ENERGY AUDIT – 2019

SREEPATHY INSTITUTE OF MANAGEMENT & TECHNOLOGY

VAVVANOOR, PATTAMBI

PALAKKAD

EXECUTED BY

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ACKNOWLEDGEMENTS

We express our sincere gratitude to the management of Sreepathy Institute of Management and Technology (SIMAT) for giving us an opportunity to carry out the project of Energy Audit. We are extremely thankful to the SIMAT for their support to carry out the studies and for input data, and measurements related to the project of Energy audit.

SIMAT

1	Dr. George C T	Principal
2	Mr.Renjith PC	Asst. Professor
3	Mr. Suhas .M	Lab Instructor

Also congratulating 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**
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4. **Mr. Harikrishnan K,** Project Engineer, B-Tech - Production Engineering.

Yours faithfully

Managing Director
Athul Energy Consultants Pvt Ltd

EXECUTIVE SUMMARY

1. ENERGY AUDIT

A. ENERGY SAVING PROPOSALS

The following table shows the 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 in Electrical System		16,517.00	6,000.00	05
2	Replacement of Ceiling Fans with BLDC fans	3472	22,280.80	1,17,800.00	31
3	Replacement of Fluorescent Tubes With LED	On the damages in the existing light fittings			
4	Replacement of old split AC with new 5-star AC	On the damages/recurring maintenance in the existing AC's			
	Total	**3,472**	**38,797.80**	**1,23,800.00**	

TABLE 1: ENERGY SAVING PROPOSALS

B. ENERGY PERFORMANCE INDEX (EPI)

EPI was based on the energy consumption in Jan 2019 to Dec 2019. The futuristic energy consumption after the implementation of energy saving proposals is given in the tables below.

Parameters	Values
Present Annual electricity consumption(kWh/year)	51594
Present annual electricity cost (Rs)	7,44,229.96
Present annual specific electricity consumption (kWh/m^2)	3.58
After Energy Saving Implementation	
Expecting annual electricity consumption (kWh/year)	48,122.00
Expecting annual specific electricity consumption (kWh/ m^2)	3.34
Electricity savings %	6.73
% of cost savings	5.21

TABLE 2: ENERGY INDEX

C. PRESENT ANNUAL ENERGY CONSUMPTION

The present annual energy consumption has been analysed in below table with the available data from the SIMAT for the period Jan -2019 to Dec 2019.

Particulars	Unit	Quantity	Gross calorific value (kCal)	Million kCal (Toe)	Percentage of distribution (%)
Electricity	kWh	51594	860	4.44	67.37
Diesel	Litres	2262	9500	2.15	32.63
Total				**6.59**	**100**

TABLE 3: ANNUAL ENERGY CONSUMPTION

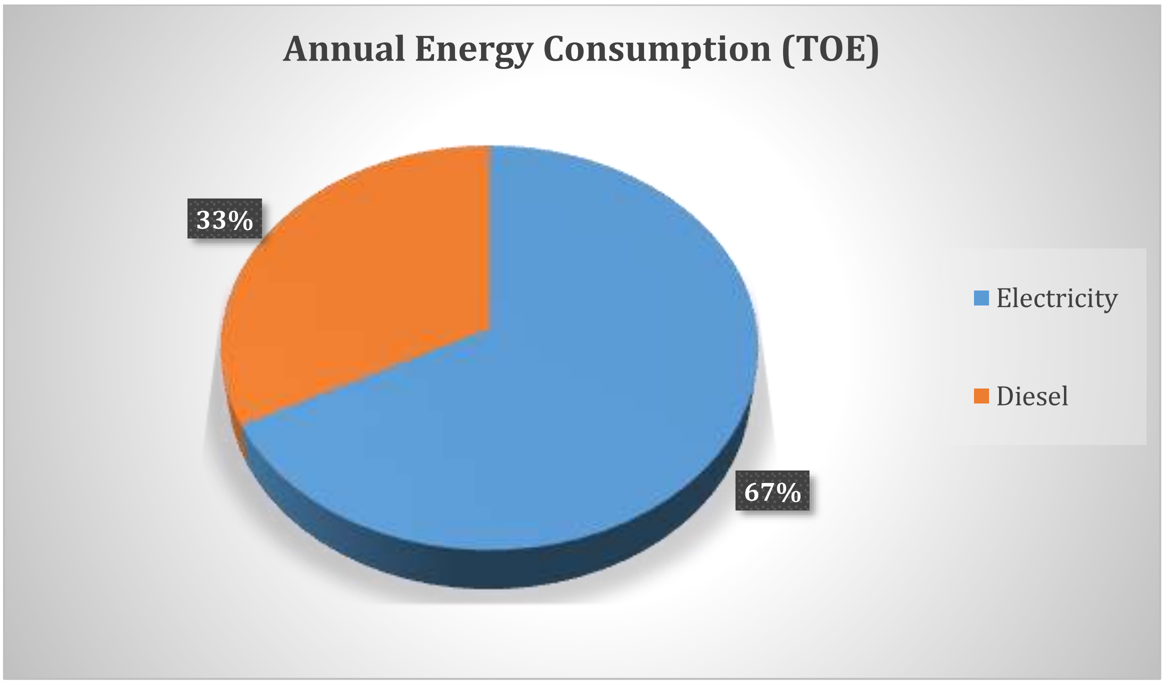


FIGURE 1: ANNUAL ENERGY CONSUMPTION

D. ENERGY AUDIT REPORT SUMMARY

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

1. **Electricity consumption analysis:**

- **Demand analysis:** The demand analysis gives an output that recorded maximum demand in the last 12 months is 63.7 kVA. The recorded demand ranged from 25.98 to 63.68 % of the contract demand which incurred unwanted payment of Rs 0.45 lakhs annually. By optimizing the Contract demand the demand charges can reduce, however the expense for reducing it is higher, as the college needs to change CT and PT.

- **Power factor analysis:** The average power factor registered in last 12 months was 0.91. Any decrease in the PF below unity reduces the amount that receives as incentives for the college. At present college receives penalty to an amount of Rs 6000 per annum for not maintaining the PF above 0.95. For improvement, an investment of Rs 6000/-, for the installation of new capacitors at the Automatic power factor controllers at the secondary side of the transformer. This will give the payback within short duration of 5 months.

- **Power factor analysis:** The annual specific electricity consumption with respect to the building area is 3.577 kWh/m^2.

2. **Electricity performance**

- **Voltage & Current imbalance**: The voltage imbalance depends on the supply voltage and the loads in the college. Considering both, the present voltage imbalance is well within the limits with maximum value of 1.2%. The current imbalance ranges in 0.7 to 200% maximum which is very high comparing to normal standards which is 10%, at the 415V side. The registered maximum imbalance was 200, due to the non-registering of current in one phase, with an average value of 42%

- **Load factor**: The present average load factor in 24 hours period is 25.5%, at the secondary side of transformer which is very low considering the variability in operation of loads.

- **Transformer loading:** the transformer was loaded to 10.7% which is very low. Thus the efficiency of transformer will also be very low as the best efficiency loading point is 50 to 60%.
- **Capacitors:** From the analyzation of active and reactive power with Power factor, the present installation method of capacitors at the transformer end, is satisfactory. However further improvement from the present 0.91 to unity is possible by replacing the damaged capacitors in the panel will avoid the penalty and incur incentives. The damaged capacitors (C1, C2 and C5) needs replacement with new one in the panel which will improve the PF in the system.

- **Light loads:** Majority of the indoor lighting fixtures are fluorescent type (T12) that shares about **95%** of the total indoor lighting load. By replacing these loads with LED light fittings will reduce the overall power consumption in SIMAT. The LED specification that needs to follow while purchase is mentioned in the Annexure-2. The suggestions for the light fitting are given in the Annexure-1.

- **Ceiling fan loads:** Ceiling fans are installed in majority of the areas in SIMAT which accounts **90%** of the total fans section. By replacing it with Brushless DC fans which consumes in the range of 20 to 25W at full speed, instead of 60W in normal fans, will reduce the power consumption considerably. The BLDC specification that needs to follow while purchase is mentioned in the Annexure-2.

- **Air conditioners**: Almost all the AC are around 10 years old mainly placed in the computer labs and offices. Any further repairing on these AC is unwanted and will consume more power. Replace it with new 5-star AC's whenever there occur failures in it.

- **Solar power plant:** The initiative from SIMAT to install 30-kWp solar power plant, is worth notified. The present average annual power generation is around 0.43 lakh units considerably. As per the NASA Data Access Viewer Climatology with the present minimum insolation of SIMAT college area is 4 kWh/m^2/day.

  For the optimization of solar power plant, the following points are recommending.

  1. The bird droppings and dust accumulation in the solar panel should be rectified by increasing the frequency of cleaning to one week which will reduce the financial loss.
  2. Check the inverter strings manually if there any issues in the connections.

3. Ensure the efficiency of inverter, once in a month, whether it is more than 98%, as every drop in efficiency will reduce the power generation.

- **Provision for Electric vehicle charging:** SIMAT can set as model College for updating with the latest technologies by installing Electric charging stations for cars and bikes in their parking lot. A detailed DPR and consultation with KSEBL is required to find the feasibility of the same.

GENERAL DETAILS

The general details of the SIMAT is given below in table based on the data availed from the college, in between the Jan 2019 to Dec 2019. The data based on the electricity bill, solar and diesel generated units, human resources and finance department of the college.

SL. NO	PARTICULARS	DETAILS
1	Name & Address	Sreepathy institute of Management & technology Vavvanoor, Koottanad Pattambi, Palakkad Dist – 679533 Ph: 0466 2370200
2	Contact person	Dr. George CT, Principal
3	No. of Employees	110
4	Building area (m^2)	14420
5	Number of students (Nos)	640
7	Annual Diesel Consumption (Litres) (Transport + DG)	32293.71
8	Annual Diesel generated units (kWh) (DG)	6559
9	Annual Electricity Consumption (KSEBL)	51594
10	Solar generated units (kWh)	35000
11	Contract Demand (kVA)	100
12	Maximum Demand (kVA)	63.68
13	Average Power factor	0.91

TABLE 4: GENERAL DETAILS

DESCRIPTION OF SITE

Sreepathy Institute of Management and Technology (SIMAT) is the offspring of the Sreepathy Trust which is formed with the collective participation of dedicated technocrats, engineers, industrialists , philanthropists and individuals having the common goal of establishing a platform to promote quality higher education and research avenues in professional disciplines like technical and engineering subjects, medical and paramedical, management studies, agriculture , biotechnology and cultural disciplines in order that the deserving cross section of the society irrespective of their cast, colour and creed are provided with an opportunity to groom.

The devoted teaching faculty of SIMAT with consistent academic records is headed by a qualified, talented and professional Director to excel in all sphere of the institution activities. The institution has put in place the state- of- the -art infrastructure and laboratory facilities to enrich the student's academic profiles. SIMAT Faculty members include PhD holders and academically proven Postgraduates who enjoy the working environment well besides availing the pay and benefits which are at par with AICTE guidelines. The college is approved by AICTE and affiliated to APJ Abdul Kalam Technological University and Calicut university.

The college provides the following engineering courses with state-of-the-art facilities.

- Civil engineering
- Electronics and communication engineering
- Mechanical engineering
- Computer science and engineering
- Electrical and electronics engineering

LAYOUT

FIGURE 2: GOOGLE LAYOUT

OBJECTIVE – ENERGY AUDIT

An energy audit is a key to assessing the energy performance of 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 energyconsumption."**

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 SIMAT** as per the request, 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.

ELECTRICITY CONSUMPTION ANALYSIS

1. BASELINE DATA & CONSUMPTION: 12 MONTHS

Base Line Data (Based on last 12 months – Jan 19 to Dec 19)		
1	Electricity provider	KSEBL
2	Supply Voltage	11 kV
3	Tariff	HT IV (A) COMMERCIAL
4	Consumer number	136539000494
5	Contract demand (kVA)	100
6	Maximum demand registered (kVA)	64
7	Average monthly electricity consumption (kWh) (KSEB + DG + Solar)	93,154
8	Average demand charges (Rs/month)	33000
9	Average excess demand charges (Rs/month)	Nil
10	Average power factor	0.91
11	Average power factor incentive (Rs/month)	939.00
	Average power factor penalty (Rs/month)	543.00
12	Demand charge (Rs / kVA)	440
13	Excess demand charge (Rs/kVA)	220
14	Average Electricity charges – KSEBL (Rs/kWh)	6.5
15	Average monthly electricity cost (DG + KSEBL) (Rs)	75,214

TABLE 5 : BASELINE DATA

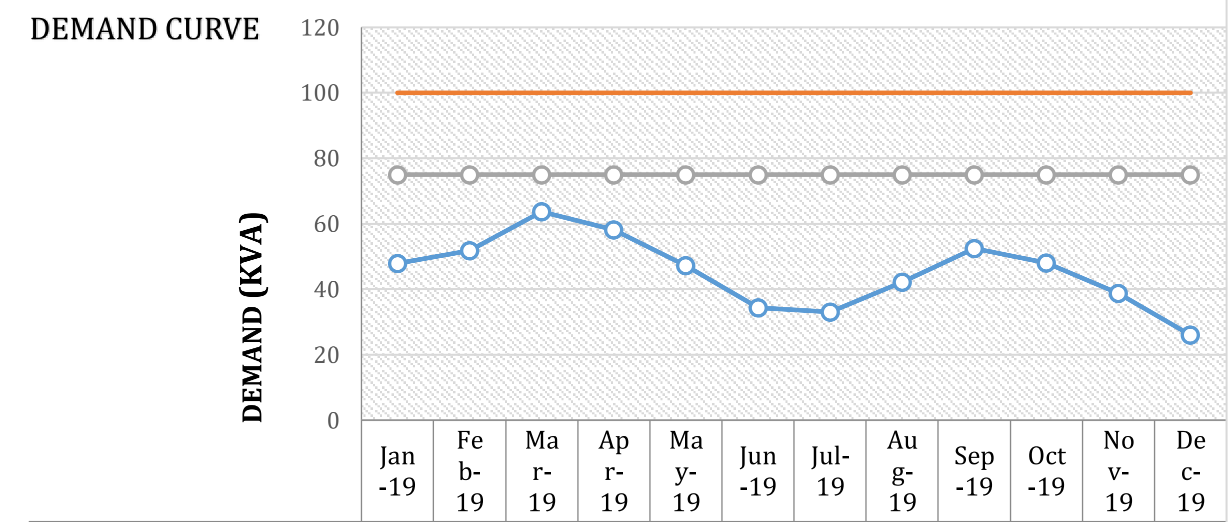
Inference

i. The average power factor was 0.91 during the last 12 months

ii. In the total electricity charges the demand shares the most which is mainly due to the low maximum demand.

2. DEMAND ANALYSIS

This section analyses the trend for the maximum demand versus the Contract Demand (CD) over a 12-month period (Jan -2019 to Dec 2019).



	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19
RECORDED MAXIMUM DEMAND	47.9	51.7	63.7	58.2	47.2	34.4	33	42.2	52.4	48	38.7	26
CONTRACT DEMAND	100	100	100	100	100	100	100	100	100	100	100	100
75% Contract demand	75	75	75	75	75	75	75	75	75	75	75	75

FIGURE 3: DEMAND ANALYSIS

Inference

i. Average demand charges came as Rs. 30,000 per month.

ii. The recorded demand ranged from 25.98 to 63.68 % of the contract demand which incurred 75% as the base charges during the 12-month period that amounts to Rs 3.77 lakhs.

3. ELECTRICITY DEMAND IN VARIOUS TIME ZONES

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

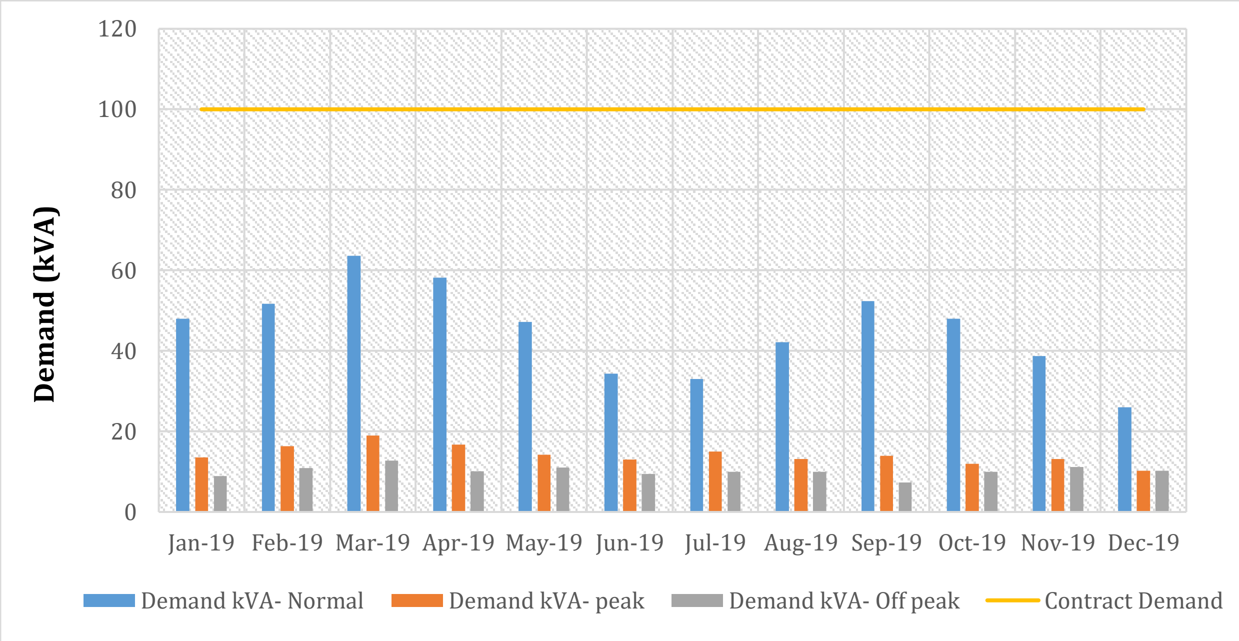


FIGURE 4: DEMAND IN VARIOUS TIME ZONES

Inference

i. The average maximum demand in the normal, Peak and off-peak period registered at SIMAT with respect to the contract demand is 45.28, 14.21 & 10.15% respectively.

ii. The high demand occurred mainly during the normal period which is the results of working pattern in the college.

4. POWER FACTOR ANALYSIS

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.

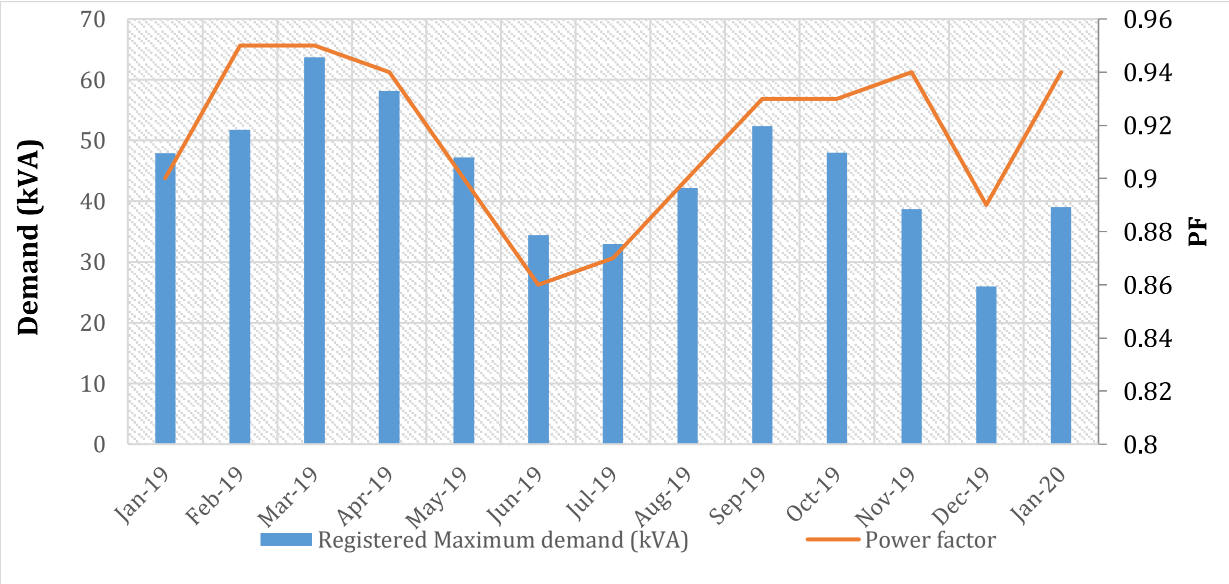


FIGURE 5: POWER FACTOR ANALYSIS

Inference

i. Average power factor during the past one year is found to be 0.91.

ii. The average incentives received to the college in last 12 months for maintaining the power factor above 0.90 is Rs 2819.

iii. **The minimum power factor to maintain by the college is changed to 0.95 from the July 2019 onwards, by the KSEBL, which resulted in loss of approximately Rs 3804 within six months**.

iv. For power factor improvement, the capacitors are placed at the main switch board across the transformers in the college.

v. From the figure, we get the inference that even though the APFC panels are installed across the transformers, the net effectiveness is low, due to the damage in the capacitor panels.

Suggestion

i. By improving the PF to unity, the present power factor incentives will **increase by approximately Rs 4000/-** annually from the present value.

ii. In order to improve the PF the all the capacitor panels should run in automatic mode after replacing the damaged ones.

5. TARIFF RATES ANALYSIS

The average monthly energy and demand charges for the period Jan 2019 to Dec 2019 is represented in Figure below.

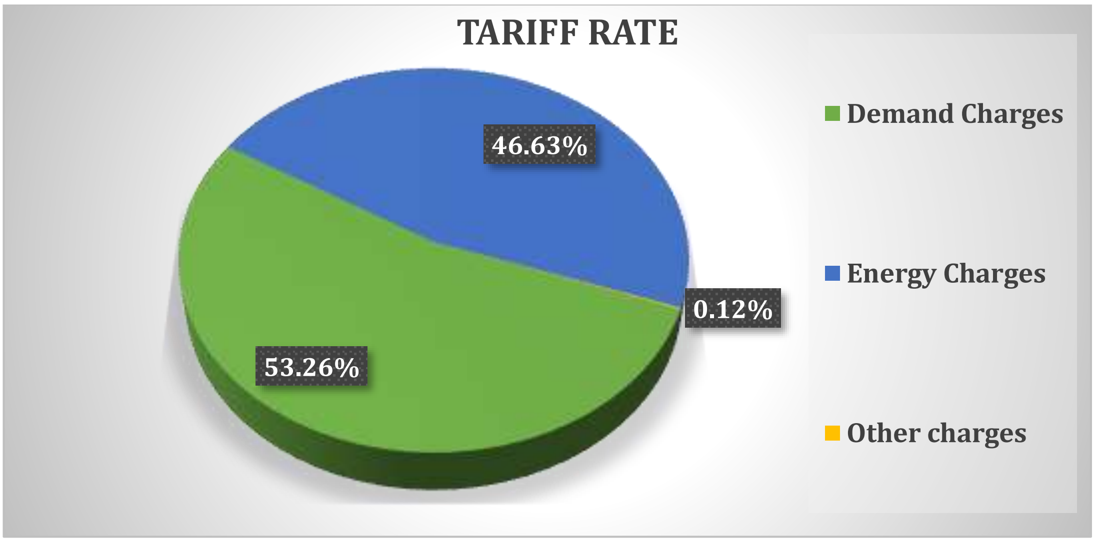


FIGURE 6: TARIFF RATE

Inference

i. Average demand charges for the past one year was Rs 30,000/ per month and energy charges were Rs 27,528.37/ per month**.**

ii. The energy charges came about **46.63%** of the total bill.

iii. The SIMAT tariff band is **POOR** considering the 54% spend for demand and other charges.

iv. Optimising the contract demand with respect to the requirement will reduce the charges significantly.

6. SPECIFIC ELECTRICITY CONSUMPTION

I. SEC BASED ON AREA (KWH/M²)

The electricity consumption from Jan 2019 to Dec 2019 has taken for the benchmarking in the SIMAT in the regression analysis method. Here the comparison is done with electricity consumption and building area, which is in square meter.

The below table shows the specific electricity consumption of SIMAT.

Month	Unit Consumption	Area	Specific Electricity Consumption
	kWh	M^2	kWh/ M^2
Jan-19	2882	14420	0.199
Feb-19	5060	14420	0.350
Mar-19	7886	14420	0.546
Apr-19	5780	14420	0.400
May-19	4622	14420	0.320
Jun-19	3156	14420	0.218
Jul-19	3786	14420	0.262
Aug-19	4068	14420	0.282
Sep-19	3830	14420	0.265
Oct-19	4712	14420	0.326
Nov-19	3504	14420	0.242
Dec-19	2308	14420	0.160
Total	**51594**	**14420**	**3.577**

TABLE 6: SPECIFIC ELECTRICITY CONSUMPTION – kWh/m²

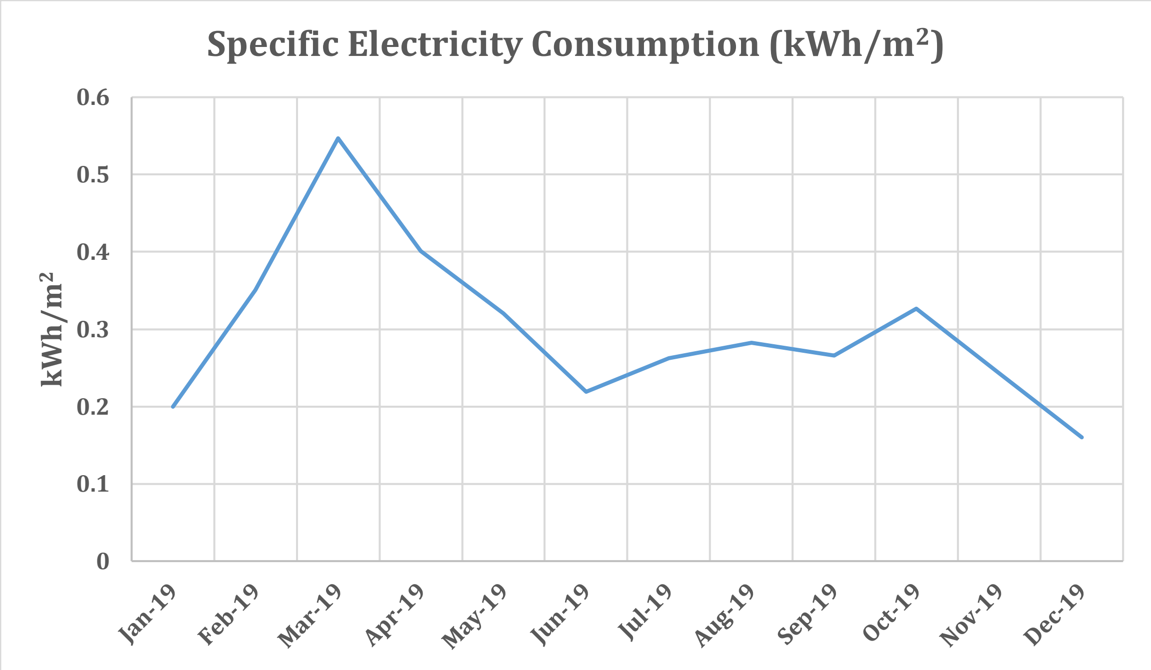


FIGURE 7: SPECIFIC ELECTRICITY CONSUMPTION (kWh/m^2)

Inference

- As one can see, the electricity consumption varies in different months as per the seasonal variations.
- The cooling or ventilation loads in the college were in full load during the March to April months that shows in here as high specific electricity consumption.
- The annual specific electricity consumption with respect to the building area is 3.577 kWh/m^2.

ELECTRICITY PERFORMANCE

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

A. SINGLE LINE DIAGRAM

This section gives the basic single line diagram of the SIMAT with transformer name and rating.

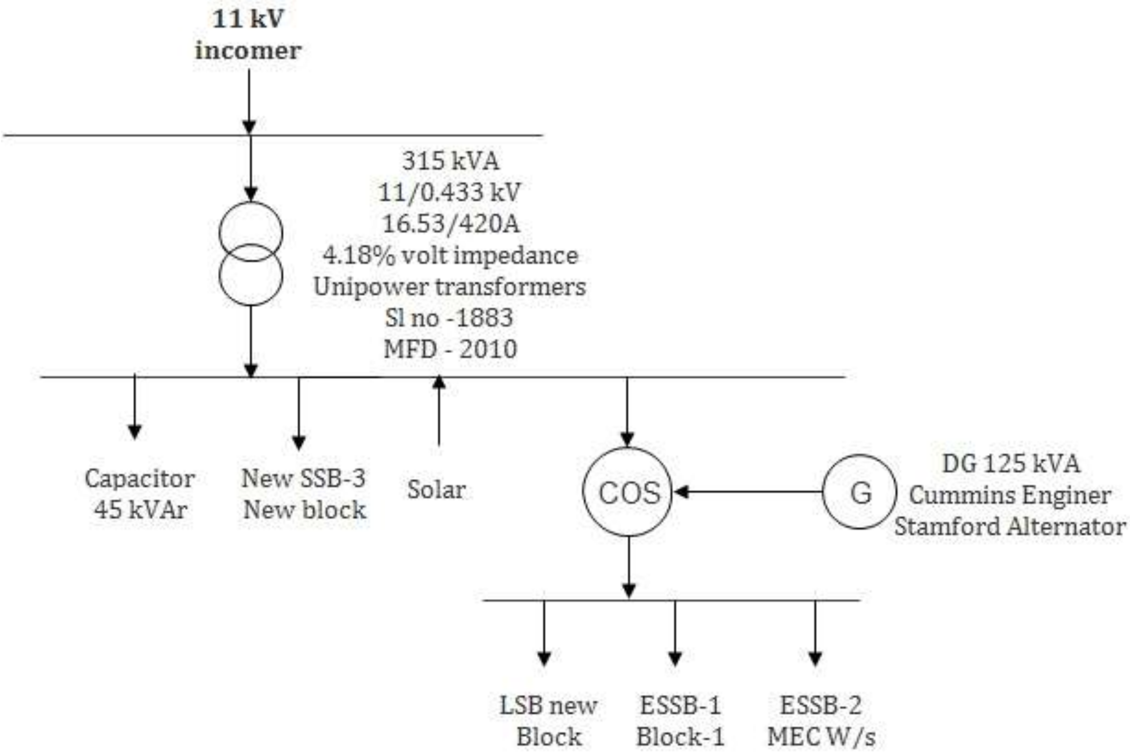


FIGURE 8: SINGLE LINE DIAGRAM

B. TRANSFORMER SECONDARY

The secondary side of the transformer was logged using power quality analyser Krykard ALM 35 for 24 hours and data is given in following table. The measurement was done in 06th March 2020 to 07th March 2020 for a period of 24 hours. The measurement-averaging was 02 minutes interval. The main incomer includes all the loads which passes in to the college.

FIGURE 9: TRANSFORMER

Measurement values – 433 V side				
Actual Energy for 24 Hrs	kWh	**202.39**		
Apparent Energy for 24 Hrs	kVAh	**286.22**		
Power Factor	**0.70 (Leading)**			
Particulars	**Units**	**Minimum**	**Maximum**	**Average**
Active Power	kW	-4.89	33.06	8.539
Apparent Power	kVA	0.03	34.96	12.07
Reactive Power	kVAr	-5.04	11.25	-0.099
Voltage Line	Volts	0.8	438.5	418.5
Current	Amps	0	71.9	16.63
THD V	%	0.5	2.2	1.20
TDD A	%	12.7	54.3	30.4
Voltage Imbalance	%	0	1.2	0.47
Current Imbalance	%	0.7	200	42

TABLE 7: MAIN INCOMER

Inference

i. The maximum demand registered during the period of measurement is 34.96 kVA, in 2 minutes' interval, and the corresponding PF was 0.70 leading that shows the importance of APFC panel.

ii. The harmonic values are high in the current, due to the high electronic controlled loads such as LED lights in the system.

iii. The voltage imbalance is minimum whereas current imbalance was high due to the imbalance of loads in the college.

1. ANALYSIS: VOLTAGE VARIATION

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

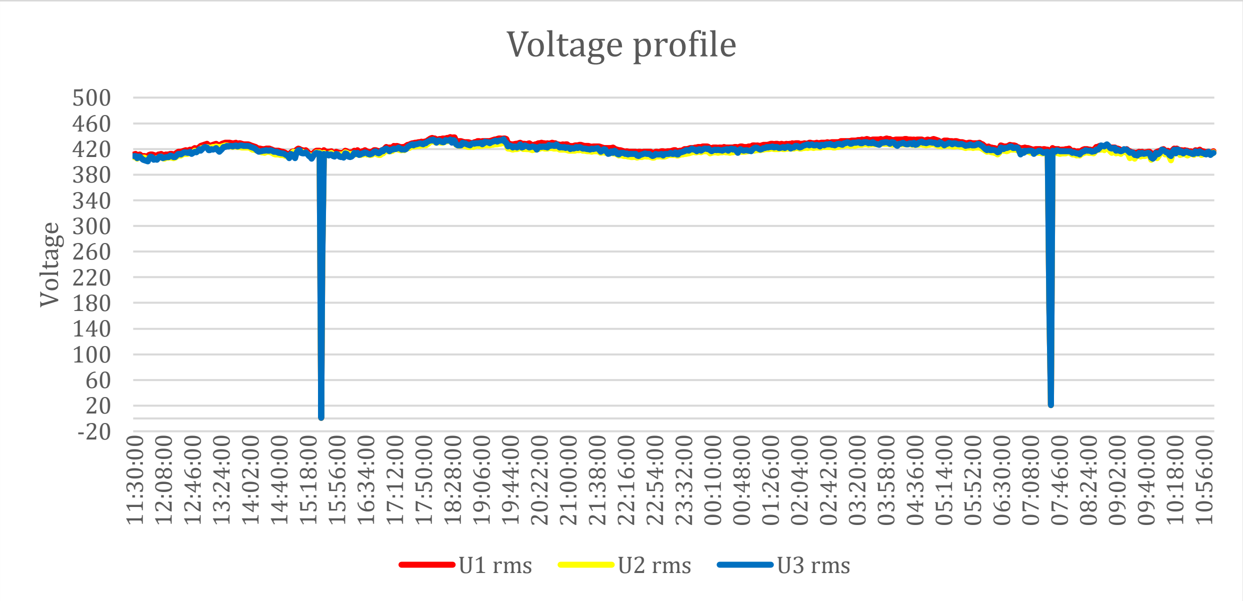


FIGURE 10: VOLTAGE PROFILE

Inference

i. The figure shows the supply voltage variation.

ii. The maximum and minimum supply voltage were during the normal operational period, excluding the power failure, is 438.5 and 407.7 V respectively with an average line voltage of 418.5V.

iii. The present voltage values are satisfactory for the working of college.

2. 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 415 V side during the period of audit is given in table below:

Date of logging	Total kWh	Max kW	Load factor at 24 hours %
06-03-2020	202.39	33.06	25.50

TABLE 8: LOAD FACTOR – TRANSFORMER

Inference

i. The higher the load factor means higher utilisation efficiency of the electrical system.

ii. The present load factor of the college is 25.5 % which is good considering the variation in loads as per the zone wise.

iii. The present load factor is satisfactory comparing to other buildings or colleges.

3. ANALYSIS: POWER FACTOR VARIATIONS

a) kW & PF vs Time:

The session carries the analysis of the power factor with respect to time of the day (TOD) for finding out how power factor is varying at different load condition. This will give an indication about healthiness of electrical distribution system and response of capacitor panel to the load

Status	Time	PF	kW	kVA	kVAr	Remarks
Minimum PF	08:38:00	-0.427	-4.87	11.38	-26.42	**Leading**
Maximum PF	09:52:00	0.971	32.98	33.95	37.37	Lagging

TABLE 9: PF ANALYSIS

kW and PF have been plotted against the time and are given below:

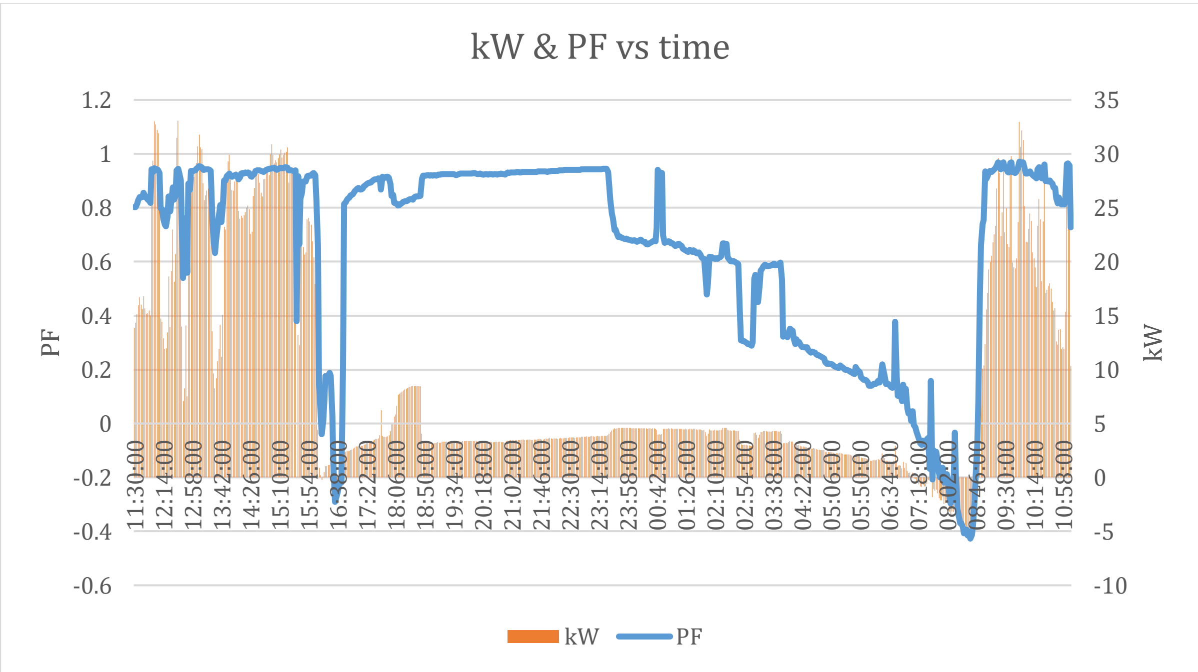


FIGURE 11: KW & PF VS TIME

Inference	• The graph shows kW variations with respect to the PF average. • Here the PF found to be within the range of 0.80 to unity, except during the power failure as shown in the above figure. • The PF improvement to unity will generate sufficient cost savings for the college.

4. ANALYSIS: UNBALANCE

Current Imbalance

Any deviation in voltage or current waveform from perfect sinusoidal in terms of magnitude or phase shift is termed as unbalance. In ideal conditions, i.e., with only linear loads connected to the system. On distribution level, the load imperfections cause current unbalance

The imbalance is calculated in terms of maximum deviation of current in a phase from the mean of three phases. Allowed current unbalance limits is 10% as per ANSI-C84-1-1995B standards. Calculation of current unbalance is calculated as per EN50160 standards.

The current profile for the 24 hours logging period is plotted in the below graph.

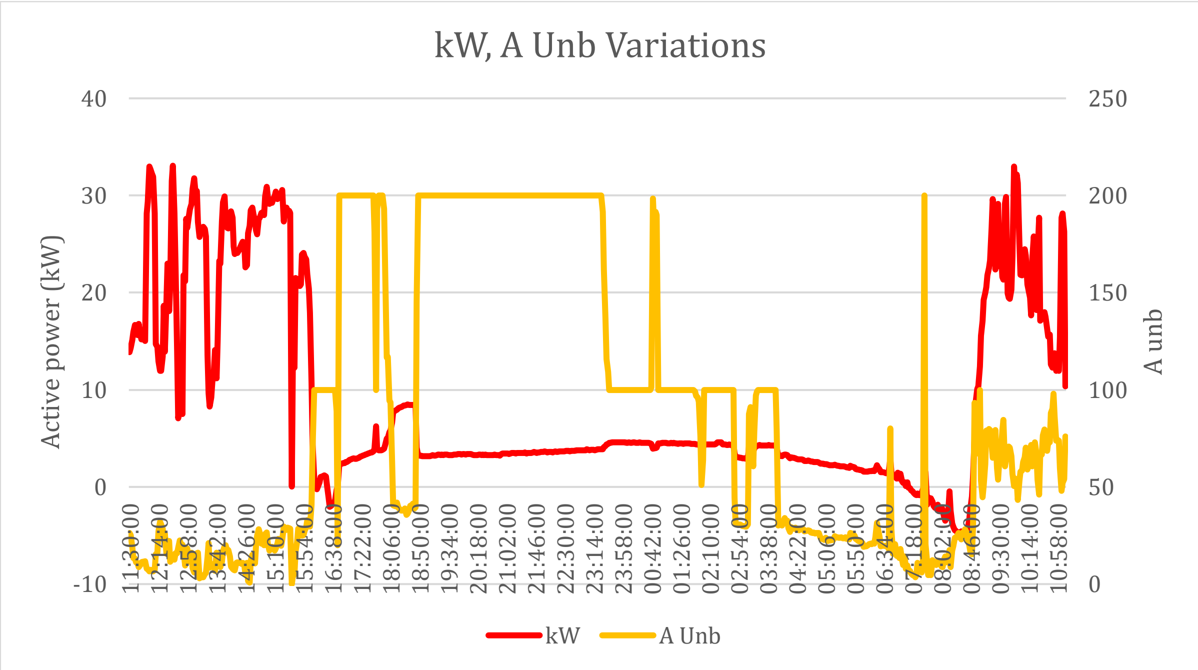


FIGURE 12: CURRENT PROFILE

Inference

- The figure show that current imbalance was higher during the night period mainly due to the single-phase loads in the college.
- The registered maximum imbalance was 200, due to the non-registering of current in one phase, with an average value of 42%.

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:

	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 10: HARMONICS CLASSIFICATION

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 11: EFFECTS OF HARMONICS (IEEE 519)

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 12: CURRENT 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

TABLE 13: VOLTAGE HARMONICS LIMIT (IEEE 519-2014

HARMONICS DATA SHEET

Measurement Location: Main Incomer (11kV PCC)							
Total harmonic distortion as per CEA standard TDDi limit is 8% and THDv limit is 5% at 415V level as per Short circuit analysis							
Total Harmonic Distortion - TDD %		**Voltage %**	**Current %**	**Remarks**			
		2.2	36.11	Over the limit			
Individual Harmonic%							
Particulars	3rd	5th	7th	9th	11th	13th	15th
Voltage %	0.4	1.5	0.7	0.5	0.4	0.4	0
Current %	7.83	21.06	9.61	2.62	4.41	10.9	1.37

TABLE 14: HARMONICS ANALYSIS

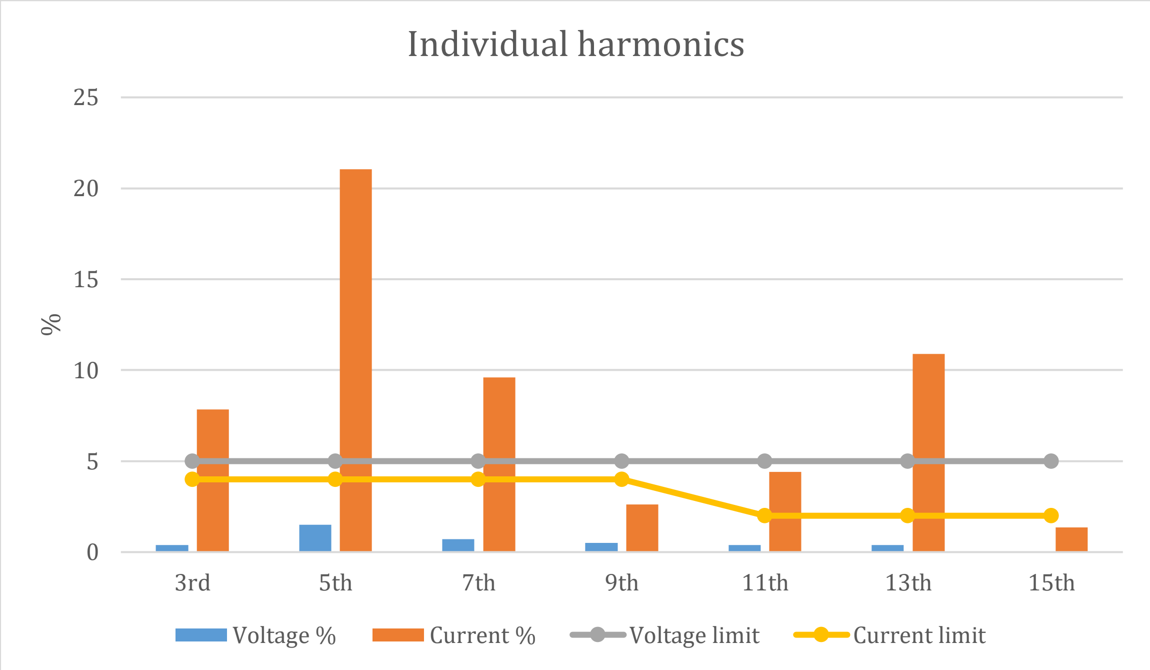


FIGURE 13: HARMONICS ANALYSIS

Inference

i. The figure in last page shows that the individual current harmonics are higher in all the order of upto 15 except 9 and 15, whereas the individual voltage harmonics are within the limit.

ii. Also the current total harmonics distortion is higher than within the limit.

Suggestions

i. While purchasing nonlinear controlling devices such as VFD, 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.

C. CAPACITOR PANEL

To reduce reactive power consumption from the grid, partial kVAr must be supplied by capacitors which in turn will reduce demand from the utility supply system. The capacitor acts as a energy storage device. The power factor correction can be done at the Main switch board or at the load end.

In the main board SIMAT provided automatic controlled capacitors to each transformer low voltage side to increase the power factor of the system. The rated details and effectiveness of each capacitors under the transformer is analysed in this section and given in the following tables.

1. HT YARD TRANSFORMER

The HT yard transformer contains 45 kVAr APFC panel in which 40 kVAr is automatically controlled whereas 5 kVAr is placed as inline. The effectiveness of each capacitors is given in the table below.

No	kVAr Rating	Design Voltage (V)	Measured Voltage (V)	Measured Active Power (W)	Measured Reactive Power (kVAr)	Reactive power w.r.t. measured voltage (kVAr)	% of deterioration	W/kVAr
	A	B	C	D	E	F= E* $(B/C)^2$	G= (A-F)* (100/A)	H=D/E
C1	10	440	420	0	0	0.00	100.00	#DIV/0!
C2	10	440	419	0	0	0.00	100.00	#DIV/0!
C3	10	440	418	5	8.7	9.64	3.60	1
C4	10	440	415	9	8.2	9.22	7.82	1
C5	5	440	420	0	0	0.00	100.00	#DIV/0!

Table 15: Capacitor details

Suggestion

- Replace the damaged capacitors (C1, C2 and C5) in the panel which will improve the PF in the system.
- Among the rest, C1 is damaged as one phase showed short circuit.
- By correcting the above issues with the capacitor panel PF will improve for the HT yard transformer.

E. DIESEL GENERATORS

SIMAT uses total of 01 Diesel generator which gives the backup supply to the whole college. The diesel generated units in the SIMAT is comparatively high due to the general supply feeder failure from the KSEBL. The name plate details of DG installed in the college is given in the table below.

Sl.No:	Rated kVA	Supplied to… transformer	Make
1	125	MSB	Powerica

TABLE 16: DG DETAILS

HISTORIC SPECIFIC ENERGY GENERATION RATIO OF DG

Diesel generator are analysed for its efficacy or Specific Energy Generation Ratio (SEGR). The ratio of units generated per litre consumption of diesel gives you the SEGR. The SEGR of DG were analysed during the period of Jan -2019 to Dec 2019 for the cost per unit analysis and to compare with the present actual SEGR, that measured during the period of study.

The following table gives the diesel consumption, generated units and SEGR of each DG for the 12 month period.

DG no	G1
Diesel consumption (Litres)	2262
Diesel Generation (kWh)	6200
SEGR (kWh/litre)	2.74
Unit cost Rs/kWh	25.54

TABLE 17: HISTORIC SEGR OF DG

Inference	i.	The SEGR of DG is satisfactory as per the given data from the SIMAT.

FIGURE 14: DIESEL GENERATOR

F. HEATING VENTILATION & AIR CONDITIONING (HVAC)

HVAC stands for **Heating Ventilation and Air-Conditioning**. This is the major share of energy consumption and hence it is very critical to monitor and improve the system for energy economy. HVAC can be a synergistic integration of components that perform effective temperature control, humidity control, freshness and purity control of air for comfort air conditioning in a facility. In this section the HVAC systems are analyzed for identifying their behavior towards energy consumption (that is performance). We can only infer the improvements based on the performance analysis and system requirements.

1. AIR CONDITIONING

SIMAT is equipped with the Split Air conditioning systems for comfort air conditioning in various locations of building. The total cooling load is considered from the rated cooling capacity of air conditioning machines. The following table shows the rated details of air conditioners in various locations.

Sl no	Location	Type	Make	Tonnage	Star rating	EER	Input power (W)	MFD	Quantity (nos)
1	Seminar hall	Split	Whirlpool	1.5	2	2.63	1920	2010	3
2	Seminar hall	Split	Voltas	1.5	5	3.11	1656	2010	2
3	Civil cad lab	Split	Whirlpool	1.5	2	2.63	1920	2010	4
4	CS computer lab	Split	Whirlpool	1.5	2	2.63	1920	2010	4
5	CS lab programming	Split	Voltas	1.5	5	3.11	1656	2010	2
6	CS lab programming	Split	Voltas	1.5	2	2.55	1800	2010	2
7	Advanced electrical eng/sw lab	Split	Whirlpool	1.5	2	2.63	1920	2010	3
8	EC software lab	Split	Whirlpool	1.5	2	2.63	1920	2010	4
	Total AC load						**44.78 kW**		

TABLE 18: SPLIT AC LOAD SUMMARY

Inference

- Most of the split ACs are old (2010 model) and has low EER value
- Arresting Infiltrated air entry or exit into a conditioned from the surroundings is very stringent to reduce the energy consumption.

- Set temperature of AC in the location such as Civil CADD lab is 18°C which is an example of inefficient operation.

Suggestions

- Replace the old type Air conditioners immediately with BEE 5 star rated ACs especially in the labs for improved performance in the HVAC system.
- The set temperature of all AC should not be less than 24 °C at any point of time.
- Infiltrated Air entry to the conditioned space should be arrested immediately to reduce the energy bills.
- Switch off the computer screens when not in use, which will reduce the heating load in the lab and thus the air conditioner load too.

H. LIGHT, FAN & COMPUTER LOADS

Effective lighting is essential for building area to carry out their work properly, yet it is possible to achieve significant savings in this area and improve the quality of the lit environment. Good lighting design can reduce costs and have the added benefit of decreasing internal heat gains. The savings options is based on the working hours as by replacing the lights that are having higher number of working hours, will generate sufficient energy savings within a short period.

The ceiling fan is one of the most commonly used ventilation equipment used in the SIMAT in most of the common open areas. The ceiling fans can also segregate as per the number of working hours.

a) Continuous lit or fan area are the following ones:

1. Staff rooms
2. Class rooms

b) Frequently lit or fan areas are the following ones:

1. Corridors
2. Labs
3. Workshops

A. Light loads

Floor	Location	Equipment	Watts	Count	Total Watt
Third Floor	Drawing Hall	T8 tube light	36	10	360
	Drawing Hall	T8 tube light	36	11	396
	MT-3	T8 tube light	36	9	324
	Drawing Hall	T8 tube light	36	11	396
	Floor	T8 tube light	36	6	216
Second Floor	ECE Software Lab	T8 tube light	36	10	360
	Communication Lab	T8 tube light	36	7	252
	Digital Electronics Lab	T8 tube light	36	5	180
Second Floor	Electronic Circuits Lab	T8 tube light	36	8	288
	Advanced Electrical Engineering Lab	T8 tube light	36	10	360
	Readers Club	T8 tube light	36	4	144
	ECE Faculty Room	T8 tube light	36	3	108
	AS&H Faculty Room	T8 tube light	36	11	396

Floor	Location	Equipment	Watts	Count	Total Watt
	AS&H HOD Room	T8 tube light	36	3	108
	S12 ECE	T8 tube light	36	6	216
	S12 ME II	T8 tube light	36	6	216
	S12 CSE	T8 tube light	36	6	216
	S12 EEE	T8 tube light	36	6	216
	S12 ME I	T8 tube light	36	5	180
	S12 CE	T8 tube light	36	8	288
Second Floor	S6 CSE	T8 tube light	36	7	252
	S4 CSE	T8 tube light	36	5	180
	S8 CSE	T8 tube light	36	5	180
Second Floor	EEE Faculty Room	T8 tube light	36	4	144
	CSE Faculty Room	T8 tube light	36	3	108
	CSE HOD Room	T8 tube light	36	3	108
Second Floor	Toilets	T8 tube light	36	5	180
	Floor	T8 tube light	36	25	900
First Floor	Computer Centre	T8 tube light	36	1	36
First Floor	Computer Centre	T8 tube light	36	1	36
First Floor	MF 4	T8 tube light	36	6	216
	MF 26	T8 tube light	36	4	144
	Staff Toilets	T8 tube light	36	2	72
	Varandha	T8 tube light	36	24	864
	EC Bath Room	T8 tube light	36	3	108
First Floor	MF 4	T8 tube light	36	6	216
	MF 26	T8 tube light	36	4	144
	Staff Toilets	T8 tube light	36	2	72
	Varandha	T8 tube light	36	24	864
	EC Bath Room	T8 tube light	36	3	108
Ground Floor		T8 tube light	36	3	108
	MG 18	T8 tube light	36	3	108
	MG 19	T8 tube light	36	5	180
	MG 20	T8 tube light	36	7	252
	MG 21	T8 tube light	36	2	72
	MG 23	T8 tube light	36	8	288
	MG 14	T8 tube light	36	10	360

Floor	Location	Equipment	Watts	Count	Total Watt
	SAC	T8 tube light	36	2	72
	M Tech Class Room	T8 tube light	36	4	144
	MG 09	T8 tube light	36	2	72
	S8 CE	T8 tube light	36	6	216
	S6 CE	T8 tube light	36	7	252
	S4 CE	T8 tube light	36	7	252
First Floor	EEE Faculty Room	T8 tube light	36	2	72
	EEE HOD Room	T8 tube light	36	2	72
	S8 EEE	T8 tube light	36	6	216
	S6 EEE	T8 tube light	36	7	252
	S8 ECE	T8 tube light	36	7	252
	S6 ME	T8 tube light	36	7	252
	ECE Faculty Room	T8 tube light	36	2	72
First Floor	MF 6	T8 tube light	36	2	72
	ECE HOD Room	T8 tube light	36	2	72
	S4 ECE	T8 tube light	36	6	216
	S6 ECE	T8 tube light	36	6	216
	MF 21	T8 tube light	36	1	36
	MF 22	T8 tube light	36	4	144
	Total sum (kW)				**14.47**

Table 19: Light loads

Inference

i. Majority of the indoor lighting fixtures are fluorescent type of 36W (T8) that shares about 95% of the total indoor lighting load whereas 5% light loads are CFL.

ii. The college has started to replace it with LED lights in time bound manner whenever any replacement occurs.

Suggestions

i. Replace the Fluorescent lights with energy efficient LED fittings for reducing the total energy consumption in the facility.

B. Fan loads

Floor	Location	Equipment	Watts	No.	Total Watt
Third Floor	MT-2	Fan	60	9	540
Third Floor	MT-3	Wall Fan	60	5	300
Third Floor	MT-4	Fan	60	8	480
Third Floor	ECE Software Lab	Fan	60	5	300
Second Floor	Communication Lab	Fan	60	10	600
Second Floor	Digital Electronics Lab	Fan	60	6	360
Second Floor	Electronic Circuits Lab	Fan	60	6	360
Second Floor	Advanced Electrical Engineering Lab	Fan	60	6	360
Second Floor	Readers Club	Fan	60	7	420
Second Floor	ECE Faculty Room	Fan	60	2	120
Second Floor	AS&H Faculty Room	Fan	60	2	120
Second Floor	AS&H HOD Room	Fan	60	5	300
Second Floor	S12 ECE	Fan	60	2	120
Second Floor	S12 ME II	Fan	60	6	360
Second Floor	S12 CSE	Fan	60	6	360
Second Floor	S12 EEE	Fan	60	6	360
Second Floor	S12 ME I	Fan	60	4	240
Second Floor	S12 CE	Fan	60	6	360
Second Floor	S6 CSE	Fan	60	6	360
Second Floor	S4 CSE	Fan	60	6	360
Second Floor	S8 CSE	Fan	60	6	360
Second Floor	EEE Faculty Room	Fan	60	6	360
Second Floor	CSE Faculty Room	Fan	60	2	120
Second Floor	CSE HOD Room	Fan	60	2	120
Second Floor	CSE HOD Room	Fan	60	2	120
Second Floor	Computer Centre	Table Fan	60	1	60
First Floor	Compiler Lab	Table Fan	60	1	60
First Floor	CAD Lab	Table Fan	60	1	60
First Floor	Computer Centre	Table Fan	60	1	60
First Floor	Compiler Lab	Table Fan	60	1	60
First Floor	CAD Lab	Table Fan	60	1	60
First Floor	MF 4	Table Fan	60	1	60
First Floor	MF4	Fan	60	6	360

First Floor	MG 17A CE Staff Room	Fan	60	6	360
Ground Floor		Fan	60	2	120
Ground Floor	MG 19	Fan	60	6	360
Floor	**Location**	**Equipment**	**Watts**	**No.**	**Total Watt**
Ground Floor	MG 20	Fan	60	6	360
Ground Floor	MG 21	Fan	60	6	360
Ground Floor	MG 23	Fan	60	2	120
Ground Floor	OFFICE	Fan	60	5	300
Ground Floor	OFFICE	Fan	60	10	600
Ground Floor	OFFICE	Exhaust	60	2	120
Ground Floor	MG-16	Wall Fan	60	4	240
Ground Floor	M Tech Class Room	Fan	60	1	60
Ground Floor	MG 09	Fan	60	2	120
Ground Floor	S8 CE	Fan	60	6	360
Ground Floor	S6 CE	Fan	60	4	240
Ground Floor	S4 CE	Fan	60	5	300
Ground Floor	EEE Faculty Room	Fan	60	5	300
First Floor	EEE HOD Room	Fan	60	2	120
First Floor	S8 EEE	Fan	60	1	60
First Floor	S6 EEE	Fan	60	6	360
First Floor	S8 ECE	Fan	60	4	240
First Floor	S6 ME	Fan	60	6	360
First Floor	ECE Faculty Room	Fan	60	6	360
First Floor	MF 6	Fan	60	2	120
First Floor	ECE HOD Room	Fan	60	2	120
First Floor	S4 ECE	Fan	60	2	120
First Floor	S6 ECE	Fan	60	6	360
First Floor	MF 21	Fan	60	6	360
First Floor	MF 21	Fan	60	1	60
First Floor	MF 22	Wall Fan	60	1	60
	Total power (kW)				**15.66**

Table 20: Fan loads

Inference

i. In total fan loads the ceiling fan shares the most loads with 90% of the total load.

ii. The approximate total connected fan load in the college is 15.66 kW

Suggestion

i. The continuous working ceiling fans can be replacing with Brushless DC fans which will consume only around 20 to 25W max per fan.

ii. This will reduce the overall power consumption of the college.

C. Computer loads

Floor	Location	Equipment	Watts	Nos	Total watts
Second Floor	ECE Software Lab	Computer	150	34	5100
Second Floor	ECE Software Lab	Printer	350	1	350
Second Floor	Communication Lab	Computer	150	1	150
Second Floor	Digital Electronics Lab	Computer	150	1	150
Second Floor	Electronic Circuits Lab	Computer	150	1	150
Second Floor	Advanced Electrical Engineering Lab	Computer	150	24	3600
Second Floor	ECE Faculty Room	Computer	150	1	150
Second Floor	AS&H Faculty Room	Computer	150	1	150
Second Floor	AS&H Faculty Room	Printer	350	1	350
Second Floor	AS&H HOD Room	Computer	150	1	150
Second Floor	EEE Faculty Room	Computer	150	1	150
Second Floor	EEE Faculty Room	Printer	350	1	350
Second Floor	CSE Faculty Room	Computer	150	1	150
Second Floor	CSE Faculty Room	Printer	350	1	350
Second Floor	CSE HOD Room	Computer	150	1	150
Second Floor	CSE HOD Room	Printer	350	1	350
First Floor	Computer Centre	Computer	150	40	6000
First Floor	Programming Lab	Computer	150	38	5700
First Floor	Compiler Lab	Computer	150	38	5700
First Floor	CAD Lab	Computer	150	44	6600
First Floor	Computer Centre	Computer	150	40	6000
First Floor	Programming Lab	Computer	150	38	5700
First Floor	Compiler Lab	Computer	150	38	5700
First Floor	CAD Lab	Computer	150	44	6600
Ground Floor	OFFICE	Computer	150	8	1200
Ground Floor	Conference Hall	Projector	250	1	250
First Floor	EEE Faculty Room	Computer	150	1	150
First Floor	EEE Faculty Room	Printer	350	1	350
First Floor	EEE HOD Room	Computer	150	1	150
First Floor	EEE HOD Room	Printer	350	1	350
First Floor	ECE Faculty Room	Computer	150	1	150
First Floor	MF 6	Computer	150	1	150
First Floor	ECE HOD Room	Computer	150	1	150
First Floor	ECE HOD Room	Printer	350	1	350
First Floor	MF 21	Computer	150	1	150
First Floor	MF 22	Computer	150	1	150
	Total power (kW)				**63.35**

Table 21: Computer loads

Suggestion

i. The computer screen should switch off after use as it will consume to around 10W in idle condition (eg. Civil CADD lab).

RENEWABLE ENERGY

Solar plant: College installed 30 kW solar power plant in its facility showing their dedication to sustainability and environmental protection.

ANNEXURE-1

ENERGY SAVING PROPOSAL - 1

PF IMPROVEMENT IN ELECTRICAL SYSTEM

Background

By referring the KSEB bills and 24-hour logging of the college indicates the power factor is maintained in the level of 0.85 to 0.95 instead of unity and found lagging. The capacitors that installed at the transformer secondary side were found damaged.

Proposal

Replace the damaged capacitors in the transformer secondary.

By increasing the Power factor to unity as per the mentioned method the SIMAT will have an increase in the PF incentives

The table below gives the investment cost for capacitor replacement, annual incentives by the PF improvement and the payback period.

Based on last 12 Months		
Particulars	**Unit**	**Values**
Present PF		0.93
Avg Energy Charges/Month	Rs	27,528.00
Present Incentive	Rs	0.00
Proposed PF		1
Avg Incentives/Month	Rs	1376.41
Avg Incentives/Year	Rs	16,517.00
Investment cost	Rs	6000.00
Payback period	Months	05

ENERGY SAVING PROPOSAL - 2

REPLACEMENT OF CEILING FANS IN THE STAFF ROOMS AND CLASS ROOMS 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 1200 mm size BLDC fan at dull speed consumes only around 22 to 27W instead of the present ceiling fan with induction motors that takes 60 to 70W as per the manufactures.

Proposal

Replace the ceiling fans with BLDC in the staff rooms and class rooms. The locations are selected based on the average working hours of more than 8. The salvage value of Rs 600/ fan while replacement is estimated for calculation.

The calculation for the savings is given in the table below.

Particulars	Unit	With BLDC
Power of existing ceiling fans at full speed	Watts	60
Power of replacing fan	Watts	25
Difference in Wattage	Watts	35
Avg No: of working hours/day	Hrs	8
No: of working days per year (Average)	Nos	200
No: of working hours per annum	Hrs	1600
Number of Ceiling Fans operating	Nos	62
kWh Saving per Annum	kWh	3472
Cost per kWH (Average)	Rs	6.4
Annual Financial Savings	Rs	22220.80
Cost of replacing Fan per piece	Rs	2,500.00
Investment for replacing Fan	Rs	1,55,000.00
Salvage value per fan	Rs	600.00
Total salvage value	Rs	37,200.00
Net investment for replacing fan	Rs	1,17,800.00
Simple Payback period	Months	31

ENERGY SAVING PROPOSAL – 3

REPLACEMENT OF FLUORESCENT TUBES WITH LED IN SELECTED LOCATIONS

Background

The present indoor light fitting are mostly dominated by fluorescent tubes (T8) which consumes 36 to 40 W. This tube light having the life expectancy less than the LED and higher than the incandescent lights. The present fluorescent tube fitting contains mercury and other toxic materials which is harmful to the human beings if it got burst off.

Proposal

By replacing the indoor T8 light fittings with LED's of appropriate ratings the power consumption will reduce considerably by approximate 50% with the present operating hours. The immediate replacement is suggesting at locations where the T8 runs more than 12 hours/day.

The auditors are suggesting to replace the fluorescent lights with the LED of 18 to 20W wherever the light gets damaged.

Power of Fluorescent lights	Watts	36
Proposed LED tube	Watts	18
Difference in Wattage	Watts	18
Avg No: of working hours/tube/day	Hrs	5
No: of working days per year (Average)	Nos	350
No: of working hours per annum	Hrs	1750
Number of Lights operating	Nos	402
kWh Saving per Annum	Rs	12,663.00
Cost per kWH (Average)	Rs	9.1
Annual Financial Savings	Rs	1,15,233.30
Cost of LED tube	Rs	300
Investment for LED lights	Rs	1,20,600
Simple Payback period	Months	13

ANNEXURE-2

1. LED specification

The Department of Electronics and information technology issued "Electronics and information Technology goods order 2012" on 3rd October 2012 the following standards for LED lamps are covered.

1. IS 15885 (Part -2/section 13)
2. IS 16102 (Part-1): 2012

As per this order LED manufactures to get their product tested from BIS recognised labs.

Thus, the following electrical parameters and standards should ensure while purchasing LED in future based on the BIS standards. These are the minimum technical requirements for the acceptance of LED. Also, the LED test certificates as per the various standards mentioned below should be examined while purchasing.

Sl no	Parameters	Requirements	Applicable IS
1	Light source	SMD LED chip	LM 80/IS 16106
2	System Efficacy	>= 110 lumen /watt	IS 16106:2012
3	LED Driver Efficiency	Minimum 85%	
4	**Harmonics**	**Maximum 10%**	**IS 16102-2-2012**
5	**Power factor**	**Minimum 0.95**	**IS 16102-2**
6	Frequency	50 Hz ±3%	LM-79 report
7	Operating voltage	110V – 320V	LM 79 report
8	Surge voltage	>4 kV	LM 79 report
9	Ambient temp	-10 to 50 deg C	LM 79 report
10	Degree of protection	IP 66	IS 10322
11	CRI	Minimum 70	IS 16102 - 2

TABLE 22: LED specification

2. BLDC SPECIFICATION

Normal trend of one ceiling fan working hours with present cost while replacing with BLDC fan and the payback period is given in below table.

Number of working hours/day for a single ceiling fan	**Hours**	9	10	11	12	13	14	15	16	17	18	19	More than 20
Simple payback period after replacement with BLDC	**Years**	5	5	4	4	4	3	3	3	3	3	3	2

The BLDC fan test certificates as per the various standards mentioned below should be examined while purchasing.

Sl no	Parameters	Requirements	Applicable IS
1	Air delivery	215 CMM	IS 374 - 2019
2	Harmonics	Maximum 10%	IS 374 - 2019
3	Power factor	Minimum 0.95	IS 374 - 2019
4	Frequency	50 Hz ±3%	IS 374 - 2019
5	Insulation resistance	>2 MΩ	IS 374 - 2019
6	Speed	350 rpm	IS 374 - 2019
7	Maximum temperature rise	70 deg C	IS 374 - 2019
8	Degree of protection	IP 65	IS 10322

TABLE 23: BLDC SPECIFICATION

3. ABBREVIATIONS

APFC	:	Automatic Power Factor controller
AVG	:	Average
BDV	:	Breakdown voltage
BEE	:	Bureau of energy efficiency
CEA	:	Central electrical authority
CFL	:	Compact fluorescent lamp
CFM	:	Feet cube per minute
DB	:	Distribution Board
DG Set	:	Diesel Generator Set
EC	:	Energy Conservation
FD	:	Forced draft
HPSV	:	High-pressure sodium vapour
HT	:	High Tension
ID	:	Induced draft
IEC	:	International electro technical commission
IEEE	:	The Institute of electrical and electronics engineers
IS	:	Indian Standard
KG	:	Kilogram
KVA	:	Kilo Volt Ampere
KVAH	:	Kilo volt Ampere Hour
KVAR	:	Kilo volt-ampere
KW	:	Kilo Watts
KWH	:	Kilowatt-hour
LED	:	Light emitting diode
MAX	:	Maximum
MH	:	Metal halide
NEMA	:	National Electrical Manufacturers Association
OLTC	:	On load tap changer
ONAN	:	Oil natural air natural
PCC	:	Point of common coupling
PSI	:	Pound square inch
RMD	:	Registered Maximum demand
SEC	:	Specific electricity consumption
SFU	:	Switch Fuse Unit
SLD	:	Single Line Diagram
TDD	:	Total demand distortion
THD	:	Total harmonics distortion
TOE	:	Tonne of oil equivalent
UPS	:	Uninterruptible power supply
VFD	:	Variable frequency drive

4. INSTRUMENTS USED

SL.NO	EQUIPMENT DESCRIPTION	MAKE & MODEL
1	Power energy & harmonic Analyser	Krykard ALM 35
2	Air quality analyser	Testo 480

TABLE 24: INSTRUMENTS USED

5. REFERENCES

1. NAAC – Institutional accreditation manual 2019
2. BEE energy audit books
3. CEA regulations of grid connectivity-2007
4. IEEE Std. 519-1992.