REPORT OF ENVIRONMENTAL/GREEN AND ENERGY AUDIT

of

Paavai Engineering College

(Autonomous)

Namakkal, Tamilnadu

EXECUTED BY

DEPARTMENT OF MECHANICAL ENGINEERING
&
ELECTRICAL AND ELECTRONICS ENGINEERING

INDUSTRY- INSTITUTE PARTNERSHIP CELL

KONGU ENGINEERING COLLEGE

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APRIL 2023

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1. Executive Summary

The Industry Institute Partnership Cell of Kongu Engineering College is thankful to the Management of Paavai Engineering College for providing an opportunity to conduct Environment/Green and Energy audit in their college premises. Paavai Engineering College had agreed to provide access to Kongu Engineering College to undertake Environmental/Green and Energy Audit related measurements at their campus. This Audit has been conducted by a team of faculty members from Mechanical and Electrical Engineering Department of Kongu Engineering College. As there is no standard model for such an audit, the committee brainstormed and evolved a questionnaire. However, the standards of Indian Green Building Council (IGBC), American Society for Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) and Bureau of Energy Efficiency (BEE) are adequately considered in this study. The data was collected, compiled and was finally analysed by the audit team members. The remaining data which involved measurement using sophisticated instruments were done by the audit team members. By and large, the audit reveals a healthy environment in the campus. The committee has made short term and long-term suggestions to protect environment at higher levels and it is hoped that this will receive due attention of authorities and all stakeholders of the College.

2. About the college

Paavai Engineering College (PEC) was established in 2001 at Namakkal, Tamil Nadu, India. It is affiliated to Anna University and part of the Paavai Institutions along with Paavai College of Engineering, Paavai College of Technology. It is accredited by the National Board of Accreditation (NBA). Realizing the enormous need for engineering and technical education, Shri.N.V.Natarajan started Paavai Engineering College in the year 2001. The total strength of the students is 4007 and the strength of the employees is 432.

3. Objective of the study

The goals of the present Environmental/Green and Energy audits typically include:

- To recognize the effects of an organization on the environment.
- To suggest the best protocols for sustainable development of organization and environment.
- To assess environmental performance and the effectiveness of the measures to achieve the defined objectives and targets.
- To establish the parameters for maintaining health and welfare of the community of the
- organization.

- To set the procedure for disposal of all types of harmful wastes.
- To identify the CO_2 level in the campus.
- To reduce energy consumption.
- To minimize the consumption of water and monitor its quality.
- To give preference to the most energy efficient and environmentally sound appliances.

4. Methodology

To achieve the mentioned objectives, the audit is executed in three stages viz. pre-audit stage, audit stage and post-audit stage. Each of these stages comprises a number of clearly defined objectives, with each objective to be achieved through specific actions and these actions yielding results in the form of outputs at the end of each stage. In the pre audit stage, the questionnaire was provided to the members of Paavai Engineering College. Based on the documents provided, an audit was conducted on 15th April 2023. The documents were verified and few measurements were taken with respect to the audit. After the audit, the data were compiled and presented to the management for further actions.

5. Environmental and Green Audit

The various activities carried out in the academic institutions affects the environment in which it is situated. To address the issues, the institutions can successfully use auditing strategies to monitor their environmental-energy related activities. An "environmental audit" is a "systematic, documented, periodic and objective review to meet environmental requirements". Although environmental audits may be performed in many ways for different purposes, the reasons for performing an audit and the goals to be achieved will determine the type of environmental audit to be performed. Green audit is the tool of management system used methodologically for protection and conservation of the environment. It is also used for the sustenance of the environment. The audit suggests different standard parameters, methods and projects for environmental protection. The green audit is useful to detect and monitor sources of environment pollution and it emphasizes on management of all types of wastes, monitoring of energy consumption, monitoring of quality and quantity of water, monitoring of hazards, safety of stakeholders and even the management of disasters.

5.1 Matured Trees and Green Cover

Taking the green related concepts into consideration the college is committed to protect and to promote greenery in its campus. Almost all the buildings are having trees in the adjacent areas. This reduces the heat island effects and provides good supply of oxygen.

Fig.1. Trees located near the building provides adequate shading

Even the roof areas of the buildings are having plants. This minimises the amount of radiation entering through the building roof. Green Awareness programmes are conducted periodically in the campus for the staffs and students to keep the campus green forever thereby enhancing the beauty of the campus. Paavai Engineering College is making continuous efforts to protect, raise awareness and improve the quality of the environment.

The college is taking the maximum efforts to reduce any adverse effects on environment arising out of the functioning of the college activities. The level of CO_2 can be reduced by growing more trees. A total of 452 matured trees are found inside the campus. The students of agricultural department involve in the agriculture activities also for which separate land is also allocated.

Fig.2. Roof top used for growing plants

Fig.3. Pedestrian walkway with tree shade and land allocated for agricultural activities

5.2 Indoor air quality

Indoor air quality (IAQ) refers to the quality of the air inside buildings as represented by concentrations of pollutants and thermal (temperature and relative humidity) conditions that affect the health and performance of occupants. It has become one of the most important issues of environment and health worldwide considering the principle of human rights to health that everyone has the right to breathe healthy indoor air.

Discomfort can be caused to the occupants due to

- Inadequate ventilation
- High temperature and humidity levels
- High levels of CO_2

Ventilation should be distributed effectively in spaces, and stagnant air zones should be avoided. ASHRAE recommends relative humidity levels between 30 and 60 percent for optimum comfort. Higher humidity may result in microbial growth. A consistently implemented good-housekeeping plan is essential to eliminate or reduce the microbial growth in the building. Damp indoor environments have been associated with many serious health effects, including asthma, hypersensitivity, and sinusitis. Moisture incursion leading to dampness can result from water leaks and/or by condensation

due to high humidity. Common sources of moisture in buildings include: plumbing; roof and window leaks; flooding; condensation on cold surfaces, e.g., pipe sweating; poorly-maintained drain pans; and wet foundations due to landscaping or gutters that direct water into or under the building. It is a product of completed carbon combustion and the by-product of biological respiration. ASHRAE states that CO_2 concentrations in acceptable outdoor air typically range from 300-700 ppm. Adverse health effects from CO_2 may occur since it is an asphyxiate gas. The CO_2 levels can be used as a rough indicator of the effectiveness of ventilation, and excessive population density in a structure. CO_2 increases in buildings with higher occupant densities, and is diluted and removed from buildings based on outdoor air ventilation rates. Therefore, examining levels of CO_2 in indoor air can reveal information regarding occupant densities and outdoor air ventilation rates. High CO_2 levels may indicate a problem with overcrowding or inadequate outdoor air ventilation rates.CO_2, a by-product of normal cell function, is removed from the body via the lungs in the exhaled air. Exposure to high levels of CO_2 can increase the amount of this gas in the blood, which is referred to as *hypercapnia* or *hypercarbia*. As the severity of hypercapnia increases, more symptoms ranging from headache to unconsciousness appear, and it can also lead to death. Exhaust fans are installed in toilets to remove the unpleasant air in the restrooms.

Fig.4. Exhaust fan located in the toilets

The traditional means of dealing with IAQ is through ventilation with outdoor air, but this approach assumes that the outdoor air is cleaner than the indoor air. In many locations and for many contaminants, this is not the case, and insufficiently treated ventilation air can actually make IAQ

worse. Poor outdoor air quality includes regionally elevated outdoor contaminant levels, as well as local sources such as motor vehicle exhaust from nearby roadways and contaminants generated by activities in adjacent buildings. Some green building programs recommend across-the-board increases in ventilation rates, but such recommendations may be counterproductive in areas with poor outdoor air quality unless accompanied by appropriate and effective increases in filtration and air cleaning.

5.3 Air Quality Measurements

With the help of Indoor Air Quality meter (Extech EA80), CO_2 level, relative humidity, dry bulb and wet bulb temperatures can be measured. The measurements are carried out based on the protocol given by Central Pollution Control Board, Ministry of Environment and Forests, Govt. of India. Indoor air quality test was carried out at different locations of the institution. Carbondioxide levels are within the ASHRAE 55-1992 limit in the outdoor and indoor. The instrument used in the present audit was Extech Make EA80 Model of Indoor air quality meter. The range of the instrument is given below

- CO_2 range : 0 to 6,000ppm
- Temperature range : -4 to 140°F (-20 to 60°C)
- Humidity range : 10 to 95%RH

Fig.5. Indoor air quality meter

Standard Level of CO_2	**ASHRAE and OSHA standards: 1000 ppm**
Standard Level of Relative Humidity	**30 – 60 % ±2% (ASHRAE 55)**
Standard Level of Temperature	**26 - 30°C ±3°C (ASHRAE, NBC)**

S.No	Location	CO_2 (ppm)	Relative Humidity (%)	Dry Bulb Temperature (^oC)	Comments & Recommendation
Temple tower-Ground floor					
1	Chemistry lab	506	55.2	31.6	Within the limits
2	DC Machines Lab	466	57	31	Within the limits
3	Exam cell	465	55.6	31.3	Within the limits
4	Dynamics Lab	550	56.7	31.6	Within the limits
5	Thermal lab	487	59.1	31.2	Within the limits
6	Strength of materials Lab	506	57.5	32	Within the limits
7	Verandah	454	52	32.3	Within the limits
8	AV studio	881	44.6	33.2	Within the limits
Temple tower-First floor					
9	IV year Civil class room	472	56.2	31.5	Within the limits
10	Computer lab	641	60	31.9	Within the limits
11	Verandah	478	55.3	31.7	Within the limits
12	Lecture hall	468	54.7	31.2	Within the limits
Temple tower-Second floor					
13	Stairs	534	56.5	31.2	Within the limits
14	Hall T307	453	55.5	31.2	Within the limits
15	Hall T311	456	56.3	31.2	Within the limits
Temple tower-Third floor					
16	Verandah	449	54.8	32.4	Within the limits
17	Hall T415	468	63.5	31.5	Within the limits
Main Block – Ground floor					
18	Verandah	573	54.9	33.6	Within the limits
Main Block – First Floor					
19	Verandah	443	54.6	31.1	Within the limits
20	Smart classroom	454	53.4	32.9	Within the limits
21	Class Room	463	54.4	32.9	Within the limits
22	Library	450	55.5	31.7	Within the limits
Main Block – Second Floor					
23	CSE staff cabin	493	54.8	32	Within the limits
24	Verandah	474	55	32.6	Within the limits
25	Lecture hall T316	417	52.6	32.9	Within the limits
Main Block – Third Floor					
26	Verandah	438	54.2	32.4	Within the limits
27	Central Library entrance	417	52.6	32.4	Within the limits

28	Central Library - book shelf	413	52.8	32.8	Within the limits
Additional Block – Ground floor					
29	Verandah	476	46.4	32	Within the limits

5.4 Inference from air quality measurements

- Carbon-di-oxide levels are within the ASHRAE 55-1992 limit in the outdoor and indoor. For indoor condition, CO_2 level should be less than 1000 ppm. CO_2 levels are well within the limits in all places.
- In Computer Centres, the temperature settings of the air conditioners may be adjusted according to the student's occupancy. This will bring better comfort inside the room.
- ASHRAE recommends relative humidity levels between 30 and 60 percent for optimum comfort. The humidity is within the limit in most of the places. The buildings are well planned and natural circulation of air is felt in all places. Even classrooms filled with nearly 50 students have good range of humidity.
- During the occupancy, the windows may be kept open and natural circulation of air may bring the humidity level below 70%.
- The ambient temperature in the campus varied between 31 ^{o}C to 33.6 ^{o}C.
- Tree plantation is highly promoted.
- Awareness programmes on environmental consciousness are organized.

5.5 Water Management

The five bore-wells inside the campus cater the total requirement of the college through water tanks of different capacities. Water is collected in separate wells and then pumped to different tanks. The College has a RO plant to cater the drinking water needs. Recharging of ground water and rainwater harvesting are implemented by the college thereby conserving the water from its inception and practice vigorously. These technologies, where surface runoff is effectively collected during yielding rain periods. It has been very helpful to augment the ground water. The college does not depend upon or buy public water supply from outside the campus. Students and faculty members of the institution are oriented by different programmes about water conservation.

Fig.6. Rain water harvesting pond

The rain water harvesting pond – Amirthavarshini, collects every drop of rain water in the campus into the 100 x 80 Feet pond, thereby replenishing the ground water. Amirthavarshini has helped recharge the ground water in the Pachal area, thereby reducing water scarcity in the area and also reducing the salt content in the water.

5.6 Waste Water treatment

The waste water generated in the campus is treated in a separate treatment plant within the campus premises.

Fig.7. Water treatment plant

The total quantity of waste water treated is 4,50,000 lpd. All the treated water is used for gardening purposes. Treat waste water generated on-site avoids polluting the local water bodies and also reduces the dependence on potable water.

5.7 Fuel usage

The management has taken many measures to encourage the reduction of diesel/petrol consumption. Throughout the campus pedestrian walkways are provided for easy movement of persons. For short distance commuting, walking is being preferred by all within the campus. This promotes physical activity and health. College buses and vehicles consume around 90000 litres of diesel per year. Fuel management software are used to effectively monitor the consumption rate.

Cooking is mostly carried by the use of LPG cylinders. Each year nearly 120 number of LPG cylinders are used in the mess/canteen. Apart from this, the waste (biomass) generated in the campus is also used as a fuel for cooking. This minimises the wastes going to the landfill.

5.8 Waste management

The campus is cleaned on daily basis. Waste bins are placed in corridors, office and staff rooms. The waste generated in the campus includes wrappers, glass, metals, paper, etc. Old newspapers, used papers and journal files, workshop scrap etc. are given for recycling to external agencies. Glass, metals and other non-biodegradable wastes are given to external agencies where they are segregated and disposed/ recycled according to the nature of the waste. Non-biodegradable and plastic wastes are disposed by municipal collection centre. Leaf litter is allowed to decompose systematically over a period of time and is used as manure for the gardens in the institute. Electronic goods are put to optimum use; the minor repairs are set right by the Laboratory assistants and teaching staff; and the major repairs are handled by the Technical Assistant and are reused. UPS Batteries are recharged / repaired / exchanged by the suppliers. The waste compact discs and other disposable non-hazardous items are used by students for decoration during college fests as a creative means of showcasing the waste management practice that has been induced in the minds of the students.

6 Electrical Energy Audit

The Management of Paavai Engineering College, Namakkal had agreed to provide access to Kongu Engineering College to undertake Energy Audit related measurements at the College PCC location and optionally at other down-stream feeders as required. During that day, Electrical parameters were recorded by the Audit team using their 3 Phase Power Analyser Instrument Fluke 435 at various location of the institution as detailed below. The recording of the various parameters were carried out on a continuous basis with a sample time of 10sec for a period 5 to 10 minutes and maximum of 30 minutes depending upon the load variations observed. The following parameters were recorded.

(a) average of 3 phase voltages

(b) average of 3 phase RMS currents and the average fundamental currents

(c) frequency

(d) various powers: active, reactive and apparent

(e) power factor

(f) percentage voltage THD

(g) percentage current THD

(h) various energy: active, reactive and apparent

(i) Unbalance in voltage and current

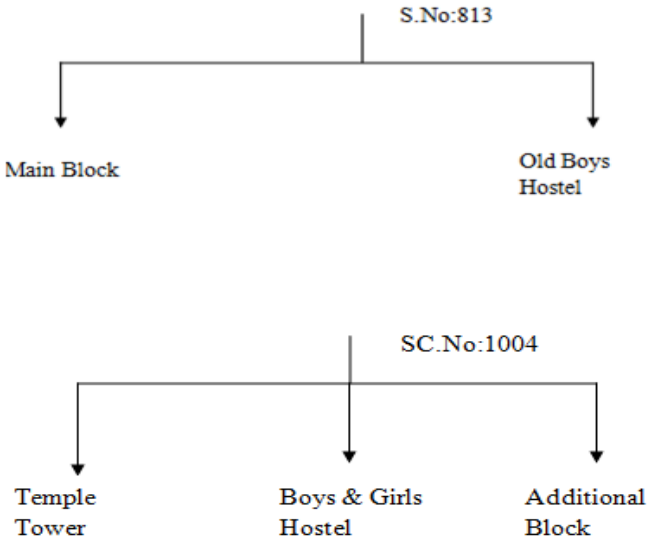

Fig.8. Electrical line diagram

6.1 Electric Energy Consumption Survey

The electrical energy audit is aimed at obtaining a detailed idea about the various end use energy consumption activities and identification, enumerating and evaluating the possible energy saving opportunities. The present level of energy consumption of the institution has been analyzed, averaged by collecting utility bills from the Paavai Engineering College for the tenure of audit from for April 2022 to March 2023. The table depicted below shoes the consumption as read from the 2 energy meters. The annual energy consumption for the campus is units.

To get a clear overview of the consumption, the previous year bills were also compared.

Month-Year	Consumption units	
	S.813	S.1004
Apr-22	11820	8632
May-22	14350	6568
Jun-22	21035	6197
Jul-22	14708	2828
Aug-22	14850	2296
Sep-22	17594	2389
Oct-22	14889	4542
Nov-22	14898	1656
Dec-22	15092	735
Jan-23	10889	1894
Feb-23	13262	4469
Mar-23	17958	9964

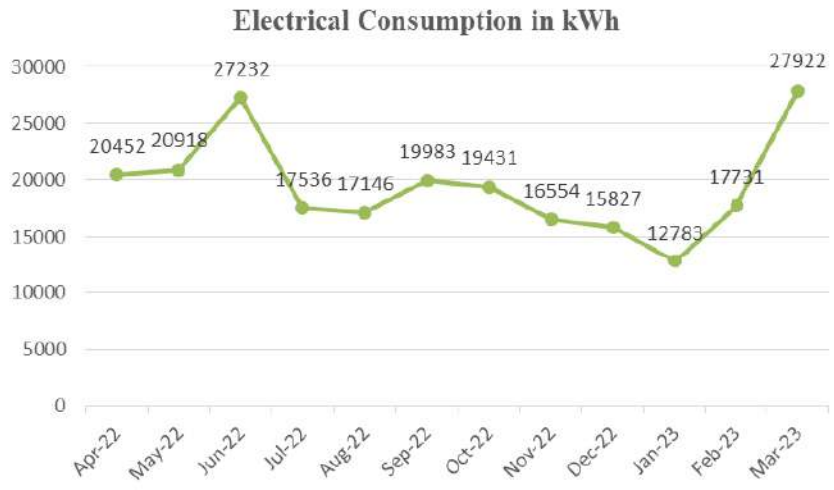

Fig.9. Electric Energy Consumption details in units

6.2 Electrical loads in campus

The details of the various electrical equipments available in the Institution such as Fan, Light, UPS and AC are given below.

Table.1 Connected Equipment Details

SL No.	Equipment	specification	Power Rating	**Main Block**	**Temple Tower**	**Additional Block**	**Total**
				Qty	Qty	Qty	Qty
1	Fan	Conventional	60 W	448	772	380	1600
2	Light	Fluorescent	40W	584	924	492	2000
		LED	12W	12			12
		LED (Street light)	40 W	40			40
		street light - Metal Halide	200W	10			10
3	Computer		100W	552	438	110	1100
4	AC		2 ton	100			100
5	Printers						67
6	Projectors						30
7	Bore well motors	Motors	10HP				1
			5HP				2
			7.5HP				1

6.3 Power distribution among feeders

The major aim of the measurement exercise is to identify the energy consumption and unbalance in load current at each place. From these observations the actual power consumed during measurement at each feeder is given in the following table.

Table.2. Feeder wise measured load details

S.NO	LOCATION	CURRENT(A)	POWER(kW)	%UNBALANCE IN CURRENT
1	Incomer	57.60	39.11	4.42
2	Main Block	53.57	36.72	7.49
3	Hostel	12.7	8.53	32.76
4	Temple Tower	48.13	31.51	14.71

The major loads are Computers, AC, Lights and Fan. From the above table it was observed that there was an unbalance in loads. It can been inferred that the main block connected loads consume about 81% of total power, hostel connected loads consuming about 19% of total power.

6.4. Recorded data at Incomer

Phase Voltage (L1,L2,L3) Avg V	Line Current (L1,L2,L3) Avg A	Phase Voltage (L1,L2,L3) Fundamental Avg V	Line Current (L1,L2,L3) Fundamental Avg A	%-age Voltage Un balance	%-age Current Un balance	Frequency In Hz	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	DPF	TPF	THD V Avg % age	THD A Avg % age
229.15	50.67	229.13	50.20	0.71	1.42	50.05	33.40	8.61	34.49	0.97	0.96	1.79	13.29
228.91	50.97	228.87	50.47	0.69	1.56	50.04	33.59	8.60	34.67	0.97	0.96	1.79	13.20
228.73	49.63	228.67	49.13	0.65	2.29	50.04	32.76	7.64	33.67	0.97	0.96	1.82	13.76
228.62	47.77	228.57	47.20	0.69	4.42	50.03	31.76	6.27	32.37	0.98	0.97	1.82	14.71
228.67	48.23	228.63	47.67	0.71	4.93	50.02	31.83	7.19	32.64	0.98	0.96	1.80	14.62
228.89	48.63	228.83	48.07	0.73	4.92	50.00	32.09	7.72	33.01	0.97	0.96	1.77	14.39
228.81	48.57	228.77	48.07	0.73	5.14	49.99	32.05	7.67	32.96	0.97	0.96	1.78	14.47
229.17	48.80	229.13	48.27	0.73	5.81	49.97	32.23	7.75	33.15	0.97	0.96	1.76	14.42
228.57	49.70	228.53	49.13	0.75	7.35	49.98	32.77	7.79	33.69	0.97	0.96	1.79	14.31
228.43	47.77	228.40	47.27	0.73	5.68	50.00	31.48	7.21	32.31	0.97	0.96	1.78	14.70
228.36	45.50	228.33	44.87	0.72	4.58	49.99	30.12	6.15	30.75	0.98	0.97	1.80	15.79
227.85	49.43	227.87	49.00	0.72	4.93	49.98	32.43	7.60	33.32	0.97	0.96	1.78	14.41
227.46	52.80	227.40	52.33	0.75	4.46	49.98	34.53	8.95	35.68	0.97	0.96	1.80	13.32
227.37	52.63	227.33	52.13	0.76	3.22	49.99	34.39	8.96	35.55	0.97	0.96	1.80	13.25
227.34	52.47	227.27	51.87	0.76	3.08	49.99	34.24	8.97	35.41	0.97	0.96	1.81	13.21
227.54	52.83	227.50	52.40	0.76	3.37	49.99	34.56	9.03	35.73	0.97	0.96	1.82	13.26
227.96	52.97	227.90	52.47	0.78	4.03	49.97	34.68	9.09	35.87	0.97	0.96	1.80	13.19
228.12	53.07	228.10	52.53	0.77	4.03	49.97	34.77	9.16	35.97	0.97	0.96	1.79	13.12
228.60	47.33	228.53	46.87	0.77	4.48	49.97	31.31	6.80	32.05	0.98	0.96	1.80	14.68
228.62	47.23	228.60	46.67	0.75	4.44	49.98	31.20	6.92	31.96	0.98	0.96	1.81	14.82
228.11	49.53	228.07	49.00	0.77	3.74	49.99	32.60	7.85	33.53	0.97	0.96	1.84	13.97
227.93	49.80	227.90	49.33	0.79	4.39	50.01	32.75	7.84	33.68	0.97	0.96	1.84	13.97
227.88	50.57	227.83	50.00	0.77	4.05	50.01	33.27	7.79	34.17	0.97	0.96	1.83	13.66
228.13	50.53	228.10	50.07	0.75	4.45	50.00	33.33	7.68	34.21	0.97	0.96	1.82	13.58

228.31	50.03	228.27	49.53	0.76	4.68	50.02	33.04	7.59	33.91	0.97	0.96	1.81	13.71
228.87	49.90	228.80	49.40	0.78	5.01	50.03	32.99	7.51	33.84	0.98	0.96	1.78	13.72
228.90	47.23	228.90	46.73	0.77	5.41	50.02	31.43	6.32	32.05	0.98	0.97	1.80	14.53
228.39	52.67	228.40	52.27	0.78	4.72	50.02	34.67	8.23	35.64	0.97	0.96	1.80	13.23
228.47	53.57	228.43	53.13	0.78	4.03	50.03	35.28	8.87	36.39	0.97	0.96	1.81	12.75
228.61	52.33	228.57	51.87	0.79	4.63	50.07	34.47	8.52	35.52	0.97	0.96	1.84	13.18
228.64	50.97	228.57	50.40	0.74	3.45	50.07	33.72	7.72	34.60	0.97	0.96	1.85	13.71
229.07	50.87	229.03	50.33	0.76	3.78	50.07	33.72	7.77	34.61	0.97	0.96	1.85	13.39
228.93	50.23	228.90	49.80	0.76	3.12	50.06	33.29	7.65	34.16	0.97	0.96	1.85	13.55
228.64	53.27	228.63	52.80	0.78	3.53	50.06	35.16	8.61	36.20	0.97	0.96	1.83	12.85
228.55	53.57	228.53	53.13	0.79	3.51	50.05	35.28	8.95	36.40	0.97	0.96	1.81	12.69
228.88	49.53	228.77	49.00	0.80	4.81	50.04	32.67	7.55	33.53	0.97	0.96	1.82	13.82
229.52	43.30	229.47	42.73	0.79	6.42	50.05	28.93	5.24	29.41	0.98	0.97	1.83	15.97
228.97	48.00	228.97	47.53	0.79	5.34	50.05	31.73	7.13	32.53	0.98	0.96	1.82	14.36
228.70	49.20	228.67	48.73	0.79	4.98	50.03	32.48	7.76	33.40	0.97	0.96	1.80	13.76
228.43	51.27	228.40	50.73	0.80	4.98	50.04	33.73	8.33	34.75	0.97	0.96	1.81	13.34
228.40	52.70	228.37	52.20	0.80	4.61	50.05	34.65	8.85	35.77	0.97	0.96	1.80	12.87
228.49	53.37	228.43	52.87	0.80	5.02	50.05	35.15	8.89	36.27	0.97	0.96	1.79	12.63
228.64	51.17	228.60	50.73	0.79	5.08	50.05	33.77	8.08	34.73	0.97	0.96	1.80	13.17
228.25	49.87	228.23	49.40	0.80	5.68	50.04	32.92	7.59	33.79	0.97	0.96	1.82	13.57
228.27	48.53	228.20	48.07	0.81	5.43	50.02	32.05	7.00	32.81	0.98	0.97	1.83	13.92
228.53	46.97	228.50	46.47	0.80	5.88	50.02	31.21	6.28	31.84	0.98	0.97	1.83	14.40
227.84	55.93	227.83	55.47	0.79	4.68	50.03	36.59	9.40	37.80	0.97	0.96	1.80	12.27
228.20	57.60	228.13	57.13	0.80	4.42	50.02	37.77	10.11	39.11	0.97	0.96	1.77	11.73
228.77	53.37	228.73	52.93	0.80	4.83	50.02	35.15	8.99	36.29	0.97	0.96	1.76	12.57

6.5. Recorded Data at Main Block

Phase Voltage (L1,L2,L3) Avg V	Line Current (L1,L2,L3) Avg A	Phase Voltage (L1,L2,L3) Fundamental Avg V	Line Current (L1,L2,L3) Fundamental Avg A	%-age Voltage Un balance	%-age Current Un balance	Frequency In Hz	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	DPF	TPF	THD V Avg % age	THD A Avg % age
230.97	32.33	230.90	31.60	0.74	5.57	50.03	21.79	2.04	21.89	1.00	0.97	1.81	20.50
231.01	31.97	230.97	31.27	0.73	6.57	50.03	21.51	2.09	21.61	0.99	0.97	1.81	20.60
230.93	33.10	230.87	32.27	0.69	6.98	50.03	22.19	2.37	22.33	0.99	0.97	1.85	21.18
230.66	37.37	230.73	36.73	0.70	6.43	50.04	24.73	4.08	25.12	0.99	0.97	1.81	19.10
229.65	52.50	229.67	52.07	0.71	3.65	50.04	34.56	9.51	35.85	0.96	0.96	1.76	12.71
229.56	51.33	229.57	50.87	0.71	3.80	50.04	33.76	9.35	35.04	0.96	0.95	1.76	12.56
229.34	50.93	229.30	50.47	0.68	3.71	50.03	33.44	9.29	34.71	0.96	0.95	1.75	12.73
229.14	50.50	229.10	50.00	0.67	3.92	50.03	33.12	9.25	34.40	0.96	0.95	1.75	12.82
229.26	50.67	229.20	50.20	0.67	3.92	50.02	33.24	9.28	34.52	0.96	0.95	1.76	12.76
229.37	50.67	229.30	50.20	0.68	4.08	50.02	33.27	9.31	34.55	0.96	0.95	1.77	12.77
229.58	50.30	229.53	49.93	0.67	4.29	50.03	33.07	9.28	34.35	0.96	0.95	1.75	12.76
229.53	50.13	229.50	49.60	0.67	4.72	50.04	32.91	9.21	34.19	0.96	0.95	1.75	12.83
229.44	51.30	229.37	50.93	0.63	5.74	50.04	33.81	9.15	35.03	0.97	0.96	1.76	12.50
229.35	51.63	229.33	51.27	0.62	6.09	50.05	34.04	9.12	35.25	0.97	0.96	1.76	12.39
229.42	51.43	229.37	51.00	0.62	5.96	50.05	33.88	9.13	35.09	0.97	0.96	1.75	12.49
229.44	51.17	229.43	50.73	0.63	5.88	50.05	33.67	9.16	34.89	0.96	0.96	1.75	12.68
229.48	51.10	229.43	50.67	0.63	5.86	50.04	33.65	9.19	34.88	0.96	0.96	1.75	12.73
229.47	51.70	229.43	51.27	0.60	6.57	50.03	34.03	9.23	35.25	0.97	0.96	1.79	13.18
229.44	51.53	229.37	51.07	0.60	5.48	50.04	33.92	9.28	35.16	0.96	0.96	1.76	12.69
229.32	51.97	229.33	51.53	0.58	6.10	50.04	34.16	9.48	35.45	0.96	0.96	1.74	12.45
229.36	51.97	229.30	51.53	0.59	6.18	50.05	34.15	9.55	35.45	0.96	0.95	1.73	12.40

229.39	52.07	229.37	51.60	0.59	6.31	50.05	34.21	9.55	35.52	0.96	0.95	1.73	12.48
229.55	52.23	229.50	51.73	0.59	5.80	50.04	34.36	9.53	35.65	0.96	0.95	1.72	12.45
229.76	50.87	229.70	50.40	0.64	4.39	50.05	33.39	9.60	34.75	0.96	0.95	1.72	12.62
229.82	50.53	229.80	50.00	0.65	4.54	50.05	33.11	9.64	34.49	0.96	0.95	1.74	12.82
229.86	50.53	229.80	50.07	0.64	4.31	50.06	33.15	9.63	34.53	0.96	0.95	1.74	12.76
230.14	50.33	230.07	49.87	0.63	4.24	50.06	33.05	9.64	34.44	0.96	0.95	1.73	12.78
230.33	50.37	230.27	49.87	0.63	4.13	50.07	33.09	9.67	34.49	0.96	0.95	1.73	12.82
230.30	50.43	230.27	50.00	0.63	3.79	50.07	33.15	9.69	34.55	0.96	0.95	1.73	12.75
230.25	50.77	230.20	50.27	0.63	3.79	50.08	33.35	9.63	34.72	0.96	0.95	1.74	12.91
230.18	51.03	230.17	50.47	0.63	4.37	50.08	33.53	9.59	34.89	0.96	0.95	1.77	13.37
230.14	50.33	230.13	49.87	0.63	4.31	50.09	33.07	9.56	34.43	0.96	0.95	1.76	12.89
230.01	50.43	229.97	50.00	0.64	4.25	50.08	33.12	9.63	34.49	0.96	0.95	1.75	12.72
230.09	50.60	230.03	50.13	0.65	3.64	50.08	33.20	9.68	34.60	0.96	0.95	1.74	12.69
230.24	51.53	230.17	51.07	0.62	5.19	50.07	33.93	9.67	35.28	0.96	0.95	1.74	12.50
230.24	52.00	230.23	51.53	0.64	4.97	50.08	34.27	9.65	35.60	0.96	0.95	1.74	12.42
230.33	52.20	230.27	51.80	0.63	4.89	50.10	34.40	9.76	35.76	0.96	0.95	1.74	12.35
230.49	52.50	230.43	52.00	0.61	5.59	50.09	34.63	9.81	36.00	0.96	0.95	1.79	12.81
230.43	52.17	230.43	51.73	0.62	4.99	50.08	34.41	9.79	35.77	0.96	0.95	1.75	12.42
230.43	52.03	230.37	51.60	0.62	4.87	50.07	34.28	9.79	35.65	0.96	0.95	1.74	12.39
230.23	52.33	230.17	51.87	0.61	5.21	50.07	34.47	9.77	35.83	0.96	0.95	1.76	12.58
230.37	53.40	230.33	52.87	0.59	6.54	50.07	35.25	9.72	36.56	0.96	0.96	1.80	12.73
230.47	53.57	230.40	53.13	0.58	7.49	50.08	35.40	9.75	36.72	0.96	0.96	1.78	12.44
230.49	53.27	230.47	52.80	0.58	7.35	50.09	35.20	9.73	36.52	0.96	0.96	1.77	12.40
230.44	53.07	230.37	52.60	0.57	6.96	50.10	35.08	9.72	36.40	0.96	0.96	1.75	12.13
230.47	53.17	230.43	52.73	0.57	6.92	50.09	35.15	9.72	36.47	0.96	0.96	1.76	12.12
230.45	53.17	230.43	52.73	0.59	6.78	50.09	35.12	9.76	36.45	0.96	0.95	1.78	12.49

230.61	51.87	230.57	51.40	0.62	5.23	50.09	34.23	9.73	35.59	0.96	0.95	1.76	12.44
230.66	50.37	230.63	49.93	0.67	3.55	50.09	33.16	9.64	34.55	0.96	0.95	1.77	12.69
230.70	50.07	230.63	49.67	0.69	2.94	50.08	32.99	9.51	34.33	0.96	0.95	1.78	12.84
230.87	50.10	230.80	49.60	0.70	3.00	50.09	33.01	9.52	34.37	0.96	0.95	1.79	12.86
230.92	50.03	230.87	49.60	0.69	3.10	50.09	33.00	9.53	34.35	0.96	0.95	1.78	12.92
230.96	50.07	230.90	49.60	0.69	3.04	50.09	33.01	9.55	34.36	0.96	0.95	1.79	12.92
230.82	50.17	230.80	49.67	0.69	3.10	50.09	33.05	9.52	34.41	0.96	0.95	1.79	12.91
230.78	50.10	230.77	49.67	0.69	3.02	50.08	33.03	9.52	34.37	0.96	0.95	1.77	12.92
230.65	49.97	230.63	49.47	0.69	3.34	50.08	32.89	9.49	34.24	0.96	0.95	1.77	13.03
230.59	49.97	230.53	49.47	0.69	3.72	50.08	32.89	9.47	34.23	0.96	0.95	1.76	12.96
230.59	49.93	230.53	49.47	0.69	3.76	50.09	32.85	9.47	34.20	0.96	0.95	1.78	13.22
230.51	50.53	230.47	50.00	0.67	4.10	50.09	33.21	9.48	34.55	0.96	0.95	1.82	13.89
230.46	50.13	230.43	49.67	0.69	2.91	50.09	32.99	9.47	34.32	0.96	0.95	1.78	13.33
230.42	50.07	230.33	49.60	0.70	2.35	50.08	32.93	9.52	34.28	0.96	0.95	1.76	12.95
230.72	45.57	230.63	45.07	0.68	2.88	50.08	30.16	7.64	31.12	0.97	0.96	1.79	14.06
230.89	43.77	230.83	43.20	0.68	3.14	50.07	29.13	6.89	29.95	0.97	0.96	1.80	15.02
230.70	43.93	230.67	43.33	0.68	3.29	50.07	29.21	6.88	30.01	0.97	0.96	1.83	15.46
230.87	43.83	230.83	43.27	0.69	2.50	50.06	29.19	6.88	29.99	0.97	0.96	1.80	14.94
230.64	43.63	230.63	43.07	0.69	3.19	50.05	29.00	6.88	29.81	0.97	0.96	1.80	14.85
230.41	47.87	230.43	47.40	0.71	2.08	50.04	31.51	8.47	32.63	0.97	0.95	1.78	13.88
230.02	50.67	230.00	50.27	0.72	1.76	50.04	33.33	9.52	34.67	0.96	0.95	1.76	12.68
229.88	50.27	229.83	49.87	0.74	1.75	50.04	33.01	9.48	34.36	0.96	0.95	1.77	12.78
229.90	50.53	229.83	50.07	0.74	1.79	50.03	33.21	9.47	34.53	0.96	0.95	1.77	12.82
229.88	50.67	229.83	50.27	0.74	1.82	50.03	33.33	9.44	34.65	0.96	0.95	1.77	12.85
229.92	50.00	229.87	49.60	0.73	2.29	50.03	32.85	9.39	34.17	0.96	0.95	1.76	12.94
229.85	49.93	229.80	49.40	0.70	2.34	50.04	32.79	9.36	34.11	0.96	0.95	1.75	12.93

229.78	50.50	229.73	50.00	0.70	2.52	50.03	33.16	9.37	34.45	0.96	0.95	1.79	13.23
229.71	50.60	229.67	50.13	0.70	2.52	50.02	33.27	9.33	34.56	0.96	0.95	1.79	13.18
229.81	50.27	229.77	49.80	0.71	2.66	50.01	33.03	9.35	34.33	0.96	0.95	1.75	12.82
229.82	50.00	229.77	49.60	0.70	2.29	50.01	32.84	9.36	34.16	0.96	0.95	1.74	12.76
229.72	49.83	229.67	49.40	0.71	2.48	50.01	32.73	9.36	34.05	0.96	0.95	1.75	12.84
229.68	49.83	229.63	49.47	0.71	2.59	50.00	32.72	9.37	34.04	0.96	0.95	1.75	12.86
229.70	49.83	229.63	49.47	0.71	2.60	50.00	32.71	9.39	34.04	0.96	0.95	1.77	12.81

6.6 Recorded Data at Hostel

Phase Voltage (L1,L2,L3) Avg V	Line Current (L1,L2,L3) Avg A	Phase Voltage (L1,L2,L3) Fundamental Avg V	Line Current (L1,L2,L3) Fundamental Avg A	%-age Voltage Un balance	%-age Current Un balance	Frequency In Hz	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	DPF	TPF	THD V Avg % age	THD A Avg % age
228.67	7.67	228.67	7.60	0.91	35.15	49.91	4.97	1.40	5.17	0.96	0.95	1.85	5.81
228.65	7.67	228.60	7.60	0.90	35.14	49.90	4.97	1.40	5.17	0.96	0.95	1.85	5.79
228.75	7.67	228.67	7.60	0.90	35.10	49.89	4.97	1.41	5.19	0.96	0.95	1.84	5.80
228.67	7.70	228.67	7.60	0.90	35.07	49.90	4.99	1.41	5.20	0.96	0.95	1.84	5.80
228.60	7.83	228.57	7.80	0.91	34.85	49.89	5.09	1.43	5.29	0.96	0.95	1.83	5.83
228.67	7.83	228.63	7.80	0.92	34.86	49.89	5.09	1.43	5.29	0.96	0.95	1.83	5.88
228.61	7.93	228.57	7.87	0.91	35.55	49.88	5.16	1.41	5.36	0.96	0.95	1.82	5.90
227.41	7.83	227.63	7.80	0.92	35.19	49.89	5.08	1.37	5.27	0.96	0.95	1.82	5.87
226.86	7.83	226.83	7.80	0.92	35.29	49.90	5.07	1.36	5.25	0.96	0.95	1.83	5.97
226.83	7.83	226.77	7.80	0.91	35.25	49.90	5.07	1.36	5.24	0.96	0.95	1.85	5.99
227.03	7.87	227.00	7.80	0.89	35.24	49.90	5.07	1.36	5.25	0.96	0.95	1.85	5.97
226.93	7.87	226.87	7.80	0.89	35.26	49.89	5.07	1.36	5.25	0.96	0.95	1.84	5.99

226.97	7.87	226.93	7.80	0.90	35.22	49.90	5.07	1.36	5.25	0.96	0.95	1.84	5.96
226.94	7.83	226.93	7.80	0.90	35.25	49.90	5.07	1.36	5.25	0.96	0.95	1.85	5.94
226.91	7.87	226.87	7.80	0.89	35.28	49.90	5.07	1.36	5.25	0.96	0.95	1.84	5.94
226.93	7.87	226.90	7.80	0.89	35.23	49.90	5.07	1.36	5.25	0.96	0.95	1.84	5.95
226.96	7.87	226.90	7.80	0.89	35.15	49.90	5.08	1.36	5.27	0.96	0.95	1.83	5.95
227.03	7.87	227.03	7.80	0.89	35.16	49.91	5.08	1.36	5.27	0.96	0.95	1.83	5.94
226.89	7.90	226.80	7.80	0.88	35.41	49.92	5.09	1.36	5.28	0.97	0.95	1.83	5.93
227.26	8.03	227.17	8.00	0.89	36.10	49.93	5.20	1.37	5.39	0.97	0.96	1.83	5.93
227.29	8.07	227.23	8.00	0.90	36.35	49.93	5.23	1.37	5.41	0.97	0.96	1.84	6.09
227.35	8.07	227.30	8.00	0.90	36.38	49.92	5.23	1.37	5.41	0.97	0.96	1.84	6.10
227.23	8.10	227.20	8.00	0.91	36.60	49.92	5.24	1.36	5.41	0.97	0.96	1.84	6.32
227.24	8.57	227.20	8.47	0.91	35.64	49.92	5.56	1.33	5.73	0.97	0.96	1.85	6.39
227.10	9.30	227.10	9.27	0.92	34.00	49.92	6.09	1.27	6.24	0.98	0.97	1.85	6.19
227.11	9.30	227.03	9.27	0.92	34.03	49.91	6.09	1.27	6.24	0.98	0.97	1.87	6.22
227.57	9.33	227.50	9.27	0.90	34.02	49.90	6.12	1.27	6.27	0.98	0.97	1.86	6.25
227.60	9.33	227.53	9.27	0.91	33.97	49.89	6.12	1.28	6.27	0.98	0.97	1.85	6.25
227.73	9.30	227.67	9.27	0.92	33.99	49.88	6.12	1.28	6.27	0.98	0.97	1.85	6.25
227.73	9.33	227.67	9.27	0.92	33.99	49.88	6.12	1.28	6.27	0.98	0.97	1.86	6.25
227.22	9.30	227.30	9.27	0.93	34.05	49.88	6.09	1.27	6.24	0.98	0.97	1.85	6.24
226.74	9.33	226.77	9.27	0.94	34.23	49.87	6.12	1.25	6.25	0.98	0.97	1.83	6.23
226.66	9.37	226.60	9.33	0.95	34.28	49.86	6.13	1.25	6.28	0.98	0.97	1.82	6.23
226.61	9.37	226.57	9.33	0.94	34.25	49.86	6.13	1.25	6.28	0.98	0.97	1.82	6.23
226.50	9.37	226.47	9.33	0.95	34.33	49.87	6.13	1.25	6.28	0.98	0.97	1.83	6.26
226.57	9.47	226.50	9.40	0.97	34.57	49.88	6.19	1.25	6.33	0.98	0.97	1.82	6.38
226.51	9.47	226.47	9.40	0.97	34.63	49.89	6.19	1.25	6.33	0.98	0.97	1.83	6.41
226.51	9.47	226.47	9.40	0.98	34.65	49.89	6.20	1.25	6.33	0.98	0.97	1.84	6.41

226.59	9.67	226.53	9.60	0.98	35.39	49.89	6.32	1.28	6.47	0.98	0.97	1.84	6.43
226.86	9.77	226.80	9.73	0.97	35.04	49.89	6.40	1.28	6.55	0.98	0.97	1.84	6.42
226.85	9.90	226.80	9.87	0.98	35.51	49.90	6.51	1.25	6.64	0.98	0.97	1.85	6.34
227.04	9.90	227.00	9.87	0.97	35.62	49.90	6.51	1.25	6.65	0.98	0.97	1.86	6.44
226.98	9.90	226.93	9.80	0.97	35.63	49.89	6.51	1.25	6.64	0.98	0.97	1.86	6.43
227.04	9.90	227.00	9.80	0.99	35.62	49.89	6.51	1.25	6.64	0.98	0.97	1.85	6.39
227.01	9.87	226.97	9.80	0.99	35.62	49.88	6.48	1.27	6.61	0.98	0.97	1.85	6.33
227.02	10.10	226.97	10.00	0.97	32.55	49.88	6.63	1.31	6.77	0.98	0.97	1.85	6.10
227.04	10.23	227.00	10.13	0.94	32.11	49.87	6.72	1.35	6.87	0.98	0.97	1.84	5.96
227.08	10.53	227.07	10.47	0.93	32.64	49.87	6.95	1.33	7.09	0.98	0.97	1.83	5.89
227.12	10.63	227.03	10.53	0.94	32.51	49.86	6.99	1.32	7.13	0.98	0.97	1.83	5.81
227.14	10.63	227.10	10.67	0.94	31.37	49.85	7.04	1.32	7.17	0.98	0.97	1.86	6.40
227.26	10.70	227.20	10.60	0.93	28.80	49.85	7.07	1.33	7.20	0.98	0.97	1.85	6.09
227.27	10.67	227.23	10.60	0.92	28.93	49.84	7.05	1.33	7.19	0.98	0.97	1.86	6.06
227.09	10.67	227.10	10.60	0.92	28.96	49.84	7.05	1.32	7.17	0.98	0.97	1.85	6.07
227.03	10.63	226.97	10.60	0.91	28.97	49.84	7.05	1.32	7.17	0.98	0.97	1.85	6.09
227.01	10.63	226.93	10.60	0.92	29.00	49.83	7.04	1.32	7.17	0.98	0.97	1.85	6.09
226.94	10.63	226.90	10.60	0.88	28.92	49.83	7.05	1.31	7.17	0.98	0.98	1.85	6.06
226.99	10.80	226.93	10.73	0.87	28.99	49.84	7.15	1.31	7.27	0.98	0.98	1.84	6.02
227.12	11.17	227.10	11.13	0.86	30.85	49.85	7.37	1.43	7.52	0.98	0.97	1.83	5.98
227.07	11.40	227.03	11.33	0.88	31.16	49.87	7.55	1.43	7.68	0.98	0.98	1.83	6.04
227.23	11.37	227.17	11.33	0.88	31.14	49.88	7.53	1.43	7.67	0.98	0.98	1.83	6.10
227.28	11.33	227.23	11.27	0.87	31.14	49.90	7.51	1.43	7.64	0.98	0.98	1.83	6.07
227.34	11.30	227.27	11.27	0.88	31.12	49.90	7.49	1.43	7.63	0.98	0.98	1.83	6.00
227.26	11.33	227.23	11.27	0.91	31.15	49.90	7.49	1.43	7.63	0.98	0.98	1.83	5.81
227.01	12.37	226.97	12.33	0.94	33.14	49.89	8.20	1.36	8.32	0.98	0.98	1.83	5.60

226.88	12.47	226.90	12.40	0.95	33.30	49.89	8.24	1.35	8.36	0.99	0.98	1.85	5.55
226.85	12.70	226.80	12.67	0.93	32.76	49.88	8.41	1.40	8.53	0.98	0.98	1.87	5.52
226.87	12.60	226.83	12.53	0.95	34.14	49.88	8.33	1.37	8.47	0.98	0.98	1.84	5.65
226.87	12.60	226.80	12.60	0.95	34.82	49.88	8.35	1.39	8.48	0.98	0.98	1.82	5.80
226.96	12.57	226.90	12.60	0.95	34.87	49.89	8.35	1.39	8.48	0.98	0.98	1.83	5.76
226.96	12.57	226.97	12.60	0.94	34.90	49.88	8.35	1.39	8.47	0.98	0.98	1.86	5.76
227.08	12.57	227.03	12.60	0.93	34.83	49.88	8.36	1.39	8.48	0.98	0.98	1.90	5.74
227.22	12.63	227.17	12.60	0.95	34.89	49.88	8.36	1.39	8.49	0.98	0.98	1.84	5.77
227.20	12.60	227.17	12.60	0.96	34.95	49.89	8.36	1.39	8.49	0.98	0.98	1.82	5.79
227.36	12.43	227.30	12.40	0.97	37.11	49.89	8.24	1.35	8.37	0.98	0.98	1.82	6.38

6.7 Recorded Data at Temple Tower

Phase Voltage (L1,L2,L3) Avg V	Line Current (L1,L2,L3) Avg A	Phase Voltage (L1,L2,L3) Fundamental Avg V	Line Current (L1,L2,L3) Fundamental Avg A	%-age Voltage Un balance	%-age Current Un balance	Frequency In Hz	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	DPF	TPF	THD V Avg % age	THD A Avg % age
218.16	47.73	218.13	47.67	0.80	12.31	49.99	30.81	4.00	31.07	0.99	0.99	2.00	4.93
218.16	47.53	218.10	47.47	0.78	12.28	49.99	30.67	4.03	30.93	0.99	0.99	2.05	5.08
218.40	46.83	218.33	46.80	0.70	11.28	49.98	30.27	4.08	30.55	0.99	0.99	2.05	5.06
218.37	47.20	218.27	47.13	0.75	11.79	49.97	30.47	4.08	30.75	0.99	0.99	2.03	5.04
218.42	46.87	218.37	46.80	0.71	11.31	49.98	30.28	4.11	30.56	0.99	0.99	2.03	5.04
218.34	47.43	218.33	47.33	0.82	12.10	49.99	30.63	4.07	30.91	0.99	0.99	2.03	5.03
218.39	46.87	218.33	46.80	0.76	11.03	50.00	30.27	4.12	30.55	0.99	0.99	2.04	5.06
218.53	46.53	218.47	46.47	0.74	10.72	50.01	30.09	4.09	30.37	0.99	0.99	2.00	4.98
218.40	47.03	218.37	47.00	0.82	11.63	50.02	30.39	4.03	30.65	0.99	0.99	1.97	4.90
218.54	46.30	218.47	46.20	0.73	10.62	50.03	29.93	4.07	30.21	0.99	0.99	1.98	4.94

218.80	46.00	218.73	45.93	0.74	10.77	50.03	29.79	4.07	30.07	0.99	0.99	1.95	4.88
218.57	46.50	218.53	46.40	0.81	11.67	50.04	30.08	3.99	30.33	0.99	0.99	1.94	4.85
218.52	46.17	218.50	46.07	0.77	11.17	50.03	29.83	4.05	30.11	0.99	0.99	1.95	4.91
218.24	46.60	218.23	46.53	0.83	11.99	50.02	30.09	4.03	30.36	0.99	0.99	2.01	5.11
218.08	46.80	218.03	46.73	0.85	12.24	50.02	30.17	4.01	30.44	0.99	0.99	2.01	5.10
218.09	46.50	218.03	46.47	0.84	11.91	50.01	30.00	4.05	30.28	0.99	0.99	2.04	5.17
218.06	46.83	218.03	46.73	0.87	12.31	50.01	30.16	4.03	30.43	0.99	0.99	2.03	5.21
218.13	46.53	218.03	46.40	0.82	11.82	50.01	30.01	4.08	30.29	0.99	0.99	2.04	5.22
218.12	46.43	218.07	46.33	0.82	11.76	50.01	29.95	4.09	30.23	0.99	0.99	2.05	5.20
218.00	46.87	218.00	46.80	0.86	12.48	50.00	30.21	4.04	30.48	0.99	0.99	2.01	5.09
218.12	46.17	218.03	46.07	0.77	11.49	49.98	29.80	4.11	30.08	0.99	0.99	1.99	5.02
218.34	46.23	218.30	46.20	0.76	11.41	49.96	29.85	4.12	30.13	0.99	0.99	1.99	5.06
218.09	47.00	218.07	46.87	0.82	12.09	49.97	30.29	4.07	30.56	0.99	0.99	2.00	5.09
218.14	46.93	218.10	46.87	0.80	11.90	49.98	30.29	4.05	30.56	0.99	0.99	2.00	5.11
218.20	46.90	218.13	46.87	0.79	11.77	49.99	30.28	4.07	30.55	0.99	0.99	1.99	5.12
218.25	46.70	218.20	46.60	0.77	11.35	49.99	30.13	4.09	30.41	0.99	0.99	2.07	5.32
218.19	47.13	218.13	47.00	0.82	12.14	49.98	30.39	4.05	30.65	0.99	0.99	2.07	5.29
218.34	46.63	218.27	46.53	0.77	11.39	49.98	30.11	4.09	30.39	0.99	0.99	2.09	5.30
218.51	46.40	218.47	46.33	0.75	11.36	49.98	29.97	4.11	30.25	0.99	0.99	2.08	5.28
218.44	46.73	218.40	46.67	0.82	12.36	49.99	30.17	4.05	30.44	0.99	0.99	2.06	5.25
218.77	46.03	218.67	45.93	0.74	11.25	49.99	29.80	4.11	30.08	0.99	0.99	2.06	5.29
218.88	45.87	218.80	45.80	0.71	11.03	50.00	29.69	4.09	29.97	0.99	0.99	2.03	5.21
218.59	46.90	218.57	46.80	0.81	12.61	50.01	30.29	4.00	30.56	0.99	0.99	2.00	5.09
219.37	47.03	219.07	46.93	0.84	12.99	50.01	30.49	4.09	30.77	0.99	0.99	2.01	5.05
220.17	47.17	220.13	47.07	0.84	12.89	50.00	30.67	4.16	30.95	0.99	0.99	2.02	5.07
220.18	47.70	220.13	47.67	0.91	14.01	50.00	31.01	4.12	31.29	0.99	0.99	2.00	4.99
220.33	47.23	220.27	47.20	0.84	13.23	50.02	30.76	4.17	31.05	0.99	0.99	2.02	5.08
220.29	47.80	220.23	47.73	0.90	13.97	50.03	31.08	4.17	31.36	0.99	0.99	2.09	5.28
220.29	47.80	220.23	47.73	0.92	14.17	50.03	31.08	4.13	31.36	0.99	0.99	2.06	5.22
220.45	47.20	220.37	47.13	0.87	13.21	50.03	30.73	4.17	31.03	0.99	0.99	2.06	5.23

220.33	47.70	220.30	47.53	0.91	13.77	50.02	31.01	4.13	31.29	0.99	0.99	2.06	5.21
220.25	47.70	220.17	47.60	0.94	13.84	50.02	31.01	4.16	31.31	0.99	0.99	2.06	5.20
220.09	47.57	220.07	47.53	0.94	13.54	50.01	30.91	4.21	31.20	0.99	0.99	2.06	5.20
220.11	47.93	220.10	47.87	0.96	14.21	50.01	31.12	4.19	31.41	0.99	0.99	2.03	5.12
220.05	47.43	220.00	47.40	0.90	13.25	50.01	30.81	4.17	31.11	0.99	0.99	2.00	5.07
220.00	47.23	219.97	47.13	0.89	12.98	50.01	30.71	4.17	30.99	0.99	0.99	1.98	5.05
219.88	47.77	219.87	47.73	0.96	13.92	50.00	31.00	4.12	31.28	0.99	0.99	1.97	5.05
219.98	47.27	219.93	47.13	0.89	13.07	50.00	30.71	4.16	30.99	0.99	0.99	1.98	5.06
219.70	47.20	219.70	47.07	0.89	13.16	49.99	30.61	4.16	30.89	0.99	0.99	2.00	5.08
219.46	48.27	219.47	48.13	1.01	14.71	49.97	31.23	4.11	31.51	0.99	0.99	2.05	5.23
219.59	47.47	219.50	47.40	0.91	13.38	49.98	30.77	4.16	31.05	0.99	0.99	2.04	5.17
219.46	47.40	219.43	47.33	0.91	13.33	49.98	30.72	4.13	31.00	0.99	0.99	2.03	5.12
219.38	48.13	219.33	48.07	0.98	14.46	49.98	31.16	4.09	31.44	0.99	0.99	2.02	5.12
219.64	47.13	219.50	47.00	0.83	12.92	49.98	30.56	4.19	30.85	0.99	0.99	2.03	5.13
219.68	46.30	219.67	46.20	0.73	11.65	49.97	30.07	4.23	30.37	0.99	0.99	2.02	5.21
219.60	47.20	219.53	47.07	0.81	12.26	49.95	30.60	4.36	30.92	0.99	0.99	1.98	5.18
219.76	46.43	219.70	46.33	0.72	10.85	49.93	30.13	4.41	30.47	0.99	0.99	1.97	5.18
219.93	46.50	219.90	46.40	0.72	10.73	49.93	30.24	4.40	30.56	0.99	0.99	1.96	5.19
219.67	47.23	219.63	47.07	0.82	11.94	49.94	30.63	4.32	30.95	0.99	0.99	1.94	5.14
219.83	46.50	219.77	46.40	0.73	10.78	49.94	30.23	4.39	30.55	0.99	0.99	1.94	5.17
219.88	46.50	219.80	46.40	0.73	10.79	49.93	30.21	4.40	30.53	0.99	0.99	1.94	5.17
219.79	47.47	219.77	47.33	0.84	12.49	49.94	30.79	4.35	31.11	0.99	0.99	2.00	5.30
219.87	46.67	219.80	46.60	0.74	11.17	49.94	30.32	4.40	30.64	0.99	0.99	2.00	5.29
219.86	46.63	219.77	46.60	0.74	11.07	49.94	30.29	4.40	30.61	0.99	0.99	1.99	5.26
219.85	47.33	219.80	47.27	0.82	12.15	49.94	30.72	4.37	31.04	0.99	0.99	1.99	5.26
220.04	46.90	219.97	46.80	0.77	11.48	49.93	30.47	4.47	30.80	0.99	0.99	2.03	5.33
220.01	46.83	220.00	46.67	0.76	11.36	49.92	30.41	4.49	30.75	0.99	0.99	2.03	5.33
219.76	47.57	219.77	47.47	0.86	12.65	49.92	30.85	4.44	31.19	0.99	0.99	1.97	5.17
219.86	46.77	219.77	46.67	0.78	11.26	49.92	30.37	4.49	30.71	0.99	0.99	1.96	5.13
219.74	47.17	219.73	47.07	0.82	11.97	49.91	30.61	4.43	30.93	0.99	0.99	1.95	5.14

219.97	46.63	219.90	46.53	0.74	10.81	49.91	30.29	4.49	30.63	0.99	0.99	1.96	5.13
220.10	45.50	220.03	45.47	0.80	13.38	49.92	29.51	4.56	29.88	0.99	0.99	1.96	5.32
219.74	46.17	219.77	46.07	0.89	14.53	49.92	29.85	4.49	30.21	0.99	0.99	1.97	5.40
220.02	45.73	219.93	45.73	0.90	14.13	49.93	29.64	4.53	30.00	0.99	0.99	2.04	5.57
220.22	45.57	220.17	45.47	0.88	13.91	49.94	29.56	4.55	29.92	0.99	0.99	2.03	5.53
220.23	46.23	220.20	46.13	0.95	14.95	49.95	29.96	4.51	30.31	0.99	0.99	2.02	5.51
220.40	45.53	220.37	45.47	0.88	13.94	49.96	29.56	4.55	29.92	0.99	0.99	2.04	5.55
220.31	45.67	220.30	45.60	0.85	14.03	49.97	29.63	4.56	29.99	0.99	0.99	2.05	5.54
220.17	46.40	220.10	46.33	0.88	14.94	49.96	30.09	4.51	30.44	0.99	0.99	2.03	5.47
220.45	45.63	220.37	45.47	0.78	13.50	49.95	29.64	4.56	30.00	0.99	0.99	2.03	5.43
220.44	45.60	220.43	45.47	0.77	13.49	49.95	29.63	4.55	29.99	0.99	0.99	2.02	5.39
220.44	46.27	220.37	46.20	0.85	14.66	49.96	30.05	4.51	30.40	0.99	0.99	2.01	5.35
220.64	45.60	220.57	45.53	0.78	13.62	49.98	29.64	4.57	30.01	0.99	0.99	2.02	5.38
220.65	45.63	220.60	45.53	0.79	13.73	49.99	29.65	4.57	30.01	0.99	0.99	2.00	5.35
220.39	46.70	220.40	46.60	0.90	15.60	50.00	30.27	4.68	30.64	0.99	0.99	1.98	5.32
220.47	46.27	220.43	46.20	0.87	15.20	50.00	29.99	4.73	30.37	0.99	0.99	2.04	5.50
220.58	46.00	220.50	45.93	0.86	15.00	49.98	29.85	4.75	30.24	0.99	0.99	2.02	5.47
220.45	46.63	220.40	46.60	0.90	15.84	49.97	30.23	4.69	30.60	0.99	0.99	2.01	5.41
220.51	45.97	220.50	45.87	0.83	14.89	49.97	29.83	4.75	30.21	0.99	0.99	2.02	5.40
220.45	46.17	220.40	46.07	0.86	15.26	49.97	29.95	4.79	30.33	0.99	0.98	2.04	5.47
220.30	47.03	220.23	47.00	0.95	16.42	49.98	30.47	4.73	30.84	0.99	0.99	2.03	5.48
220.55	46.20	220.50	46.07	0.86	15.17	49.99	29.97	4.79	30.36	0.99	0.98	2.01	5.44
220.45	46.10	220.43	46.00	0.83	14.93	49.99	29.89	4.75	30.28	0.99	0.99	1.99	5.34
220.32	46.43	220.33	46.40	0.88	15.46	49.99	30.11	4.65	30.48	0.99	0.99	1.97	5.25
220.30	46.57	220.27	46.47	0.83	14.11	50.00	30.21	4.61	30.57	0.99	0.99	2.00	5.21
220.45	46.20	220.37	46.13	0.82	14.10	50.00	30.01	4.61	30.37	0.99	0.99	1.99	5.17
220.64	45.47	220.57	45.33	0.77	13.77	50.00	29.55	4.68	29.92	0.99	0.99	2.00	5.24
220.56	46.20	220.53	46.13	0.84	14.82	50.00	29.99	4.68	30.36	0.99	0.99	2.06	5.44
220.74	46.03	220.63	45.93	0.80	14.33	50.00	29.91	4.71	30.28	0.99	0.99	2.05	5.45
220.89	45.70	220.80	45.60	0.77	13.89	50.00	29.72	4.71	30.11	0.99	0.99	2.05	5.44

220.69	46.23	220.73	46.13	0.84	14.73	50.01	30.01	4.67	30.39	0.99	0.99	2.05	5.44
220.62	46.00	220.53	45.87	0.81	14.35	50.00	29.88	4.68	30.25	0.99	0.99	2.05	5.43
220.62	45.83	220.57	45.73	0.79	14.18	50.00	29.79	4.69	30.16	0.99	0.99	2.05	5.42
220.49	46.33	220.47	46.20	0.84	14.70	50.00	30.07	4.64	30.44	0.99	0.99	2.02	5.32
220.56	45.83	220.50	45.67	0.77	13.67	50.01	29.76	4.65	30.13	0.99	0.99	2.00	5.26
220.63	45.70	220.57	45.60	0.77	13.63	50.02	29.69	4.68	30.07	0.99	0.99	2.01	5.28
220.50	46.37	220.47	46.33	0.86	14.74	50.03	30.12	4.61	30.48	0.99	0.99	2.02	5.28
220.79	45.73	220.73	45.60	0.78	13.66	50.03	29.73	4.68	30.11	0.99	0.99	2.01	5.28
220.74	45.80	220.70	45.80	0.79	13.66	50.04	29.79	4.81	30.19	0.99	0.98	2.01	5.32
220.41	47.53	220.43	47.40	0.87	13.64	50.03	30.84	4.76	31.23	0.99	0.99	2.06	5.39
220.31	47.50	220.23	47.40	0.78	11.70	50.04	30.89	4.67	31.25	0.99	0.99	2.05	5.17
220.40	47.67	220.33	47.60	0.80	11.85	50.04	31.01	4.68	31.36	0.99	0.99	2.05	5.18
220.30	47.93	220.27	47.80	0.85	12.48	50.04	31.13	4.61	31.49	0.99	0.99	2.03	5.15
220.37	46.97	220.33	46.87	0.78	11.08	50.03	30.53	4.69	30.89	0.99	0.99	2.03	5.18
220.34	46.63	220.30	46.53	0.77	11.36	50.03	30.32	4.65	30.68	0.99	0.99	2.03	5.19
220.20	47.20	220.20	47.07	0.81	12.24	50.01	30.67	4.57	31.01	0.99	0.99	1.99	5.10
220.30	46.47	220.23	46.40	0.74	11.07	50.00	30.20	4.61	30.56	0.99	0.99	1.97	5.05
220.29	46.37	220.30	46.27	0.73	11.00	50.01	30.15	4.59	30.51	0.99	0.99	1.97	5.04
220.59	46.87	220.43	46.73	0.80	11.87	50.02	30.49	4.60	30.85	0.99	0.99	1.99	5.04
221.22	46.03	221.13	46.00	0.75	10.77	50.02	30.07	4.69	30.44	0.99	0.99	2.00	5.05
221.00	45.93	220.93	45.87	0.75	10.82	50.01	29.97	4.68	30.35	0.99	0.99	2.00	5.08
220.75	46.83	220.73	46.80	0.84	12.40	50.00	30.51	4.61	30.87	0.99	0.99	2.06	5.22
220.91	46.17	220.80	46.07	0.78	11.33	50.00	30.09	4.68	30.47	0.99	0.99	2.05	5.19
220.91	46.23	220.87	46.20	0.78	11.47	50.00	30.13	4.69	30.51	0.99	0.99	2.06	5.21
220.76	46.93	220.77	46.80	0.85	12.61	50.00	30.55	4.64	30.91	0.99	0.99	2.04	5.18
220.88	46.00	220.77	45.93	0.76	11.37	49.99	29.97	4.73	30.35	0.99	0.99	2.05	5.23
220.80	45.67	220.80	45.53	0.74	11.32	49.99	29.73	4.76	30.12	0.99	0.99	2.05	5.27
220.52	46.13	220.53	46.07	0.78	12.01	49.97	29.99	4.69	30.36	0.99	0.99	2.02	5.19
220.69	45.47	220.63	45.40	0.72	11.20	49.96	29.60	4.75	29.99	0.99	0.99	2.00	5.16
220.75	45.37	220.67	45.27	0.71	11.05	49.96	29.52	4.75	29.91	0.99	0.99	2.00	5.18

220.62	46.17	220.63	46.07	0.76	11.41	49.96	30.04	4.69	30.41	0.99	0.99	1.99	5.08
220.64	45.80	220.53	45.73	0.72	10.75	49.96	29.80	4.71	30.17	0.99	0.99	1.99	5.05
220.91	45.77	220.80	45.67	0.69	10.63	49.96	29.81	4.76	30.20	0.99	0.99	2.00	5.08
221.05	46.53	221.03	46.40	0.77	11.89	49.96	30.32	4.76	30.69	0.99	0.99	2.05	5.22
221.07	46.33	220.97	46.27	0.76	11.63	49.96	30.21	4.76	30.59	0.99	0.99	2.05	5.20
221.08	46.03	221.03	45.93	0.77	11.21	49.96	30.01	4.80	30.40	0.99	0.99	2.05	5.22
220.98	46.13	221.00	46.07	0.84	11.74	49.96	30.01	4.89	30.41	0.99	0.98	2.04	5.21
220.88	46.17	220.83	46.07	0.84	11.82	49.95	30.04	4.91	30.44	0.99	0.98	2.03	5.18
220.91	45.93	220.87	45.80	0.81	11.32	49.96	29.87	4.88	30.27	0.99	0.98	2.04	5.16
220.74	46.27	220.73	46.20	0.84	11.81	49.96	30.09	4.84	30.48	0.99	0.99	2.01	5.06
220.77	45.77	220.73	45.67	0.76	10.47	49.97	29.77	4.88	30.17	0.99	0.98	2.02	5.08
220.78	45.77	220.73	45.67	0.74	10.45	49.97	29.76	4.88	30.16	0.99	0.98	2.01	5.08
220.76	46.17	220.70	46.07	0.79	11.22	49.96	30.03	4.81	30.43	0.99	0.99	2.01	5.08
220.91	45.20	220.87	45.13	0.71	9.44	49.93	29.44	4.79	29.83	0.99	0.98	2.01	5.12

7.Annual Energy Consumption

The total energy consumed in the campus may be due to the usage of electrical energy , liquid or gaseous fuel . The total energy usage and its cost has been tabulated below.

S.No.	Description	Type of fuel and their conversion process		
		Electrical energy consumed	**Diesel**	**LPG**
1	Annual Energy Consumption	223660 kWh	90000 lt	120 nos.
2	Annual Energy Cost	Rs 79,33,790		
3	CO_2 Emission (tonne/Annum)	208	234	6.6
4	Total CO_2 emission (tonne/Annum)	448.6		
5	Total No. of students and staff	4002		
6	Per capita CO_2 emission (tonne)	0.112		
7	No. of Matured Trees	452		
8	CO_2 neutralised due to trees (tonne)	9.5		
9	Per Capita CO_2 Emission to be Neutralized (tonne)	0.109		

8. Energy saving opportunities

Lot of opportunities are there for energy savings in the campus. A few of them are calculated and the associated payback period in each category has been discussed below.

8.1 Energy savings in Lighting

DESCRIPTION	FTL FITTINGS	LED FITTINGS
	40W	18W
No. of fittings	100	100
Wattage	40	18
Total Wattage	4000	1800
Consumption units per day (@10 hrs working per day)	40	18
Running cost per day (@Rs 6.5 per unit)	260	117
Units saved per day	22 kWh	
Units saved per month (25 working days per month)	550 kWh	
Cost savings per day	Rs 143	
Cost savings per month	Rs 3575	
Initial investment for LED light fittings for 100 nos. (=100*Rs.650)	Rs 65000.00	
Payback period (Considering 300 working days per year)	1 year 6 months	

8.2 Energy savings after replacing conventional fans BLDC fans

DESCRIPTION	NORMAL FAN	BLDC FAN
	65W	30W
No. of fans	100	100
Total Wattage	6500	3000
Consumption units per day (@10 hrs working per day)	65	30
Running cost per day (@Rs 6.5 per unit)	422.5	195
Units saved per day	35 kWh	
Units saved per month (25 working days per month)	875 kWh	
Cost savings per day	Rs 227.50	
Cost savings per month	Rs 5687.5	
Initial investment for BLDC fans -100 nos. (=100*Rs.3250)	Rs 325000	
Payback period (Considering 300 working days per year)	4 years 9 months	

8.3 Energy savings after installing roof top solar PV plant

Cost of 150 kW rooftop solar PV	Rs 54,00,000.00
Units generated per year in 150 kW solar PV (100 kW solar PV generates approximately 12000 -13000 units per month)	223660 kWh
Energy Savings due to the installation of 150 kW roof top solar PV plant (Life cycle time = 20 years)	Rs 14,53,790.00
Payback period	3 years 8 months

9. Recommendations for energy savings and sustainability

The following observations are made during the audit.

- ✓ All class rooms and laboratory's displayed messages regarding optimum use of electrical appliances in the room like lights, fans, computers and projectors. More number of banners should be displayed.
- ✓ All computers to have power saving settings to turn off monitors and hard discs, say after 10 minutes / 30 minutes.
- ✓ The comfort air conditioning temperature to be set between 24˚C to 28˚C.
- ✓ As the college is located at a place where solar intensity is sufficiently available, day lighting is sufficient for the class room environment which reduces the usage of lighting
- ✓ It is good practice of testing the Earth Electrode and maintaining the minimum Earth Electrode resistance at college campus area
- ✓ The college utilizes more number of Fluorescent Lamps and less number of LED for Lighting purpose. It is recommended to replace fluorescent light by LED whenever they get fused.
- ✓ The energy saving opportunities for various equipments and cost savings are discussed in subsequent chapters.
- ✓ It is observed that there is unbalance in current. This is due to large number of single phase loads.. When the neutral current is not zero which can lead to
    1. de-rating of power cables and thus increase I^2R losses in the cable
    2. permanent damage of the electrical equipment

- ✓ All class Rooms and labs to have display messages regarding optimum use of electrical appliances in the room like, lights, fans, computers and projectors.
- ✓ All computers to use power saving settings to turn off monitors and hard discs, say after 10 minutes/30 minutes.
- ✓ The comfort air conditioning temperature to be set between 24℃ to 26℃. This can save approximately 20 % of energy consumption.
- ✓ Policies and procedures for handling, storage and disposal of chemicals and all types of wastes may be formulated and the same can be circulated throughout the college.
- ✓ Forming of small committees to track and monitor the work of different processes relevant to energy and environment.
- ✓ Periodic maintenance should be done for all electrical related equipment/systems.
- ✓ The food waste in the hostel can be quantified and the same can be displayed to students to reduce the wastage.
- ✓ Awareness to be brought among students to use the minimum number of fans during the interval and lunch time. In such times, only few students will be present, but all the fans will be running.
- ✓ Checking for any apparent leaks is one of the best ways to make sure that no amount of LPG gets wasted in LPG cylinders. Keep a check on the regulator, the pipe and burner for any small leakages that can easily develop with time and can go unnoticed.
- ✓ Wipe utensils dry before placing them on a burner.
- ✓ Do not overcook. Overcooking can kill the nutrients in the food along with wastage of LPG.
- ✓ In order to save LPG, always use a pan that covers the burner entirely for efficient cooking and optimal usage of gas. Using a small bottom pan over a large burner would only increase wastage.
- ✓ Cooking in an open vessel is a bad idea as it allows for far more wastage of gas compared to cooking with a covered vessel. Cooking with a covered vessel can help you save a lot of gas when performed regularly.

- ✓ The usage of cycles by students and staffs can be encouraged by the management. Separate parking areas for cycles can be allocated.
- ✓ Awareness of growing more number of trees in the campus to be made.
- ✓ A policy to convert the waste to energy can be framed and necessary actions may be taken to implement it.

10. Annexure

EXTRACTS FROM IEEE -519 FOR VOLTAGE THD AND CURRENT TDD LIMITS

EXTRACTS FROM IEEE 519-1992
CURRENT DISTORTION LIMITS FOR GENERAL DISTRIBUTION SYSTEMS
(120V THROUGH 69 000V)

Maximum Harmonic Current Distortion in Percent of I_1					
Individual Harmonic Order /odd Harmonics/					
I_{sc}/I_L	**<11**	**11≤h<17**	**17≤h<23**	**23≤h<35**	**35≤h**
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
12.0					
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					
Even harmonics are limited to 25% of the odd harmonic limits above.					
Current distortions that result in a de offset, e.g., half-wave converters, are not allowed.					
*All power generation equipment is limited to these values of current distortion, regardless of action I_{sc} / I_L					
Where I_{sc} = maximum short-circuit current at PCC. I_L = maximum demand load current (fundamental frequency component) at PCC.					

Current Distortion Limits for General Sub transmission Systems
(69 001 V Through 161 000 V)

Maximum Harmonic Current Distortion in Percent of I_L					
Individual Harmonic Order (odd Harmonics)					
I_{sc}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h
TDD					
<20	2.0	1.0	0.75	0.3	0.15
2.5					
20<50	3.5	1.75	1.25	0.5	0.25
4.0					
50<100	5.0	2.25	2.0	0.75	0.35
6.0					
100<1000	6.0	2.75	2.5	1.0	0.5
7.5					
>1000	7.5	3.5	3.0	1.25	0.7
10.0					

Even harmonics are limited to 25% of the odd harmonic limits above.
Current distortions that result in a de offset, e.g., half-wave converters, are not allowed.
*All power generation equipment is limited to these values of current distortion, regardless of action I_{sc} / I_L
Where I_{sc} = maximum short-circuit current at PCC. I_L = maximum demand load current (fundamental frequency component) at PCC.

Voltage Distortion Limits. The recommended voltage distortion limits (see Table 11.1) are concerned with the follow indices:
THD: Table (RSS) Harmonic voltage distortion in percent of nominal fundamental frequency voltage.

The limits listed in Table 11.1 should be used as system design values for the "worst case" for normal operation (conditions lasting longer than one hour). For shorter periods, during start-ups or unusual conditions, the limits may be exceeded by 50%.

Voltage Distortion Limits

Bus voltage at PCC	Individual voltage Distortion (%)	Total voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001kV through 161kV	1.5	2.5
161.001 kV and above	1.0	1.5

Note: High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

(ii) CEA Regulations

Ministry of Power
(Central Electricity Authority)
Notification No: 12/X/STD(CONN)/GM/CEA (21-Feb-07)
Extracts from
The Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007

Part II
Grid Connectivity Standards applicable to the Generating Units

The units at a generating station proposed to be connected to the grid shall comply with the
following requirements besides the general connectivity conditions given in the regulations
and general requirements given in Part I of the Schedule:

New Generating Units ---------

----- (5) The project of the requester shall not cause voltage and current harmonics on the grid which exceed the limits specified in Institute of Electrical and Electronics Engineers (IEEE) Standard 519.

Part IV
Grid Connectivity Standards applicable to the Distribution Systems and Bulk Consumers

The following additional requirements shall be complied with, besides the connectivity conditions in these regulations and general Standards for Connectivity to the Grid given in Part-I and those applicable to transmission lines and sub-stations in Part -III. ----------

----------**Voltage and Current Harmonics**

(1) The total harmonic distortion for voltage at the connection point shall not exceed 5% with no individual harmonic higher than 3%.

(2) The total harmonic distortion for current drawn from the transmission system at the connection point shall not exceed 8%.

(3) The limits prescribed in (1) and (2) shall be implemented in a phased manner so as to achieve complete compliance not later than five years from the date of publication of these regulations in the official Gazette.

----------End of the Report----------

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