ENERGY AUDIT – 2020

VIMALA COLLEGE

Thrissur

Kerala

EXECUTED BY

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ACKNOWLEDGEMENTS

We express our sincere gratitude to the **Vimala College, Thrissur** for giving us an opportunity to carry out the project of Energy Audit. We are extremely thankful **to Dr. Sr. Beena Jose , Principal** and all the staffs for their support to carry out the studies and for input data, and measurements related to the project of Energy audit.

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

ELECTRICAL SAFETY & ENERGY AUDIT TEAM

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   Energy Manager No – EA 25612

Yours faithfully

Managing Director
Athul Energy Consultants Pvt Ltd

EXECUTIVE SUMMARY

1. ANNUAL ENERGY CONSUMPTION

Annual cost for energy consumption during last 12 months (Mar-2019 to Feb-2020).

Particulars	Unit	Quantity	Average Cost (Rs Lakhs)
Electricity	kWh	154706	12.94

TABLE 1: ANNUAL ENERGY COST

2. 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	PF Improvement in Electrical System		16476	15000	11
2	Replacement of ceiling fans with BLDC fans (217no: Preferred to change in Office, Staff room, security cabin and then hostels)	13392	69638	372000	64
3	Replacement of Fluorescent tubes with energy efficient LED lights (90No: Office, staff room, convent)	7776	40435	89100	27
4	Replacement of T-8 lights with LED in library, class rooms and labs	8640	44928	178200	48
5	Replacement of existing old fan regulators with new electronic regulators	2136	11107	4450	05
	Total	31944	182584	658750	43
4	Installation of solar panel (25KW) Grid Tie mode system	30,000	156000	1750,000	132
Total					

TABLE 2: ENERGY SAVING PROPOSALS

3. AUDIT SUMMARY - ACTIONS

The actionable summary of the audit report is given in the table below.

Sl No:	Particulars	Location	Action to be taken	Remarks
1	Power factor improvement	Main distribution panel	Replace the faulty capacitors in the APFC panel	Which results in increasing the rate of incentives as well as reduce the demand charges
2	Replacement of ceiling fans with BLDC fans	Classrooms, Staff rooms	Change the existing old ceiling fans with BLDC fans	Energy consumption will come down
3	Replacement of old split AC with New 5 star rated ones	Computer Labs, Office Rooms	Change the old existing ACs with 5 star ACs.	Energy consumption will come down
4	Replacement of old split AC with new Inverter AC	Server Room	Change the existing AC to Inverter type AC for less power consumption	In Server room AC is working continuously and the payback period will immediate
5	Replacement of Fluorescent lights with LED	Class rooms, Staff rooms	Replace with LED lights.	Energy consumption will come down
7	Renewable energy	Vimala College	Install 30 kW solar power plant	The whole consumption will reduce

TABLE 3: ENERGY AUDIT SUMMARY – ACTIONS

4. ENERGY AUDIT SUMMARY & RECOMMENDATIONS

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 was always below the minimum value which is 75% of the contract demand. In only few months it came above the minimum billing demand.

- **Power factor analysis:** For last month, the pf was found to be low and there are penalties.

2. **Electricity performance**

- **Voltage:** The Voltage found to be low at the time of audit and unbalance was observed.
- **Capacitors:** From the analyzation of active and reactive power with Power factor, the present installation method of capacitors at the transformer end, is not satisfactorily maintained. By replacing the existing inline capacitors with APFC panel at the Main Switch board in both transformers, will optimize the PF to near unity.
- **Air conditioners:** Replacement of old AC's with new energy efficient star rated AC's.
- **Light loads:** Majority of the lighting fixtures are fluorescent type (T12). By replacing these loads with LED light fittings will reduce the overall power consumption.
- **Ceiling fan loads:** Ceiling fans are installed in majority of the areas by replacing it with Brushless DC fans which consumes in the range of 25 to 30W at full speed, instead of 70W in normal fans, will reduce the power consumption considerably. Also while purchasing new fans priority should be given for BLDC.
- **Solar power plant:** It is better to install a 25kW ON Grid Tie mode system

5. ENERGY PERFORMANCE INDEX (EPI)

EPI was based on the energy consumption in Mar-19 to Feb-20. 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)	154706
Building area of college in M^2	12098
Total annual electricity cost (Rs.)	1293875
Present Specific Electricity Consumption (kWh/M^2)	12.79
After Energy Saving Implementation	
Annual electricity consumption (kWh/year)	122762
Present Specific Electricity Consumption (kWh/M^2)	10.15
Electricity Savings in % without solar installation	20.65
Total cost Savings in % without solar installation	**14.11**

TABLE 4: ENERGY INDEX

6. GENERAL DETAILS

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

Sl.No:	Particulars	Details
1	Name of the College	Vimala College
2	Address	Ramavarmapuram Road, Adiyara,
		Thrissur - 9
3	Contact Person	Dr. Sr. Beena Jose (Principal)
4	Contact Phone numbers & Fax	0487-2332080
		Fax – 0487-2321759
5	E-mail ID	mail@vimalacollege.edu.in
6	Website Details	www.vimalacollege.edu.in
7	Type of college	Autonomous Educational Institution
8	Annual Working Days	210
9	No: of Shifts	Day Shift (One) (9AM -4PM)
10	No: of staff	214
11	No : of students in 2019-20	2582
12	Details of college departments	UG -16, PG -16 AND PhD- 06
13	Total built up area(M^2)	12098
14	Total land area of college	26 acres

TABLE 5: GENERAL DETAILS

OBJECTIVE

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 Vimala College 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.

DESCRIPTION OF SITE

Sprawling over 26 acres of land and situated in the cultural capital of a state lauded for its rich heritage, **Vimala College**, Thrissur was set up as a citadel of education, enlightenment and progress of young women in 1967. Undying enthusiasm, visionary diligence and a passion to bring out change, defined, moulded and transformed the dream of the CMC Management into what the College has become today. In her 53rd year of inception, Vimala stands high with her flag unfurled to glory and true to the ideals of her founders whose vision is extolled in the words: Our aim is the pursuit of intellectual and professional excellence for the total transformation of the human person for his/ her own enrichment and for the service of the society and the nation in the spirit of Jesus Christ. Bifurcated from St. Mary's College and affiliated to the University of Calicut, Vimala offers 19 Undergraduate and 15 Post Graduate programmes along with other certificate and short term courses and is a Centre for Research in English, Physics, Commerce, Social work, Economics and Malayalam.

Managed by Nirmala Province, Thrissur of the Congregation of Mother of Carmel (CMC), the College is under the religious jurisdiction of the Catholic Archbishop of Thrissur. With an enrolment of 2667 students, faculty strength of 149 members and an administrative team of 36 staff, the College is engaged in bringing into fruition the dream that shaped the legacy bequeathed to her by the founders. All efforts are made to sustain and enhance quality through the synchronisation of innovative measures and traditional values. With remarkable strides in curricular, co-curricular and extra- curricular spheres, the College has defined a concrete position for herself in the educational map of the state and envisions a journey of greater achievements in the future. The infrastructure and educational resources have been consistently expanded to meet the growing academic requirements. Technology enhanced teaching-learning experience and work culture have propelled the productivity forward and raised the merit of the institution.

The College in high stead the vision and mission that forms the foundation of its very existence and accordingly engages in uncompromising and dedicated service to the field of education. Accredited at the national level with a Five Star status in 2001 by the NAAC, the institution has undergone two subsequent cycles of re-accreditation in 2008 and 2014 and presently holds the top grade A with a CGPA of 3.50 on a 4-point scale. The University Grants Commission (UGC) conferred autonomy in 2015 and identified her as a College with Potential for Excellence in 2016. The Ministry of Human Resource Development, Government of India awarded the College the 52nd and 77th positions in the National Intuition Ranking Framework (NIRF) of the years 2017 and 2018 respectively. The college

was in 100-150 band of NIRF Rankings 2019 and got 99th position in NIRF 2020 Rankings. Vimala College is a mentor college in NAAC Paramarsh Scheme from 2018. Vimala College has a full-fledged DST -FIST funded laboratory and presently 6 science departments of college are supported under DBT-STAR college Scheme.

In 2018 UGC approved two B.Voc programmes - Web Technology and Food processing, and community college offering three courses Diploma in Interior Architecture and Design (DIAD), Diploma in Digital Video Production and Diploma in Tourism Management and Hospitality.

Figure 1 COLLEGE CAMPUS FRONT VIEW

ELECTRICITY CONSUMPTION ANALYSIS

1. BASELINE DATA & CONSUMPTION: 12 MONTHS

Base Line Data (Based on last 12 months – Mar -19 to Apr 20)			
1	Electricity provider	KSEBL	
2	Supply Voltage	11 kV	
3	Tariff	HT 11 (A) General	
4	Consumer No:	1356810019001	
5	Contract demand (kVA)	100	
6	Maximum demand registered (kVA)	99	
7	Average monthly electricity consumption (kWh)	12892	
8	Average demand charges (Rs/month)	28964	
9	Average power factor	0.937	
10	Annual power factor incentive	6009	
11	Annual power factor penalty	2070	
12	Average Tariff rate for energy consumption, (Rs / kWh)	Normal – 5.40 Peak – 8.10 Off Peak – 4.05	Average – 5.85
13	Demand charge (Rs / kVA)	350	
14	Average monthly electricity cost (Rs)	107823	

TABLE 6 : BASELINE DATA

Inference

i. Power factor found to be average of 0.937 in which present tariff having penalties.

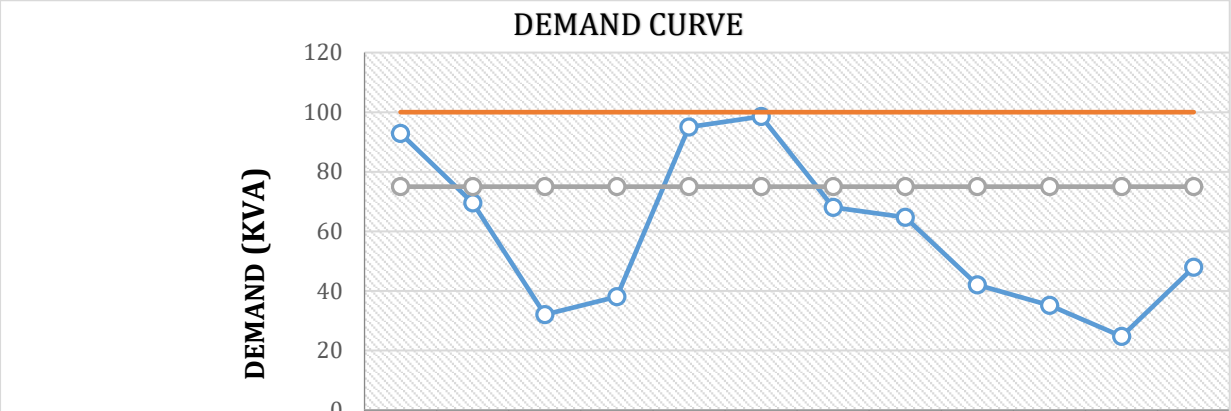
ii. Recorded maximum demand during past 12 month was **99 kVA** and which is only 99% of the contract demand.

iii. In last year, only in 3 months the contract demand comes more than 75%.

iv. PF was in the range of 0.92 to 0.96, but in last few months it comes only 0.98 and the rate of getting incentives becomes reduced.

2. DEMAND ANALYSIS

This section analyses the trend for the maximum demand versus the Contract Demand (CD) over a 12-month period (Mar 2019 to Feb 2020).



	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20
RECORDED MAXIMUM DEMAND	93	70	32	38	95	99	68	65	42	35	25	48
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 2: DEMAND ANALYSIS

Inference

i. Average demand charges came as **Rs. 28,964** per month.

ii. The recorded maximum demand came almost less than 75% in 9 months.

Suggestion

i. Improving the pf will reduce the demand charges.

3. ELECTRICITY DEMAND IN VARIOUS TIME ZONES

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

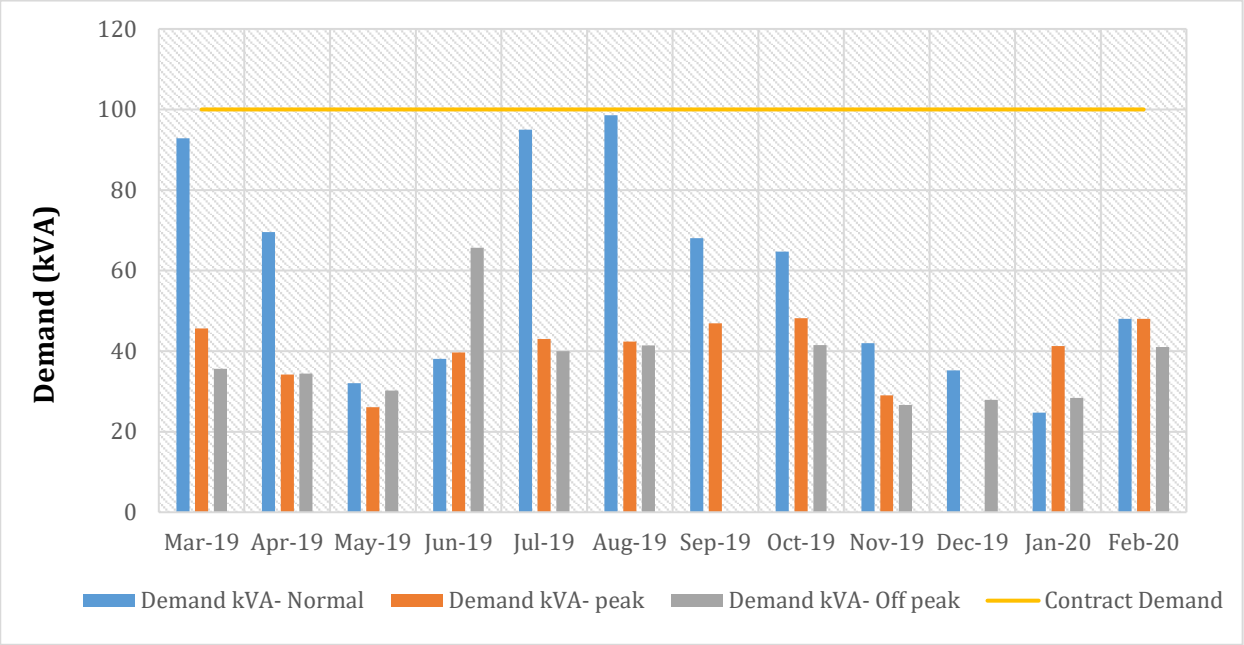


FIGURE 3: DEMAND IN VARIOUS TIME ZONES

Inference

i. The average maximum demand in the normal, Peak and off-peak period registered at Vimala College with respect to the contract demand is 59.07%, 37.03% and 34.39% respectively.

ii. The percentage of maximum demand in the normal, Peak and off-peak period registered at Vimala College with respect to the contract demand is 98.56%, 48.2%, and 65.64% respectively.

4. POWER FACTOR ANALYSIS IN KSEB 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.

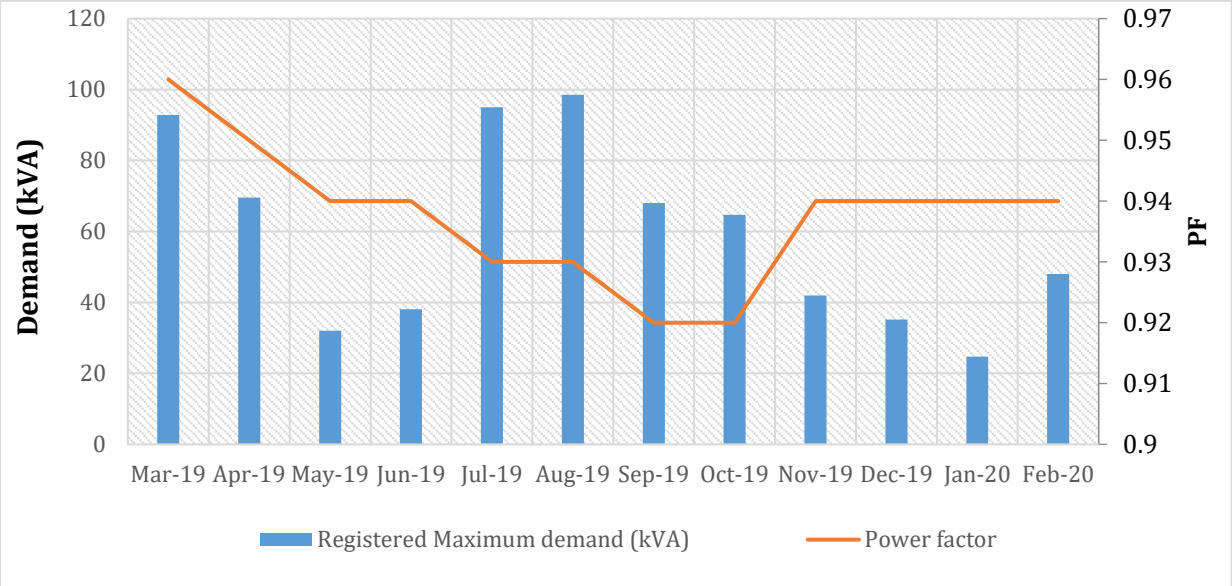


FIGURE 4: POWER FACTOR ANALYSIS

Inference

i. Average power factor during the past one year is found to be 0.937.

ii. From the figure, we get the inference that most of the some of the capacitors that placed at the load end were not working well.

iii. For last few months, there is penalties due to low power factor.

Suggestion

i. By improving the PF, the incentives will increase.

5. TARIFF RATES ANALYSIS

The average monthly energy and demand charges for the period Mar 2019 to Feb 2020 is represented in Figure below.

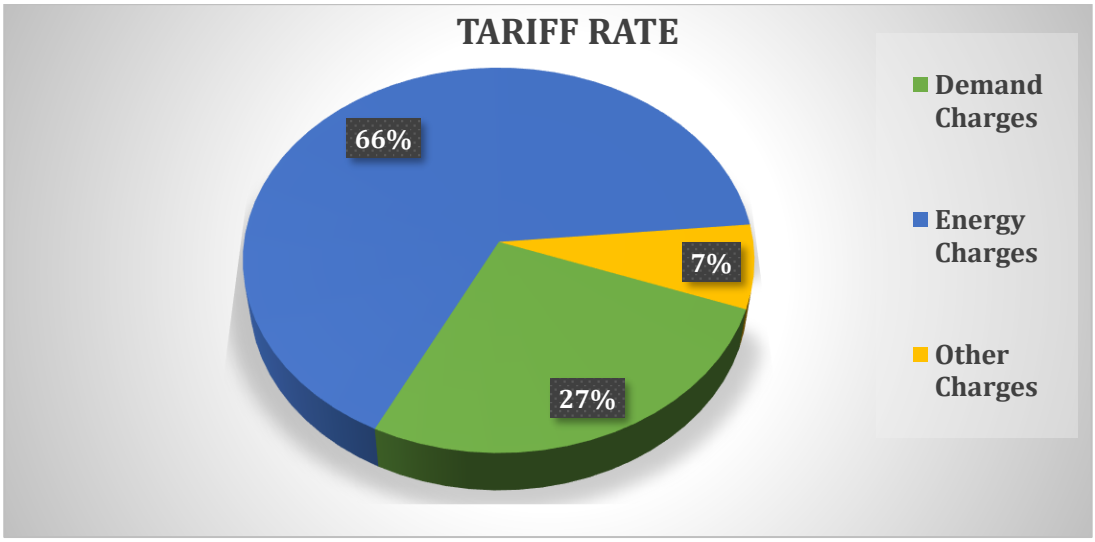


FIGURE 5: TARIFF RATE

Inference

i. Average demand charges for the past one year was Rs 28,964/ **per month** and energy charges was Rs 71,591/ per month**.**

ii. The energy charges came about **66%** of the total bill.

iii. The Vimala College tariff band is **not good** because 34% spend for demand and other charges.

6. SPECIFIC ELECTRICITY CONSUMPTION (kWh/M²)

The electricity consumption from March 2019 to Feb 2020 has taken for the benchmarking in the Vimala College in the regression analysis method. Here the comparison is done with electricity consumption (KSEB) and the building area, which is in Square meters.

The below table shows the specific electricity consumption of Vimala College.

Month	Unit Consumption	Total Build-up Area	Specific Electricity
	kWh	M²	kWh/ M²
Mar-19	23578	12098	1.95
April-19	15788	12098	1.31
May-19	2223	12098	0.18
Jun-19	11032	12098	0.91
Jul-19	14304	12098	1.18
Aug-19	13617	12098	1.13
Sep-19	11561	12098	0.96
Oct-19	13116	12098	1.08
Nov-19	13376	12098	1.11
Dec-19	10235	12098	0.85
Jan-20	13610	12098	1.12
Feb-20	12266	12098	1.01
Avg	**12892**	12098	1.07

TABLE 7: SPECIFIC ELECTRICITY CONSUMPTION – kWh/M²

ELECTRICITY PERFORMANCE

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

TRANSFORMER SECONDARY LOGGING

The LT side of the transformer was logged using power quality analyser Krykard ALM 35 for 24 hours and given in following table The measurement-averaging period was 10 minutes. The Measurement details of the transformer are given below:

Make		**Intrans Electro Components**		
Rating	**kVA**	315		
Voltage ratings	**kV**	11/0.433		
Current ratings	**A**	16.53/420		
Volt impedance	**%**	4.71		
Year of manufacturing		2006		
Measurement values – LT side				
Actual Energy for 24 Hrs	kWh	**529**		
Apparent Energy for 24 Hrs	kVAh	**578**		
Power Factor		**0.915**		
Particulars	**Units**	**Minimum**	**Maximum**	**Average**
Active Power	kW	**5.60**	**65.33**	**23.77**
Apparent Power	kVA	**6.69**	**67.93**	**25.96**
Reactive Power	kVAr	**-7.46**	**20.39**	**3.63**
Voltage phase	Volts	**193.60**	**253.80**	**240.28**
Current	Amps	**8.40**	**128.40**	**36.50**
THD V	%	**1.40**	**5**	**2.09**
TDD A	%	**7.90**	**66.20**	**22.20**
Voltage Imbalance	%	**0.20**	**1.10**	**0.72**
Current Imbalance	%	**0.20**	**43.10**	**13.14**

TABLE 8: TRANSFORMER LOGGING

Inference

i. The maximum demand registered during the period of measurement is 67.93 kVA, in 10 minutes' interval, and the corresponding PF was 0.915 that shows the importance of PF improvement.

ii. The variation of voltages found at the time of audit. (193.6 to 253.8V)

iii. The average loading of transformer is only about less than 10%.

iv. Current imbalances were found to be higher (Maximum of 3.1%)

1. ANALYSIS: VOLTAGE VARIATION

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

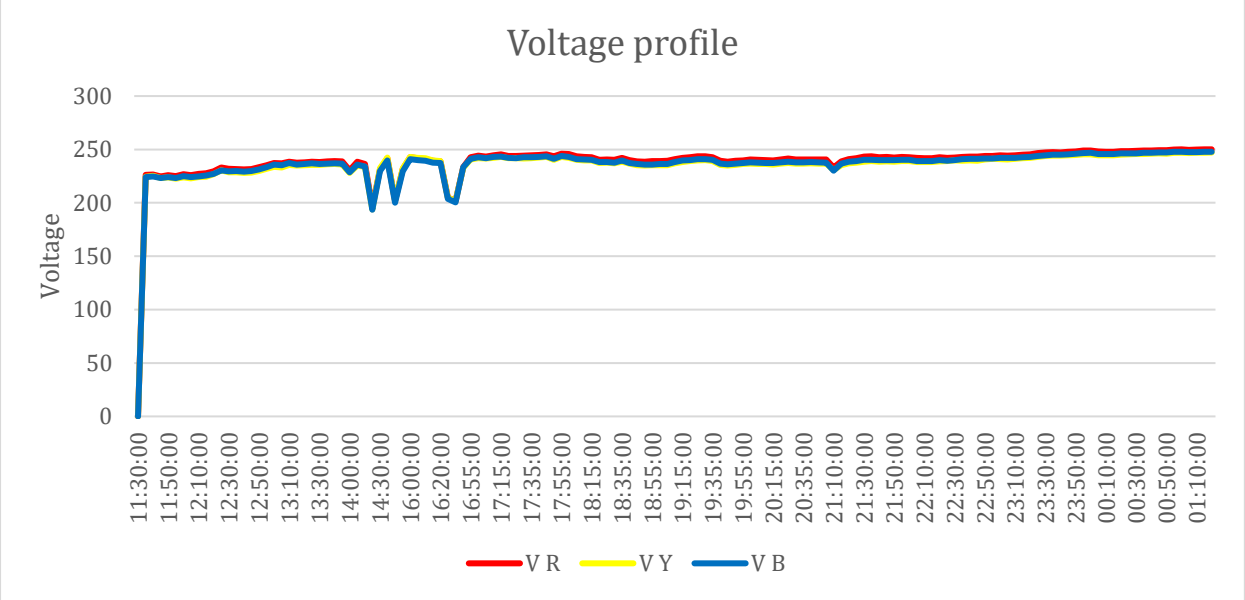


FIGURE 6: VOLTAGE PROFILE

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 253.80 and 193.60 respectively with an average phase voltage of 240.28 V.

iii. The high voltage will increase the power consumption and increases the capacitance value in the system.

2. ANALYSIS: CURRENT VARIATIONS

This section carries the current variations during the 24-hour measurement period with the power analyser.

The figure below gives the current profile of the phases at the LT side.

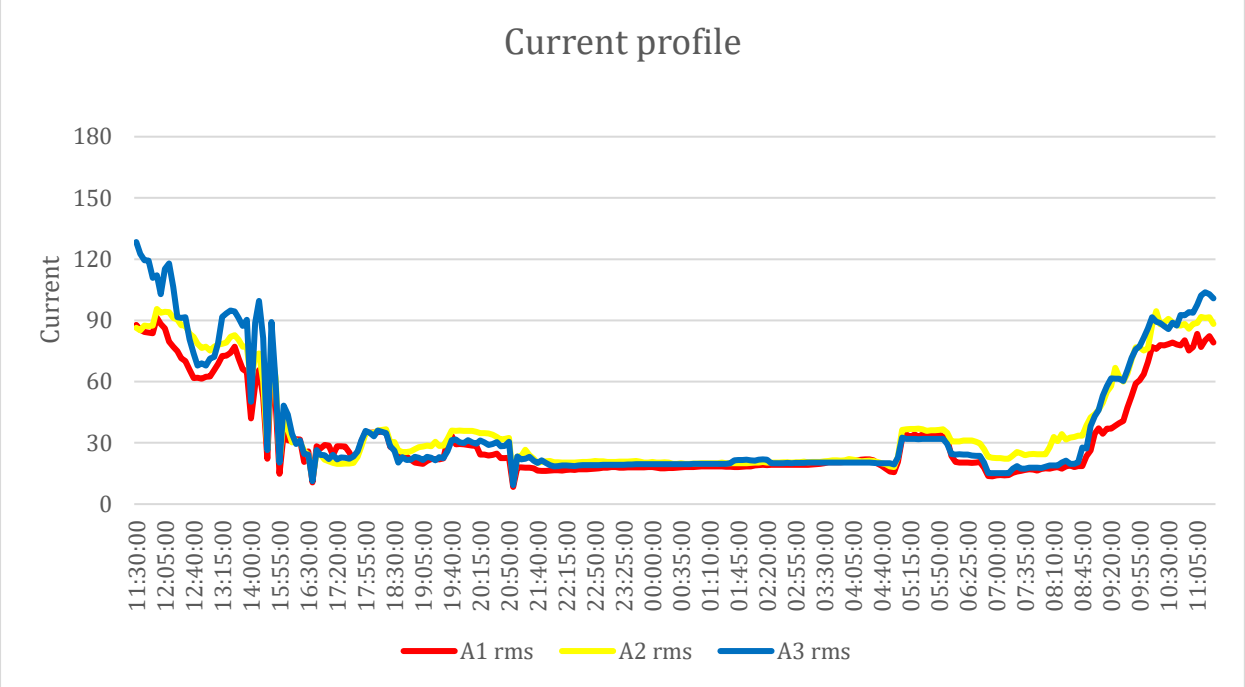


FIGURE 7: CURRENT VARIATIONS

Inference

i. Figure 11 denotes current variations at the LT side.

ii. The maximum current occurred during the Normal period at 128.40A and minimum during peak period with 8.40A.

iii. The current varies between 2 to 30.57% of the rated current of the transformer at the secondary side.

3. 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:

Total kWh	Max kW	Time (Hrs)	Load factor (%)
529	65.33	24	33.74

TABLE 9: LOAD FACTOR – TRANSFORMER

Inference

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

ii. Here the load factor found to be low.

4. ANALYSIS: POWER FACTOR

The section provides an overview of the power factor variations at the LT side. The Power factor variation with respect to the active and reactive power are given in table.

	Time	PF	kW	kVA	kVAr	Remarks
Normal period						
Minimum PF	07:15:00	0.727	8.90	12.23	-7.01	Leading
Maximum PF	09:50:00	0.986	48.68	49.36	1.93	Lagging
Peak period						
Minimum PF	22:00:00	0.807	10.83	13.41	6.43	Lagging
Maximum PF	18:10:00	0.978	25.36	25.93	0.21	Lagging
Off peak period						
Minimum PF	04:20:00	0.695	11.10	15.96	8.66	Lagging
Maximum PF	05:10:00	0.981	25.05	25.53	1.10	Lagging

TABLE 10: PF VARIATIONS

Inference

- There is leading found at the time of audit in the normal period.
- The PF was found to be very low in some time intervals.

Recommendations Replace the faulty capacitors with new capacitors to improve the power factor.

The below figure shows the kW and PF variations.

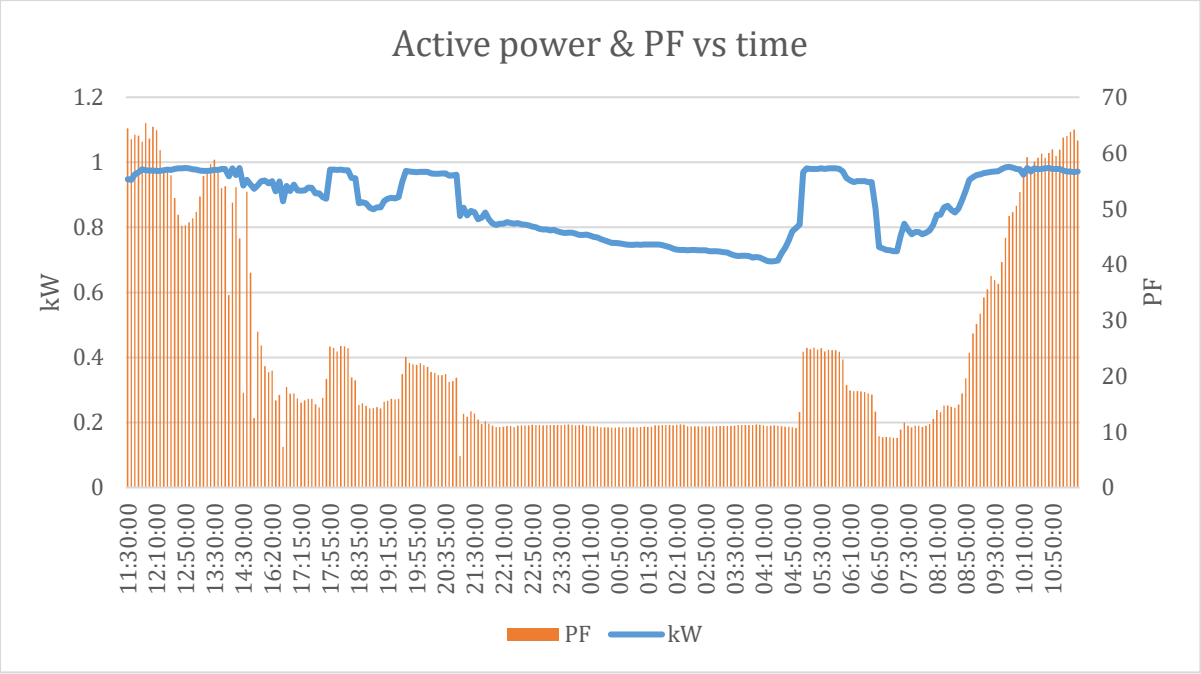


FIGURE 8: KW, & PF VARIATIONS

5. ANALYSIS: CURRENT IMBALANCE

This section carries out the current imbalance at the LT side during the logging period. The current imbalance with respect to the ampere in three phases are given below:

	TIME	R PHASE	Y PHASE	B PHASE	UNBALANCE
NORMAL TIME					
MAX. CURRENT	11:30:00	**87.8**	**86.3**	**128.4**	27.3
MIN. CURRENT	14:45:00	**8.3**	**10.6**	**10.6**	15.6
CURRENT AT MAX. UNBALANCE	08:20:00	17.3	34.3	20.3	**43.1**
CURRENT AT MIN. UNBALANCE	17:55:00	35.2	34.6	35.8	**1.7**
PEAK TIME					
MAX. CURRENT	18:10:00	**35.2**	**36.1**	**36.1**	1.7
MIN. CURRENT	21:10:00	**8.4**	**10.8**	**9.3**	13.7
CURRENT AT MAX. UNBALANCE	19:20:00	22.1	30.6	21.4	**23.9**
CURRENT AT MIN. UNBALANCE	18:10:00	35.2	36.1	36.1	**1.7**
OFF PEAK TIME					
MAX. CURRENT	04:55:00	**15.7**	**18.2**	**19.4**	11.6
MIN. CURRENT	05:20:00	**34.1**	**36.8**	**32**	7.3
CURRENT AT MAX. UNBALANCE	04:50:00	16	18.4	20	**11.8**
CURRENT AT MIN. UNBALANCE	04:35:00	19.9	20.6	20.1	**2**

TABLE 11: CURRENT UNBALANCE

Inference

- The current imbalance (43.10%) occurred on Normal period. I.e. at 8.20 hrs morning which is above the standard of 10%.
- The average current imbalance measured was 13.14%, which is well within the specified standard limit (10%).
- The variation of current unbalance in Normal time zones are given below:

The current imbalance at the Transformer secondary side are given below:

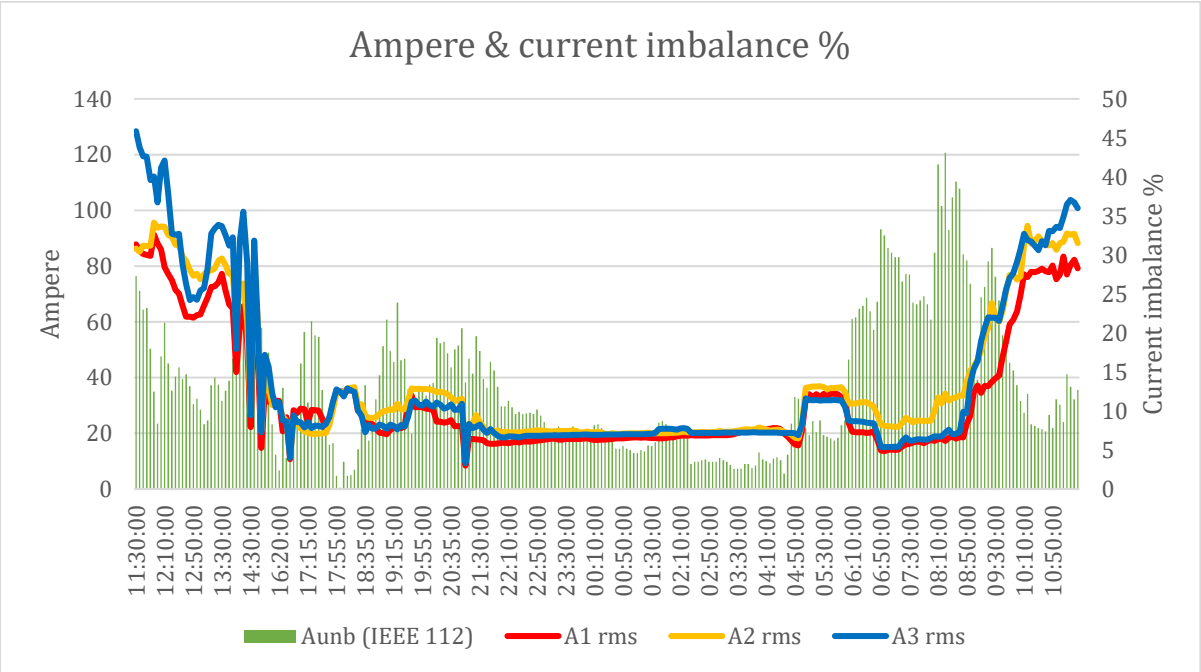


FIGURE 9: AMPERE VS IMBALANCE GRAPH

Suggestion:

- The current unbalance is creating in morning time and in B-phase current rating is more. Check the routine of switching on of the electrical system for reducing the unbalance.

6. ANALYSIS: COMPARISON OF LOADS IN DIFFERENT TIME ZONES

This section provides an overview of the total electricity consumption, split across the 3 different time zones as defined by the Kerala State Electricity Board (KSEB):

Time Zone 1: Normal: 6.00 Hrs. to 18.00 Hrs.

Time Zone 2: Normal: 18.00 Hrs. to 22.00 Hrs.

Time Zone 3: Normal: 22.00 Hrs. to 6.00 Hrs.

Electricity consumption according to the time of use, as calculated from the 24-hour logging.

Particulars	Zone-1 (6am - 6pm) (kWh)	Zone -2 (6pm-10pm) (kWh)	Zone-3 (10pm-6am) (kWh)	Total (kWh)
	Normal	**Peak**	**Off-peak**	
Unit consumption	361	67	101	**529**
Average kWh in each period (normal/12, peak/4, off peak/8)	**30.08**	**16.75**	**12.63**	

TABLE 12: ZONE WISE KWH CONSUMPTION

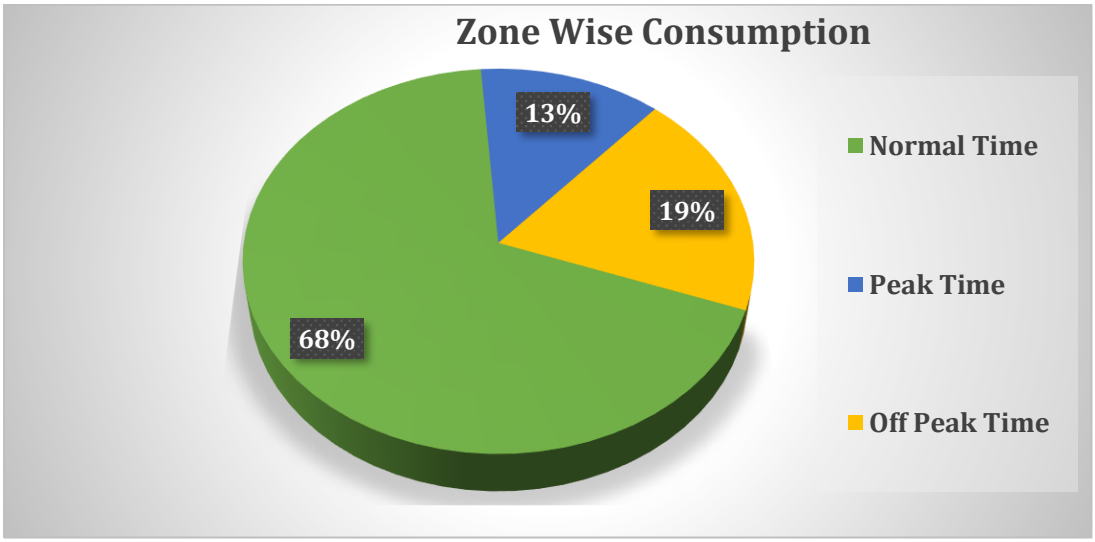


FIGURE 10: ZONE WISE KWH CONSUMPTION

According to KSEB, the energy charges in each time zone is calculated as follows:

In Time Zone 1(EC1): Consumption in Zone 1* Rate

In Time Zone 2(EC2): Consumption in Zone 2* Rate* 1.5

In Time Zone 3(EC3): Consumption in Zone 3* Rate* 0.75

Majority of the unit consumption occurs during the normal period, which is **68%**.

7. 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 13: 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 14: 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 15: 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 16: VOLTAGE HARMONICS LIMIT (IEEE 519-2014

HARMONICS DATA SHEET

Location:	**Main Control Panel (LT Side)**						
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**			
		2.08	66.20	Voltage harmonics is within limit But Current Harmonics' is more			
Individual Harmonic%							
Particulars	3rd	5th	7th	9th	11th	13th	15th
Voltage %	1.5	3.3	2.1	5.2	0.8	0.7	2.4
Current %	13.5	44.3	37.6	13.5	17	11.9	3.9

TABLE 17: HARMONICS ANALYSIS

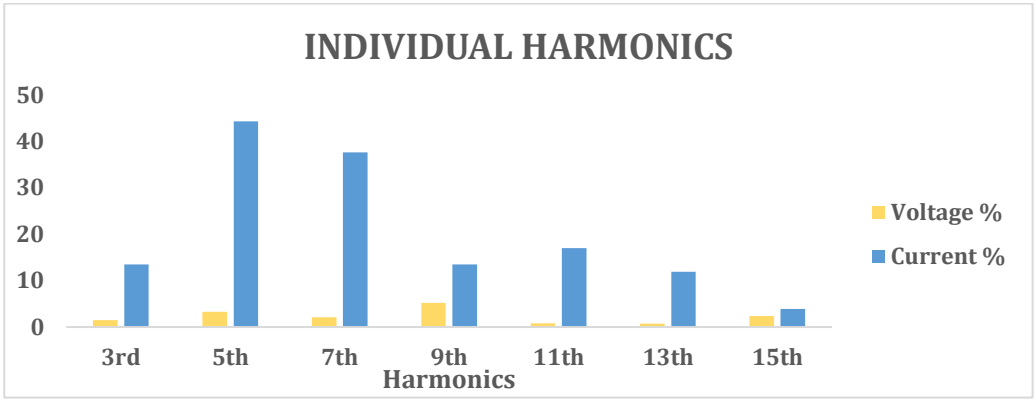


FIGURE 11: HARMONICS ANALYSIS

Inference

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

ii. The table also gives the fact that the voltage harmonics are within the 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.

DIESEL GENERATORS

Vimala College uses Two Diesel generators, which gives the backup supply to the MSB, works in auto mode, according to the load during the power failure in which the details are given below:

DG-kVA	**180**	**50**
Engine	Cummins	Mahindra
Generator	Stamford	KEL

TABLE 18: DG DETAILS

CAPACITOR PANEL

To reduce kVAr, partial kVAr must be supplied by capacitors which in turn will reduce the burden of kVAr on the utility supply system. The capacitor acts as a kVAr generator. The power factor correction can be static correction where capacitors are connected to each starter, or it can be bulk correction where capacitors are connected at the distribution boards.

In Vimala College, APFC panel is provided with parallel to MSB. The performance of individual capacitors in the APFC panel are given below:

Name	Rated kVAr	Design Voltage	Measured Voltage	Measured kVAr	kVAR wrt to Volts	% of deterioration
	A	B	C	E	F= A*(C/B)	G= (F-E)*(100/F)
C1	20	440	390	Not Working		
C2	15	440	390	10.76	13.30	19.07
C3	10	440	390	Not Working		
C4	10	440	390	8.54	8.86	3.65
C5	10	440	390	Not Working		
C6	10	440	390	4.25	8.86	52.05
C7	15	440	390	Not Working		

TABLE 19: CAPACITOR DETAILS

Inference

i. From the table above, most of the installed capacitors are damaged or degraded.
ii. Due to the damage of capacitors, the pf will come down.
iii. One Phase of the capacitors C6 (B Phase) are not working.

Suggestions

i. Periodic checking of capacitors should be done once in two weeks analysing the ampere rating taken after the new installation as the base value.
ii. Replace the faulty capacitors with new capacitors for the maintaining of power factor.
iii. Install APFC panel in parallel to the Main switch board to optimise the power factor to unity, for the present varying loads the PF is 0.98 only.

LIGHTING SYSTEMS AND FAN LOADS

Effective lighting is essential for process and utility areas 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, thus reducing the need for air conditioning too. The lighting details of the Vimala college at various buildings are given below:

TYPE LIGHTING FIXTURES	WATTAGE	NUMBER	TOTAL KW
INCANDESCENT LAMP	**60**	**22**	1.32
FLUORESCENT LAMP T-8 with copper chock	**50**	317	15.85
FLUORESCENT LAMP T-12 with copper chock	**54**	63	3.402
CFL	**15**	312	4.68
CEILING FANS	**70**	465	32.55
COMPUTER	**60**	109	6.54
TOTAL	**64.342 KW**		

TABLE 20: LIGHT AND FAN LOADS SUMMARY

Notes:

- Here the power consumption is **64.342 KW**

Suggestions:

- ✓ Replace the CFL and Fluorescent tubes with LED's and the power consumption will be low and the calculations are given in the Annexure 1.
- ✓ Maximize the use of daylight.
- ✓ Switched off the unwanted lights inside the plant.
- ✓ Labelling should be done for lighting panels.
- ✓ Replace the existing ceiling fans with BLDC (Brush Less Direct Current) fans for energy saving.

DISTRIBUTION OF LAMPS, FANS AND COMPUTERS IN THE COLLGE BUILDINGS

LOCATION	FLUORESCENT LAMP T-8 with copper chock	FLUORESCENT LAMP T-12 with copper chock	INCANDESCENT LAMP	CFL	CEILING FANS	COMPUTER
Chavara	41	0	4	34	82	42
Main	118	4	15	21	112	34
Liessux	24	6		88	47	85
Euphrasia	29			42	44	22
Hostel	8			4	16	0
Libraray	58	53		14	99	15
Convent	39		3	109	65	1
Total	317	**63**	22	312	465	109

Table 21 DISTRIBUTION OF LAMPS AND FANS AMONG BUILDINGS

DISTRIBUTION OF LAMPS AND FANS IN THE COLLEG

LOCATIONS	FLUORESCENT LAMP T-8 with copper chock	FLUORESCENT LAMP T-12 with copper chock	INCANDESCENT LAMP	CFL	CEILING FANS
Class room	70			50	120
Lab	57		14	8	40
Dept	33			9	44
Office	16	4		1	15
Convent	39	0	3	109	65
Corridors	2			25	2
Library	58	53	0	14	99
Miscellaneous		6	5	38	11
Auditorium	42			58	69

ENERGY SAVING PROPOSALS - 1

POWER FACTOR IMPROVEMENT

Background

By referring the last year electricity bills, the average power factor of the Vimala College is 0.937 in thr last year even if the APFC is installed in the college. We observed some of the capacitors are failed to serve its function and which are identified in the audit report.

Proposal

We propose to replace those capacitors with new ones and install lower variants of capacitors like 2, 3and 5 capacitors for fine tuning f the system I the APFC panel.

Calculation

Particulars	Unit	Values
Average power factor		0.937
Present minimum power factor required to avoid penalty		0.95
Penalty for the last 8 months	Rs	2976
Loss in incentive for the last 12 months		13500
Total loss	Rs	16476
Investment	Rs	15,000
Simple Payback Period	Months	11

TABLE 22: EC PROPOSAL 1

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 security cabin and in hostels The calculation for the savings is given in the table below.

Calculation

Existing Ceiling Fans	70 W
Proposed BLDC Fans	30 W
Difference in Wattage	45 W
Avg No: of working hours/day	10
No: of working days per year (Average)	300
No: of working hours per annum (300*10)	3000
Number of Fans operating for 7300 Hrs/Annum	217
Usage factor of fan	0.8
kWh Saving per Annum (0.8*124*45*3000/1000)	**13392**
Cost per kWh (Average Rs /kWh)	**Rs** 5.2
Annual Financial Savings (8 x 55,444)	**Rs** 69638
Cost of BLDC Fans	Rs 3000
Investment for BLDC Fans (124*3000)	**Rs 372000**
Simple Payback period	**64 Months**

TABLE 23: EC PROPOSAL 2

ENERGY SAVING PROPOSALS – 3

REPLACEMENT OF FLUORESCENT TUBES WITH ENERGY EFFICIENT LED LIGHTS IN OFFICE, DEPARTMENTS AND CONVENT

In the above areas the working time is comparably more and it is continuous even if the college is not functioning in the vocational holidays. Hence, we calculated it as separately. At present LED lights are used in very few areas. Replacement of Fluorescent lights to be done in phase manner with LED lights.

Calculation

Existing Fluorescent lights (T-8 with Copper chock)	50 W
Proposed LED light	28 W
Difference in Wattage	32W
No: of working hours/day	10
No: of working days per year (Average)	300
Number of Lights operating for Annual factor	0.8
No: of replaceable light	90
Annual energy saving of kWh for (10*300*92*.0.9*32/1000	7776kWh
Cost per kWh (Average Rs /kWh)	Rs.5.2
Annual Financial Savings (8 x 17,739)	**Rs** 40435
Cost of LED light	Rs 990
Investment for LED (90*990)	**Rs 89100**
Simple Payback period	**27 Months**

TABLE 24: EC PROPOSAL 3

ENERGY SAVING PROPOSALS – 4

REPLACEMENT OF T-8 FTLS WITH LED IN LIBRARAY, CLASS ROOMS AND LAB

At present LED, lights are used in very few areas. Replacement CFL to be done in phase manner with LED lights

Calculation

Existing Fluorescent lights (T-8 with Copper chock)	50W
Proposed LED light	18 W
Difference in Wattage	32 W
No: of working hours/day	06
No: of working days per year (Average)	250
No: of working hours per annum (250*6)	1500
Number of Lights operating for 1500 Hrs/Annum	180
kWH Saving per Annum (1500*180*32/1000	**8640**
Cost per kWH (Average Rs /kWH)	Rs 5.2
Annual Financial Savings (5.2 x 8640)	**Rs 44928**
Cost of LED light	Rs990
Investment for LED (150*300)	**Rs 178200**
Simple Payback period	**48 Months**

Table 25 EC PROPOSAL NO 4

ENERGY SAVING PROPOSALS – 5

REPLACEMENT OF EXISTING OLD FAN REGULATORES WITH NEW ELECTRONIC REGULATORES

Calculations:

Number og old regulators used in office, convent and departments	89
Power consumption of oild regulatores	12W
Power consumption of new regulatores	2W
Energy saving per regulator	10
No: of working hours/day	10
No: of working days per year (Average)	300
Number of Lights operating for Annual factor	0.8
Annual energy saving of kWh for (10*300*92*.0.9*32/1000	2136kWh
Cost per kWh (Average Rs /kWh)	Rs.5.2
Annual Financial Savings (8 x 17,739)	**Rs** 11107
Cost of LED light	Rs 50
Investment for LED (90*990)	**Rs 4450**
Simple Payback period	**5 Months**

Table 26 EC PROPOSAL NO 5

ENERGY SAVING PROPOSALS – 6

INSTALLATION OF 25KW ONLINE SOLAR SYSTEM

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. A growing worldwide concern for conservation of energy has reignited our interest in ecologically sustainable materials, processes and sources of energy.

Of the numerous renewable sources of energy known to humankind, Solar Photo Voltaic or SPV is one that has the potential to supply power for our future needs: Solar radiation is the largest renewable energy source

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

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

Solar Grid Tie mode system of **25 kW** system installation details are given in the section:

Calculations:

Particulars	Unit	
Proposed system	kW	25
Average Units per day	kWh	100
No: of sunny days	days	300
Average Units per year	kWh	30000
Average utility electricity cost	Rs	5.2
Annual financial savings (Rs 30000*5.2)	**Rs**	**156000**
Investment (Subsidized & in Grid tied mode)	**Rs**	**17,50,000**
Simple payback period	**Years**	**11**

TABLE 27: SOLAR GRID TIE MODE SYSTEM

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

INSTRUMENTS USED

SL.NO	EQUIPMENT DESCRIPTION	MAKE & MODEL
1	Power energy & harmonic Analyser	Krykard ALM 35
2	Thermal Imager	FLIR E50

TABLE 28: INSTRUMENTS USED

REFERENCES

1. BEE energy audit books
2. CEA regulations of grid connectivity-2007
3. IEEE Std. 519-1992.
4. National lighting code - 2010