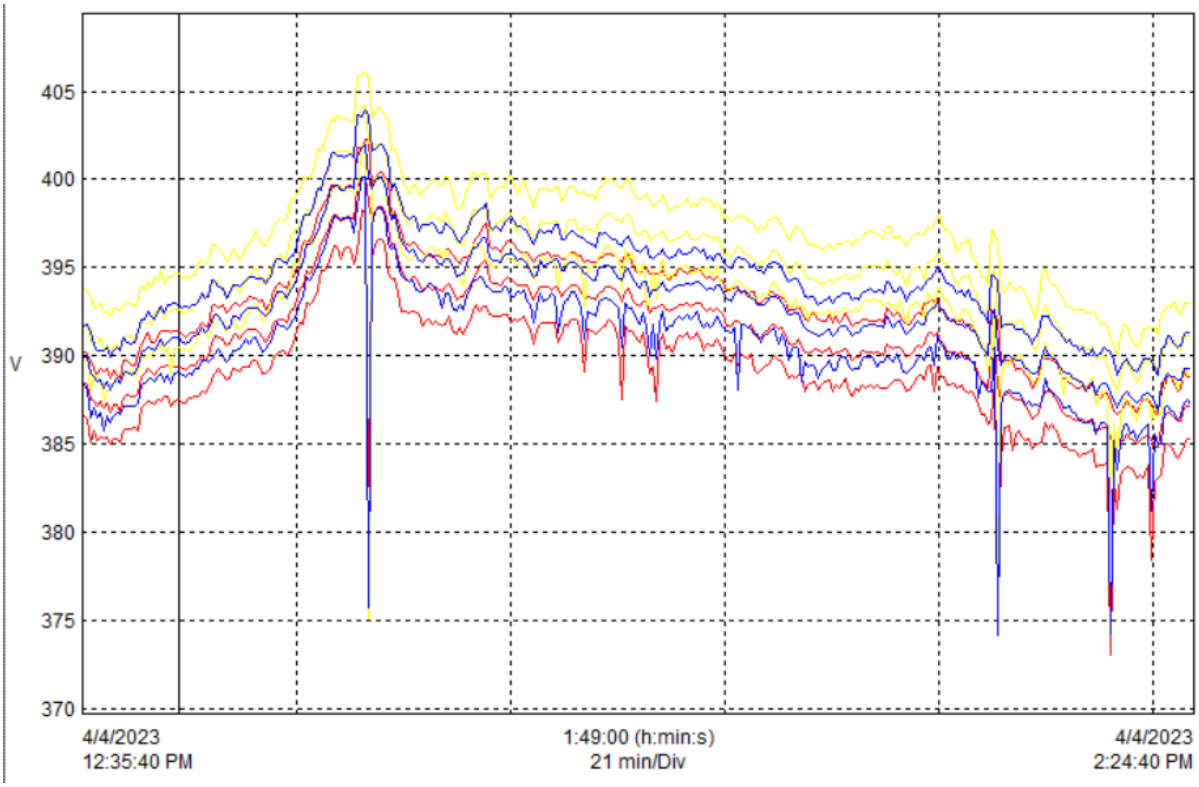


FIGURE 14: VOLTAGE PROFILE

Inference

- The figure shows the supply voltage variations and voltage unbalances during the audit period at main incomer.
- The maximum and minimum supply voltage were during the normal operational period, excluding the power failure, is 404.1 V and 384.7 V respectively with an average voltage of 392.95 V.
- Voltage unbalance comes in the range of 0.3 to 0.7 which are within the normal operational standards.

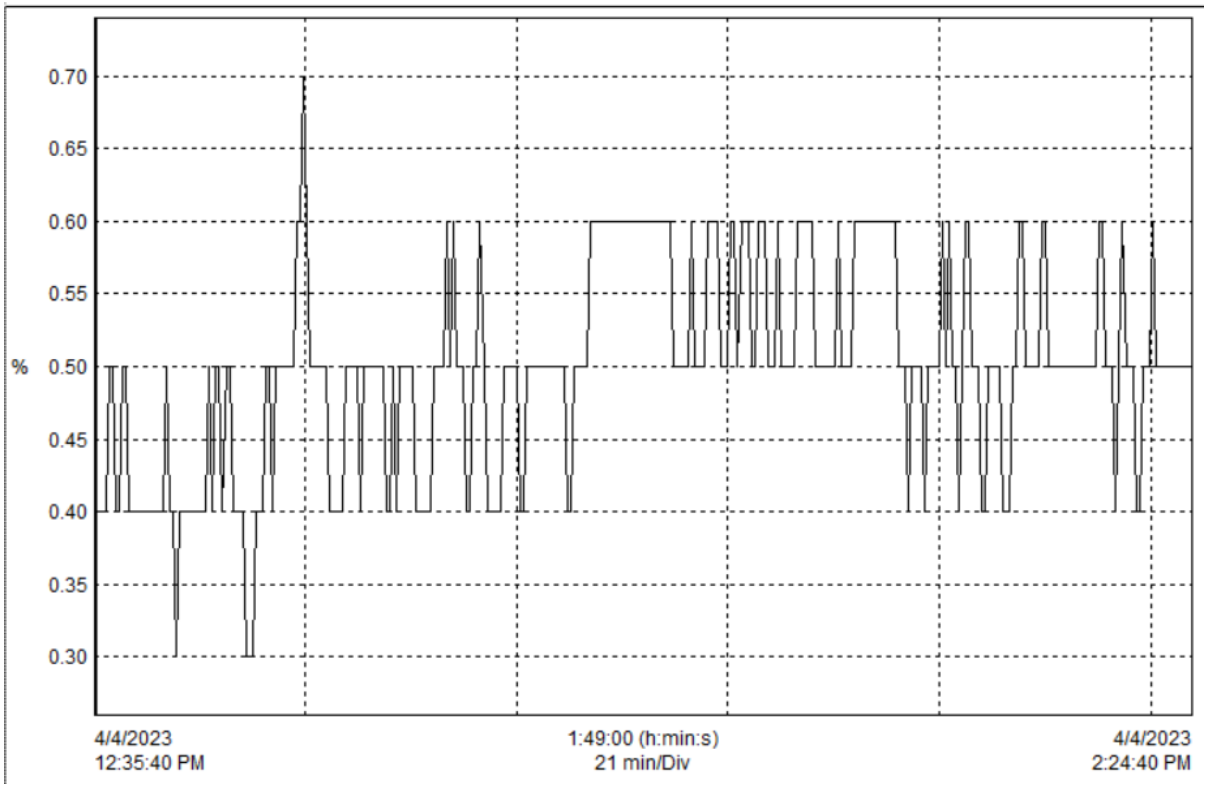


FIGURE 15: VOLTAGE UNBALANCE

II. ANALYSIS: CURRENT VARIATIONS IN MEASUREMENT PERIOD

This section carries the current variations during the 02-hour measurement period with the power analyzer.

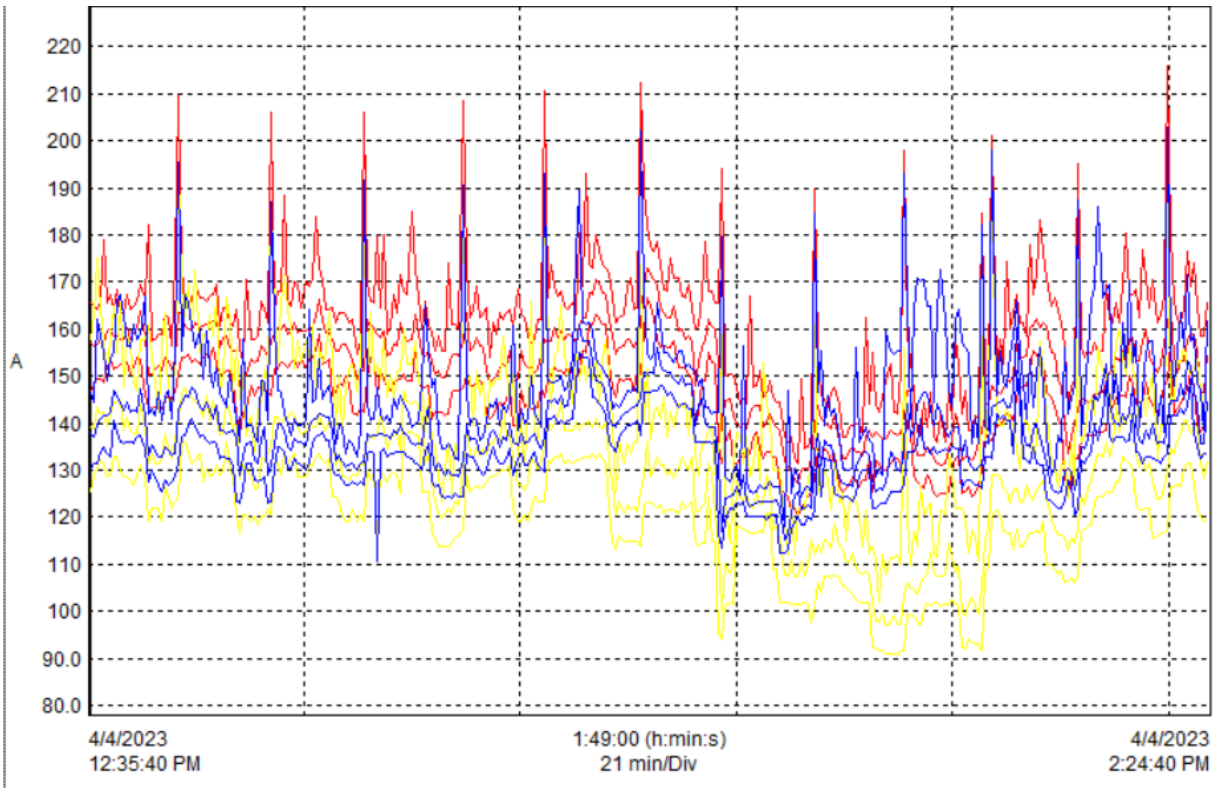


FIGURE 16: CURRENT VARIATIONS

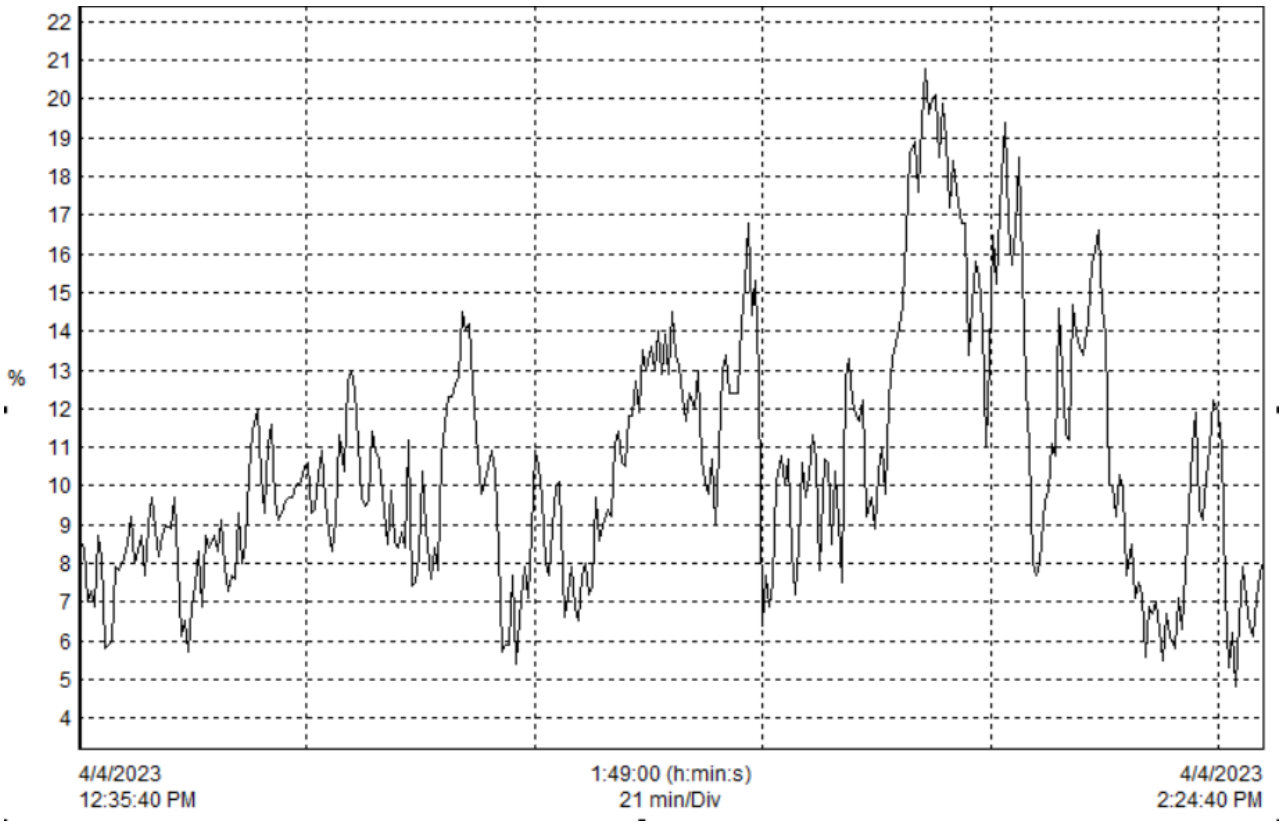


FIGURE 17: CURRENT UNBALANCE

Inference

i. Figure denotes current variations at the LT side.

ii. The maximum current occurred during the normal period was measured at 172.9 A.

iii. The current imbalance varies between 4.8 to 20.8 which is not within the normal operational standard (<8%).

III. ANALYSIS: POWER FACTOR

The section provides an overview of the power factor variations at the LT side.

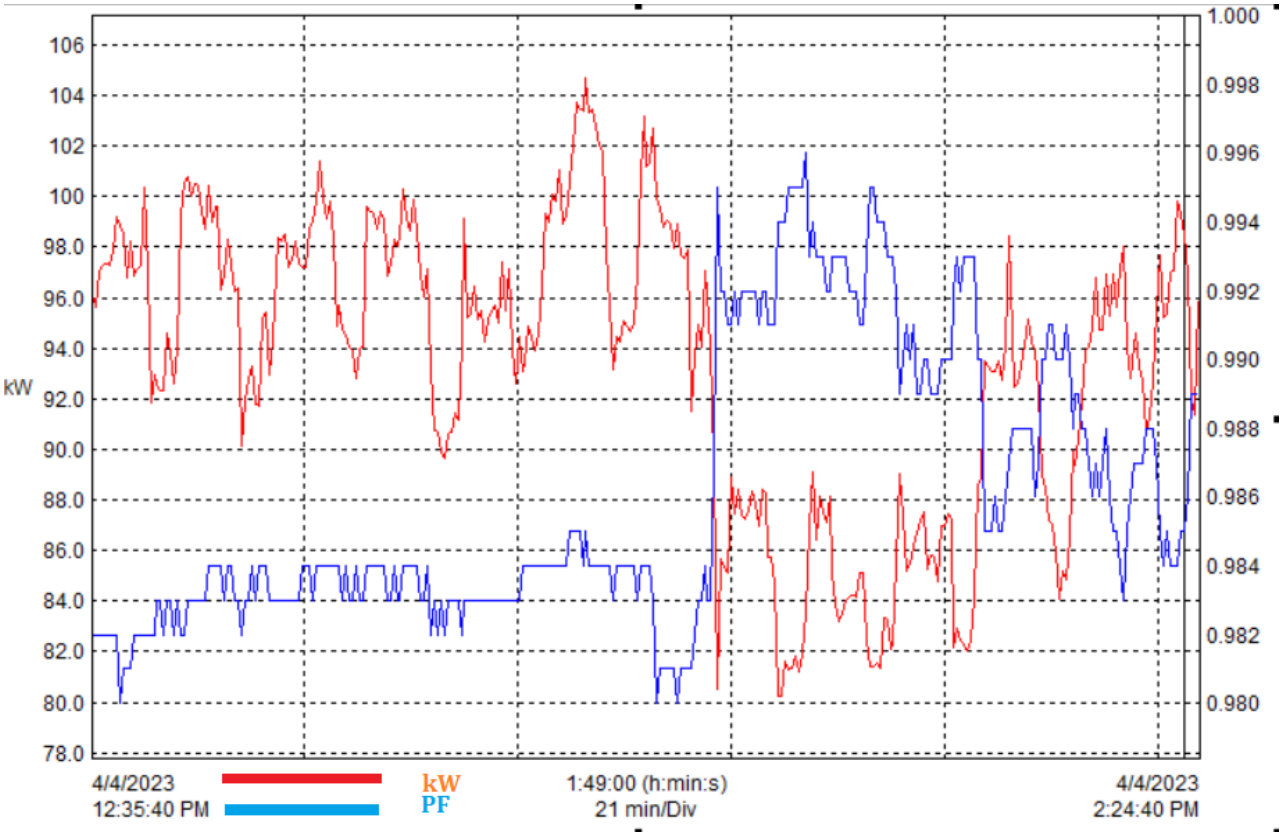


FIGURE 18: KW & PF VARIATIONS

HARMONICS ASSESSMENT – AT TRANSFORMER SECONDARY

Harmonics study revolves around the use of non-linear loads that are connected to electric power systems including static power converters, arc discharge devices, saturated magnetic devices and to a lesser degree, rotating machines. Static power converters of electric power are the largest non-linear loads and are used in industry for a variety of purposes such as electro- chemical power supplies, adjustable speed drives, and uninterruptible power supplies. These devices are useful because they can convert ac to dc, dc to dc, dc to ac, and ac to ac. Non-linear loads change the sinusoidal (a succession of waves or curves) nature of the ac power current (and consequently the ac voltage drop) thereby resulting in the flow of harmonic currents in the ac power system that can cause interference with communication circuits and other types of equipment. Classification, effects and standards are given below:

TABLE 12: HARMONICS CLASSIFICATION

	1st order	2nd order	3rd order	3rd order	4th order	5th order	6th order
Frequency Hz	50	100	150	200	250	300	350
Sequence	+	-	0	+	-	0	+

TABLE 13: EFFECTS OF HARMONICS (IEEE 519)

Effect on - Motor & generator	**-Transformers**	**- Cables**	**- Electronic equipment**	**- Metering**
Rotor heating, causes Reverse rotating magnetic field, causes pulsating torque output, Mechanical oscillations, increases Cogging & Crawling	Increase in copper & stray losses, increase in iron losses, transformer heating	Voltage stress & corona, I^2R losses increases	Voltage notching, Electromagnetic interference, Shifting of the voltage zero crossing	Erroneous reading

TABLE 14: CURRENT HARMONICS LIMIT (IEEE 519-2014)

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)[a, b]						
I_{SC}/I_L	$3 \le h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h \le 50$	TDD
$< 20^c$	4.0	2.0	1.5	0.6	0.3	5.0
$20 < 50$	7.0	3.5	2.5	1.0	0.5	8.0
$50 < 100$	10.0	4.5	4.0	1.5	0.7	12.0
$100 < 1000$	12.0	5.5	5.0	2.0	1.0	15.0
> 1000	15.0	7.0	6.0	2.5	1.4	20.0

[a]Even harmonics are limited to 25% of the odd harmonic limits above.

[b]Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

[c]All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L.

where

I_{sc} = maximum short-circuit current at PCC

I_L = maximum demand load current (fundamental frequency component) at the PCC under normal load operating conditions

TABLE 15: VOLTAGE HARMONICS LIMIT (IEEE 519-2014)

Voltage distortion limits		
Bus voltage at PCC	**Individual voltage distortion %**	**Total voltage harmonics distortion %**
V ≤ 01 kV	**5.0**	**8.0**
01 kV < V ≤ 69 kV	3.0	5.0
69.001 kV < V ≤ 161 kV	1.5	2.5
161.001 kV and above	1.0	1.5

HARMONICS MEASUREMENT

1. **Standard for harmonics** - IEEE 519-2014
2. **Normal range of Isc/I_L in the plant** - 20< x ≦ 50
3. **Maximum standard Total demand distortion – current** - 5%
4. **Maximum standard Total harmonic distortion – voltage** - 5%

TABLE 16: TOTAL HARMONIC DISTORTION AT THE TRANSFORMER SECONDARY

Particulars	Rated power	THDv max	THDa max	Remarks	Status with IEEE 519-2014
	kVA	%	%		
Transformer Secondary	400	2	20.90	THDa is higher than the prescribed limit	High

Where:

- *THDv – Total harmonic distortion voltage*
- *THDa – Total harmonic distortion current*

I. VOLTAGE HARMONICS ANALYSIS

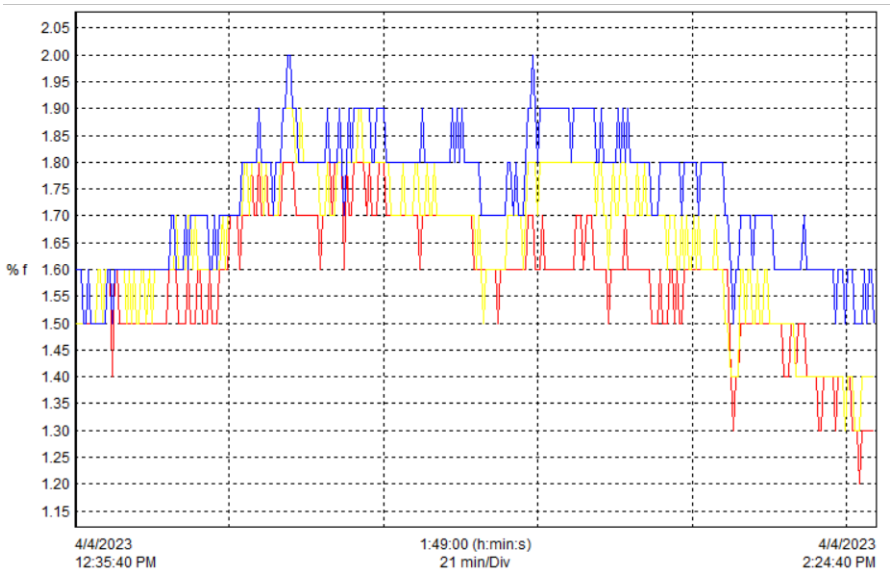


FIGURE 19: THDv

II. CURRENT HARMONICS ANALYSIS

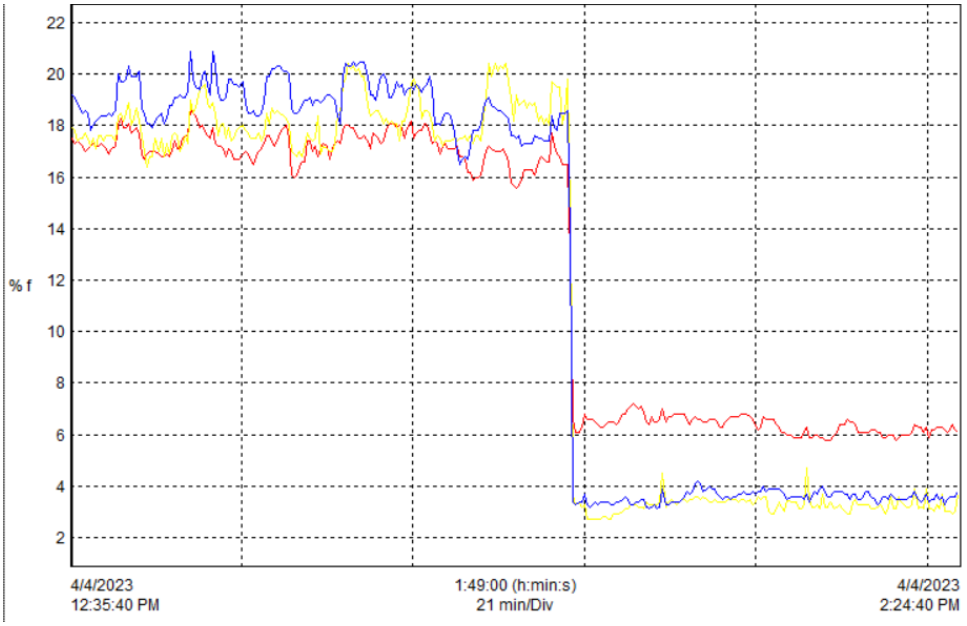


FIGURE 20: THDa

INFERENCE & OBSERVATION – HARMONIC ASSESSMENT

TABLE 17: INFERENCE & OBSERVATION – HARMONIC ASSESSMENT

Harmonics	
Observation	**Suggestion**
➢ The present THD current at the secondary side of the transformer is higher than the prescribed limit. <5% shall be the current value). ➢ The voltage THD is found to be within the limits of 5%. ➢ When we analysed, the major cause for the effect of high THD current is the presence of UPS.	➢ To reduce the harmonic effect in the system, the purchase tender of equipment such as UPS, VFD & LED shall contain the Harmonic limitation standard as per the IEEE 519. ➢ This will reduce the effects of non-linear loads in the system.

REACTIVE POWER COMPENSATION - ANALYSIS

APFC panels are installed at the secondary side of the transformer. The rated details and performance of the installed units of capacitors is given below:

TABLE 18: CAPACITOR DETAILS

Name	Rated kVAr	Design Voltage	Measured Voltage	Measured kVAr	kVAr wrt to Volts	% of deterioration
	A	B	C	E	F= E*(B/C)²	G= (A-F)*(100/A)
College						
C1	25	440	390	24.48	31.16	-24.64
C2	20	440	390	16.5	21.00	-5.01
C3	20	440	390	16.34	20.80	-3.99
C4	15	440	390	8.11	10.32	31.18
C5	10	440	390	12.09	15.39	-53.89
C6	10	440	390	7.96	10.13	-1.32
C7 (Direct)	10	440	390	Not Working		
Ladies Hostel						
C1	5	440	400	3.34	4.04	19.17
C2	15	440	400	12.21	14.77	1.51
C3	5	440	400	4.21	5.09	-1.88
C4	10	440	400	8.47	10.25	-2.49
C5	15	440	400	12.51	15.14	-0.91
C6	20	440	400	16.92	20.47	-2.37

Inference

1. All Power factor can be improved to unity so as to increase the incentives received by the college.

Suggestion

1. Provide small rating capacitors to the APFC panel especially in college to fine tune the power factor
2. Remove the direct connected capacitor from the MSB to avoid leading power factor during low load(night and holidays)

DIESEL GENERATOR

Diesel generator used in the college as backup supply. There are three DG's provided in the facility. The following table gives the basic details of diesel generator in the facility.

TABLE 19 DG DETAILS

Location	Rated Capacity	Engine	Alternator
	kVA		
College	380	Volvo	Leroy Somer
College	125	Cummins	Stamford
Ladies Hostel	82.5	Kirloskar	Kirloskar

Inference & Suggestions	*The diesel consumption for DG is not recorded properly. A log book to monitor the diesel consumption(L) and unit consumption(kWh) shall be maintained and record it after its running.*

RENEWABLE ENERGY

The Sun is an inexhaustible, reliable and non-polluting source of power. Since the inception of life on earth, the only energy that was available came from the sun. The time is now approaching when mankind will again depend upon the sun as dominant energy source. The fossil fuels are depleting at a rapid rate. A growing worldwide concern for conservation of energy has reignited the interest in ecologically sustainable materials, processes and sources of energy. The advantages of solar power are:

- The solar energy is more evenly distributed in the world than wind or bio-mass.
- It is well proven and demonstrated technology
- It promises to be most cost effective renewable power at high volumes.

The solar energy potential in India is immense due to its convenient location near the Equator. India receives nearly 3000 hours of sunshine every year, which is equivalent to 5000 trillion kWh of energy.

Kristu Jyoti College have installed solar of 120 kW and is under installation.

ANNEXURE – 1

ENERGY SAVING PROPOSALS - 1

CHANGING THE LEADING POWER FACTOR TO LAGGING POWER FACTOR

Background

By referring the last year bills, it is clear that the average power factor was 1 (lead) in college and hostel. Direct connected capacitor is provided in the MSB.

Proposal

Replace the direct connected capacitors from the APFC panel to improve the PF to unity and gain incentives.

Calculations for the energy saving proposal is given in the table below.

TABLE 20: EC PROPOSAL 1

Particulars	Units	College	Hostel
Present PF		1 (Lead)	1 (Lead)
Proposed PF		1 (Lag)	1 (Lag)
Present average energy consumption/month	kWh/month	41,880	12,771
Present average energy charge/month	Rs/month	3,24,415	85,962
Last year Incentives	Rs/annum	7,504	0
Incentives for improving the PF from leading to lagging	Rs/annum	97,324	25,789
Annual incentive increment **(Annual Savings)**	**Rs/annum**	**89,820**	**25,789**
Investment	**Rs**	**10,000**	**5000**
Payback period	**Months**	**02**	**03**

ENERGY SAVING PROPOSALS - 2

REPLACEMENT OF CEILING FANS IN THE OFFICE WITH ENERGY EFFICIENT BLDC FANS

BACKGROUND

A BLDC fan takes in AC voltage and internally converts it into DC using SMPS. The main difference between BLDC and ordinary DC fans is the commutation method. A commutation is basically the technique of changing the direction of current in the motor for the rotational movement. In a BLDC motor, as there are no brushes, so the commutation is done by the driving algorithm in the Electronics. The main advantage is that over a period, due to mechanical contact in a brushed motor the commutators can undergo wear and tear, this thing is eliminated in BLDC Motor making the motor more rugged for long-term use. To explain, BLDC technology in simpler terms, BLDC uses a combination of Permanent Magnets and Electronics to achieve the kind of efficiency and performance, it delivers. A BLDC fan composes of 3 main components: - 1. Stator 2. Rotor 3. Electronics

PROPOSAL

Replace the ceiling fans with BLDC in the as per preference of operating hours as office areas, staff rooms and in classrooms, the calculation for the savings given in the table.

TABLE 21: EC PROPOSAL 2

Particulars	Units	Value
Present Power Consumption	Watts	60
Proposed Power Consumption	Watts	28
Reduction in power	Watts	32
Operating hours per day	Hr/day	8
No: of working days per year (Average)	Nos	210
No: of working hours per annum	Hrs	1680
Number of Fans operating	Nos	40
kWh Saving per Annum	**Rs**	**2150.4**
Cost per kWH (Average)	Rs	7.8
Annual Financial Savings	**Rs**	**16773.12**
Cost of BLDC Fans	Rs	3500
Investment for BLDC Fans	**Rs**	**140000**
Simple Payback period	**Months**	**100**
SUMMARY		
Annual unit savings	kWh	2150
Total savings	Rs	16773
Total investment	Rs	140000
Payback period	months	100

ENERGY SAVING PROPOSALS - 3

REPLACEMENT OF FLOURESCENT TUBES WITH LED LIGHTS

Replace continues working fluorescent lights with LED lights.

TABLE 22: EC PROPOSAL 3

Particulars	Units	Values
Power of Fluorescent lights	Watts	36
Power of proposed LED tube	Watts	20
Difference in Wattage	Watts	16
Avg No: of working hours/day	Hrs	8
No: of working days per year (Average)	Nos	210
No: of working hours per annum	Hrs	1680
Number of Lights operating	Nos	50
kWh Saving per Annum	**Rs**	**1344**
Cost per kWH (Average)	Rs	7.8
Annual Financial Savings	**Rs**	**10483.2**
Cost of LED tube	Rs	350
Investment for LED lights	**Rs**	**17500**
Simple Payback period	**Months**	**20**
Summary		
Annual unit savings	**kWh**	**1344**
Total savings	**Rs**	**10483.2**
Total investment	**Rs**	**17500**
Payback period	**months**	**20**

ANNEXURE-2

I. CONNECTED LOAD

I. LIGHT & FAN LOAD

Location	*T8*	*LED Tube*	*LED*				*LED ceiling light*										*Ceiling Fan*
Watts	*36*	*22*	*3*	*7*	*9*	*14*	*3*	*7*	*8*	*14*	*15*	*22*	*28*	*36*	*100*	*200*	*60*
Chavara Block																	
Ground Floor	34			3		1											33
First Floor	36			5					13			12					47
Second Floor	33			4										4			40
Third Floor	31			3													33
Fourth Floor	1		60		1									28			43
MCA Block																	
Ground Floor	45			8				7					9	13	2	2	47
First Floor	41			2			30	1	10		6			4			45
Second Floor	36	8		2						14							58
Third Floor	4	48		3										18			70
Total Nos	***261***	***56***	***60***	***30***	***1***	***1***	***30***	***8***	***23***	***14***	***6***	***12***	***9***	***67***	***2***	***2***	***416***
Total kW	***9.4***	***1.223***	***0.18***	***0.21***	***0.009***	***0.014***	***0.09***	***0.056***	***0.184***	***0.196***	***0.09***	***0.264***	***0.252***	***2.412***	***0.2***	***0.4***	***24.96***
Total kW - 40.145																	

II. AIR CONDITIONER LOAD

Location	Make	Type	Capacity	EER	Star rating	Rated Power	Year
			TR			Watts	
Server Room	General	Split	1.5	3.83	3	1086	2021
Server Room	Totalline	Split	1.5			1400	
Principal Room	General	Ductable	5			4500	2021
Conference Hall	Voltas	Ductable	5			4500	2014
Chapel - Ladies Hostel	Bluestar	Split	2			1650	2020

III. OTHER POWER LOAD

Sl.No:	*Particulars*	*Rated Power (Watts)*	*Nos*	*Total Power (kW)*
1	PC	110	117	12.87
2	Laptops	100	8	0.8
3	Laser Printers	200	2	0.4
4	Printer with Scanner	300	4	1.2
5	Printer with Scanner and Copier	350	2	0.7
6	Coffee Machine	250	2	0.5
7	Water Cooler	1100	7	7.7
8	Water Filter	20	2	0.04
9	Water Filter	250	2	0.5
10	LCD Projector	200	31	6.2
11	LED TV	100	2	0.2
12	Mic Set	700	1	0.7
13	Mic Set	2000	2	4
Total				***35.81***

ANNEXURE-3

I. LIST OF INSTRUMENTS

SL.NO	EQUIPMENT DESCRIPTION	MAKE & MODEL
1	POWER ENERGY & HARMONIC ANALYZER	KRYKARD ALM 31

II. ABBREVIATIONS

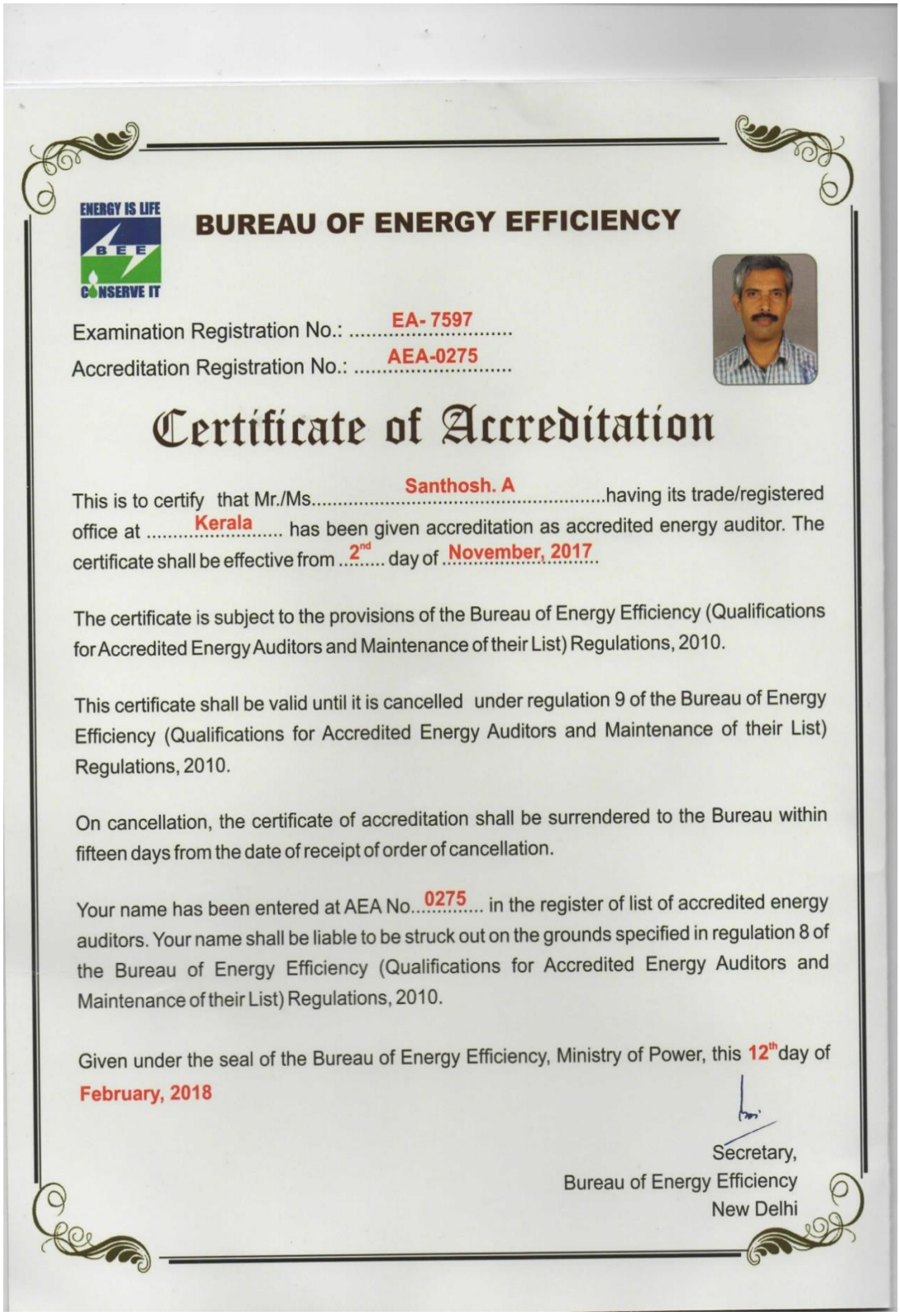
APFC	:	Automatic Power factor Control
AVG	:	Average
BEE	:	Bureau of energy efficiency
BH	:	Boys Hostel
CO_2	:	Carbon dioxide
KSEB	:	Kerala State Electricity Board.
DB	:	Distribution Board
EC	:	Energy Conservation
IEEE	:	The Institute of electrical and electronics engineers
IS	:	Indian Standard
kL	:	kilo Litre
KVA	:	kilo Volt Ampere
kVAh	:	kilo volt Ampere Hour
kVAr	:	kilo volt ampere
kW	:	kilo Watts
kWh	:	kilo watt hour
LH	:	Ladies Hostel
LPG	:	Liquified Petroleum Gas
LT	:	Low tension
MAX	:	Maximum
NSS	:	National Service Scheme
SLD	:	Single Line Diagram
THD	:	Total Harmonic Distortion
TR	:	Transformer

III. REFERENCES:

- Handbook on energy audit and environment management by TERI.
- Bureau of Energy Efficiency (BEE) books for certification of Energy Auditors & Managers.

IV. CERTIFICATES

I. BEE Accreditation Certificate



ENERGY IS LIFE
BEE
CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

Examination Registration No.: EA- 7597
Accreditation Registration No.: AEA-0275

Certificate of Accreditation

This is to certify that Mr./Ms. Santhosh. A having its trade/registered office at Kerala has been given accreditation as accredited energy auditor. The certificate shall be effective from 2nd day of November, 2017

The certificate is subject to the provisions of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010.

This certificate shall be valid until it is cancelled under regulation 9 of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010.

On cancellation, the certificate of accreditation shall be surrendered to the Bureau within fifteen days from the date of receipt of order of cancellation.

Your name has been entered at AEA No. 0275 in the register of list of accredited energy auditors. Your name shall be liable to be struck out on the grounds specified in regulation 8 of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010.

Given under the seal of the Bureau of Energy Efficiency, Ministry of Power, this 12th day of February, 2018

Secretary,
Bureau of Energy Efficiency
New Delhi

II. EMC Empanelment certificate

Energy Management Centre - Kerala
(Department of Power, Govt of Kerala)

CERTIFICATE OF EMPANELMENT

This is to certify that ***M/s.Athul Energy Consultants Pvt Ltd****(4/2, Capital Legend Building, Korapath Lane, Rouund North, Thrissur)is empanelled as Energy Audit firm in Energy Management Centre Kerala to conduct mandatory energy audit as per Government of Kerala G.O (Rt) No.2/2011/PD dated 01.01.2011.*

Empanelment No:
EMCEEA-0811F-3

Scope/Area	Building	Industry -Electrical	Industry Thermal
	Yes	Yes	Yes

This empanelment is valid up to 01/02/2024
Issuing Date: 02/02/2021
Place: Thiruvananthapuram

Director,
Energy Management Centre - Kerala