Athul
ENERGY CONSULTANTS

Athul Energy, we stand for
Quality Reliability and Efficiency
Accredited Energy Audit Firm Empanelled by BEE

No: AEC/GAC/22-18

27-05-2022

Audit Certificate

This is to certify that **Sree Sankara College**, Kalady, Ernakulam has successfully completed the **Energy Audit** of the academic year 2021-2022 on 18th & 19th May 2022. The college had submitted all the necessary data and credentials for scrutiny and the delegates of **Athul Energy Consultants Pvt Ltd** verified the building, campus and all the facilities of the institution.

We, **Athul Energy Consultants Pvt Ltd**, Thrissur congratulate the Chairman, Advisor, Principal and staff members and students for the successful completion and participation in the audit report process.

ATHUL ENERGY CONSULTANTS PVT. LTD. THRISSUR 680 020

Managing Director

Athul Energy Consultants Pvt Ltd

Athul Energy Consultants Pvt Ltd
CIN: U74999KL2016PTC046898
info@athulenergy.com
www.athulenergy.com

Registered Office:
4/2, Capital Legend Building
Korapath lane, Round-North
Thrissur-680020, Kerala
+91 7356111990

Branch Office:
F-7, James Square
Asian paint Chowkady, GIDC
Ankleshwar-393002, Gujarat
+91 7356111991

ENERGY AUDIT - 2022

SREE SANKARA COLLEGE

KALADY, ERNAKULAM

EXECUTED BY

ATHUL ENERGY CONSULTANTS PVT LTD
4th FLOOR, CAPITAL LEGEND BUILDING,
KORAPPATH LANE, ROUND NORTH, THRISSUR-680020
Ph: +91 7356111990-6 Web: www.athulenergy.com E-Mail: info@athulenergy.com

May 2022

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 being 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 house holds 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 is 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 Sree Sankara College, Kalady for giving us an opportunity to carry out the project of Energy Audit. We are extremely thankful to all the staffs for their support to carry out the studies and for input data, and measurements related to the project of Energy Audit.

1	Dr. Suresh A	Principal
2	Dr. Preethi Nair	IQAC Co-ordinator

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. Ashok K M P**
   Registered Energy Manager of Bureau of Energy Efficiency (BEE – Govt. of India)
   Accredited Energy Manager No – EA 25612

3. **Mr. Harikrishnan K**
   Project engineer

4. **Ms. Keerthana K**
   Project engineer

5. **Ms. Neema Joy P**
   Project engineer

ATHUL ENERGY CONSULTANTS PVT. LTD. THRISSUR 680 020

Yours faithfully

Managing Director
Athul Energy Consultants Pvt Ltd

EXECUTIVE SUMMARY

I. ENERGY SAVING PROPOSALS

TABLE 1: ENERGY SAVING PROPOSALS

Sl. no	Energy conservation measures	Annual Energy Savings	Annual Financial Savings	Investment	Simple payback period
		kWh	Rs	Rs	Months
1	Power Factor Improvement by installing 16 kVAr capacitor.		36053	16000	5
2	Replacement of (250 nos) ceiling fan (75W) with BLDC (28W)	10575	71022	875000	148
3	Replacement of T8(36W)-130 nos and T12(40W)-49 nos with LED Tube light (20W)	2203	14806	53700	44
4	Replacement of 3-star AC (1.5 Ton) with 5-star AC (1 Ton)	1337	8985	38000	51
Total		**14115**	**130865**	**982700**	90
5	Installation of 50 kW Solar PV system		372000	2250000	6

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 demand analysis was done for the last 12 months. It is found that the recorded maximum demand was 111.34 kVA which is 93% of the contract demand. The percentage of recorded maximum demand in the normal, Peak and off-peak period registered with respect to the contract demand (120 kVA) is 93%, 43%, and 39% respectively.
- **Power factor**: The PF in the last 12 months was found to be 0.94 (average) and penalties were levied for several months. Rs 3845 was paid as penalties for low PF during the May 2021– Sep 2021. Installing 16kVar inline capacitor across the incomer (LT side) would help to maintain the power factor above the prescribed limit.

- **Renewable energy integration:** College is benefitted with space in its roof top hence they can go for solar installations in their facility and go for zero billing and claimed as solar powered college or self-sustainable College**.**
- **Sub metering of panels:** Sub metering of panels suggested to know the separate energy consumption of each building.

2. Equipment and utility description

- **Voltage:** The maximum and minimum supply voltage during the normal operational period, excluding the power failure, is 424.9V and 399.8V respectively with an average voltage of 413.7V. Voltage unbalance comes in the range of 1.3 to 2.4%.
- **Current imbalance**: The maximum current occurred during the period and measured at 58.5A. The current imbalance varies between 1to 25.5%.
- **Load factor**: The present average load factor in 24 hours' period is 53%.
- **Capacitors**: Capacitors are not installed in the college.
- **Harmonics:** The present Harmonics values (THDv = 1.17 & THDi = 5.66%) both the current and voltage harmonics are satisfactory.
- **Light loads:** By replacing the fluorescent lighting fixtures (T12, T8) with LED light will reduce the overall power consumption. Detailed analysis given in the energy conservation measures section.
- **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 75W in normal fans, will reduce the power consumption considerably. Also, while purchasing new fans priority should be given for BLDC.

III. ENERGY PERFORMANCE INDEX (EPI)

EPI was based on the energy consumption in May 2021 to April 2022. The projected energy consumption after the implementation of energy saving proposals is given in the table below.

TABLE 2: ENERGY PERFORMANCE INDEX

Energy Performance	Unit	Present Consumption	Projection
Annual Electricity Consumption *	kWh	123352	109236
Annual Diesel Consumption	Litre	800	800
Annual LPG Consumption	kg	328	328
Energy Performance Index	TOE/m^2	0.00061	0.00055
Specific Energy Consumption	TOE/Head	0.00459	0.00411
Annual Energy Cost	Rs.	945170	850362
Carbon Footprint - Electricity	Ton CO2	97.45	86.30
Carbon Footprint - Diesel	Ton CO2	1.92	1.92
Carbon Footprint - LPG	Ton CO2	0.98	0.98
Annual Carbon Footprint	Ton CO2	100.35	89.20
Specific Carbon Footprint - Annual	Ton CO2/Head	0.0393	0.0349

* *Only sixty percentage of the total electricity consumption is taken into consideration since the electric connection is common for all other institution in the campus premises.*

Note: Unit conversions:

TOE	=	*10 million kCal (BEE energy audit manual)*
MWh of electricity	=	*0.79 Ton of CO_2 (www.cea.gov.in)*
Ton of LPG	=	*2.99 Ton of CO_2 (www.cea.gov.in)*
Ton of Diesel	=	*2.4 Ton of CO_2 (www.cea.gov.in)*
kWh of electricity	=	*860 kCal (BEE energy audit manual)*
Kilogram of LPG	=	*10500 kCal (BEE energy audit manual)*
Liters of Diesel	=	*9500 kCal (BEE energy audit manual)*

IV. ANNUAL CARBON FOOTPRINT OF APPLIANCES

The present carbon dioxide generation by appliances in the college and the projected value after the implementation of the energy conservation measures is given in the figure below

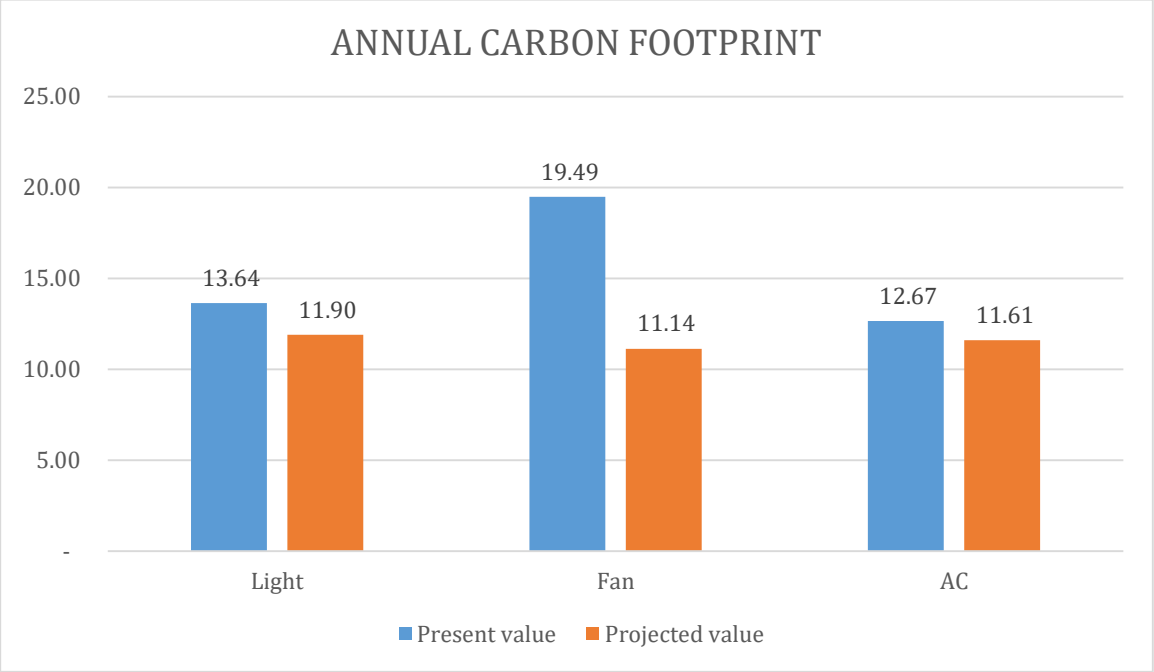


FIGURE 1: ANNUAL CO_2 EMISSION

V. CARBON FOOT PRINT

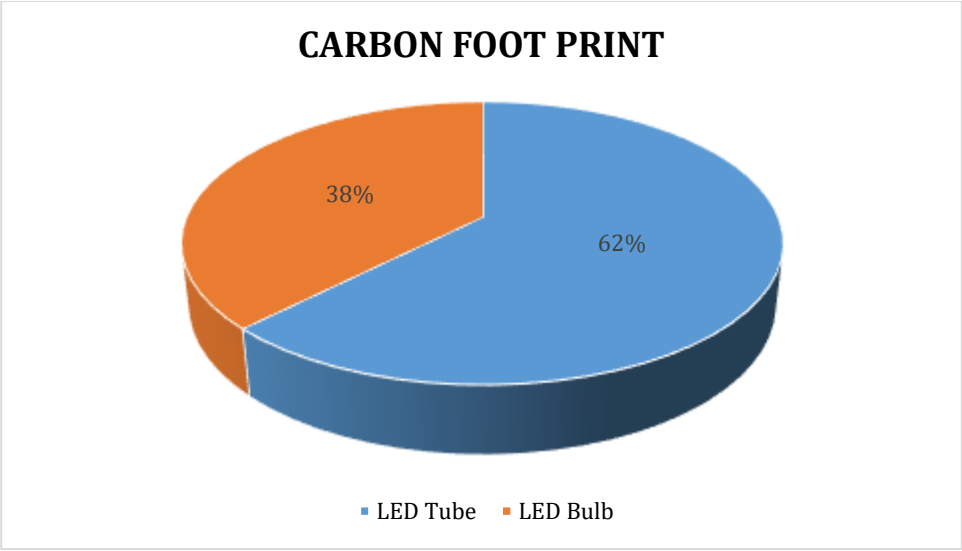
Carbon foot print is often used as short hand for the amount of carbon emission (usually in Tonnes) being emitted by an activity or by organization this is an important component in ecological foot print or the depicting the biological space reduction in the earth. Various environment protection and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

1. Protecting and conserving trees inside and outside the campus through various students' activities
2. Replacement of old CFLs and tubes with energy efficient LED lights
3. Sustainable construction of buildings for natural ventilation and light in the classrooms and laboratories.

TABLE 3 CARBON FOOT PRINT

Particulars	Energy consumption reduction (kWh)	Carbon Emission reduction (Ton CO_2)	% of total
Replacement of 281numbers of T8 Tube (36W) with LED tube light	3237	2.56	62
Replacement of 301 numbers of CFL with (9W)LED	1950	1.54	38
Total	**5187.6**	**4.10**	**100**

FIGURE 2: 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 are conducted to evaluate the effectiveness of an energy efficiency project or program. In Jawaharlal College 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. SREE SANKARA COLLEGE, KALADY

Sree Sankara College, Kalady was founded in the year 1954 by Swami Agamananda, a social reformer and a foresighted scholar of Sri Ramakrishna Advaita Ashram. The institution was established with a view to perpetuating the memory and doctrines of the great saint and philosopher, Adi Sankaracharya and to nurture his birth place as a cultural citadel. The foundation stone was laid on 28 August, 1953 by His Highness the Maharaja of Travancore in the presence of The Maharaja of Cochin and several other distinguished personalities. The Sree Sankara College Association was formed in July 1954.

The vision & mission of the organization was to establish a Centre of Higher Learning with two major objectives —dissemination of knowledge in tune with a university curriculum and fostering community development.

The institution was raised to the status of a First Grade College in 1956. It is affiliated to the Mahatma Gandhi University and is included under sec.2 (f) and 12 (B) of the UGC act, 1956.

In June 1960, the patronage of the college became vested in His Holiness the Jagadguru Sri Sri Sankaracharya Swamigal of Dakshinamnaya. Currently, Sri Sri Bharathi Theertha Mahaswamigal, of Sringeri Mutt, steers the administration through a Board of Directors with Sri. K. Anand as the Managing Director.

The college has done consistently well in Curricular and Cocurricular activities. The National Assessment and Accreditation Council (NAAC), accredited the college by B++ Grade with 2.80 CGPA on a four-point scale. The Departments of Economics, Commerce, Sanskrit and Microbiology are approved Research Centres under the Mahatma Gandhi University.

VISION

To achieve excellence in higher Education, with a stress on, creativity, skill development, employability, personal values with social

MISSION

To mould good citizens with ingenuity, adaptability, social commitment and ethical values who can provide innovative leadership in all walks of life.

III. GENERAL DETAILS

The general details of the College are given below in table.

TABLE 4: GENERAL DETAILS

Sl. No:	Particulars	Details
1	Name of the College	Sree Sankara College, Kalady
2	Address	Sree Sankara College Sankar Nagar, Mattoor, Kalady P.O., Ernakulam – 683 574
3	Contact Person	Dr. Mini K D, Ph: 9605055445
4	Contact Number &	0484-2462341
	E mail	info@ssc.edu.in
5	Web site	www.ssc.edu.in
6	Type of Building	Educational Institution
7	Annual Working Days	180
8	No: of Shifts	Day Shift (One) (9:30AM -3:30PM)
9	No: of students enrolled	2421
10	No: of teaching & non-teaching staff	133
12	No: of departments	21
13	Total Built Up area	19078 Sq. m
14	Total land area	18 acres
15	Average power consumption per month.	17132 kWh
16	Average electricity charges per month.	Rs. 107360/-

IV. LOAD BALANCE- ELECTRICAL

The details of the loads installed in the college are given below:

TABLE 5: CONNECTED LOAD

Sl. No:	Particulars	Total Load (kW)	Percentage
1	Light & Fan	76.90	34
2	Computer and other electronic loads	55.46	25
3	Air Conditioner Load	29.60	13
4	Other Loads	62.66	28
	Total Power (kW)	**224.61**	**100**

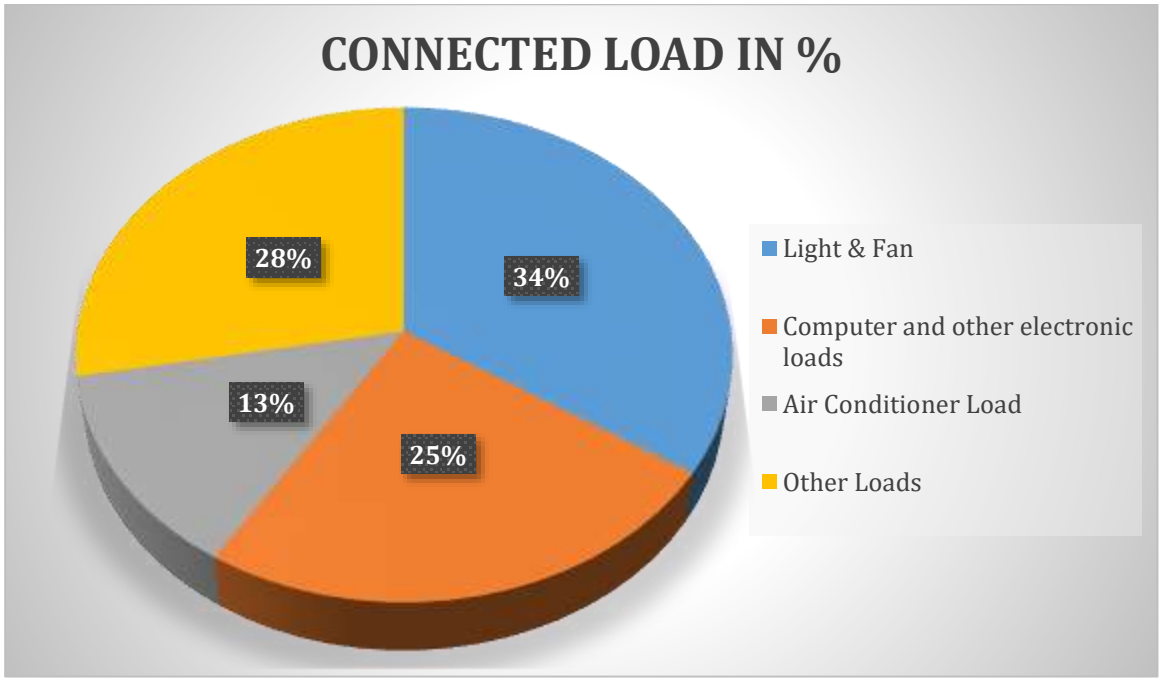


FIGURE 3: LOAD BALANCE – ELECTRICAL

ENERGY & UTILITY DESCRIPTION

In this section the single line diagrams of electricity and water are 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 is given below:

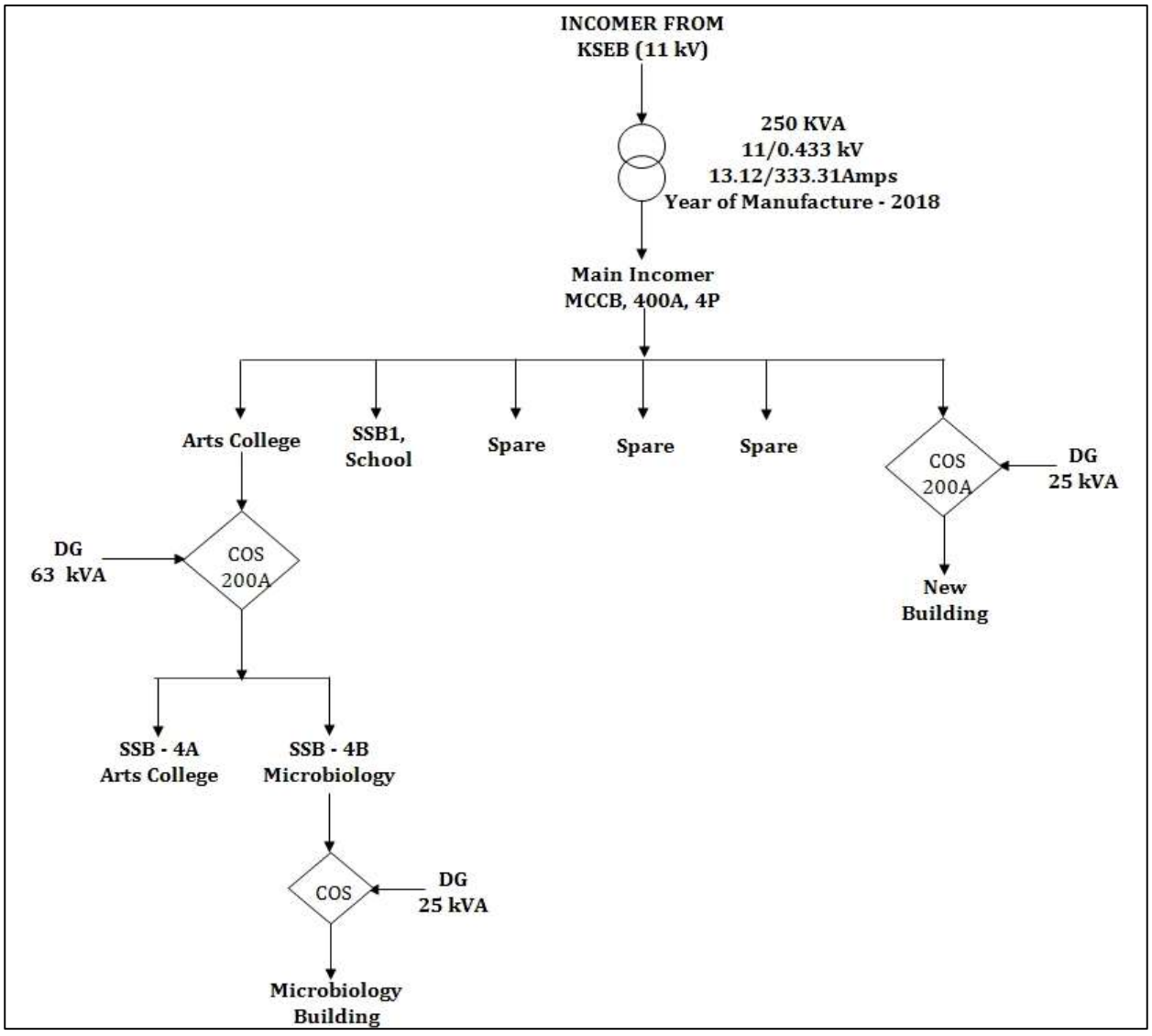


FIGURE 4: SINGLE LINE DIAGRAM – ELECTRICAL

II. SINGLE LINE DIAGRAM – WATER

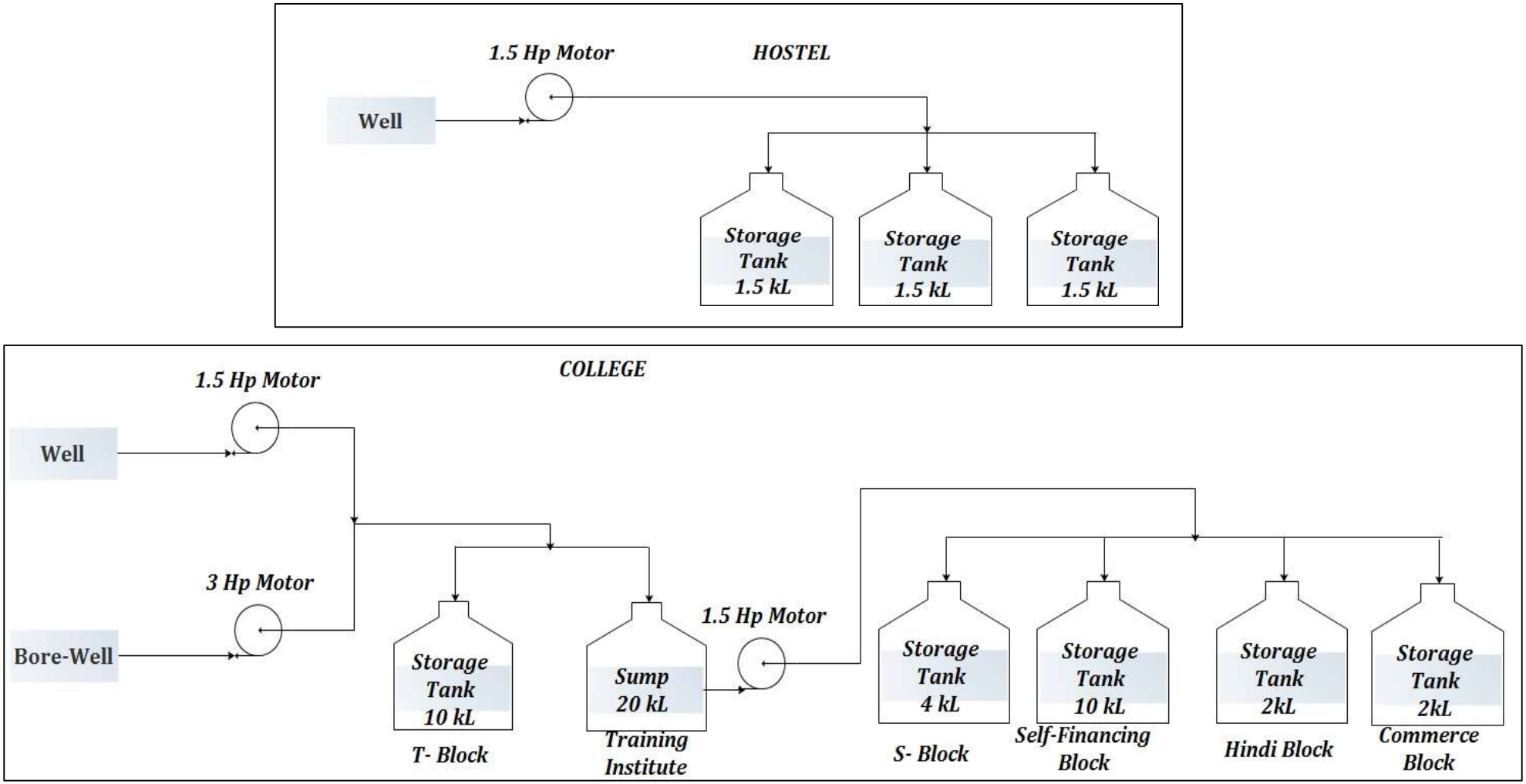


FIGURE 5: SINGLE LINE DIAGRAM - WATER

ENERGY ANALYSIS

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

ELECTRICITY CONSUMPTION ANALYSIS

The major source of electricity to the college and hostel is the electrical connection from the KSEBL. Three 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 May 2021 to April 2022 is as follows in the Table.

TABLE 6: KSEBL BILL ANALYSIS

Particulars	Details
Consumer No	LCN: 4/9247
Contract Demand (kVA)	120 kVA
Connected Load (kW)	288.476 kW
Tariff	HT II (B) General
Recorded maximum demand (kVA)	111.34
Average monthly electricity consumption (kWh/month)	17132
Average Power factor	0.94
Average Demand charges (Rs/month)	41,873
Annual power factor penalty & Incentive (Rs/year)	Penalty – Rs. 3845/- Incentives – Rs. 5065/-
Demand charge (Rs / kVA)	440
Energy charge (Rs/kWh)	Normal-6.2 Peak-9.3 Off Peak-4.65
Average electricity cost (Rs/month)	1,60,362

Inference & Suggestions

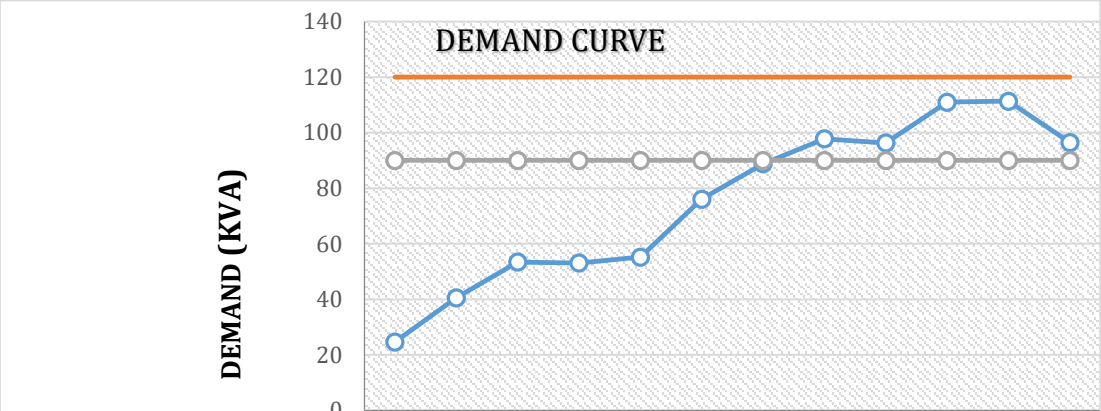
i. Average Power factor is found to be 0.94. The college was levied PF penalties during several months since the PF was below the prescribed limit of 0.95.

ii. 16kVAr inline capacitor can be connected at the transformer secondary side to improve the PF to unity.

iii. Recorded maximum demand (RMD) during past 12 month was 111.34 kVA. It was recorded during the month of March 2022.

II. DEMAND ANALYSIS

This section analyses the trend for the maximum demand versus the Contract Demand (CD) over a 12-month period (May 2021 to April 2022).



	May -21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22
RECORDED MAXIMUM DEMAND	25	41	53	53	55	76	89	98	96	111	111	96
CONTRACT DEMAND	120	120	120	120	120	120	120	120	120	120	120	120
75% Contract demand	90	90	90	90	90	90	90	90	90	90	90	90

FIGURE 6: DEMAND IN VARIOUS TIME ZONE

Inference

i. Annual demand charges came as **Rs. 5,02,480/-**

ii. The recorded maximum demand came in the range of 10% to 93% with respect to the contract demand with an average of 39%.

Suggestion

i. Maintaining the power factor to near unity in lagging mode yields dual benefits, the demand will further reduce and the incentives for the power factor will rise.

ii. Installing capacitor will help to maintain the power factor to near unity.

III. ELECTRICITY DEMAND IN VARIOUS TIME ZONES

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

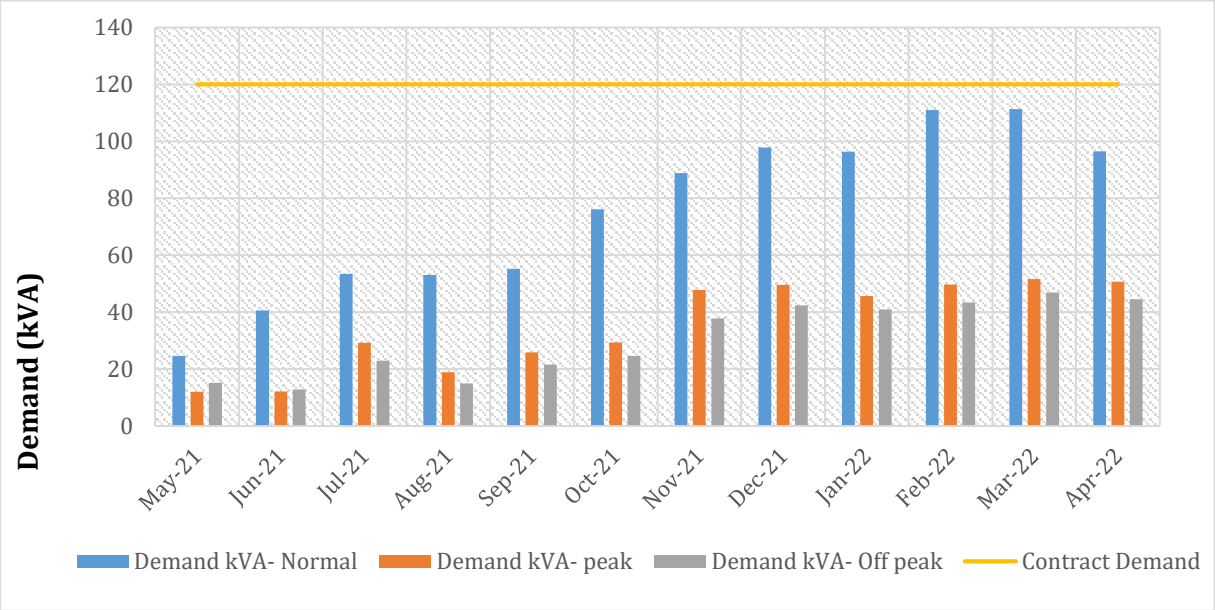


FIGURE 7: ELECTRICITY DEMAND IN VARIOUS TIME ZONE

Inference

i. The average demand registered during the normal, Peak and off-peak period at college with respect to the contract demand (120 kVA) were 75%, 35% and 31% respectively.

ii. The percentage of maximum demand during the normal, Peak and off-peak period registered at institution with respect to the Contract demand (120 kVA) were 93%, 43% and 39% respectively.

IV. POWER FACTOR ANALYSIS IN KSEBL BILL

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

$$PF = Active\ energykWh/Apparentenergy\ (kVAh)$$

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

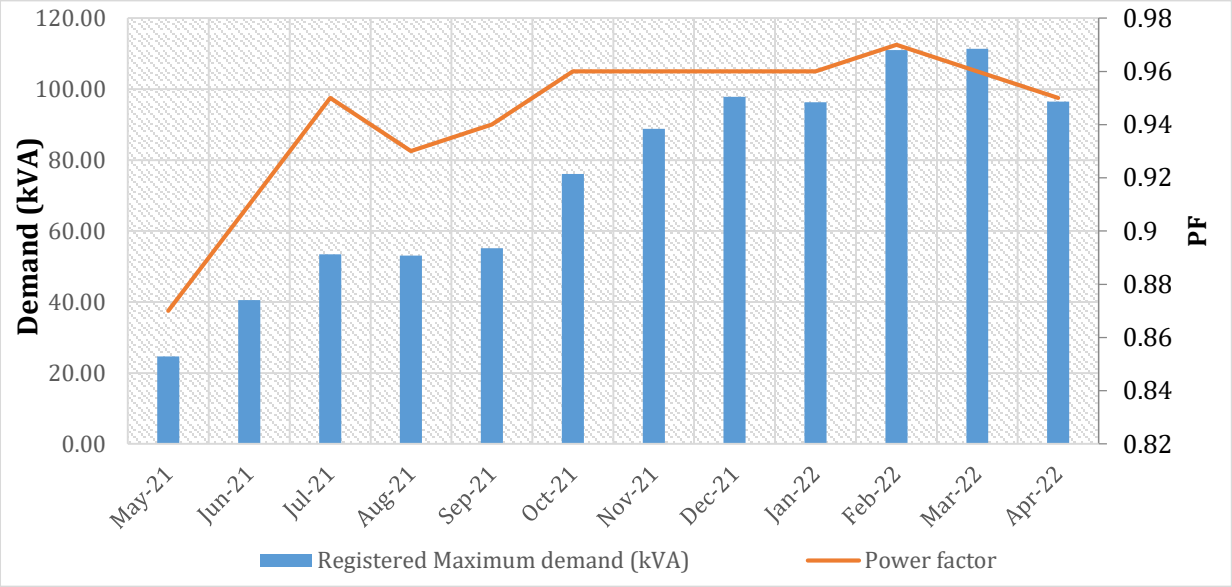


FIGURE 8: POWER FACTOR ANALYSIS

Inference

i. Average power factor during the past one year is found to be 0.94
ii. Power factor penalty was paid by college for May 2021 – September 2021. If the power factor is maintained close to unity, penalty incurred can be avoided.
iii. Capacitors are not installed.
iv. Capacitors can be installed so as to improve the PF and gain incentives. Detailed explanation is given in the section Energy Conservation Measures ECM 01.

V. TARIFF RATES ANALYSIS

The average monthly energy and demand charges for the period May 2021 to April 2022 is represented in Fig.

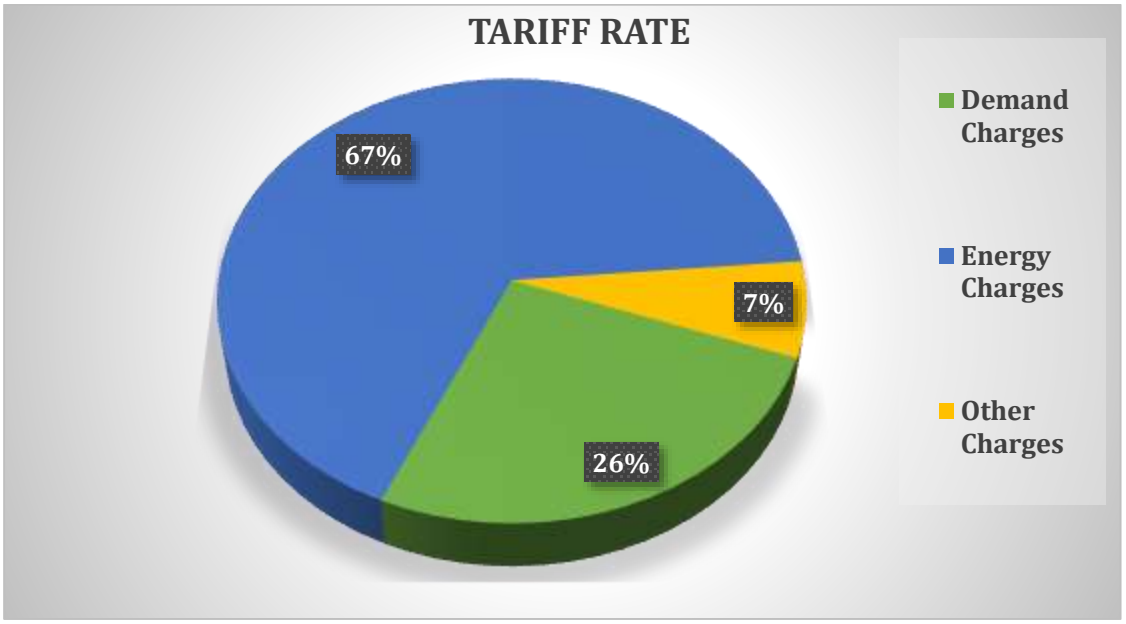


FIGURE 9: TARIFF RATE ANALYSIS

Inference

i. Average demand charges for the past one year were **Rs 41,873/-** per month and energy charges was **Rs 1,07,360/-** per month**.**

ii. The energy charges come about 67**%** of the total bill.

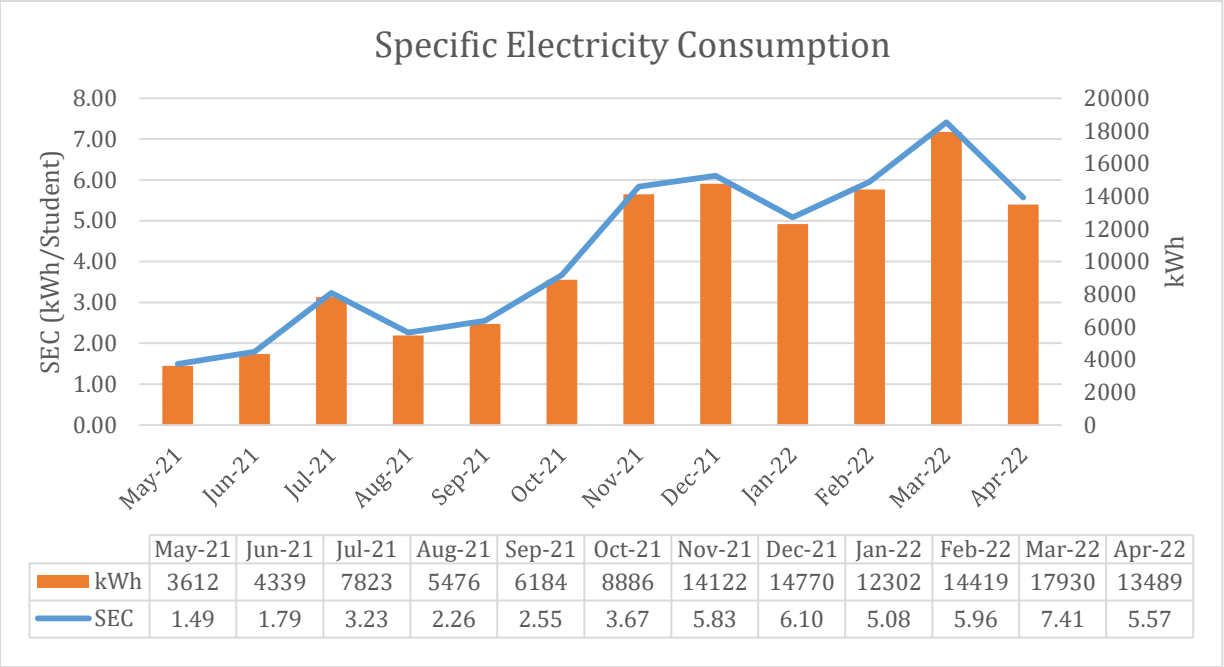
VI. SPECIFIC ELECTRICITY CONSUMPTION (KWH/M2)

The electricity consumption from the May 2021 to April 2022 has been taken for the benchmarking. Here the comparison is done with electricity consumption and the Building area and number of students. The below table shows the specific electricity consumption of the college.

TABLE 7: SPECIFIC ELECTRICITY CONSUMPTION

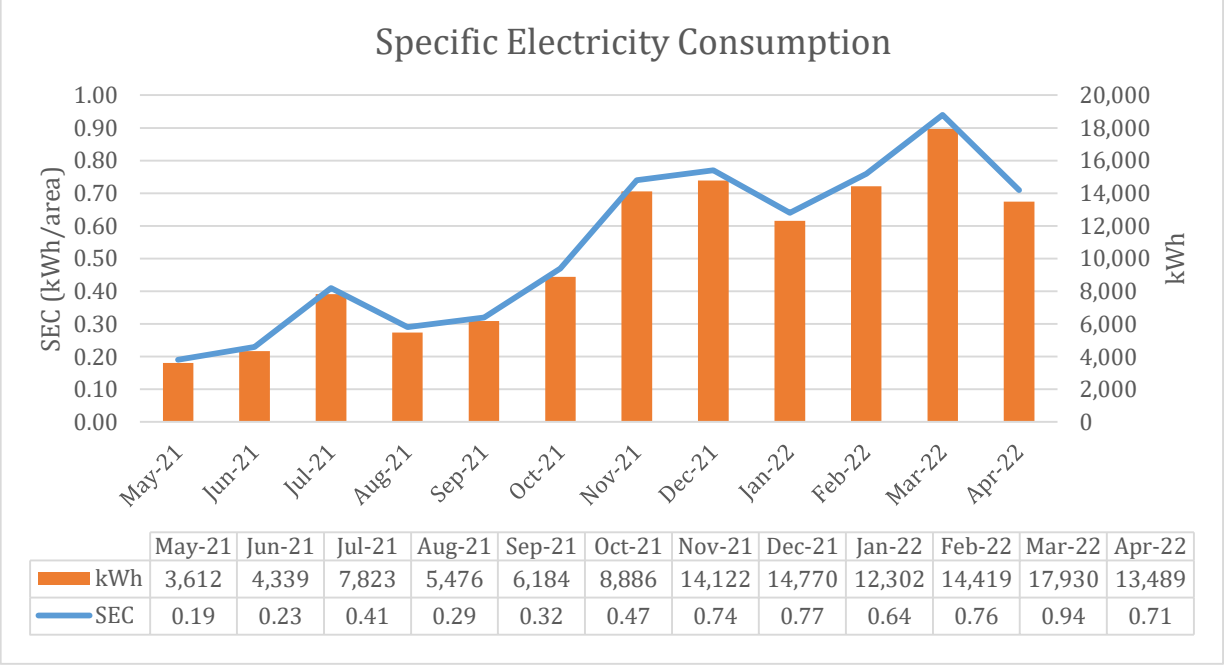
Month	Electricity Consumption*	Number of Students	Building Area	SEC	SEC
	kWh	Number	m^2	kWh/Student	kWh/ m^2
May-21	3612	2421	19,078	1.5	0.19
Jun-21	4339	2421	19,078	1.8	0.23
Jul-21	7823	2421	19,078	3.2	0.41
Aug-21	5476	2421	19,078	2.3	0.29
Sep-21	6184	2421	19,078	2.6	0.32
Oct-21	8886	2421	19,078	3.7	0.47
Nov-21	14122	2421	19,078	5.8	0.74
Dec-21	14770	2421	19,078	6.1	0.77
Jan-22	12302	2421	19,078	5.1	0.64
Feb-22	14419	2421	19,078	6.0	0.76
Mar-22	17930	2421	19,078	7.4	0.94
Apr-22	13489	2421	19,078	5.6	0.71
Average	**10279.3**	**2421**	**19078**	**4.25**	**0.54**
Annual Specific Electricity consumption				**51.0**	**6.47**
Annual Electricity Consumption(kWh)*				**123352**	

* *Only sixty percentage of the total electricity consumption is taken into consideration since the electric connection is common for all other institution in the campus premises.*



	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22
kWh	3612	4339	7823	5476	6184	8886	14122	14770	12302	14419	17930	13489
SEC	1.49	1.79	3.23	2.26	2.55	3.67	5.83	6.10	5.08	5.96	7.41	5.57

FIGURE 10: SPECIFIC ELECTRICITY CONSUMPTION (KWH/STUDENTS)



	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22
kWh	3,612	4,339	7,823	5,476	6,184	8,886	14,122	14,770	12,302	14,419	17,930	13,489
SEC	0.19	0.23	0.41	0.29	0.32	0.47	0.74	0.77	0.64	0.76	0.94	0.71

FIGURE 11: SPECIFIC ELECTRICITY CONSUMPTION (KWH/AREA)

DIESEL CONSUMPTION ANALYSIS

The Diesel is the fuel which is used for the DGs. The details of the diesel consumption in the last academic year and the generator details are given in the table below.

TABLE 8: DIESEL CONSUMPTION

Particulars	Annual Diesel consumption (Lt)	Calorific value (TOE)
Generator	800	0.76

Calorific value of Diesel is 9500 Kcal and 1 TOE means 10000000 Kcal.

TABLE 9: GENERATOR DETAILS

Particulars	Make	kVA	Fuel
New Building	-	25	Diesel
Microbiology Block	Kriloskar	25	Diesel
Main Block	KOEL	62.5	Diesel

LPG CONSUMPTION ANALYSIS

The details of the LPG consumption in the last academic year is given in the table below.

TABLE 10: LPG CONSUMPTION

Particulars	Annual LPG consumption (Kg)	Calorific value (TOE)
Microbiology Lab	193	0.20
Biotechnology Lab	77.2	0.08
Biochemistry Lab	19.3	0.02
Zoology Lab	38.6	0.04
Total	**328**	**0.34**

Calorific value of LPG is 10500 Kcal and 1 TOE means 10000000 Kcal.

ELECTRICAL MEASUREMENT ANALYSIS

TRANSFORMER SECONDARY LOGGING

The main incomer at the college was logged using power quality analyser Krykard ALM-31 for 1 hour and given in following table the measurement-averaging period was 20 seconds.

TABLE 11: TRANSFORMER LOGGING

Measurement values				
Actual Energy for 1 Hrs	kWh	31.21		
Apparent Energy for 1 Hrs	kVAh	33.96		
Power Factor	0.92			
Particulars	**Units**	**Minimum**	**Maximum**	**Average**
Active Power	kW	28.2	34.9	31.2
Apparent Power	kVA	30.8	37.8	33.9
Reactive Power	kVAr	11.3	14.4	12.9
Voltage phase	Volts	399.8	424.9	413.7
Current	Amps	33.3	58.5	47.3
THD V	%	0.7	1.9	1.17
TDD A	%	2.4	11.3	5.68
Voltage Imbalance	%	0.7	1.6	1.2
Current Imbalance	%	1	25.5	10.34

Inference

i. The maximum demand registered during the period of measurement is 37.8 kVA, in 20 seconds interval, and the corresponding PF was 0.92.
ii. The variation of voltages found at the time of audit. (399.8 V to 424.9 V)
iii. Current imbalances were found to be higher.

I. ANALYSIS: VOLTAGE VARIATION

The Voltage profile at the main incomer of college is plotted below in figure.

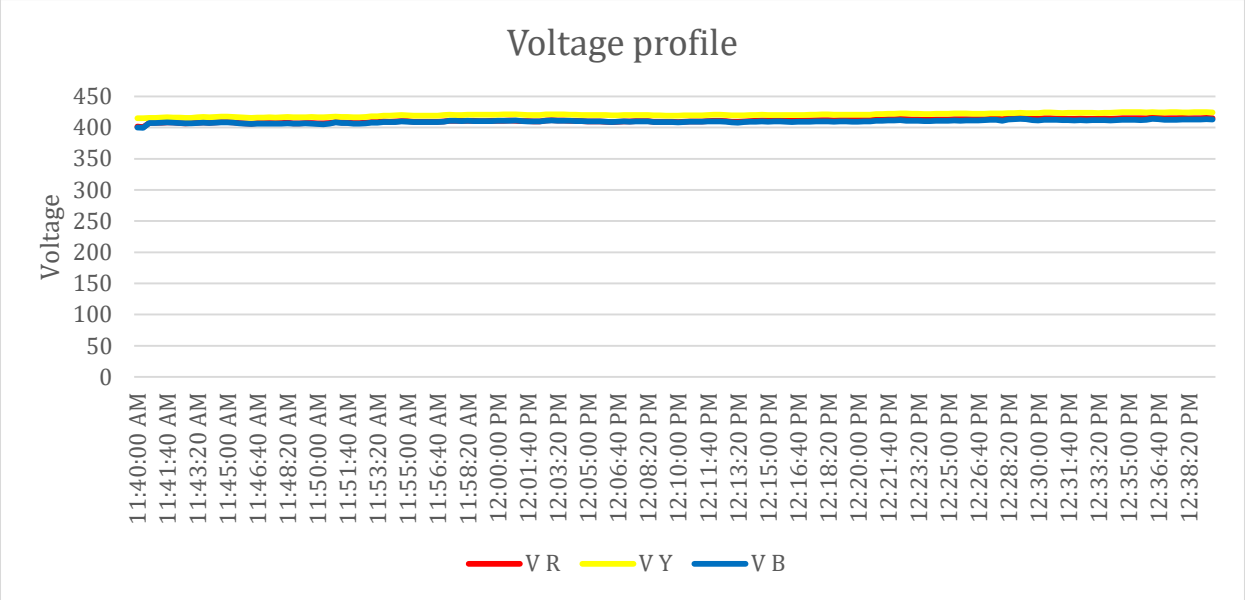


FIGURE 12: VOLTAGE PROFILE

Inference

i. The figure shows the minimum voltage imbalance and supply voltage variation.

ii. The maximum and minimum supply voltage were during the normal operational period, excluding the power failure, is 424.9V and 399.8V respectively with an average voltage of 413.7 V.

iii. Voltage imbalance comes about the maximum value of 1.6%.

II. ANALYSIS: CURRENT VARIATIONS

This section carries the current variations during the 1-hour measurement period with the power analyzer. The figure below gives the current profile of the phases.

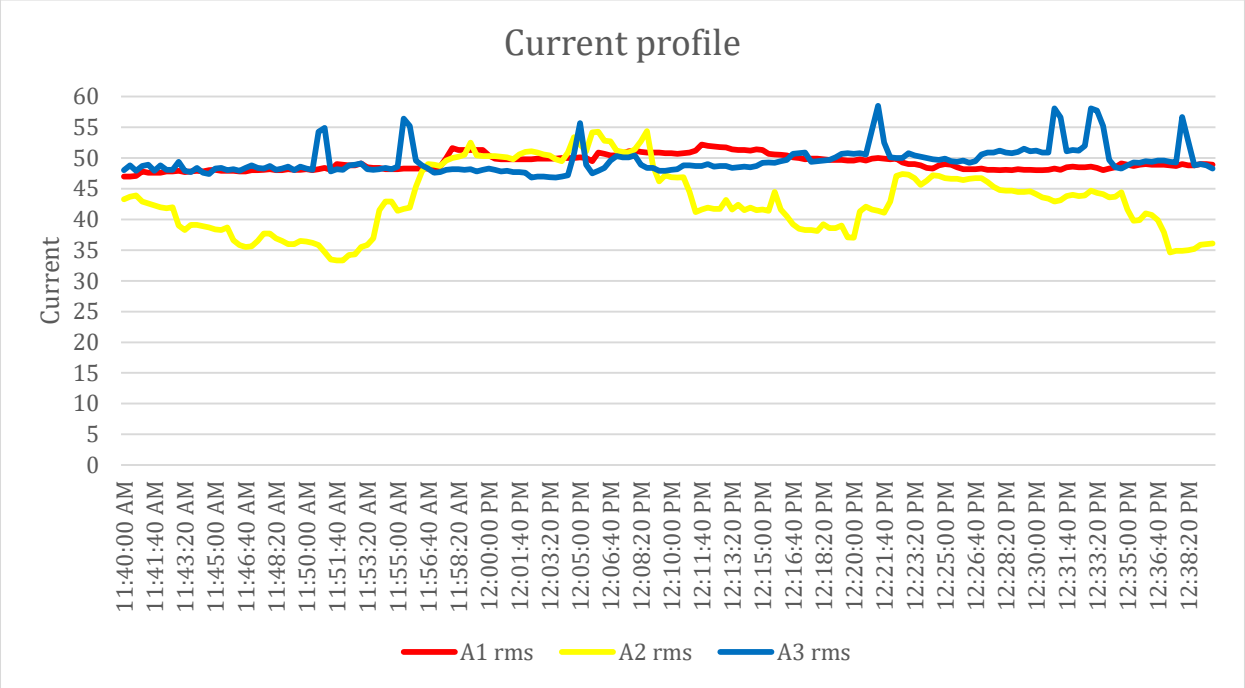


FIGURE 13: CURRENT VARIATIONS

Inference

i. The maximum current occurred during the period was at 58.5A.

ii. The current unbalance varies between 1 to 26%.

III. LOAD FACTOR

The load factor is the ratio of the energy consumed during a given period (in the audit period or in last 12 months) to the energy, which would have been consumed if maximum demand had been maintained throughout the period.

$$\text{Load factor (\%)} = \frac{\text{Energy used during the period (kWh)} \times 100}{\text{Maximum demand (kW)} \times \text{Time under consideration (hr)}}$$

Load factor calculated from the 24-hour logging at the LT side during the period of audit is given in table below:

TABLE 12: LOAD FACTOR – TRANSFORMER

Total kWh*	Max kW*	Time (Hrs)	Load factor (%)
1088	85	24	53

**Energy used and maximum demand considered is based on the overall load on transformer i.e.: all the institution in the campus premises is considered.*

Inference

i. Here the load factor comes about 53% during the 24-hour logging period.

IV. ANALYSIS: POWER FACTOR

The section provides an overview of the power factor variations. The below figure shows the kW and PF variations.

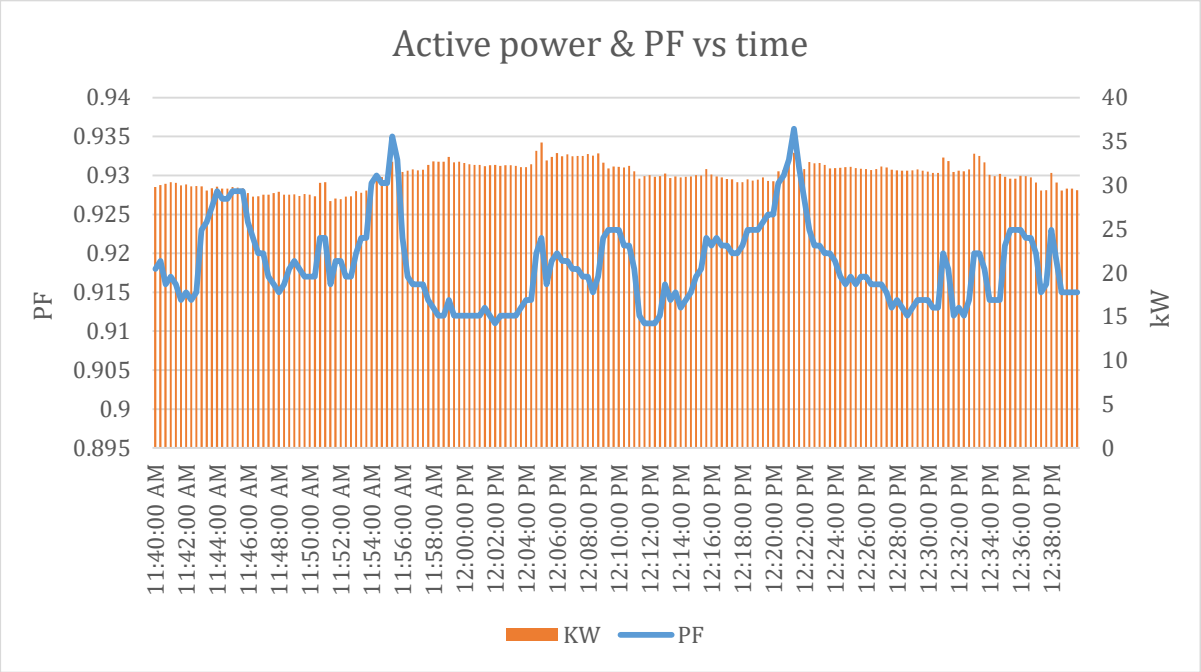


FIGURE 14: KW, & PF VARIATIONS

Inference

i. The PF is found to be very low in some intervals.

ii. The active power was analysed during the working period of building and it varies between 28 to 35 kW.

V. ANALYSIS: CURRENT IMBALANCE

This section carries out the current imbalance during the logging period. The current imbalance at the main incomer of the college are given below:

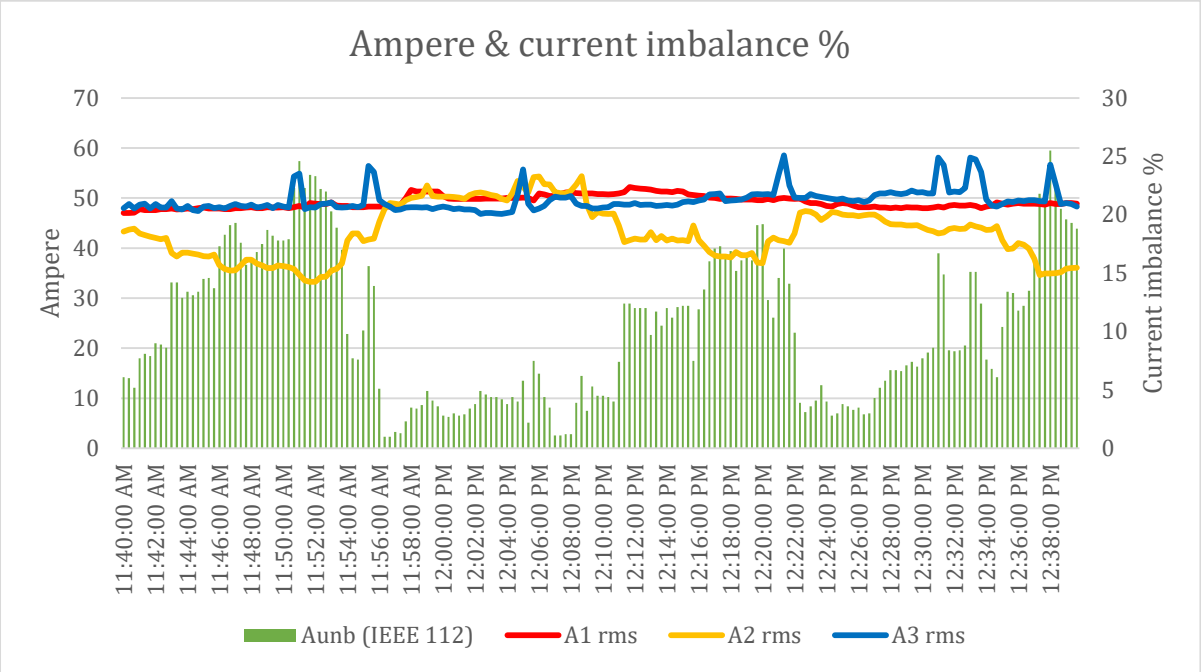


FIGURE 15: AMPERE VS IMBALANCE GRAPH

Inference

i. The average current unbalance was 10.34%.

VI. HARMONIC STUDY

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 13: 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 14: 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

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 DATA SHEET

TABLE 16: HARMONICS ANALYSIS

Location: College Main Incomer							
Total harmonic distortion as per CEA standard TDDi limit is 8% and THDv limit is 8% at 400V level as per Short circuit analysis							
Total Harmonic Distortion - TDD %		**Voltage %**	**Current %**	**Remarks**			
		1.12	5.68	Voltage and current harmonics are within limit			
Individual Harmonic%							
Particulars	**3rd**	**5th**	**7th**	**9th**	**11th**	**13th**	**15th**
Voltage %	0.7	0.6	0.5	0.11	0.07	0.01	0.009
Current %	4.2	2.6	1.88	0.99	0.41	0.39	0.34

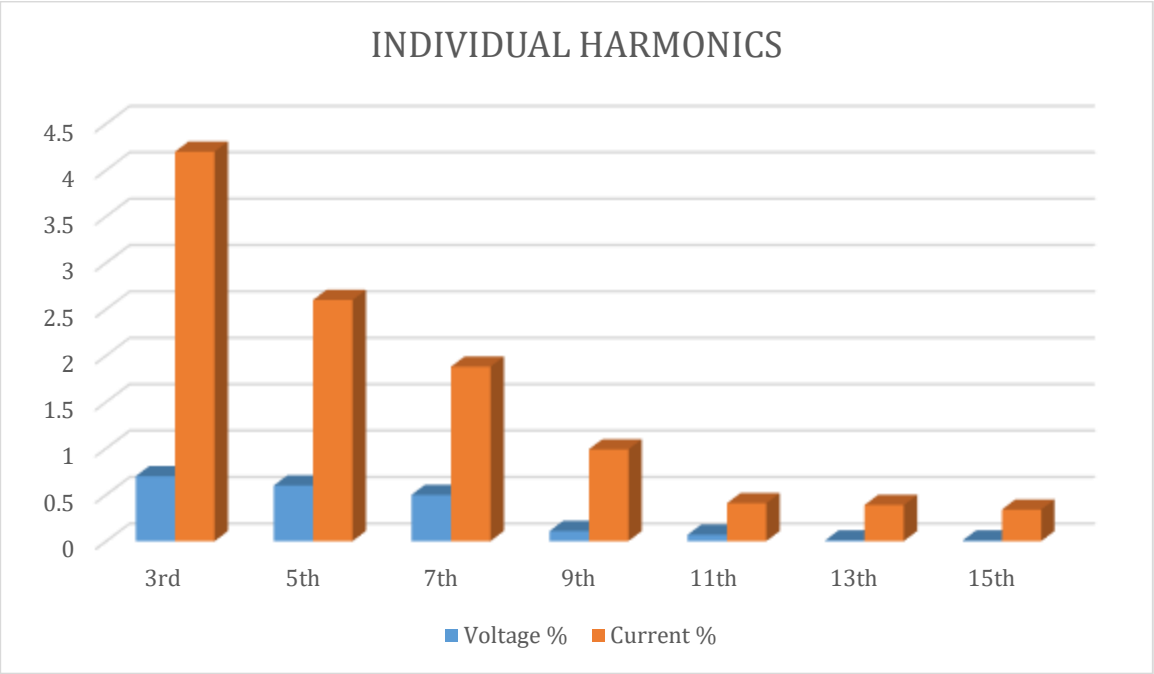


FIGURE 16: HARMONICS ANALYSIS

Inference

i. The table gives the input that the individual and total current harmonics are within the specified limit of 8%.

Suggestions

i. While purchasing nonlinear controlling devices such as UPS and loads such as LED, DC fans, more care should take to ensure the output harmonics values and specification should contain the IEEE/CEA standard limit which mentioned in the above table.

ii. This will reduce the overall effect of harmonics in the equipment and supply system.

ANNEXURE – 1

I. ENERGY SAVING PROPOSALS - 1

PF IMPROVEMENT IN ELECTRICAL SYSTEM

Background

By referring the last year bills, it is clear that the power factor was below the prescribed limit for several months. As per the KSEBL tariff structure, if the PF is maintained above 0.95(lag), the consumer is entitled to receive incentives.

Proposal

- Provide inline capacitor of 16kVAr at the transformer secondary side to improve the PF to unity and gain incentives.

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

TABLE 17: EC PROPOSAL 1

Particulars	Units	Values
Present PF		0.94
Proposed PF		0.99
Present average energy consumption/month	kWh/month	17,132
Present average energy charge/month	Rs/month	107,360
Incentives for improving the PF/month	Rs/month	2,684
Annual incentive	Rs/annum	32,208
Present penalty for the plant	Rs/annum	3,845
Annual Savings	**Rs/annum**	**36,053**
Investment @Rs.1000 per kVAr	**Rs**	**16,000**
Payback period	**Months**	**5**

II. 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 class rooms and in hostels the calculation for the savings is given in the table.

TABLE 18: EC PROPOSAL 2

Particulars	**Units**	**BLDC fan**
Present Power Consumption	Watts	75
Proposed Power Consumption	Watts	28
Reduction in power	Watts	47
Operating hours per day	Hr/day	5
No: of working days per year (Average)	Nos	180
No: of fans operating	Nos	250
Annual energy savings	**kWh/year**	**10575**
Cost per kWh	Rs	6.72
Annual Financial Saving	**Rs/year**	**71022**
Cost of BLDC fan	Rs	3500
Investment	**Rs**	**875000**
pay back	**Month**	**148**

III. ENERGY SAVING PROPOSALS – 3

REPLACEMENT OF FLUORESCENT TUBES WITH ENERGY EFFICIENT LED LIGHTS

BACKGROUND

The present light fittings are mainly been the LED and fluorescent light of different ratings. Replacement of Fluorescent lights to be done in phase manner with LED lights.

PROPOSAL

By replacing the light fitting with LEDs of appropriate ratings the power consumption will reduce considerably by approximate 50% with the present operating hours. The calculation for the savings, approximate investment cost and payback period is given in the table below.

TABLE 19: EC PROPOSAL 3

Particulars	**Units**	**T8**	**T12**
Power of Fluorescent lights	Watts	40	36
Power of proposed LED tube	Watts	20	20
Difference in Wattage	Watts	20	16
Operating hours per day	Hrs/day	4	4
No: of working days per year (Average)	Nos	180	180
Number of Lights operating	Nos	49	130
kWh Saving per Annum	**kWh/year**	**706**	**1498**
Cost per kWh (Average)	Rs	6.72	6.72
Annual Financial Savings	**Rs/year**	**4742**	**10064**
Cost of LED tube	Rs	300	300
Investment for LED lights	**Rs**	**14700**	**39000**
Simple Payback period	**Months**	**37**	**47**

SUMMARY

Annual unit savings	kWh	2203
Total savings	Rs	14806
Total investment	Rs	53700
Payback period	months	44

IV. ENERGY SAVING PROPOSAL – 4

REPLACEMENT OF 3 STAR AC WITH ENERGY EFFICIENT 5 STAR AC

BACKGROUND

The present Air conditioners in the server room are having high power consumption as they having low star AC. This is the sample calculation for replacement of AC at PG block server room (Room No:T38) the operating hours are 24 Hrs. and with low star value.

PROPOSAL

Replace the 1.5 Tr 3-star with new 1 ton 5 star rated one will provide sufficient energy savings. The calculation for savings is given in the tables below.

TABLE 20: EC PROPOSAL 4

Particulars	Units	Value
Present power consumption of AC	Watts	1334
Power of proposed 5 Star AC	Watts	715
Difference in Wattage	Watts	619
Avg No: of working hours/day	Hrs/day	12
No: of working days per year (Average)	Nos/year	180
No: of working hours per annum	Hrs/year	2160
Number of AC operating	Nos	1
kWh Saving per Annum	**kWh/year**	**1337**
Cost per kWh (Average)	Rs	6.72
Annual Financial Savings	**Rs/year**	**8985**
Cost of 5 Star AC	Rs	38000
Investment for AC	**Rs**	**38000**
Simple Payback period	**Months**	**51**

RENEWABLE ENERGY INTEGRATION

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 humankind will again depend upon the sun as dominant energy source. We are aware that fossil fuels are not going to last forever. Of the numerous renewable sources of energy known to mankind, Solar Photo Voltaic or SPV is one that has the potential to supply power for our future needs. The advantages of solar power are:

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

I. GENERAL REQUIREMENT FOR ROOF TOP SOLAR PV PLANT INSTALLATION

Space Requirement for Panel Mounting:

A minimum shadow free space of 10 m^2 is required for the solar panel mounting for the capacity of 1KW. The panel must be mounted facing south with appropriate inclination for maximum output from installation. Suitable structure according to wind speed and roof structure must be used without shading the panel surface.

Solar PV modules and Inverter:

Solar PV panels of 300W or above must be selected for the rooftop installation above 10KW. The efficiency of individual panel must not be less than 16%.

String inverter with MPPT charge controllers is more suitable for the solar power plant installation in roof top. Equipment and installation must be complied with CEA grid regulations-2013.

Location:

Open terrace on roof top is available in the indoor stadium 1323 m^2 approximately.

II. CALCULATION

The area available for solar installation is 1323 m^2 in the Roof top area at indoor stadium. On grid system of 50 kW can be installed in this location without any shades.

TABLE 21: RENEWABLE ENERGY INTEGRATION

Particular	**Unit**	**Value**
Proposed system	kW	50
Average Energy Generation	kWh/day	200
Average Energy Generation	kWh/year	60000
Present annual unit consumption	kWh/year	122134
Average utility electricity cost	Rs	6.20
Present annual electricity cost	Rs/year	757231
Annual Financial Savings	**Rs/year**	**372000**
Subsidised rate of solar powerplant/Kw	Rs/kW	45000
Investment (subsidized & in grid tied mode)	**Rs**	**2250000**
Simple payback period	**Years**	**6**

ANNEXURE-2

I. CONNECTED ELECTRICAL LOADS

i. *LIGHT & FAN LOADS*

TABLE 22: LIGHT & FAN LOADS

Particular	T12	T8	LED Tube Light	LED	CFL	LED Spot Light	Sodium Vapour lamp	Mercury Vapour Lamp	Ceiling Fan	Pedestal Fan	Wall Fan	Exhaust Fan	Exhaust Fan
Block/Watts	**40**	**36**	**20**	**9**	**18**	**40**	**50**	**60**	**75**	**60**	**60**	**80**	**120**
Commercial Block	14	22	39	2					56	1			
PG Block	3	3	15						5				
Microbiology Block	45	7	28	1	6				34			6	
Ladies Hostel		12	25	31			1		34			1	
Canteen			55	4					42			3	
New Block		219	15	58					130	3			
S - Block	12	16	16	22					53				
Office block		6	6	12					10				
Common Toilet (Girls Toilet)	5	3	6	7								1	
Stadium		23									16		
Library Block				79					37				
Auditorium		8		72					25				
Main Block	103	118	76	13	7	1	1	1	134	1	7	4	2
Total Number	**182**	**437**	**281**	**301**	**13**	**1**	**2**	**1**	**560**	**5**	**23**	**15**	**2**
Total Watts	**7280**	**15732**	**5620**	**2709**	**234**	**40**	**100**	**60**	**42000**	**300**	**1380**	**1200**	**240**
Net Total Watts	**7690**												

ii. OTHER LOADS

Table 23: OTHER LOADS

Particular	PC	Printer	Projector	Amplifier	Water Filter	Water Dispenser	Xerox	Printer 3 in 1	Scanner	Kettle	Coffee Maker	Incinerator	Vending M/C	TV	Induction Cooker	Motor	Motor
Block/Watts	**200**	**120**	**150**	**250**	**120**	**920**	**750**	**400**	**80**	**1500**	**750**	**250**	**40**	**120**	**2000**	**1119**	**2237**
Commercial Block	4	32	2			1						1					
PG Block	16		1					1									
Microbiology Block	16	1	2														
Ladies Hostel					1									1	1		
Canteen	1		1		1						1						
New Block	4	2	7			4	1	1		2							
S - Block	3	2	2			1		1		1		1					
Office block	3		1				4										
Common Toilet (Girls Toilet)												1	1				
Stadium																	
Library Block	15	1			1		1										
Auditorium																	
Main Block	24	10	7	1	1	1	2		2	2							
Others																1	1
Total Number	**86**	**48**	**23**	**1**	**4**	**7**	**8**	**3**	**2**	**5**	**1**	**3**	**1**	**1**	**1**	**1**	**1**
Total Watts	**17200**	**5760**	**3450**	**250**	**480**	**6440**	**6000**	**1200**	**160**	**7500**	**750**	**750**	**40**	**120**	**2000**	**1119**	**2237**
Total Watts	**55456**																

iii. LAB EQUIPMENT

Table 24: LAB EQUIPMENT

Particular	Block/Watts	Microbiology Block	Canteen	New Block	Main Block
Centrifuge	350	2			
Water bath	200	3			
Water Bath	500	2		1	
Water Bath	2000			1	
Water Bath	1200			1	
Distillation Unit	350	1		2	
Distillation Unit	2500			1	
Hot Air Oven	2000	1			
Hot Air Oven	1000	1		3	2
Hot Air Oven	1500			2	
Freezer	800	2	3		
Incubator	2000	1			
Hot Plate	200			1	
Incubator	1500	1		2	
Fridge	160	10		6	4
Colorimeter	20	2		6	
Weighing M/C	20	2			
Incubator	500	2		2	
Incubator	800	3			
Incubator	1200			1	
Centrifuge	1650	1			
Laminar Air Flow	400	4		3	
Microwave oven	1100	2		1	
Ice M/C	750	1			
Centrifuge	500	1		1	
Shaker	110	1		1	
Auto Clave	2000	3			
Auto Clave	3000			2	
Auto Clave	500			1	
Vaccum Oven	187				1
Total Watts		**28640**	**2400**	**28790**	**2827**
Net Total (W)		**62657**			

iv. AIR CONDITIONER LOADS

Table 25: AIR CONDITIONER LOADS

Block	Floor	Location	Make	Type	Capacity	EER	Star rating	Working condition	Rated power
					Tr				Watts
Commercial Block	First Floor	FF11	Voltas	Split	1.5	2.95	3	Good	1695
	Second Floor	SF19	Voltas	Split	1	3.15	3	Good	1015
			Voltas	Split	1	3.15	3	Good	1015
		SF15	Lloyd	Split	1.5	3.59	3	Good	1875
PG Block	First Floor	T37	Voltas	Split	1	3.16	3	Good	1013
		T38 Server Room	Godrej	Split	1.5	3.7	3	Good	1334
Microbiology Block	Ground Floor	M2	Voltas	Split	1.5	3.16	3	Good	1656
	First Floor	Research Lab Micro Biology	LG	Split	1.5	3.19	3	Good	1900
		M9	Godrej	Split	1	3.11	3	Good	1061
Main Block	First Floor	Seminar Hall	Voltas	Split	2		3	Good	2071
			Voltas	Split	2		3	Good	2071
			Voltas	Split	2		3	Good	2071
			Voltas	Split	2		3	Good	2071
			Voltas	Split	2		3	Good	2071
		T3, Research Lab	Haier	Split	1	3.11	3	Good	1076
Office Block	Ground Floor	Front Office	Godrej	Split	1.5		3	Good	1334
			Godrej	Split	1.5		3	Good	1334
		G1, Manager Office	Voltas	Split	1.5			Good	1695
		Principal Office	Bluestar	Split				Good	1250
Total (W)									**29604.63**

ANNEXURE-3

I. LIST OF INSTRUMENTS

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

II. ABBREVIATIONS

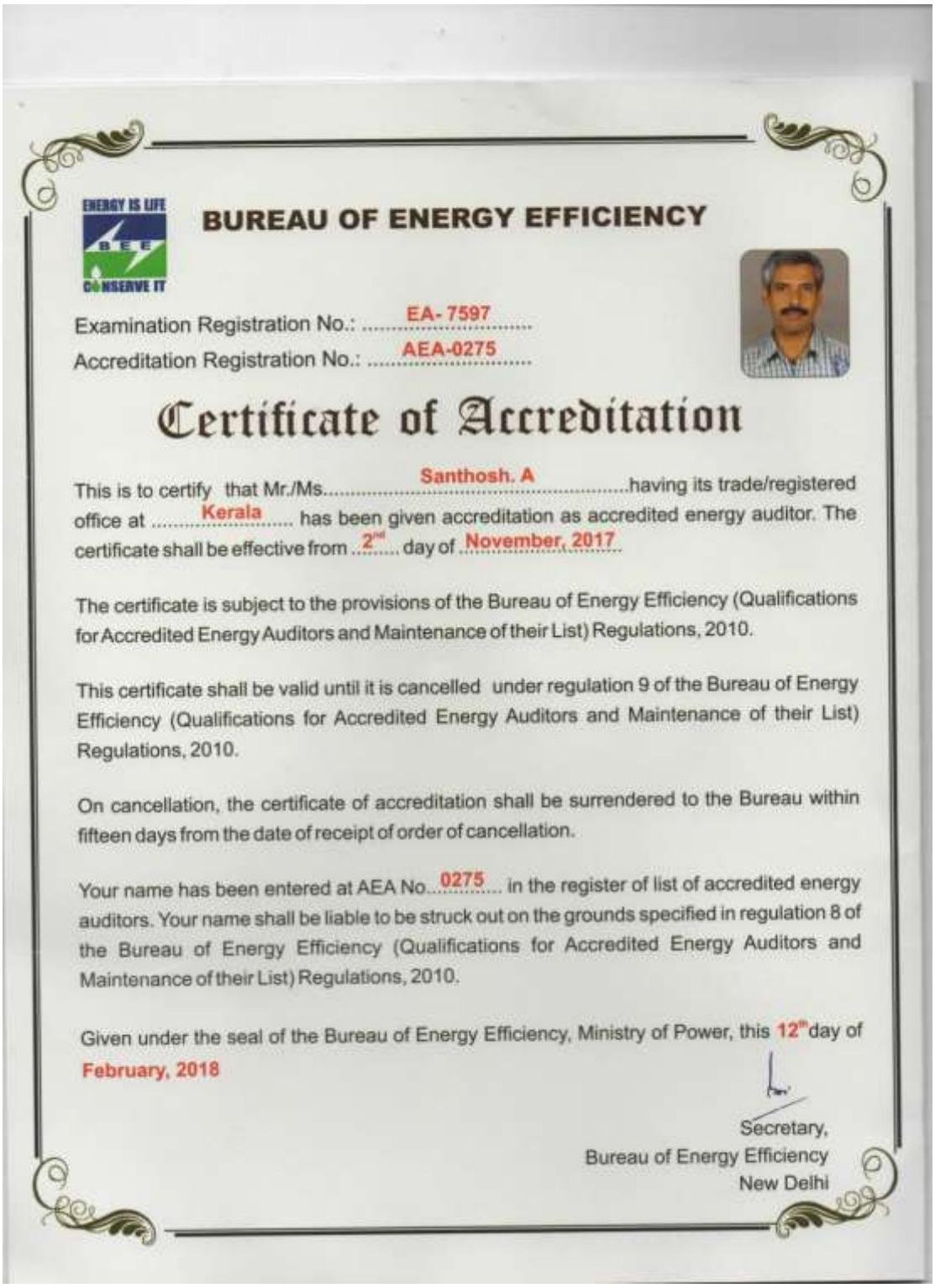
AVG	:	Average
BEE	:	Bureau of energy efficiency
CO_2	:	Carbon dioxide
KSEB	:	Kerala State Electricity Board.
DB	:	Distribution Board
EC	:	Energy Conservation
IEEE	:	The Institute of electrical and electronics engineers
IS	:	Indian Standard
kL	:	kilo Littre
KVA	:	kilo Volt Ampere
kVAh	:	kilo volt Ampere Hour
kVAr	:	kilo volt ampere
kW	:	kilo Watts
kWh	:	kilo watt hour
LT	:	Low tension
MAX	:	Maximum
NSS	:	National Service Scheme
SLD	:	Single Line Diagram

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



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