BHARATI VIDYAPEETH'S COLLEGE OF ENGINEERING KOLHAPUR

ENERGY AUDIT REPORT

SEPTEMBER-2021

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Date-30-09-2021

TO WHOSOEVER IT MAY CONCERN

This is to certify that we had carried out the Energy & Water Audit in the Bharati Vidyapeeth's College of Engineering at Morewadi, Kolhapur.

It was observed that client already have installed energy efficient equipment in their premise. Most of energy efficiency improvement work has been already done by client; which shows their positive approach to energy efficiency and sustainability.

Our Observations & Recommendations are summarized as below-

Energy saving and sustainability improvement measures undertaken by college management are as follows.

4. **Replacement of Fluorescent Tube Lights (FTL) with LED Tube Lights**
5. **Installation of solar PV rooftop for renewable energy generation& reduction in carbon emission**
6. **College building designed to minimize energy required for lighting& HVAC needs**

Recommendations for further energy savings are as follows-

4. **Replace degraded and faulty capacitors to maintain unity power factor**
5. **Choose energy efficient pumps for future pump replacement or installations**
6. **Consider strainer cleaning on every six months of pumps (or as a part routine maintenance)**

Yours truly,

UPENDRA G. DEUSKAR
BEE Certified Energy Auditor.
Regn. No.- EA - 1674

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i. Acknowledgement

We are grateful to the management of BharatiVidyapeeth College of Engineering, Morewadi, Kolhapur(Client) for giving us an opportunity to contribute in their efforts towards efficient energy management by undertaking this Energy Audit exercise.

We team of Upendra Deuskar & Associates acknowledges with thanks the co-operation and support extended by management and operating personnel from client side during the audit exercise. Detailed discussions and interaction were held with plant personnel throughout the course of the audit and awareness of energy conservation was noted as exemplary. We would also like to place on record our sincere thanks and appreciation for all plant executives.

We are also thankful to the other staff members who were actively involved while collecting the data and conducting the field studies. We take this opportunity to also thank all the team members at various departments associated with this study of energy audit for extending cooperation during collection of on-site data.

We trust that the findings of this study will help college facility management in improving the equipment performance thereby giving optimum energy consumption at the premise.

ii. Energy Audit Team

Upendra Deuskar & Associates	Mr. Upendra Deuskar (BEE Certified Energy Auditor) Mr. Gaurav Ghewade (BEE Certified Energy Auditor) Mr. Ajay Toraskar
Bharati Vidyapeeth College of Engineering	Mr. Rahul Kadam-Administrative Officer Dr. Vijay R. Ghorpade -Principal Mr. Sachin Patil-OS Mr. Lad-Site Engineer Mr. Abhinav Patil-Electrician
Date of Audit	20th Sep, 2021

iii. Instruments

1. Power Quality Analyser
2. Ultrasonic Flow meter
3. Thermal Imager
4. Temperature – RH logger
5. Lux Meter
6. Power Clamp Meter
7. Measuring Tape

iv. Executive Summary

Client already have installed energy efficient equipment in their premise. Most of energy efficiency improvement work has been already done by client which shows their positive approach to energy efficiency and sustainability.

Observations & Recommendations are summarised below.

Energy saving and sustainability improvement measures undertaken by college management are as follows.

1. **Replacement of Fluorescent Tube Lights (FTL) with LED Tube Lights**
2. **Installation of solar PV rooftop for renewable energy generation& reduction in carbon emission**
3. **College building designed to minimize energy required for lighting& HVAC needs**

Recommendations for further energy savings are as follows

Most of the energy efficiency improvement work has been already done by client in their premise. There is less scope remains in energy efficiency improvement, recommendations for the further improvement in energy efficiency and power quality areas are listed below.

1. **Install Energy Efficient BLDC ceiling fans**
2. **Replace degraded and faulty capacitors for unit power factor**
3. **Install aerators for water and energy savings**
4. **Choose energy efficient pumps for future pump replacement or installations**
5. **Consider strainer cleaning on every six months (or as a part routine maintenance)**

1 Introduction

1.1 General Description of Facility

Bharati Vidyapeeth College of Engineering, Kolhapur(Client) is located at Morewadi, in Kolhapur District of Maharashtra, India. The college was established in the year 2001. The campus is located at a distance of 10 km from the central bus stand, 2 km from the airport and 9 km from the Railway station. The campus occupies 10 acres of land with a beautiful landscape and all other amenities. Since the institute is located at the outskirts of Kolhapur city, it is completely pollution free and therefore provides a good teaching learning environment.

The institute runs four branches viz. Computer Science and Engineering, Electronics and Telecommunication Engineering, Mechanical Engineering and Civil Engineering. The college is designed and constructed from renowned Architects and Civil Engineers such that it takes care of all the environmental artifacts like, water harvesting, aerodynamic building structures, solar heaters etc. and according to the standards and norms set by All India Council for Technical Education. The workshop facility is constructed away from the classrooms so that teaching process doesn't get disturbed. An entire building is erected consisting of only classrooms and also dedicated buildings are provided for every branch. There is a state-of-the-art, acoustically designed central auditorium which is used for various events like seminars, workshops, conferences, cultural programmes etc. The college also has the following departments / committees which work consistently for the development of students.

1.2 Objectives

- To undertake an energy audit so as to identify areas for energy saving, both without and with investment.
- To prioritize distinct areas identified for energy savings depending upon saving potential, skills, and time frame for execution, investment cost, paybacks etc.

1.3 Scope of Work

- To correlate monthly data of production with electricity, fuels & water consumption, for a period of 12 months of normal operation to establish bench mark values for energy consumption.
- To study electrical energy metering, monitoring and control system existing at the plant and to recommend a suitable system for future monitoring.
- To study monthly power factor, maximum demand, working hours, load factor etc. for the reference period along with monthly electricity consumption and establish scope for MD control through possible optimization of load factor and through detailed load management study.
- Based on above, to evaluate the possibility of replacing major motors with energy efficient motors. To provide cost benefit analysis for the replacement policy.
- To study existing requirements of energy provisions at present locations and to identify distinct possibilities of rationalization / savings.
- To study existing maintenance practices for utility systems and recommend areas for improvement in energy efficiency / savings.
- To identify, evaluate and priorities energy saving opportunities into short, mid and long-term time spans depending upon investments, quantum of savings, skills and time required for implementation, etc.
- To prepare draft energy audit report, present to management, undertake necessary modifications based on presentation meeting and submit the final report.

1.4 Electricity Consumption

Client is receiving electricity supply from Maharashtra State Electricity Distribution Company Limited (MSEDCL) with Transformer installation of 11 KV/433 V, 315 KVA & Contract Demand of 210 KVA.

Following table represents bill analysis for last 12 months energy use of the plant.

Table 1 Bill Analysis – Last 12 months

Month	Billed Demand	Highest Recorded MD	Energy Consumption		Power Factor	Demand Charges	Energy Charges	Total Current Bill
	kVA	kVA	kWh	kVAh		Rs.	Rs.	Rs.
July-21	126	35	10404	10563	0.98	54432	97285	190810
Jun-21	126	40	10414	10590	0.98	54432	97533	193200
May-21	126	34	8478	8789	0.96	54432	80946	171150
Apr-21	126	57	10990	11223	0.97	54432	103363	155870
Mar-21	116	54	10846	11299	0.95	47676	107114	195820
Feb-21	116	50	5532	8524	0.98	47676	112274	159950
Jan-21	116	56	12298	12576	0.98	47676	122979	170655
Dec-20	116	57	13414	13680	0.98	47676	116125	163801
Nov-20	116	55	12525	12788	0.98	47676	108662	156338
Oct-20	116	39	8787	9079	0.96	47676	86068	167431
Sep-20	116	32	8350	8628	0.96	47676	81793	161120
Aug-20	116	30	8330	8666	0.96	47676	82153	161780
Total	-	-	**1,20,368**	**1,26,405**	-	-	**11,96,295**	**20,47,925**
Average	**130**	**54**	**10,030**	**10,533**	**0.97**		**99,691**	**1,70,660**

Energy consumption, PF, MD recorded, billed demand, Excess Demand charges, PF penalty trends are represented in graphical format as below.

1.5 Transformer

Client has one transformer of 315 kVA capacity. 11 kV supply provided by MSEDCL express feeder which then stepped down to 415 V for supply to the college buildings and utility area.

Voltage, Current, Power and power factor profile with other electrical measurements were carried out at the main incomer coming of installed Transformer using a Power Quality Analyser. The profiles for the same are given below.

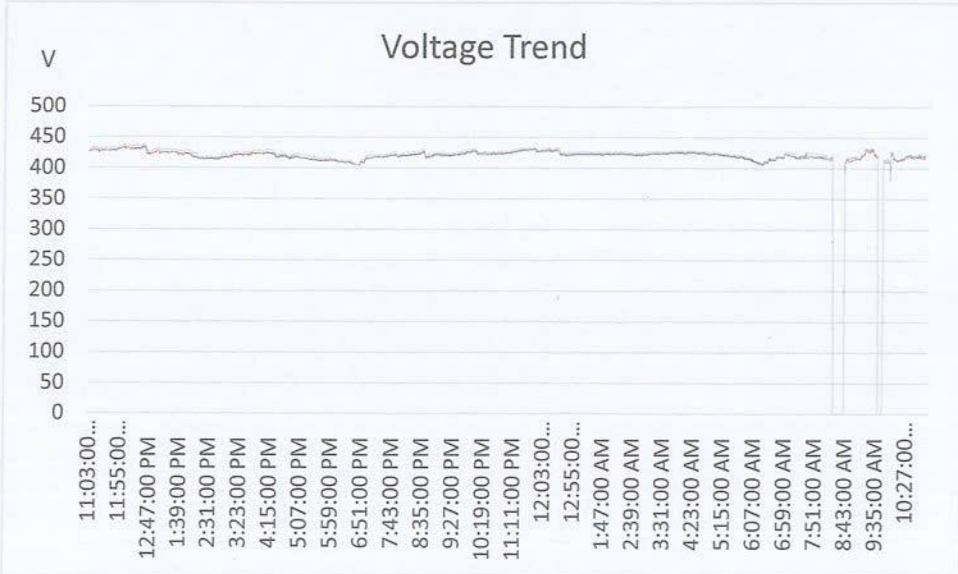


Figure1. Main Incomer Voltage Profile

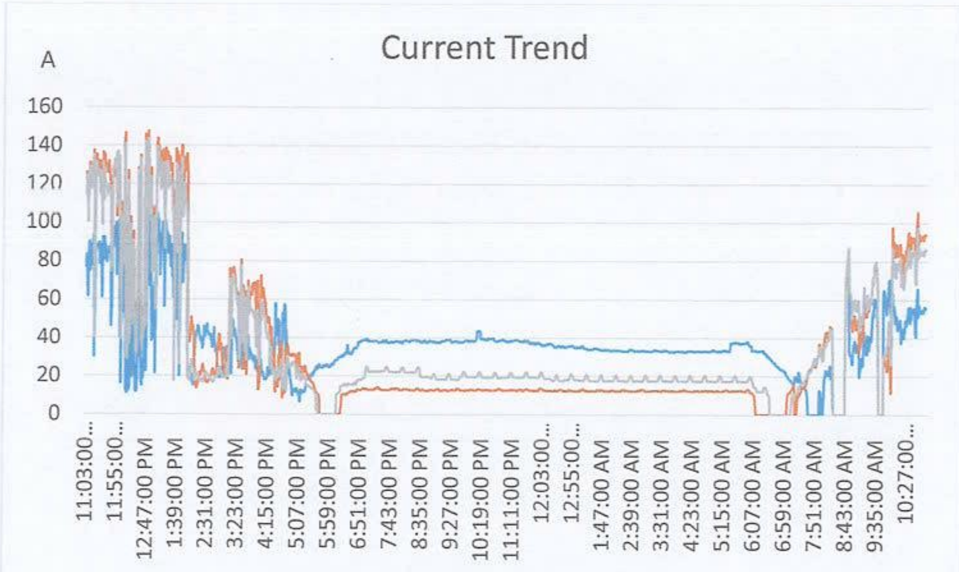


Figure2. Main Incomer Current Profile

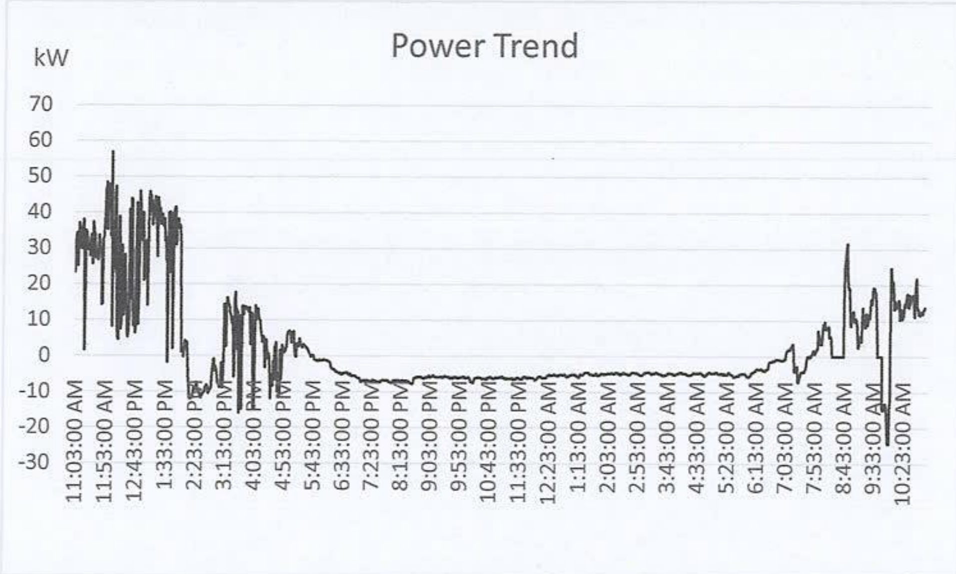


Figure3. Main Incomer Power Consumption Profile – kW

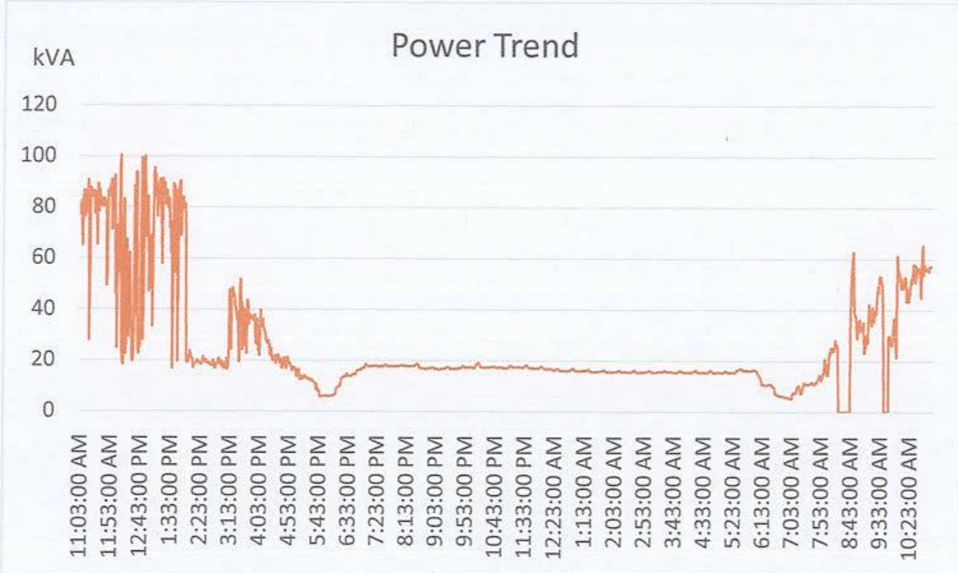


Figure 4 Main Incomer Power Consumption Profile – kVA

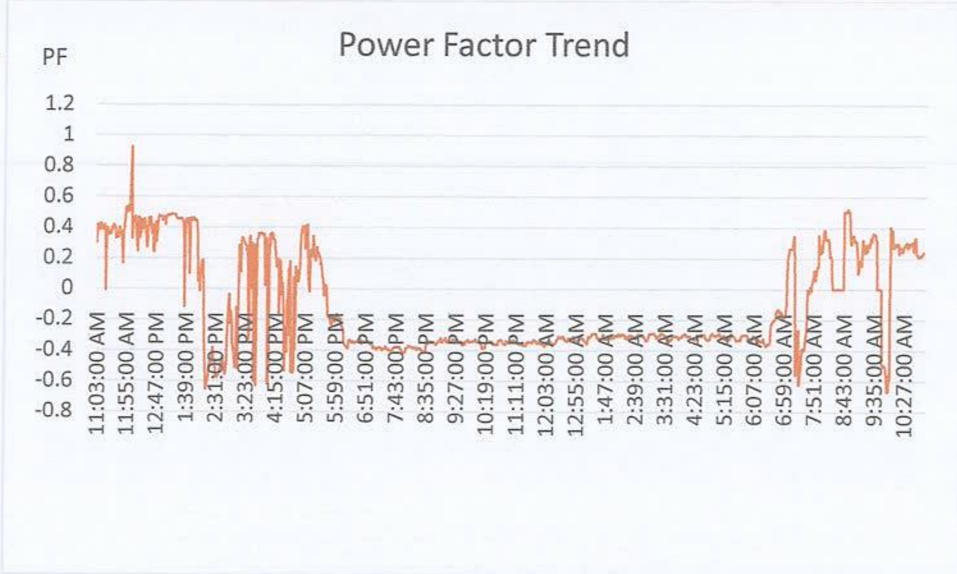


Figure5. Main Incomer Power Factor Profile

Observations:

- It is observed that negative PF occurring and the issue need to be resolved on immediate basis.

Cause:

- Negative power factor occurs when electrical power generated from the load and flows back towards the source.
- Another reason for occurring negative power factor is when in an electrical circuit both inductive and capacitive load is connected. In this case, if the reactive part of the consuming power is more capacitive than inductive.

Effects:

- Negative Power Factor causes the terminal voltage across the load to rise above its open circuit value. This may damage the voltage-sensitive load.
- Negative power factor can damage the power generating devices such as solar panels, generators, etc.

Improvement:

- As there are two reasons for the occurring negative power factor, there also two methods for improvement.
  1. If the negative power factor occurs due to power flow in the opposite direction, then it should be stopped. A PN Junction diode can be used to stop power flow in reverse direction.
  2. Another way to improve the negative power factor is, controlling reactive power. If the power factor is lagging then it is to be added to the load to compensate for the power factor. If the power factor is leading then reactive power is to be absorbed.

1.6 Harmonics Study

Harmonic of a wave is the wave which has frequency as the positive integer multiple of the frequency of the original wave, known as the fundamental frequency.

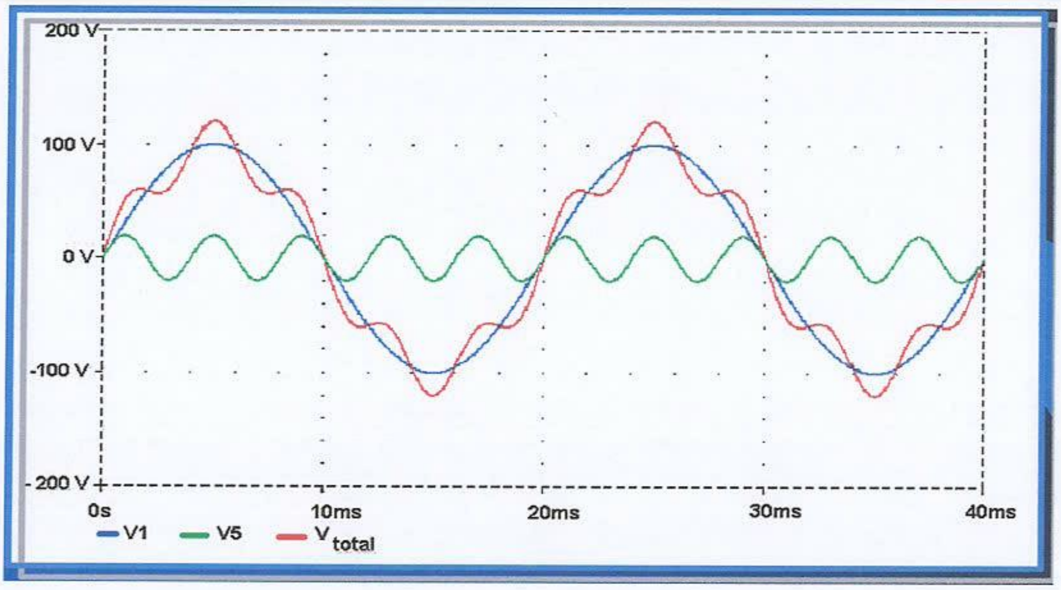
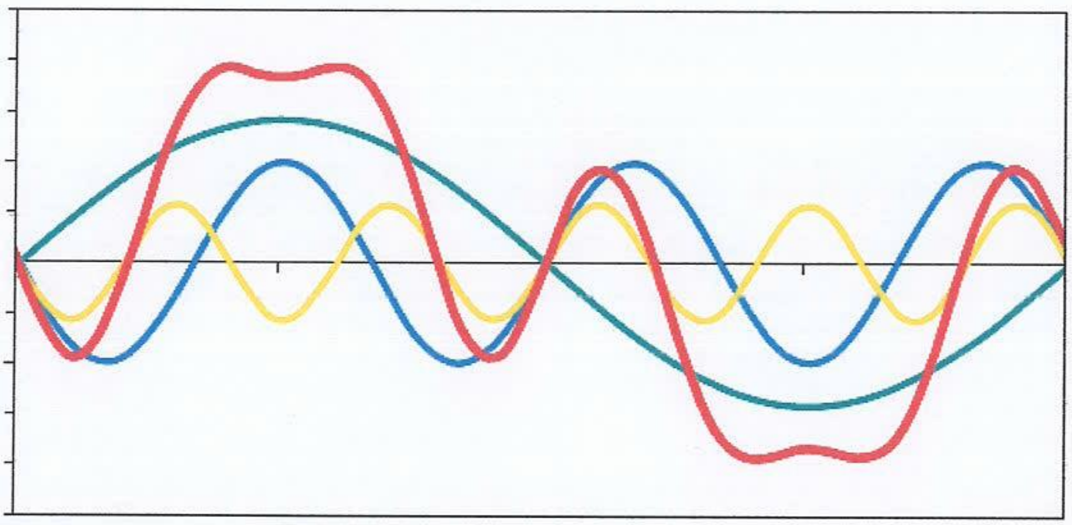


Figure6. Harmonics



V_1 –1[st] Harmonic (Fundamental wave)

V_5 –5[th] Harmonic

V_3 – 3[rd] harmonic

V total – Resultant Wave form

Figure7. Harmonics Generation

Electrical loads can be classified as linear and non-linear loads. A linear load is one, which draws a sinusoidal current when subjected to sinusoidal voltage. The current wave may or may not have a phase difference with respect to the voltage. A pure resistance, inductance or capacitance or any combination of these forms a linear load. On the contrary, a non-linear load is one, which draws non-sinusoidal or pulsating current when subjected to sinusoidal voltage.

Any non-sinusoidal current can be mathematically resolved into a series of sinusoidal components (Fourier series). The first component is called as fundamental and the remaining components whose frequencies are integral multiples of the fundamental frequency are known as harmonics. If the fundamental frequency is 50 Hz, then 2nd harmonic will have a frequency of 100Hz and the 3rd will have 150Hz and so on.

Non-linear loads that draw current in abrupt pulses rather than a smooth sinusoidal manner create harmonics. The pulses of current cause distorted current wave shape, which in turn cause harmonic currents to flow back into other parts of the power system.

1.6.1 Voltage Harmonics

Main reason for voltage harmonics is current harmonics. The voltage wave form from voltage source is distorted by the current harmonics due to source impedance. Larger the source impedance, higher will be the voltage harmonics caused by current harmonics. It is typically the case that voltage harmonics are indeed small compared to current harmonics. Thus, harmonic voltage can be defined as the product of harmonic current and source impedance at the harmonic frequency.

The source impedance includes the Impedance of the power source (Transformer, Generator, and Grid etc.), Impedance of the Bus bars, Cables, Switchgears and other loads in the network.

Following are some of the non-linear loads, which generate harmonics:

- Static power converters and rectification circuits, which are used in ups, battery chargers, etc.
- Power electronics drivers for motor controls (AC/DC) drives.
- Computers
- Television receivers
- Saturated transformers
- Fluorescent lighting
- Telecommunication equipment's

Table 2. Voltage Harmonics level at Main Incomer

Voltage Harmonics	R	Y	B
THD	4.32	3.12	3.52
3rd Level Harmonics	2.13	1.88	1.96
5th Level Harmonics	3.51	2.21	2.64
7th Level harmonics	1.07	0.90	1.02
9th Level harmonics	0.22	0.17	0.19
11th Level harmonics	0.35	0.30	0.21
13th Level harmonics	0.13	0.10	0.15

Table 3 Voltage harmonics Min, Max & Average

Harmonics Level	Min	Avg.	Max
THD	1.77	3.65	4.50
H3	0.00	1.97	2.63
H5	0.67	2.78	3.73
H7	0.40	1.00	1.53
H9	0.00	0.19	0.67
H11	0.00	0.29	1.37
H13	0.00	0.13	0.70
H15	0.00	0.04	0.27
H17	0.00	0.02	0.37

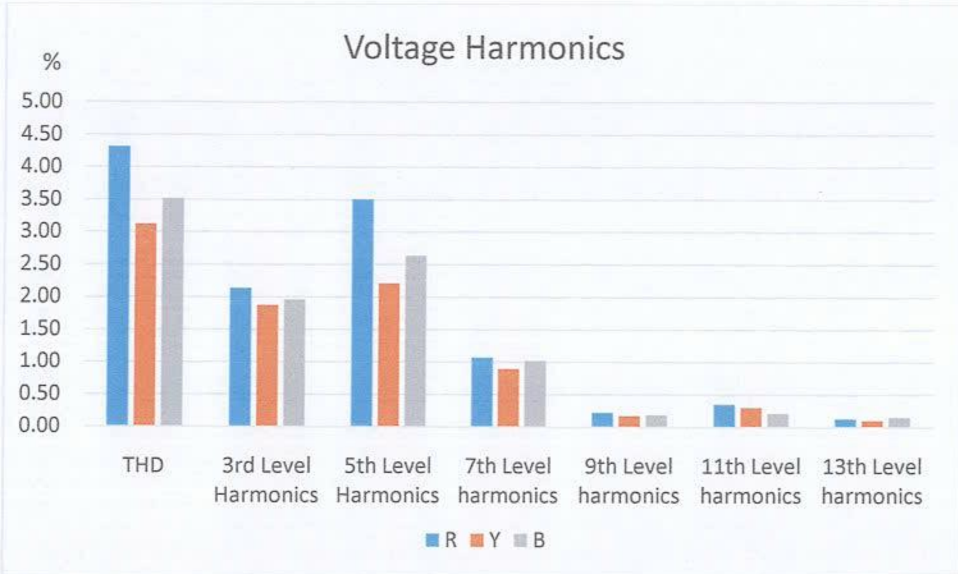


Figure8. Voltage Harmonics Profile

Observations:

- It is observed that the voltage harmonics for Main Incomer is 3.67% which is acceptable as standard value of 5% (voltage harmonics (V_{THD} %) limit as per IEEE 519:2014 standards).

1.6.2 Current Harmonics

In a normal alternating current power system, the current drawn by a linear load will be sinusoidal at the specified frequency. The current wave may or may not have a phase difference with respect to the voltage. Current harmonics are caused by non-linear loads which draw current that is not necessarily sinusoidal. The current wave form can be distorted and complex depending on the load and the interaction between other components of the system. Using Fourier series, the complex wave form can be resolved into simple sinusoidal waves of multiple frequency for analysis purpose.

Any non-sinusoidal current can be mathematically resolved into a series of sinusoidal components (Fourier series). The first component is called as fundamental and the remaining components whose frequencies are integral multiples of the fundamental frequency are known as harmonics. If the fundamental frequency is 50 Hz, then 2^{nd} harmonic will have a frequency of 100Hz and the 3^{rd}will have 150Hz and so on.

Table 4. Current Harmonics Level

Current Harmonics	R	Y	B
THD	27.04	27.29	21.10
3rd Level Harmonics	11.97	8.46	11.13
5th Level Harmonics	19.78	21.89	12.42
7th Level harmonics	7.36	6.71	6.78
9th Level harmonics	3.90	4.98	3.29
11th Level harmonics	4.52	3.98	2.97
13th Level harmonics	2.53	2.71	2.44

Table 5 Current Harmonics Min, Max & Average

Harmonics Level	Min	Avg.	Max
THD	5.83	24.97	451.53
H3	0.43	10.48	220.03
H5	2.20	17.91	297.73
H7	0.40	6.89	100.90
H9	0.00	4.01	24.77
H11	0.10	3.78	31.97
H13	0.07	2.53	27.27
H15	0.00	1.83	15.20
H17	0.07	1.76	16.50

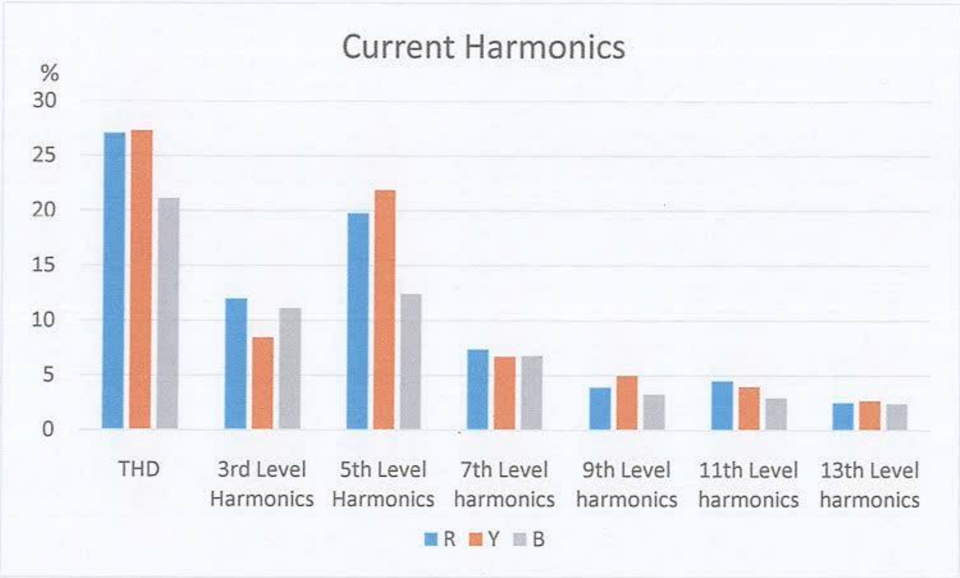


Figure 9. Current Harmonics

Observations:

- It is observed that THD is 24.97%, third level Current harmonics is10.48%andfifth level current harmonics is 17.91% which is on higher side than standard value of 8% (Current harmonics (I_{THD} %) limit as per IEEE 519:2014 standards). Harmonics mitigation needs to be considered.

1.6.3 Limits of Harmonics

IEEE recommended practices and requirements for harmonic control in electrical power system: It represents a standard level of acceptable harmonic distortion in a power system.

Table 6. Harmonics Distortion Limits: – IEEE – 519C:2014

I_{sc}	Short Circuit current at the point of common coupling (PCC), under normal operating conditions
I_L	Fundamental full load current in Amps
H	Harmonic number
11<h<17	Limits of individual current at PCC
THD	Total harmonic distortions

Table 7.Current distortion limits for systems rated 120 V to 69 kV – User's responsibility

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)						
I_{sc}/I_L	**3≤h<11**	**11≤h<17**	**17≤h<23**	**23≤h<35**	**35≤h<50**	**TDD**
<20*	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
100<1000	12.0	5.5	5.0	2.0	1.0	15
>1000	15.0	7.0	6.0	2.5	1.4	20

*All power generation equipment is limited those values regardless their I_{sc}/I_L.

- Odd harmonics are represented as % of fundamental at PCC
- Even harmonics are limited to 25% of odd harmonic's limits.

2 Performance Assessment

2.1 Pumps

One submersible pump is installed to lift water to overhead tank having capacity to hold 100 kilo Litre of water & pump operating hours per day are very less due to high capacity pumps installed compared to previous pumps. As per discussion with operating personnel pumps are operated approximately 2-3 hrs per day as the system is based on water level sensors. Performance assessment of the pump is represented in table below.

Table 8 Water Pump – PerformanceAssessment

Sr. No.	Description	Unit	Value
1	Rated Flow	m^3/h	-
2	Rated Head	m	-
3	Rated Power	kW	-
4	Measured Flow	m^3/h	25
5	Discharge Head*	m	45
6	Actual Power consumption	kW	7.66
7	Hydraulic Power	kW	3.07
8	Pump Efficiency	%	40%

**Head measurement is done at actual based on building height*

2.2 APFC Bank – Capacitor Performance

Performance assessment of the capacitors is represented below.

Table 9 Capacitor Health Check Up

Sr. No.	Capacitor Rating	R	Y	B	Remark
	kVAr	A	A	A	
1	10	14.6	21.3	15.7	Degraded
2	10	23.1	23.5	23.6	Capacitor Ok
3	10	16.8	0	16.1	Capacitor Faulty
4	10	15.9	15.6	15.1	Capacitor Faulty
5	20	31.9	31.8	31.5	Degraded
6	20	30.8	30.5	31	Degraded

As per the test conducted during audit most of the capacitors of APFC bank are degraded or faulty and thus needs repair & maintenance for improved performance and near unity PF.

3 Energy Saving Initiatives by College

Client already have installed energy efficient equipment in their premise. Most of energy efficiency improvement work has been already done by client & Client has also installed rooftop solar (PV) power plant this shows their positive approach to energy efficiency and sustainability.

Energy saving and sustainability improvement measures undertaken by college management are as follows.

1. **Replacement of Fluorescent Tube Lights (FTL) with LED Tube Lights**

College management has replaced most of FTL to LED lights and achieved nearly 50% reduction in energy consumption for lighting purpose. Thus achieved substantial savings in energy consumption and carbon emission.

2. **Installation of solar PV rooftop for renewable energy generation**

College management has installed of 200 kW solar photovoltaic power plant on rooftop of college building which will not only reduce the energy expenditure but also reduce carbon emission and this initiative shows positive approach of college management towards energy and environmental sustainability.

3. **College building designed to minimize energy required for lighting& HVAC needs**

College building design itself helps to reduce daylight needs in college building and classrooms. Windows and openings allow sufficient air ventilation thus minimises the need for HVAC systems & this ultimately leads to reduced or minimum energy demand for the premise.

Vijay Ram Ghorpade
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Date: 2023.04.20 13:03:42 +05'30'