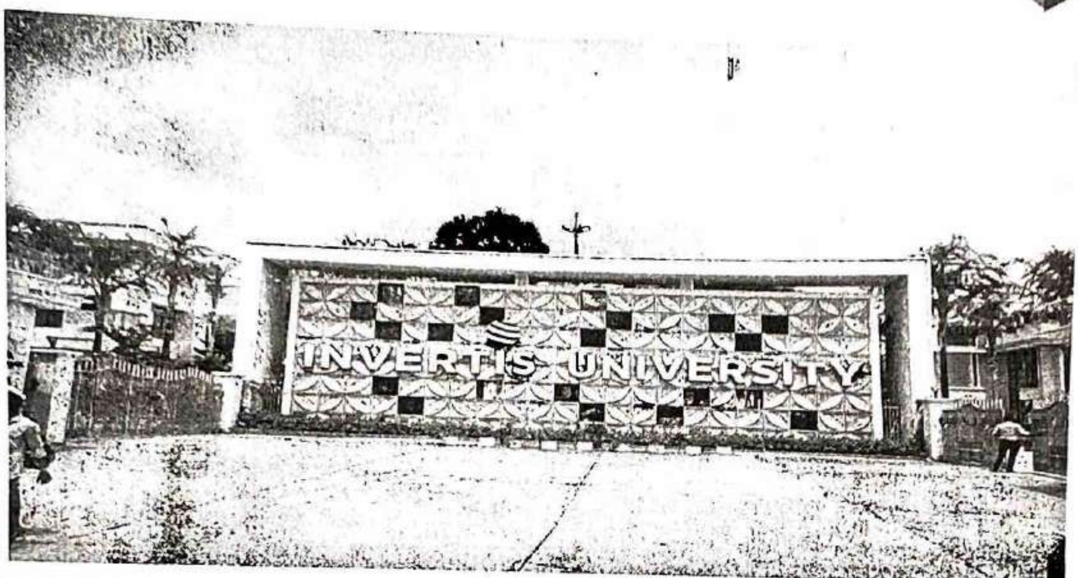
DETAILED ENERGY AUDIT

INVERTIS
UNIVERSITY BAREILLY



AUGUST 2021

INVERTIS VILLAGE, BAREILLY-LUCKNOW NATIONAL HIGHWAY, N.H. 24, BAREILLY - 243123 (U.P)

Conducted By:-

A-Z ENERGY ENGINEERS PVT. LTD.

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ABBREVIATIONS

AC	Air Conditioning
APFC	Automatic Power Factor Control
CFL	Compact Fluorescent Lamp
CFM	Cubic Feet per Minute
CoP	Coefficient of Performance
CO_2	Carbon Dioxide
CT	Cooling Tower
CW	Cooling Water
DG	Diesel Generator
EE	Energy Efficient
EER	Energy Efficiency Ratio
ENCON	Energy Conservation Measures
EPI	Energy Performance Index
FRP	Fibre Reinforced Plastic
FTL	Fluorescent Tube Light
HP	Horse Power
HPSV	High Pressure Sodium Vapour
HT	High Tension
HVAC	Heating, Ventilation and Air conditioning
ID	Induced Draft
IEEE	Institute of Electrical and Electronics Engineers
INR	Indian Rupees
IRR	Internal Rate of Return
kVA	Kilovolt Ampere
kVAh	Kilovolt Ampere Hour
kVAR	Kilovolt Ampere Reactive
kWh	Kilowatt Hour
LED	Light Emitting Diode
LT	Low Tension
MH	Metal Halide
Mkcal	Million Kilo Calories
PF	Power Factor
THD	Total Harmonic Distortion
TR	Ton of refrigeration
TRh	Ton of refrigeration in one hour
TOD	Time of Day
VFD	Variable Frequency Drive
WBT	Wet Bulb Temperature

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BACKGROUND

Most of present human activities draw its energy from fossil fuel energy sources. The secondary form of energy, the Electricity, which is mainly generated from fossil fuel, is the lifeline of today's modern and highly mechanized lifestyle. Energy is a basic requirement for economic development in almost all major sectors of economy i.e. agriculture. Industry, transport, commercial, and residential (domestic); Consequently, consumption of energy in different forms has been steadily rising all over the country, and more so in Commercial Buildings, which has maintained a steady growth pattern in the past and the trend is likely to continue in future as well. However major concern is that the fossil fuel based sources of Energy are limited and these sources will get exhausted soon. Therefore Every nation whether developed or under-developed is very much concerned about optimal utilization of energy resources. Energy conservations is one of the initiatives which is a proven measure to optimize the uses to retard the depletion of energy resource.

Therefore considering the vast potential of energy saving and benefits of energy efficiency, the Government of India enacted the Energy Conservation Act, 2001 in October 2001. The Energy Conservation Act.2001, become effective from 1st March 2002. The Act provides for institutionalizing and strengthening delivery mechanism for energy efficiency programs in the country and provides a framework for the much needed coordination between various government entities. As per the EC Act, Government of India established "Bureau of Energy Efficiency" (BEE) with the mission to develop policy and strategies with a thrust on self-regulation and market principles, within the overall frame work of the Energy Conservation Act (EC Act) 2001 with the primary objective of reducing the energy intensity of the Indian economy.

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ACKNOWLEDGEMENT

We are thankful to the Management of Invertis University for awarding the energy audit study of this university to A-Z Energy Engineers Pvt. Ltd. Energy Audit was conducted in the month of August 2021. This report captures the outcomes of Energy Audit conducted at Invertis University.

We are thankful and appreciative of the keen interest and commitment of Management and we convey our special thanks to;

Name	Designation	Mobile
Mr. Santosh Kumar	Registrar	9690017906

We also thank to each & every official of Engineering Section for showing keen interest and co-operation during the course of our study.

AUDIT TEAM

Audit team for this assignment consisted of Energy Auditors, Engineers and Experts namely Dr. P.P. Mittal, Accredited Energy Auditor (AEA-0011), Sh. Pankaj Chauhan, Sr. Energy Consultant & Sh. Alok Tiwari, Sr. Engineer.

NOTE: It is intimated that this whole exercise is for Identifying Energy Saving Potential and for Quality of Power.

Place: **DELHI** Date: **AUGUST 2021**

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1. Project Background & Introduction

1.1 The Project

With the advent of energy crisis and exponential hikes in the costs of different forms of energy, Energy Audit is manifesting its due importance in every establishment. Energy Audit helps to understand more about the way's energy is used in any establishment and helps in identifying areas where waste may occur and scope for improvement exists.

It was with this objective that "**M/s. A-Z Energy Engineers Pvt. Ltd.**, Plot No.12, 4860-62, Harbans Singh Street, Kothi No. 24, Ward No. II, Darya Ganj, New Delhi-11002, was entrusted with the job of conducting Energy Audit of "Invertis University", Bareilly.

Invertis University is a private university located in Bareilly, Uttar Pradesh, India. It is situated on Bareilly-Lucknow NH-24, equidistant 250 km from the national capital Delhi and state capital Lucknow. The Chancellor of the university is Umesh Gautam and the Vice-Chancellor is Y. D. S. Arya.

1.2 Scope of work

The present audit laid emphasis on the following areas to identify energy saving opportunities:

- ✓ Power Distribution System
- ✓ Lighting system
- ✓ ACs & Ventilation
- ✓ Water Pumping and treatment System
- ✓ Transformers
- ✓ DG Sets
- ✓ APFC
- ✓ Renewable Energy

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1.3 Instruments Used for Energy Audit

The following portable instruments were used for data measurement:

- ✓ 3 – phase Power Analyzer
- ✓ Single phase Power Analyzer
- ✓ Anemometer
- ✓ Hygrometer
- ✓ Digital Thermometer
- ✓ Pressure gauge
- ✓ Lux Meter
- ✓ Thermograph Camera
- ✓ Flow Meter
- ✓ Earth Tester

1.4 Object of Study

The purpose of this study is to demonstrate the technical and financial feasibility of implementation of energy efficiency measures in Invertis University. The purpose of this report is:–

(i) to analyze the present energy consumption pattern

(ii) to investigate for energy conservation measures without compromising the production level

(iii) to assess the techno-economic feasibility of the energy conservation measure

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2. Approach & Methodology

2.1 Approach

A team of 3 engineers was involved in carrying out the study, the general scope of which was as follows:

- Identify areas of opportunity for energy saving and recommend an action plan to bring down total energy cost
- Conduct energy performance evaluation and process optimization study
- Conduct efficiency test of equipment's and make recommendations for replacement (if required) by more efficient equipment with projected benefits
- Suggest improved operation & maintenance practices
- Provide details of investment for all the proposals for improvement
- Evaluate benefits that accrue through investment and payback period
- Analyze various energy conservation measures and to prioritize based on the maximum energy saving & investment i.e. short, medium and long term.

PRIORITIZATION	PAYBACK PERIOD
Short Term Project	Less than 1 year
Medium Term Project	Between 1 and 3 years
Long Term Project	More than 3 years

2.2 Methodology

The general methodology followed is captured in the following figure –

The study was conducted in 3 stages:

- Stage 1: Walk through audit to understand process energy drivers, measurability and formulation of audit plan
- Stage 2: Detailed Energy Audit
- Stage 3: Off-site work for data analysis and report preparation

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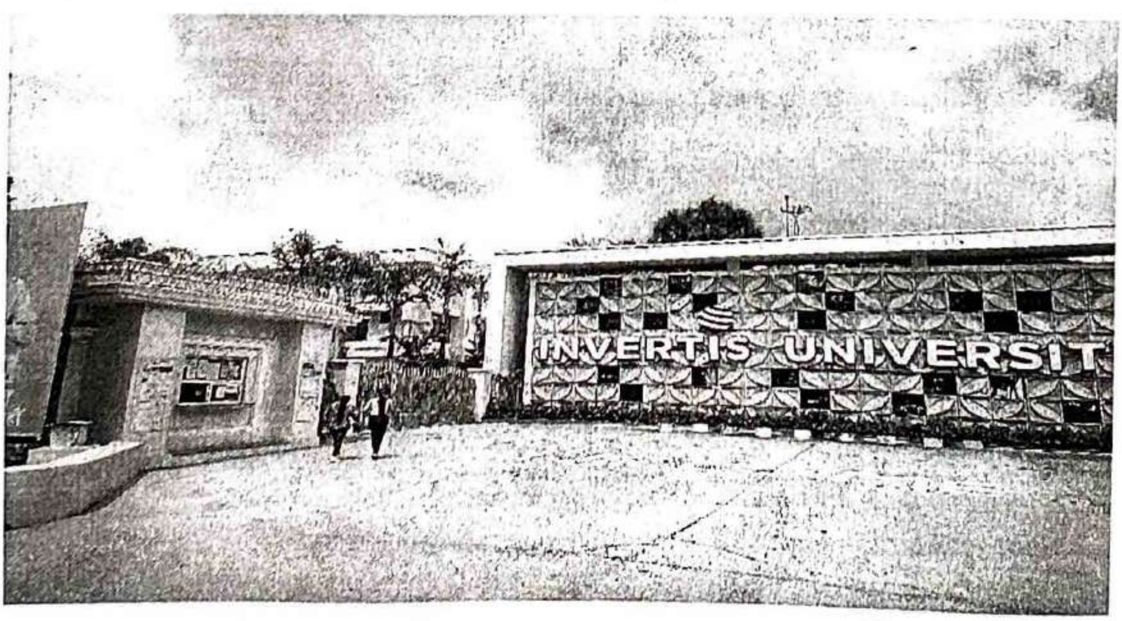
3. About the energy audit location

Invertis University is a private university located in Bareilly, Uttar Pradesh, India. It is situated on Bareilly-Lucknow NH-24, equidistant 250 km from the national capital Delhi and state capital Lucknow. The Chancellor of the university is Umesh Gautam and the Vice-Chancellor is Y. D. S. Arya.

Invertis University has its roots with the Invertis Institute of Management Studies, established 1998 with 83 students. In 2010 it was established as a university

PARTICULARS	UNITS	DETAILS
Name of the establishment	-	Invertis University
Address	-	Invertis Village, Bareilly-Lucknow National Highway – 24, Bareilly (U.P)- 243123
Contact Person	-	Sh. Mr. Santosh Kumar, Registrar
Coordinates		28.2923317°N 79.4915667°E
Website		www.invertisuniversity.ac.in



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4. Base Line Data

Contact Details		
Brief description of Assignment	:	Detailed Energy Audit of Electrical Systems & Utility Equipment's
Name & Address of the Building	:	Invertis University
Operational Days	:	5
Contact Officer	:	Sh. Santosh Kumar, Registrar
Power		
Source	;	Madhyanchal Vidyut Vitaran Nigam Ltd. (MVVNL)
AC No.	:	761702356284
Contracted Load	:	800 KVA
Average Purchased Power Cost	:	
Energy Charge (0-2500 Unit)	:	Rs. 8.32 per KVAh
Energy Charge (2500 Above)	:	Rs. 8.68 per KVAh
Fixed Charges	:	Rs. 430 per KVA
Solar Energy Charges	:	Rs. 6.19 per KWh

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5. Present Energy Scenario

5.1 Purchased Power

Invertis University draws power from the Madhyanchal Vidyut Vitaran Nigam Ltd. (MVVNL) at 11 kV; subsequently the voltage is stepped down by transformers from 11 KV to 0.433 KV. The Contracted load is 800 KW. Billing is done on 11 KV.

5.2 Power Consumption

Invertis University draws power from the Madhyanchal Vidyut Vitaran Nigam Ltd. (MVVNL); for campus comprising of various blocks, building, Hostel & staff quarters etc. The campus is being billed on kVAh basis; therefore the effect of power factor is inbuilt in the billing structure.

5.3 Self-generated Power

The premises has two Nos. DG Sets of 380 & 750 KVA are installed for in-house power generation during power cut. The operation of the DG Sets is during in power cut & testing only.

5.4 Solar PV

The University management has installed 800 KWp solar panel on building roof.

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6. Executive Summary

The Electricity, HSD and solar are sources of energy for the campus. The Invertis University is getting electrical power supply from Madhyanchal Vidyut Vitaran Nigam Ltd. (MVVNL) at 11 kV supply. There are three transformers of 630 KVA, 630 kVA & 400 kVA (11kV/ 0.433 kV) installed and feed to campus. The premise is also having two diesel generators of 380 KVA & 750 KVA provide power supply during power failure/emergency. The one-year electrical bill analysis indicates there is very variation in MDI. The major energy consuming equipment's in the premises are lights, A/C unit, water pumping system, Computer, Printer and other equipment's etc.

- *The Detailed Energy Audit of Invertis University was carried out in the month of June-July 2021 to find out the energy saving potential and the performance level of campus. The report provides the major highlights on potential energy saving opportunities available in the campus and quality of power.*
- *Invertis University draws power from the MVVNL, at 11 kV; subsequently the voltage is stepped down by three transformers of 630 KVA x 2Nos. & 400 KVA from 11 KV to 0.433 KV. The Connected load of premises is 800 KVA.*
- *The campus is being billed on KVAh basis; therefore, the effect of power factor is inbuilt in the billing structure. There are two APFC Panels installed in substation but both APFC panel not working condition. The operating power factor measured varied from 0.695 to 0.991 in main income. However, if we look at the overall average power factor is around 0.938, which is at lower side.*

APFC Panel or the capacitor banks wherein the delivery is poor (less than 70%) or out of order may be replaced, so that the overall system power factor is maintained at around 0.99 (lag). Improvement in the power factor would subsequently reduce the KVAh consumption, the resultant benefits in terms of energy savings. The details of measurement is given in Capacitor Chapter.

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- The harmonics levels in main incomer has been measured and found within range limits in both voltage & current.

Harmonic Level of Main Supply			
Voltage	Max.	Min.	Ave.
THD Phase1 (V)	2.6	0.7	1.3
THD Phase2 (V)	3.5	0.7	1.4
THD Phase3 (V)	2.2	0.7	1.4
Current			
THD Phase1 (A)	4.4	3.8	4.0
THD Phase2 (A)	4.4	3.6	4.0
THD Phase3 (A)	4.4	3.6	3.9

- The Building Management is highly conscious about its Energy Efficiency and cost and has initiated several measures to reduce the energy consumption, which include replacement of conventional lamps with LEDs
- Around 2777 No's of LED Fixture and non LED Fixture installed in premises at different locations and LED Light, Street Light, Flood Light, PL, etc. Energy Efficient LED Lights offer reduction in the power consumption besides excellent color rendering properties and high luminous efficacy
- During the site visit, measurements were taken to record the load profile of the building, which included the variations in the voltage, current, power factor, harmonics etc. Analysis of the recordings indicated that the average voltage level was around 240 Volts. This may be an adequate voltage for motive loads like motors etc., but for the lighting systems normally, the voltage should be around 220 volts (phase to neutral). A reduction of around 15% in the lighting voltage can reduce the power consumption by around 20%.
- Although there is no simpler way to reduce the amount of energy consumed by lighting system than to manually turn OFF whenever not needed, this is not done as often as it could be. In response, automatic lighting control strategies like installation of occupancy sensors can be considered to control light in response to the presence or absence of

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people in the space. Quantification of energy savings on this account is not possible.

- *The Management is highly conscious with regard to its energy efficiency levels and they have initiated several measures to reduce the energy consumption. There are 304 nos. Split AC's, Window A.C & Cassette A.C of various capacity & type installed in the complex. Out of these 304 nos. ACs 220 Nos. are Cassette AC, 46 Nos. are Window AC's, 21 Nos. are Split AC's, 5 Nos. are Floor standing AC's & 12 Nos. Centralized AC's of different Star rating. A-Z Energy Engineers Pvt. Ltd. acknowledges and appreciates the commitment of the management towards conservation of Energy.*
- ***The Management is highly conscious about its Energy Efficiency Levels and they have initiated several measures to reduce the energy consumption, which include amongst others the use of LED lights, Star Rated AC & solar PV etc. A-Z Energy Engineers Pvt. Ltd., acknowledges and appreciates the commitment of the management towards conservation of Energy***

The summary of recommendations are as under:

1. APFC panel required to be maintained properly with adequate numbers of capacitors to improve the Power Factor up to 0.999
2. Installation of capacitors at load-end to raise Power Factor.
3. Proper maintaining of record regarding unit generation from DG Set.
4. Light Sensor be used in office areas.
5. Replacing left-over non-star rated Lighting Fixture with LEDs fixtures and non-star rated ACs with Star rated ACs.
6. Use of smart building management system.
7. Energy Management Certification (ISO 50001 Certification) of the Campus.
8. Cleaning of all light points.
9. Switching of lights in day time where ever not required
10. Switching off lights in day time at locations where there is enough light.
11. Street-light should be in automatic mode, providing the necessary sensors.

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7. Energy Input & Savings

7.1 Energy inputs

Electricity (Utility & Solar PV)	For various machines, equipment, illumination system- offices and work place lighting, platforms, colony, motors, pumps, Instruments etc.
HSD	DG Sets
Renewable Energy	Solar PV

7.1.1 Energy Consumption

There are two source of Energy i.e. Grid supply & own generation through Solar and DG Sets. The Electricity is major Energy input of the premises. The historical consumption pattern for last 12 months are as per following details:

Table.1: Details of Electrical Energy uses from power utility

Sr. No.	Billing Month	MDI	Total electricity consumption (kVAh)
1	Mar 2020	366.6	33810.0
2	April to Aug. 2020	440.0	36350.0
3	Sep. 2020	412.0	19235.0
4	Oct. 2020	412.0	19270.0
5	Nov. 2020	111.6	15835.0
6	Dec. 2020	133.6	40490.0
7	Jan. 2021	146.2	38620.0
8	Feb. 2021	130.6	33200.0
	Total		**236810**
	Avg.	**269.1**	**29601.3**
	Max	**440.0**	**40490.0**
	Min	**111.6**	**15835.0**

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Table. 2: Details of Electrical Energy from Solar PV

Srl.	Month	Unit Generated (kWh)
1	Jul. 2020	90695.3
2	Aug. 2020	88610.1
3	Sep. 2020	82052.4
4	Oct. 2020	87089.0
5	Nov. 2020	70417.0
6	Dec. 2020	55866.0
7	Jan. 2021	49230.0
8	Feb. 2021	67327.0
9	Mar. 2021	89215.0
10	Apr. 2021	102463.0
11	May. 2021	108453.0
12	Jun. 2021	101573.0
	Total	**992990.80**

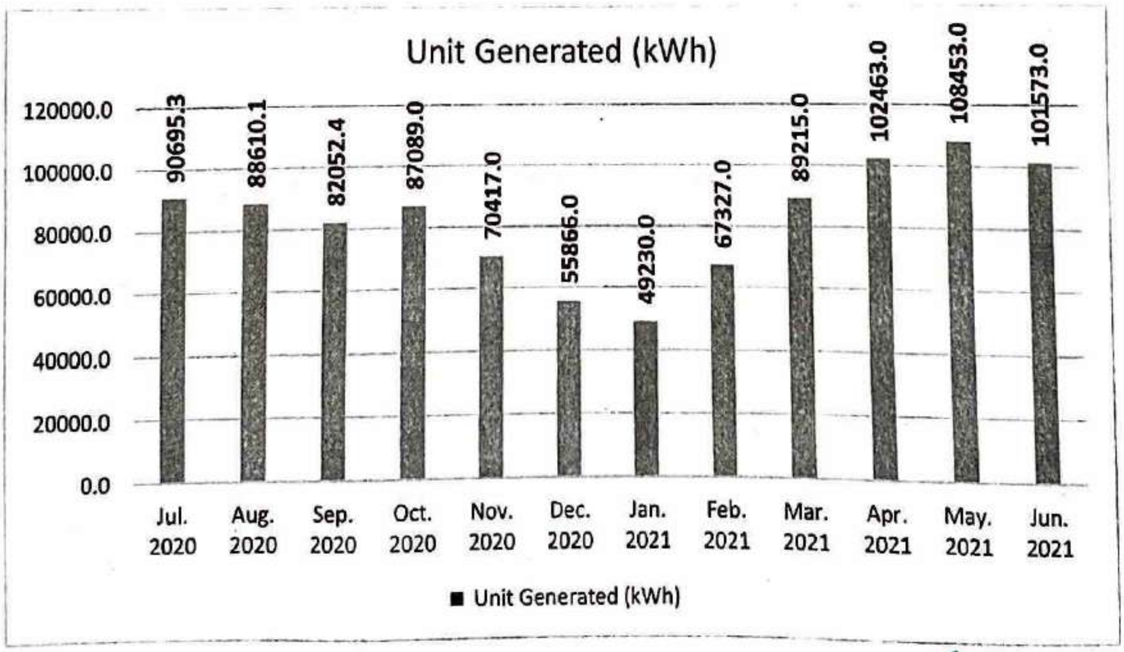

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Table. 3: Details of Electrical Energy from DG

Srl.	Month	Diesel Consumption (Ltrs.)
1	Aug. 2020	1687.9
2	Sep. 2020	1068.8
3	Oct. 2020	331.9
4	Nov. 2020	609.3
5	Dec. 2020	777.3
6	Jan. 2021	378.3
7	Feb. 2021	546.5
8	Mar. 2021	706.8
9	Apr. 2021	702.3
10	May. 2021	1001.1
11	Jun. 2021	1079.3
12	Jul. 2021	1497.8
	Total	**10387**

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7.2 Proposed Summary of Savings

Table.4: Summary of savings

S. No.	Proposed energy conservation measures	Annual energy savings (kVAh/kWh)	Annual monetary savings (INR)	Anticipated investment (INR)	Simple payback period (Month)
1	Improvement of Power Factor to 0.999	16356.0	130848.00	100000.00	9-10
2	Replacement of existing unitary non-star ACs with higher energy five star rated ACs	21641	17312.40	367500.00	25-26
3	Replacement of Old Celling Fan with New Energy Efficient Ceiling Fan	4374	34992.00	100000.00	34-35
4	single phase by load voltage optimization in lighting system	24000	192000.00	200000.00	12-13

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8. Lighting Details

Lighting fixtures are installed in different areas and locations. Premises has already installed energy efficient LED Lights at most of the places. But still some lighting fixtures needs to be replaced with LEDs. Energy Efficient LED Lights offer reduction in the power consumption besides excellent color rendering properties and high luminous efficacy.

Table 5: Types of LED Light

Srl	Fixture	Power Rating (Watt)
1	LED Tube (18W)	18
3	LED Tube (12W)	12
6	LED COBE (18W)	18
7	LED Round (36W)	36
8	LED-36W (2'x2')	36
10	LED Light (30W)	30
11	LED Light (60W)	60
11	LED Light (200W)	200

8.1 Timed Based Control or Daylight Linked Control

Timed-turnoff switches are the least expensive type of automatic lighting control. In some cases, their low cost and ease of installation makes it desirable to use them where more efficient controls would be too expensive. Newer types of timed-turnoff switches are completely electronic and silent. The best choice is an electronic unit that allows the engineering staff to set a fixed time interval behind the cover plate. This system is recommended for street Lighting application in the building. Photoelectric cells can be used either simply to switch lighting on and off, or for dimming. They may be mounted either externally or internally. It is however important to incorporate time delays into the control system to avoid repeated rapid switching caused, for example, by fast moving clouds. By using an internally mounted photoelectric dimming control system, it is possible to ensure that the sum of daylight and electric lighting always reaches the design level by sensing the total light in the controlled area and adjusting the output of the electric lighting accordingly. If daylight alone is able to meet the design requirements, then the electric lighting can be turned off. The energy saving potential of dimming control is greater than a simple photoelectric switching system

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8.2 Localized Switching

Localized switching should be used in applications, which contain large spaces. Local switches give individual occupants control over their visual environment and also facilitate energy savings. By using localized switching it is possible to turn off artificial lighting in specific areas, while still operating it in other areas where it is required, a situation which is impossible if the lighting for an entire space is controlled from a single switch.

8.3 Percentage load of Equipment's

Table 6: Load of Equipment

SL. NO.	NAME OF PLACE	TYPES OF LIGHT	NO. OF LIGHT	COMPANY	WATT
1	MAIN GATE	LED BULB	4	STANZO	40 W
2	GUARD ROOM	TUBE LIGHT	3	PHILIPS	40 W
3	ATM SIDE BOUNDARY	LED BULB	23	STANZO	40 W
4	GUARD ROOM SIDE	LED BULB	9	STANZO	40 W
5	TRANSPORT OFFICE	TUBE LIGHT	1	PHILIPS	40 W
6	MAIN GATE LEFT SIDE WALL	LED LIGHT	1	HAVELLS	40 W
7	MAIN GATE RIGHT SIDE WALL	LED LIGHT	1	HAVELLS	40 W
8	POLE	LED LIGHT	1	HAVELLS	40 W
9	CAR GARAGE	FOCUS LIGHT	9	ORPAT	40 W
10	CAR GARAGE SIDE	PANJI LIGHT	1	CROMPTON	40 W
11	LIFT SIDE	LAMP LIGHT	12	ORPAT	40 W
12	ADMIN OFFICE MAIN ENTRANCE	LED LIGHT	5	STANZO	40 W
13	VICE CHANCELLOR SIR'S OFFICE	TUBE LIGHT/ LED LIGHT	9	PHILIPS /STANZO	40 W
14	ADMIN KITCHEN	TUBE LIGHT	1	PHILIPS	40 W
15	ADMIN OFFICE		39	STANZO	40 W
16	MARCOM OFFICE	LED LIGHT	11	STANZO	40 W
17	HR OFFICE	LED LIGHT	13	STANZO	40 W
18	ADVISOR ROOM	LED LIGHT	7	STANZO	40 W
19	CONFERENCE HALL 1	LED LIGHT	7	STANZO	40 W
20	CONFERENCE HALL 2	LED LIGHT	15	STANZO	40 W
21	EXECUTIVE DIRECTOR SIR'S OFFICE	LED LIGHT	20	STANZO	40 W
22	CHANCELLOR SIR'S OFFICE	LED LIGHT	12	STANZO	40 W
23	ACCOUNTS OFFICE	LED LIGHT	12	STANZO	40 W
24	NEAR COMPUTER CENTRE	PANJI LIGHT	1	CROMPTON	40 W
25	COMPUTER CENTRE BACK SIDE	PANJI LIGHT	1	CROMPTON	40 W
26	BUS STAND SIDE	LED LIGHT	1	HAVELLS	40 W
27	M-BLOCK SIDE POLE	LED LIGHT	2	HAVELLS	40 W
28	FRONT OF PETROL PUMP	LED LIGHT	4	HAVELLS	40 W
29	FRONT OF AUDITORIUM POLE	LED LIGHT	6	HAVELLS	40 W

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SL. NO.	NAME OF PLACE	TYPES OF LIGHT	NO. OF LIGHT	COMPANY	WATT
30	CRICKET GROUND UNIVERSITY BUILDING	LED LIGHT	6	HAVELLS	40 W
31	FOOTBALL GROUND UNIVERSITY BUILDING	LED LIGHT	6	HAVELLS	40 W
32	B.TECH BUILDING POLE	LED LIGHT	2	HAVELLS	40 W
33	UNIVERSITY BUILDING ROAD	HANDI LIGHT	35	STANZO	40 W
34	KAVERI HOSTEL (GIRLS HOSTEL)				40 W
35	GROUND FLOOR	TUBE LIGHT	25	PHILIPS	40 W
36	FIRST FLOOR	TUBE LIGHT	25	PHILIPS	40 W
37	SECOND FLOOR	TUBE LIGHT	25	PHILIPS	40 W
38	OPEN AREA KAVERI HOSTEL				40 W
39	GROUND FLOOR	TUBE LIGHT	4	PHILIPS	40 W
40	FIRST FLOOR	TUBE LIGHT	6	PHILIPS	40 W
41	SECOND FLOOR	TUBE LIGHT	4	PHILIPS	40 W
42	BHAGIRATHI HOSTEL				40 W
43	GROUND FLOOR	TUBE LIGHT	65	PHILIPS	40 W
44	FIRST FLOOR	TUBE LIGHT	64	PHILIPS	40 W
45	SECOND FLOOR	TUBE LIGHT	65	PHILIPS	40 W
46	THIRD FLOOR	TUBE LIGHT	64	PHILIPS	40 W
47	OPEN AREA BHAGIRATHI HOSTEL				40 W
48	GROUND FLOOR	TUBE LIGHT	12	PHILIPS	40 W
49	FIRST FLOOR	TUBE LIGHT	12	PHILIPS	40 W
50	SECOND FLOOR	TUBE LIGHT	11	PHILIPS	40 W
51	THIRD FLOOR	TUBE LIGHT	11	PHILIPS	40 W
52	GROUND FLOOR WASHROOM	TUBE LIGHT	12	PHILIPS	40 W
53	FIRST FLOOR WASHROOM	TUBE LIGHT	12	PHILIPS	40 W
54	SECOND FLOOR WASHROOM	TUBE LIGHT	12	PHILIPS	40 W
55	TOP FLOOR WASHROOM	TUBE LIGHT	12	PHILIPS	40 W
56	GODAVARI HOSTEL				40 W
57	GROUND FLOOR	TUBE LIGHT	31	PHILIPS	40 W
58	FIRST FLOOR	TUBE LIGHT	41	PHILIPS	40 W
59	SECOND FLOOR	TUBE LIGHT	37	PHILIPS	40 W
60	OPEN AREA GODAVARI HOSTEL				40 W
61	GROUND FLOOR	TUBE LIGHT	15	PHILIPS	40 W
62	FIRST FLOOR	TUBE LIGHT	12	PHILIPS	40 W
63	SECOND FLOOR	TUBE LIGHT	11	PHILIPS	40 W
64	WARDEN'S OFFICE	TUBE LIGHT	2	PHILIPS	40 W
65	HIMALAYA HOSTEL (BOYS HOSTEL)				40 W
66	GROUND FLOOR	TUBE LIGHT	22	PHILIPS	40 W
67	FIRST FLOOR	TUBE LIGHT	25	PHILIPS	40 W
68	SECOND FLOOR	TUBE LIGHT	25	PHILIPS	40 W
69	HIMGIRI HOSTEL				40 W

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SL. NO.	NAME OF PLACE	TYPES OF LIGHT	NO. OF LIGHT	COMPANY	WATT
70	GROUND FLOOR	TUBE LIGHT	37	PHILIPS	40 W
71	FIRST FLOOR	TUBE LIGHT	34	PHILIPS	40 W
72	SECOND FLOOR	TUBE LIGHT	36	PHILIPS	40 W
73	NILGIRI HOSTEL				40 W
74	GROUND FLOOR	TUBE LIGHT	85	PHILIPS	40 W
75	FIRST FLOOR	TUBE LIGHT	85	PHILIPS	40 W
76	SECOND FLOOR	TUBE LIGHT	85	PHILIPS	40 W
77	THIRD FLOOR	TUBE LIGHT	85	PHILIPS	40 W
78	SHIVALIK HOSTEL				40 W
79	GROUND FLOOR	TUBE LIGHT	26	PHILIPS	40 W
80	FIRST FLOOR	TUBE LIGHT	25	PHILIPS	40 W
81	SECOND FLOOR	TUBE LIGHT	24	PHILIPS	40 W
82	THIRD FLOOR	TUBE LIGHT		PHILIPS	40 W
83	GUEST HOUSE NO. 1	TUBE LIGHT		PHILIPS	40 W
84	GUEST HOUSE NO. 2	TUBE LIGHT	5	PHILIPS	40 W
85	GUEST HOUSE NO.3	TUBE LIGHT	5	PHILIPS	40 W
86	GUEST HOUSE NO. 4	TUBE LIGHT	6	PHILIPS	40 W
87	GUEST HOUSE NO. 5	TUBE LIGHT	5	PHILIPS	40 W
88	GUEST HOUSE NO. 6	TUBE LIGHT	5	PHILIPS	40 W
89	VICE CHANCELLOR SIR'S RESIDENCE	TUBE LIGHT	11	PHILIPS	40 W
90	DIRECTOR ADMINISTRATION SIR'S RESIDENCE	TUBE LIGHT	11	PHILIPS	40 W
91	ACADEMIC BLOCK -1 (M-BLOCK)	CONCEALED LIGHT/ TUBE LIGHT	180	STANZO / PHILIPS	40 W
92	ACADEMIC BLOCK - 2 (B.TECH BUILDING)	CONCEALED LIGHT/ TUBE LIGHT	300	STANZO/ PHILIPS	40 W
93	UNIVERSITY BUILDING	CONCEALED LIGHT / TUBE LIGHT		STANZO/ PHIPLIPS	40 W/ 18 W
94	STAFF QUARTER	TUBE LIGHT	30	PHILIPS	40 W
95	FACULTY QUARTER	TUBE LIGHT	134	PHILIPS	40 W
96	MESS DOMATTORY	TUBE LIGHT	24	PHILIPS	40 W
97	COMPUTER CENTRE	TUBE LIGHT	125	PHILIPS	40 W
98	WORKSHOP	TUBE LIGHT	51	PHILIPS	40 W
99	SEMINAR BUILDING	TUBE LIGHT	29	PHILIPS	40 W
100	STORE	TUBE LIGHT	4	PHILIPS	40 W
101	MESS	TUBE LIGHT/ CONCEALED LIGHT	89	STANZO/ PHILIPS	40 W
102	AUDITORIUM	TUBE LIGHT	20	PHILIPS	40 W
103	OLD LIBRARY	TUBE LIGHT	86	PHILIPS	40 W
104	NEW LIBRARY IN UNIVERSITY BUILDING	CONCEALED LIGHT	191	STANZO	18 W
105	POWER HOUSE	TUBE LIGHT	1	PHILIPS	40 W
106	DRIVER ROOM	TUBE LIGHT	1	PHILIPS	40 W

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9. Improvement in operating Power Factor

The premises is being billed on kVAh basis; therefore the effect of power factor is inbuilt in the billing structure. There are two APFC Panel installed in substation but both APFC panel not working & de-rated. Based on the electrical bills the operating power factor on the main incomer is varies from 0.695 - 0.991, the average power factor was around 0.938, which appears to be on the lower side. It is thus recommended to install more capacitor banks on the main feeder so that the overall system power factor is maintained at around 0.99 (lag). Improvement in the power factor would subsequently reduce the KVAh consumption, resulting in energy savings as follows:

The month of July-2020 MVVNL bill power factor show 0.920, which is low side. However, it is recommended that capacitor (200 KVAR) are required to be installed/shifted at load center-end for improving the power factor

9.1 Improvement in the Operating Power Factor

The campus is being billed on KVAh basis; therefore, the effect of power factor is inbuilt in the billing structure. However, it is recommended that capacitor (200 KVAR) are required to be installed/shifted at load center-end for improving the power factor.

It is thus recommended to install additional capacitor banks on the APFC Panel or the capacitor banks wherein the delivery is poor (less than 70%) or out of order may be replaced, so that the overall system power factor is maintained at around 0.99 (lag). Improvement in the power factor would subsequently reduce the KVAh consumption, resulting in energy savings as follows:

9.2 Energy Saving

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Table 7: Energy saving potential to improved power factor

	July 2020 Billing	
A	Power Consumption at Present	17015 KWh
B	Power Consumption at Present	18550 KVAh
C	Average Operating Power factor at present (A/B)	0.920
D	Average Power Consumption post improvement of power factor from 0.920 to 0.99 (A/0.99)	17187 KVAh

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E	Net Reduction in Power Consumption May Month Bill (B-D)	1363 KVAh per month
F	Total Monitory Benefit month of Avg (**Rs. 8.0/kVAh)**	Rs. 10904
G	Average Total Monitory Benefit per Annual (F X 12)	130848
H	Estimated Investments [for Capacitor Panel]	Rs 1.0 Lakhs
I	Simple Payback Period	9-10

Implementation of this measure needs an investment of INR 1.0 Lakhs and will have a simple payback period of 9-10 months.

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10.Lighting system in single phase by load voltage optimization

During our study, we found that the voltage level of the plant was at 237-240 volt for Single phase and 426 – 431 for three phase system.

It was observed that there is no segregation for lighting / single phase load and three phase motive load i.e. all three phases and single phase load are running with common voltage supply.

It is our suggestion that all lighting single phase load should be separated and be feed by a suitable rating voltage stabilizer. A huge amount of power can be saved because all single phase load appliances are designed for 220 V supply.

Example

Total single phase load measured for lighting Load approx. = 120 KW

Average 60 % load is running = 72 KW

Existing voltage level = 240 V

Proposed voltage level = 200 V

Percentage deduction in voltage = 16.67%

Power saving in KW / hour = 12 KW

Saving in power = 24000 kWh per year

Annual monitory saving @ Rs. 8.00 / kWh

12.0 x 8 x 250 x 8.00 = Rs. 192000/-

Investment required for voltage optimizer of 1 no. 200 KVA SVS for lighting and other connected load with LT panel for output voltage of 330 - 440 V, output voltage 380 is Rs. 2,00,000/- Payback period = 12-13 months (Approximate)

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11. Window/Split AC Units Specification

Split / Window AC's are installed at several locations in the campus. The details of AC are as follows:

Table 8: Details of AC's

SL. NO. AREA	NAME OF BUILDING	TYPES OF AC	NO. OF AC	CAPACITY (TR)	COMPANY
1	ADMIN BUILDING				
	CHANCELLOR SIR'S OFFICE	CASSETTE AC	1	3	DAIKIN
	VICE CHANCELLOR SIR'S OFFICE	WINDOW AC	1	1.5	DAIKIN
	MARCOM OFFICE	WINDOW AC	2	1.5	SAMSUNG
	HR OFFICE	WINDOW AC	1	1.5	GODREJ
	ADMIN (ADMISSION CELL DESK)	CASSETTE AC, FLOOR STANDING AC	1, 2	2 , 4	DAIKIN
	CONFERENCE HALL 1	SPLIT AC	1	1.5	DAIKIN
	CONFERENCE HALL 2	CASSETTE AC	3	3	DAIKIN
	ACCOUNTS OFFICE	SPLIT AC	1	1.5	DAIKIN
	EXECUTIVE DIRECTOR	SPLIT AC	1	1.5	DAIKIN
2	SEMINAR BUILDING				
	CRC OFFICE	SPLIT AC	2	1.5	DAIKIN
	SEMINAR HALL 1	CASSETTE AC	5	3	DAIKIN
	SEMINAR HALL 2	CASSETTE AC	5	3	DAIKIN
3	ACADEMIC BLOCK 1 (M-BLOCK)				
	DIRECTOR ADMINISTRATOR SIR'S OFFICE	WINDOW AC	1	1.5	SAMSUNG
	DEAN OF ENGINEERING	SPLIT AC	1	1.5	DAIKIN
	ROOM NO. 1	FLOOR STANDING AC	1	4.5	DAIKIN
	FACULTY CABIN GROUND FLOOR	WINDOW AC	1	1.5	SAMSUNG
	ROOM NO. 8	WINDOW AC	1	1.5	SAMSUNG
	FACULTY CABIN SECOND FLOOR	WINDOW AC	1	1.5	SAMSUNG
	ROOM NO. 18	WINDOW AC	1	1.5	SAMSUNG
	CHIEF PROCTOR'S OFFICE	WINDOW AC	1	1.5	SAMSUNG
	ROOM NO. 29	CASSETTE AC	1	3	DAIKIN
	ROOM NO.30	CASSETTE AC	1	3	DAIKIN
	ROOM NO.32	CASSETTE AC	1	3	DAIKIN
4	COMPUTER CENTRE				

SL. NO. AREA	NAME OF BUILDING	TYPES OF AC	NO. OF AC	CAPACITY (TR)	COMPANY
	LAB NO. 1	CENTRALIZED AC	1	8	DAIKIN
	LAB NO. 2	CENTRALIZED AC	1	8	DAIKIN
	LAB NO. 3	CENTRALIZED AC	1	8	DAIKIN
	LAB NO. 4	CENTRALIZED AC	1	8	DAIKIN
	LAB NO.5	CENTRALIZED AC	1	8	DAIKIN
	LAB NO. 6	CENTRALIZED AC	1	8	DAIKIN
	LAB NO. 7	CENTRALIZED AC	1	8	DAIKIN
	LAB NO.8	CENTRALIZED AC	1	8	DAIKIN
	LAB NO.9	CENTRALIZED AC	1	8	DAIKIN
	LAB NO. 10	CENTRALIZED AC	1	8	DAIKIN
	LAB NO. 11	CENTRALIZED AC	1	8	MITSHUBHI
	LAB NO. 12	CENTRALIZED AC	1	8	DAIKIN
5	ACADEMIC BLOCK 2 (B.TECH BUILDING)				
	DEAN STUDENT WELFARE	SPLIT AC	1	1.5	SAMSUNG
	ROOM NO. 1	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 2	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 3	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 4	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 5	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 6	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 7	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 8	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 9	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 10	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 11	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 12	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 13	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 14	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 15	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 16	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 17	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 18	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 19	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 20	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.21	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.22	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.23	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.24	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 25	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 26	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.27	CASSETTE AC	2	4.5	DAIKIN

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SL. NO. AREA	NAME OF BUILDING	TYPES OF AC	NO. OF AC	CAPACITY (TR)	COMPANY
	ROOM NO. 28	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.29	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 30	CASSETTE AC	2	4.5	DAIKIN
	HoD CABIN	WINDOW AC	1	1.5	SAMSUNG
	FACULTY CABIN FIRST FLOOR RIGHT SIDE	WINDOW AC	1	1.5	SAMSUNG
	FACULTY CABIN FIRST FLOOR LEFT SIDE	WINDOW AC	1	1.5	SAMSUNG
	FACULTY CABIN SECOND FLOOR RIGHT SIDE	WINDOW AC	1	1.5	SAMSUNG
	FACULTY CABIN SECOND FLOOR LEFT SIDE	WINDOW AC	1	1.5	SAMSUNG
6	ACADEMIC BLOCK 3 (UNIVERSITY BUILDING)				
GROUND FLOOR	ROOM NO. 1	CASSETTE AC	2	4.5 / 2.5	DAIKIN
	ROOM NO. 2	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 3	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 4	CASSETTE AC	2	4.5 / 2.5	DAIKIN
	ROOM NO. 5	CASSETTE AC	2	4.5 / 2.5	DAIKIN
	ROOM NO. 6	CASSETTE AC	2	4.5 / 2.5	DAIKIN
	ROOM NO. 7	CASSETTE AC	2	4.5 / 2.5	DAIKIN
	ROOM NO. 8	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 9	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 10	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 11	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 12	CASSETTE AC	2	4.5	DAIKIN
	TEA POINT	SPLIT AC	1	1.5	DAIKIN
	ASST. REGISTRAR	SPLIT AC	1	1.5	DAIKIN
	REGISTRAR OFFICE	SPLIT AC	1	1.5	DAIKIN
	FACULTY CABIN	CASSETTE AC	1	4.5	DAIKIN
	MOOT COURT	CASSETTE AC	1	4.5	DAIKIN
	CONFERENCE ROOM	CASSETTE AC	2	4.5 /2.5	DAIKIN
FIRST FLOOR	ROOM NO. 13	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 14	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 15	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 16	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 17	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.18	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 19	CASSETTE AC	2		DAIKIN
	ROOM NO. 20	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 21	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 22	CASSETTE AC	1	4.5	DAIKIN

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SL. NO. AREA	NAME OF BUILDING	TYPES OF AC	NO. OF AC	CAPACITY (TR)	COMPANY
	ROOM NO. 23	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO.24 FACULTY CABIN	CASSETTE AC	2	4.5	DAIKIN
	CHIEF PROCTOR'S OFFICE	SPLIT AC	1	1.5	DAIKIN
	HoD CABIN LEFT SIDE	SPLIT AC	1	1.5	DAIKIN
	HoD CABIN RIGHT SIDE	SPLIT AC	1	1.5	DAIKIN
	FACULTY CABIN RIGHT SIDE	CASSETTE AC	1	4.5	DAIKIN
	FACULTY CABIN LEFT SIDE	CASSETTE AC	1	4.5	DAIKIN
SECOND FLOOR	DEAN'S ACADEMIC	SPLIT AC	1	1.5	DAIKIN
	ROOM NO. 30	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.31	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.32	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 44 CABIN	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 45	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 46	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO 47	CASSETTE AC	1	4.5	DAIKIN
	HoD CABIN	SPLIT AC	1	4.5	DAIKIN
	HoD CABIN	SPLIT AC	1	4.5	DAIKIN
	ROOM NO. 50	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 51	CASSETTE AC	1	4.5	DAIKIN
	ROOMK NO.52	CASSETTE AC	1	4.5	DAIKIN
	GAME LAB	CASSETTE AC	2	4.5	DAIKIN
	COMPUTER LAB	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO.55	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 56	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 57	CASSETTE AC	2	4.5	DAIKIN
	SERVER ROOM	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 59 LAB	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 60 LAB	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 61 LAB	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. LAB 62	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 66 FACULTY CABIN	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 67	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 68	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 69	CASSETTE AC	2	4.5	DAIKIN
	CHIEF PROCTOR SIR'S OFFICE	SPLIT AC	1	4.5	DAIKIN
TOP FLOOR	ROOM NO. 72	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 73	CASSETTE AC	2	4.5	DAIKIN

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SL. NO. AREA	NAME OF BUILDING	TYPES OF AC	NO. OF AC	CAPACITY (TR)	COMPANY
	ROOM NO. 74	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 75 BIOTECH LAB	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO.87	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 88	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 89	CASSETTE AC	2	4.5	DAIKIN
	HOD CABIN	SPLIT AC	1	4.5	DAIKIN
	HOD CABIN	SPLIT AC	1	4.5	DAIKIN
	ROOM NO. 92	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 93	CASSETTE AC	3	4.5	DAIKIN
	ROOM NO. 94	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 96 ARCHITECTURE HALL	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 97	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 98	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 99	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 100 ARCHITECTURE	CASSETTE AC	4	4.5	DAIKIN
	ROOM NO. 104 FACULTY CABIN	CASSETTE AC	1	4.5	DAIKIN
	ROOM NO. 105	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 106	CASSETTE AC	2	4.5	DAIKIN
	ROOM NO. 107	CASSETTE AC	2	4.5	DAIKIN
7	GUEST HOUSE NO.1				
	ROOM NO. 1	WINDOW AC	1	1.5	DAIKIN
	ROOM NO.2	WINDOW AC	1	1.5	GODREJ
	ROOM NO. 3	WINDOW AC	1	1.5	GODREJ
8	GUEST HOUSE NO. 2				GODREJ
	ROOM NO. 1	WINDOW AC	1	1.5	
	ROOM NO. 2	WINDOW AC	1	1.5	GODREJ
	ROOM NO.3	WINDOW AC	1	1.5	GODREJ
9	GUEST HOUSE NO.3				GODREJ
	ROOM NO. 1	WINDOW AC	1	1.5	
	ROOM NO. 2	WINDOW AC	1	1.5	GODREJ
	ROOM NO. 3	WINDOW AC	1	1.5	GODREJ
10	GUEST HOUSE NO.4				GODREJ
	ROOM NO. 1	WINDOW AC	1	1.5	
	ROOM NO. 2	WINDOW AC	1	1.5	GODREJ
	ROOM NO. 3	WINDOW AC	1	1.5	GODREJ
11	GUEST HOUSE NO.5				GODREJ
	ROOM NO. 1	WINDOW AC	1	1.5	
	ROOM NO. 2	WINDOW AC	1	1.5	GODREJ
12	GUEST HOUSE NO. 6				GODREJ
	ROOM NO. 1	WINDOW AC	1	1.5	GODREJ

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SL. NO. AREA	NAME OF BUILDING	TYPES OF AC	NO. OF AC	CAPACITY (TR)	COMPANY
	ROOM NO.2	WINDOW AC	1	1.5	GODREJ
13	VICE CHANCELLOR SIR'S RESIDENCE				
	ROOM NO. 1	WINDOW AC	1	1.5	GODREJ
	ROOM NO. 2	WINDOW AC	1	1.5	GODREJ
14	DIRECTOR ADMINISTRATOR SIR RESIDENCE				
	ROOM NO. 2	WINDOW AC	1	1.5	GODREJ
15	FACULTY QUARTER A2	WINDOW AC	1	1.5	DAIKIN
16	FACULTY QUARTER B1	WINDOW AC	2	1.5	DAIKIN
17	OLD CAFFE	CASSETTE AC	8	4.5	DAIKIN
18	NEW CAFFE	CASSETTE AC	4	4.5	DAIKIN
19	NILGIRI BOYS HOSTEL	WINDOW AC	1	1.5	DAIKIN
20	HIMGIRI BOYS HOSTEL GYM	SPLIT AC	2	1.5	DAIKIN
21	HIMALAYA BOYS HOSTEL	WINDOW AC	3	1.5	DAIKIN
22	SHIVALIK BOYS HOSTEL	WINDOW AC	3	1.5	DAIKIN
23	LIBRARY UNIVERSITY BUILDING	CASSETTE AC	5	4.5	DAIKIN
24	OLD LIBRARY	FLOOR STANDING AC	3	4	DAIKIN
25	GODAVARI GIRLS HOSTEL GYM	WINDOW AC	2	1.5	

Indicative TR Load Profile for Air Conditioning

Small Office Cabins	: 0.1 TR m^2
Medium Size Office with 10-30 people occupancy with Central A/c	: 0.06 TR/m^2
Large Multistoried office complex with Central A/c	: 0.04 TR/m^2

There are 304 nos. Split AC's, Window A.C & Cassette A.C of various capacity & type installed in the complex. Out of these 304 nos. ACs 220 Nos. are Cassette AC, 46 Nos. are Window AC's, 21 Nos. are Split AC's, 5 Nos. are Floor standing AC's & 12 Nos. Centralized AC's of different Star rating. Some Air conditioning system is not operating during the energy audit. AZ Energy Engineers Pvt. Ltd. acknowledges and appreciates the commitment of the management towards conservation of Energy. Further it is recommended to replace left-over non-star rates ACs with Star Rated ACs, resulting further saving in energy.

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Existing Non-star AC to be replaced with 5 Star AC's		
Particulars	**Unit**	**Value**
Existing ACs need to be replaced	Number (1.5 tr)	10
Total Cooling Load	TR	15
Cost of Energy Efficient ACs	INR/Piece	35000
Operating parameters		
Particulars	**Unit**	**Value**
Number of running hours	Per Day	10
Number of operating Days	Per Year	210
Average life of Energy Efficient ACs	Years	8
Average Electricity tariff	INR/kVAh	8
Energy and financial savings		
Parameters	**Unit**	**Value**
Power consumption of Non Star Acs-Measured value	kW/TR	2.364
Power Consumption of 5 Star rated	kW/TR	1.677
Total Power consumption of Existing Non-Star rated ACs	kW	35.46
Total power consumption of 5 star rated ACs	kW	25.16
Energy Savings	kW	10.31
Annual energy savings	kWh/year	21641
Annual monetary savings	INR/year	173124
Installation charges	@5%	17500
Total investment required	INR	367500
Simple payback period	Months	25
Internal rate of return (IRR)	%	41.04%

Table 9: Savings in replacement of Non star AC'S to star rated AC'S

Recommendation/ Observation of AC System

- Monthly cleaning schedule Air Filters
- Replace Damage filters.
- Yearly service
- Check and clean condenser coils
- Check and clean air filters
- Check pipe Insulation

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12. Ceiling Fan

There are many number of ceiling fans installed at various office rooms & building in the University. All these ceiling fans are very old and consumes around 60-70 W. In market more efficient fan is available so management change to old fan to new energy efficient fan BEE star rated in face manner.

General Suggestion

Present power consumption of the conventional fan is 70-80 Watt. We have suggested replace this fan with 5 star fan, as per Star BEE labelling programme Notification. 5 Star rated fan power consumption is 43 Watt. Monetary saving is describe below table,

Table 10: Old Celling Fan replace by New Energy Efficient Fan

Parameter	Units	Watt
Conventional Fan Power Consumption	Watt	70
Conventional Fan Air Delivery	m3/min	200
5 Star Energy Efficient Fan Power Consumption	Watt	43
5 Star Energy Efficient Fan Air Delivery	m3/min	220
Celling Fan Quantity	Nos.	50
Saving in Power Consumption	kW	1.35
Calculated Annual Saving In Power Consumption @ 270 Days @ 12 Hr.	kWh	4374
Calculated Annual Cost Saving @ INR 8.0/kWh	INR	34992
Estimated Investment for New Fan @ INR 2000/fan	INR	100000
Simple Pay Back Period	Month	34-35

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13. Self-Power Generation (D.G)

The campus has two nos. DG Sets of 380 kVA & 750 kVA installed for in- house power generation & supply during power cut, power failure and backup during day/night operations. The technical details of these DG sets are as under:

13.1 D.G. Rated Specification

Table 11: Technical details of DG sets

Name Plate Data		DG-1	DG-2
ALTERNATOR			
Rated	kVA	380	750
	KW	304	600
Voltage	L.V.	415	415
Amp.	L.V.	529	1043
Phase		3	3
P.F.		0.8	0.8
RPM		1500	1500
Frequency	Hz	50	50
Excitation	Volts	48	52
Excitation	Amps	2.3	2.5

Historical data of DG set running hours and fuel consumption given below.

13.2 Performance Assessment of D.G

During the audit we measured the specific fuel consumption (kWh/Ltr.) of DG sets. The load profile of the electrical parameters was recorded by using a portable 3-phase power analyzer. During the recording, the power analyzer recorded all the electrical parameters for further detailed analysis. The analysis of the different parameters recorded 1 Hr. Reading at the L.T. incoming main supply and during this period the diesel consumption was also recorded empty tank method.

Particular	Unit	DG-2 (380 KVA)
Time	Hr.	1 Hr.
Unit Generate	kWh	210
Fuel Consumption	Ltr.	75.0
SEC	kWh/Ltr.	**2.9**

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13.3 Historical Fuel Analyses Data

Analyses of last one-year DG log book details for Aug 2020 to Jul. 2021. Specific energy consumption shows in below table as per standard

Table 12: Historical Energy Consumption of DG set

Srl.	Month	Diesel Consumption (Ltr.)
1	Aug. 2020	1687.9
2	Sep. 2020	1068.8
3	Oct. 2020	331.9
4	Nov. 2020	609.3
5	Dec. 2020	777.3
6	Jan. 2021	378.3
7	Feb. 2021	546.5
8	Mar. 2021	706.8
9	Apr. 2021	702.3
10	May. 2021	1001.1
11	Jun. 2021	1079.3
12	Jul. 2021	1497.8
	Total	10387
	Avg.	866.0

Further observations and recommendations are as under:

1. The specific fuel consumption (SFC) of DG sets in the range of 2.8 to 3.5 kWh/ltr, as present Average SPC of all DG set is 2.9 kWh/Ltr. which is okay.
2. D.G. sets are neat & clean
3. DG set room have been with Proper Ventilation
4. However, there is No-Load Testing schedule

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13.4 Fuel Gas Analyses

1. TYPICAL DIESEL EXHAUST GAS COMPOSITION

Component		Typical Component Concentration Range in Diesel Exhaust Gas	Component Concentration in Natural Dry Ambient Air
Nitrogen	N_2	75 – 77 %-vol	78.08 %-vol
Oxygen	O_2	11.5 – 15.5 %-vol	20.95 %-vol
Carbon dioxide	CO_2	4 – 6.5 %-vol	0.038 %-vol
Water	H_2O	4 – 6 %-vol	
Argon	Ar	0.8 %-vol	0.934 %-vol
Totally		> 99.7 %-vol	

%-vol: Concentration, percentage, volume basis

ppm-vol: Concentration, parts per million, volume basis

Additional components found in diesel exhaust – typical concentration range (steady state, high load, residual and distillate fuel oil):

Nitrogen oxides	NO_x:	1000 - 1500 ppm-vol
Sulphur oxides	SO_x	30 - 900 ppm-vol: Fuel composition related
Carbon monoxide	CO	20 - 150 ppm-vol
Total Hydrocarbons	THC (as CH_4)	20 - 100 ppm-vol
Volatile org.comp.	VOC (as CH_4)	20 - 100 ppm-vol
Particulates *)	PM	20 - 100 mg/Nm³, dry, 15% O_2: Fuel composition related
Smoke:	Related to low load (<50% load), start-up and fast load increase	

13.5 Diesel Generator Stack Height

DG sets emit some amounts of oxides of Nitrogen, Carbon Monoxide, Sulphur Dioxide, and other particulate matter, which can harm the surrounding habitat and organisms. This is why the CPCB has laid down a specific formula for deriving a minimum stack height of the DG sets' exhaust outlet with respect to the height of the facility it is installed in to ensure that the emissions don't come on contact with the surrounding habitat.

Calculating Stack Height of DG sets For A Facility:

The minimum height of stack to be provided with each generator set can be worked out using the following formula:

$H = h + 0.2 \times \sqrt{KVA}$

Where:

H = Total height of stack in meter

h = Height of the building in meters where the generator set is to be installed

KVA = Total generator capacity of the set in KVA

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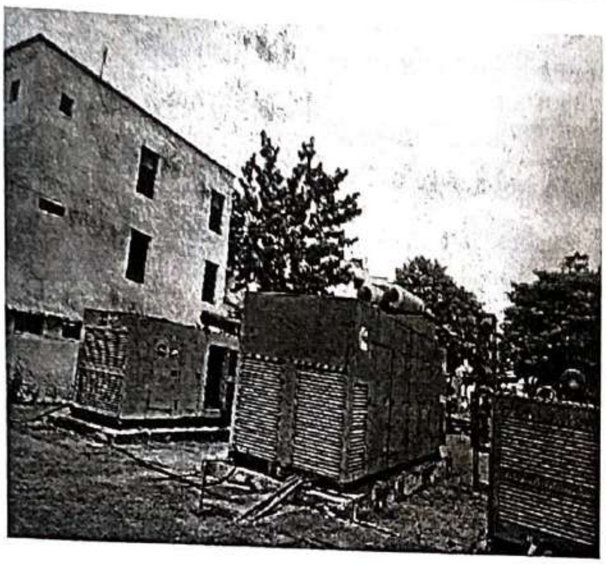
This is an explicit formula for DG SET stack height calculation, irrespective of the type of industries where the generator set is installed.

Based on the above formula the minimum stack height to be provided with different range of generator sets



DG Set exhaust not provided as per CPCB requirement. It should be raised to a height required as per norms

Recommendations for Energy Efficiency Measures in DG Sets

1. Ensure Steady load condition on the DG set and avoid idle running.
2. Improve air filtration.
3. Ensure fuel oil storage, handling and preparation as per manufacturers' guidelines/oil company data.
4. Calibrate and overhaul fuel injectors and injection pumps regularly as recommended by manufacturer.
5. Ensure compliance with maintenance checklist
6. Ensure steady load conditions, avoiding fluctuations, imbalance in phases, harmonic loads.
7. Carryout regular field trials to monitor DG set performance, and maintenance planning as per requirements.
8. Efficiency of DG Set can be increase by loading 70-80% load
9. The starting current of squirrel cage induction motor is as much as six times the rated current for a few seconds with direct-on-line starters. In practice, it has been found that the starting current value should not exceed 200% of the full load capacity of the alternator. The voltage and frequency throughout the motor starting

interval recovers and reaches rated values usually much before the motor has picked up full speed

10. It is always recommended to have the load as much balanced as possible, since the unbalanced loads can cause heating of the alternator, which may result in unbalanced output voltage. The maximum unbalanced load between phases should not exceed 10% of the capacity of the generating sets.
11. The electricity rules clearly specify that two independent earths to the body and neutral should be provided to give adequate protection to the equipment in case of an earth fault and to drain away any leakage of potential from the equipment to the earth.

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14. Solar Photovoltaic Cell

The campus has already installed 800 kWP Solar PV. Solar generation power is connected to the panel and consumed energy in-house plant. A photovoltaic power system is an electricity generating Solar PV power system that is connected to the main LT panel. The total generation recorded since installation up to the time of energy audit is as follows:

Table 13: Details of Power Generation from Solar Plant

Sr No.	Month	No of days	Unit Generated (kWh)	kWh/ Day	kWh/kWp /day	Amount	CUF (%)
1	Jul. 2020	31	90695.3	2925.65	3.66	545079	15.2
2	Aug. 2020	31	88610.1	2858.39	3.57	532547	14.9
3	Sep. 2020	30	82052.4	2735.08	3.42	493135	14.2
4	Oct. 2020	31	87089.0	2809.32	3.51	523405	14.6
5	Nov. 2020	30	70417.0	2347.23	2.93	423206	12.2
6	Dec. 2020	31	55866.0	1802.13	2.25	335755	9.4
7	Jan. 2021	31	49230.0	1588.06	1.99	295872	8.3
8	Feb. 2021	28	67327.0	2404.54	3.01	404635	12.5
9	Mar. 2021	31	89215.0	2877.90	3.60	536182	15.0
10	Apr. 2021	30	102463.0	3415.43	4.27	634246	17.8
11	May. 2021	31	108453,0	3498.48	4.37	671324	18.2
12	Jun. 2021	30	101573.0	3385.77	4.23	628737	17.6
		365	**992990.8**			**6024122**	**14.2**

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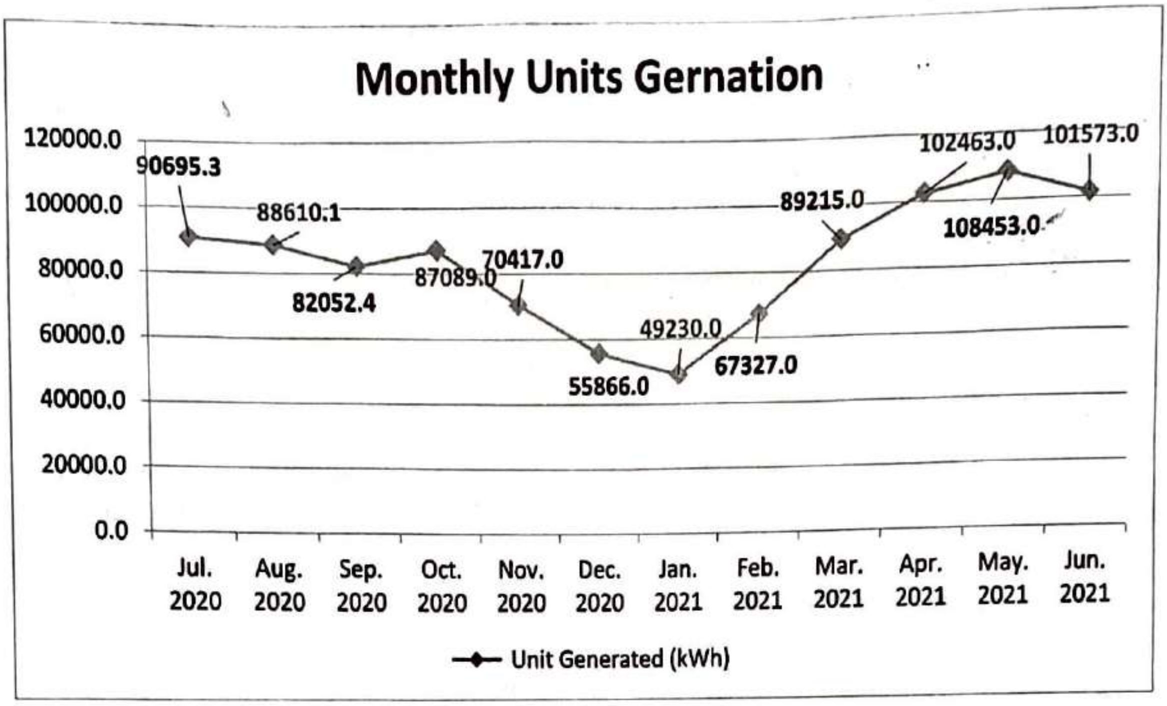

The units or kWh output of a solar panel will depend on the panel efficiency and availability of sunlight in a location. The factor that defines this output is called CUF (or Capacity Utility Factor). For India, it is typically taken as 19% and the calculation of units goes as:

Capacity Utilization Factor (C.U.F) = <u>(Actual energy from the plant(kwh))</u>
(Plant Capacity (kWp) x 24 x 395)

Solar photovoltaic technologies convert solar energy into useful energy forms by directly absorbing solar photons—particles of light that act as individual units of energy—and either converting part of the energy to electricity.

Average solar irradiation in U.P state is 1156.39 W / sq.m. 1 kWp solar rooftop plant will generate on an average over the year 4.6 kWh of electricity per day (considering 5.5 sunshine hours)

The performance of Solar PV plant is national average of 17 & 19%. It is therefore, suggested to regularly clean these panels for better performance.

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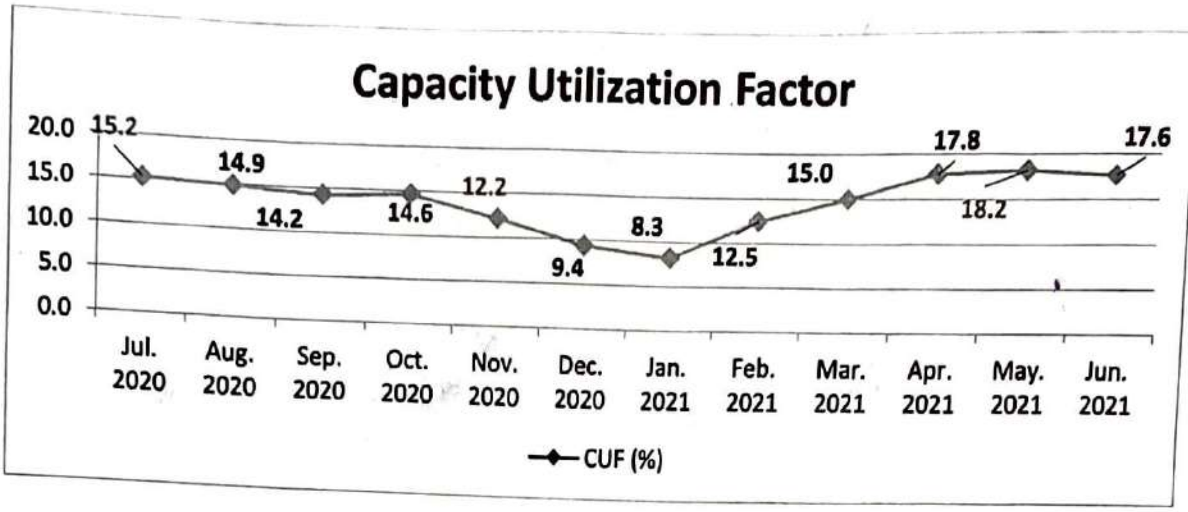

The less generation of units is due to inadequate maintenance of Solar panel, as dust, found deposited on the surface of solar plates, which act as shield from sun rays thus effecting the Power generation badly. We suggest to regular cleaning of Solar Panels.

The Campus has lot of space at roof-top / shed area. Where additional solar PV panels can be installed. So typically a 1 kW capacity solar system will generate 1600-1700 kWh of electricity per year. This can provide electricity for 25 years.

• Total Capacity of SPV	= 1 KW
• Area required per KW	= 10 m2/ KW
• Area required for 50 KW	= 100 m2
• Facing	= Shadow free South facing
• CUF/PLF	= 19%
• 1 kWp solar rooftop	= 4.6 kWh

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15. Power Quality

15.1 HARMONICS

Harmonics are the periodic steady-state distortions of the sine wave due to equipment generating a frequency other than the standard 50 cycles per second as now a day's equipment became more sophisticated and with the proliferations of non-linear loads, harmonics have become a pronounced problem on many power systems. Now a-days in many areas non-linear load are approaching significantly.

The Effects of the Harmonics current are:

- Additional copper losses
- Increased core losses
- Increased electromagnetic interference with communication circuits.

The Effects of the Harmonics Voltage are:

- Increased dielectric stress on insulation
- Electro static interference with communication circuits
- Resonance between reactance and capacitance

Causes: There are many sources of harmonics in Power system but all harmonics sources share a common characteristic. This is a non-linear voltage current operating relationship and any device that alters the sinusoidal wave form of voltage or current is harmonics producer. The following are the source of harmonics: **Electronic ballasts; non—linear loads; variable frequency drives, diodes, transistors, thyrusters, rectifier output, frequency conversion, Transformers; circuit breakers; phone systems; capacitor banks; motors, Computers (power supplies) PC, laptop, mainframe, Servers, Monitors, Video display, Copiers, scanners, FAX machines, printers, plotters, lighting controls, UPS systems, battery charges & data centers etc. etc.**

Effects: Overheating of electrical equipment; random breakers tripping, High Neutral current due to 3rd Harmonics, interference with communication, non-proper recording of metering, increase in cooper loss, heating of equipment's such as transformer & generators, breakers & fuse operation occur.

Harmonics contents can place serious Burden on power distribution system. If harmonics distortion may suppose 35%, the distribution of harmonics then will be 5th order 27% 7th order 5%, 11th order – 2 % and 13th order 1%.

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As per IEEE 519-992& IEEE C-57.110-1986 The current harmonics should be less than 8% as higher value may result in mal-operation of electronics system like control & protection etc. and may result in de-rating of transformer, the most preferred international standard of harmonic for Voltage should not be more than 3% and for current it should not be more than 8%.

HARMONIC CAN BE LIMITED WITH FOLLOWING METHODS:

1. 12 Pulse drives
2. Harmonic filters
3. High-end performance drives
4. Power re-distribution

Further:

1 Every harmonic can create problem, the nature of problem can be different. Due to higher voltage harmonic there can be components failure in electronic circuits, in higher current harmonics there can be high heat generation, which can lead to burning and fire, again due to higher third & ninth harmonic, there will be higher neutral current which can be very dangerous for maintenance team, due to higher negative harmonic there can be mechanical problems which leads to machine failures etc. Therefore, it will be incorrect to say any harmonic is to be given more preference. Mitigation to harmonic should always be specific to the problem and of course be just not more and not less. This is where many people get mislead by marketing team.

2. Every machine has inbuilt capacity to withstand certain amount of harmonics, be it voltage or current. IEEE 519 A& B gives more details on the subject, though there is nothing much mentioned in Indian standard on the subject (To the best of my knowledge). As per thumb rule, voltage harmonic should be less than 3% and current harmonics should be less than 8%. All odd harmonics are dangerous. As I mentioned earlier third & ninth harmonic will increase neutral current and related problems as these are generated mostly by single phase loads and the circuit is completed through the neutral. Other odd harmonics (5th, 7th, 11th, 13th etc.) will be either positive harmonics or negative harmonics. Besides higher current and heat (Other problems will also be there) the negative harmonics will also cause mechanical problems to complicate the problems further. So the danger level is to be analyzed depending upon the situation and problem at hand.

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Solutions: Harmonics filters employ the use of power electronic technology, which monitors the nonlinear load and dynamically corrects a wide range of harmonics, such as the 3rd to 51st harmonics orders. By the injection of a compensating current into the load, the waveform is restored which dramatically reduce distortion to less than 5% THD, meeting IEEE 519 standards. Further to meet other power quality demand surge protection, metering, relay protection, control, SCADA and communication can be one of the solution. Solution can range from simply tightening connections in a switchboard to help overheating of conductors, to use of a 200% rated neutral in a panel board.

The total harmonic distortion (THD) of current or voltage is equal to the effective value of all the harmonics divided by the effective value of the fundamental.

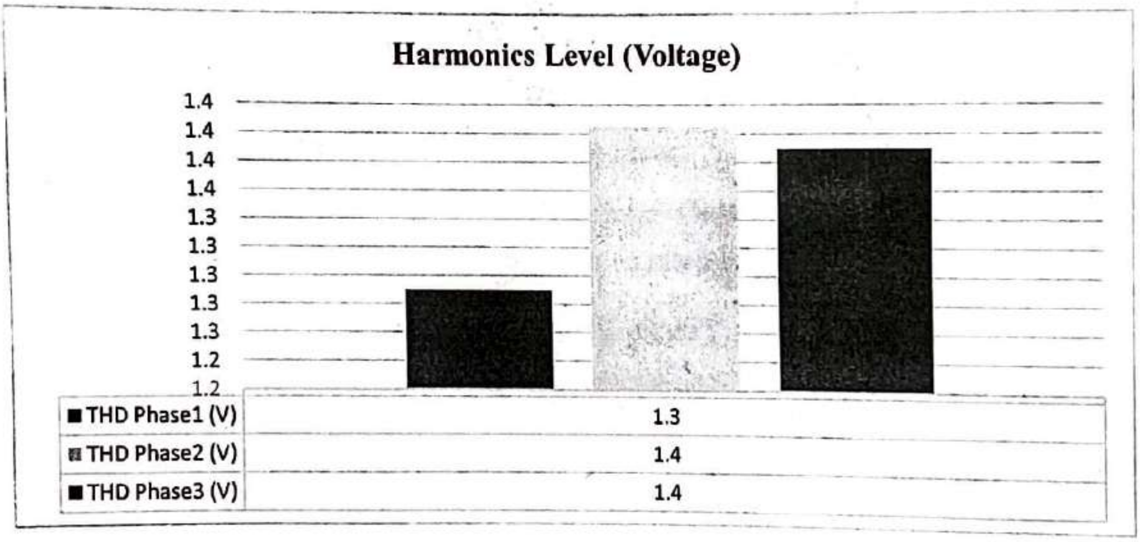


Figure 15.1: Trend of Transformers harmonics in Voltage

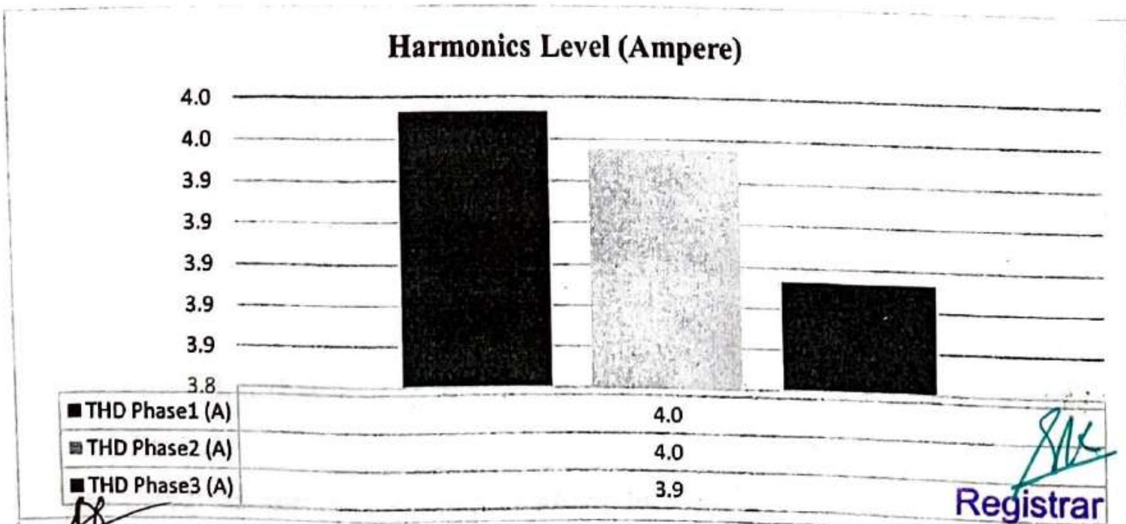


Figure 15.2: Trend of Transformers harmonics in Current

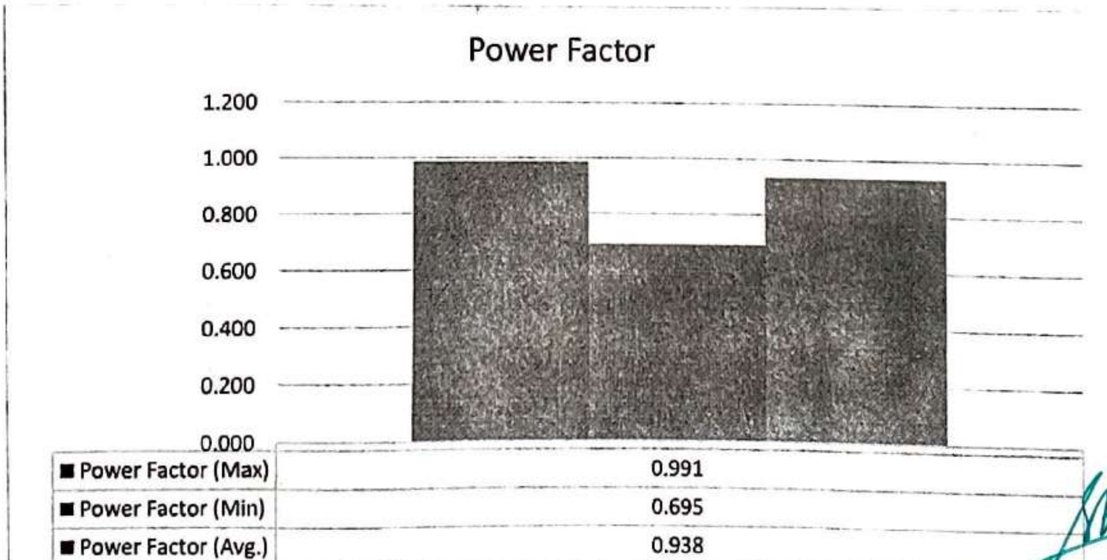
15.2 Power factor

The concept of power factor in the case of sinusoidal voltages and currents, relates to the real power, reactive power, and apparent power associated with a load consisting of resistance and reactance bringing about a direct phase shift between the voltage and current.

Capacitor is a device that generates reactive current and consumes very less power. Installing capacitor will improve the power factor and will also reduce the kVA demand of the system and will increase the capacity of the network i.e. the network cables can be loaded further. Reduction in reactive current will result in reduction of I^2R losses and efficiency of the system will improve.

So it is recommended to keep 50% PF the capacitor at down stream (Load end) of the electrical distribution network and balance 50% at up stream (power house) end with automatic features (APFC). It is the best suited reactive compensating method as it will reduce distance transport of reactive power. It is also recommended to replace all the capacitors which have more than 35% reduction in rated capacity.

Figure 15.3: Trend of power factor of Transformers



It is recommended that instead of installing all the capacitors at the beginning 50% should be shifted to load center immediately. As at the main supply system also average power factor recorded is found to be 0.910, it is recommended that at individual locations power factor correction system be installed after conducting

detailed study at the time of operation of Air Conditioning system. The location of power factor correction should by taking following into account:

1. It should be on the main distribution board.
2. It should be either on sub-distribution board
3. It should be at the load end.

The benefits of power factor can be summarized as under:

1. Rebate from State Electricity Board
2. Improvement in Voltage
3. Reduction in maximum demand charges
4. Reduce heat loss

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16. Cables

The electric current corresponds to Total Power (kVA) that depends on power factor, flows from utility-supply point to various load points of the unit through power cables (mostly made of aluminum). During the above power transport, considerable power is wasted to oppose the resistance of the cable. The cable resistance increases with length but decreases with cross-section i.e. increase in size. Therefore, the cable capacity has to be selected accordingly to keep the loss within 0.75% and it is only active load which cause the change in PF from no load to full load. By applying capacitor, we will change the PF of supply system hence I^2R of the old cable between supply source and motor.

14.1 Flowing current in feeders

The cable loss is proportional to I^2R (square of current flow and resistance of cable). Normally the current rating given by manufacturer is to withstand thermal stress. Energy conservation point of view, the above needs to be devalued based on length i.e. to curtail excess energy loss caused by off centered powerhouse, longer cables are to carry lesser than the rated current.

14.2 Reducing loss

There are two methods to reduce I^2R cable loss in feeders. They are: (i) reducing the current in cables by adding capacitors near to load or bifurcating the overloaded feeders (ii) reducing the resistance of cable by increasing its size or running additional run of cable of equal size.

14.3 Capacitor shifting/addition

It is possible to reduce current; thereby I^2R losses in cable by providing additional capacitors near to feeder end/ motor end.

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17. Energy Demand Management

The energy audit study was under taken at this complex comprising of offices, platforms areas etc. Electricity is the main energy source for this complex. Electricity is used for meeting requirements of equipment's, machines, lightings, fans, air-conditioning, Water pumps & office equipment etc.

17.1 Electricity Bill Analysis

The Invertis University is getting electrical power supply from Madhyanchal Vidyut Vitaran Nigam Ltd. (MVVNL) at 11 kV supply.

There are three step down transformers of 630 kVA, 630 KVA & 400 kVA (11kV / 0.433kV) to meet the demand of whole complex. The premise is also having two diesel generators to provide power supply during power failure /emergency to the campus.

Table 14: Technical details of Connection

Parameter	Details
Consumer Name	M/S INVERTIES UNIVERSITY
Address	BAREILLY (U.P)
Supply From	Madhyanchal Vidyut Vitaran Nigam Ltd. (MVVNL)
Supply Type	11 KV-HT
A/C No.	761702356284
Meter No	XC435139
Contract Demand (kVA)	800
Tariff type	HV-1

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Table 15: Historical Electrical Bill Analysis

Sr. No.	Billing Month	MDI	Total electricity consumption (kVAh)	Solar Export	Energy Consump-tion	Energy Charge	Fixed Charges	ED	Rebate	Arrear	Arrears Sur-charges	Last Pay-ment Sch.	Total Payable Amount
1	Mar 2020	366.6	33810.0	44480.00	-10670.0	-91715.6	258000.0	12471.33	1662.84	-	-	-	177093.0
2	April to Aug. 2020	440.0	36350.0	210055.0	-173705.0	-	1290000.0	96750.00	12900.00	-	-	-	1363913.0
3	Sep. 2020	412.0	19235.0	406950.0	-387715.0	-	258000.0	19350.00	2580.00	-	-	-	274770.0
4	Oct. 2020	412.0	19270.0	57760.0	-38490.0	-	258000.0	19350.00	2580.00	-	-	-	274770.0
5	Nov. 2020	111.6	15835.0	37660.0	-21825.0	-	258000.0	19350.00	2580.00	-	-	-	274770.0
6	Dec. 2020	133.6	40490.0	21280.0	19210.0	165842.8	258000.0	31788.21	4238.43	-	-	-	451393.0
7	Jan. 2021	146.2	38620.0	18035.0	20585.0	177777.8	258000.0	32683.34	-	4238.0	84.76	300.93	473085.0
8	Feb. 2021	130.6	33200.0	37875.0	-4675.0	-	258000.0	19350.00	2580.00	-	-	-	274770.0
	Total		236810	834095	-597285	251905	3096000	251093	29121	4238.0	84.76	300.93	3564564
	Avg.	269.1	29601.3	104261.9	-74660.63	83968.3	387000.0	31386.61	4160.18				445570.5
	Max	440.0	40490.0	406950.0	20585.00	177777.8	1290000.0	96750.00	12900.00				1363913.0
	Min	111.6	15835.0	18035.0	-387715.00	-91715.6	258000.0	12471.33	1662.84				177093.0

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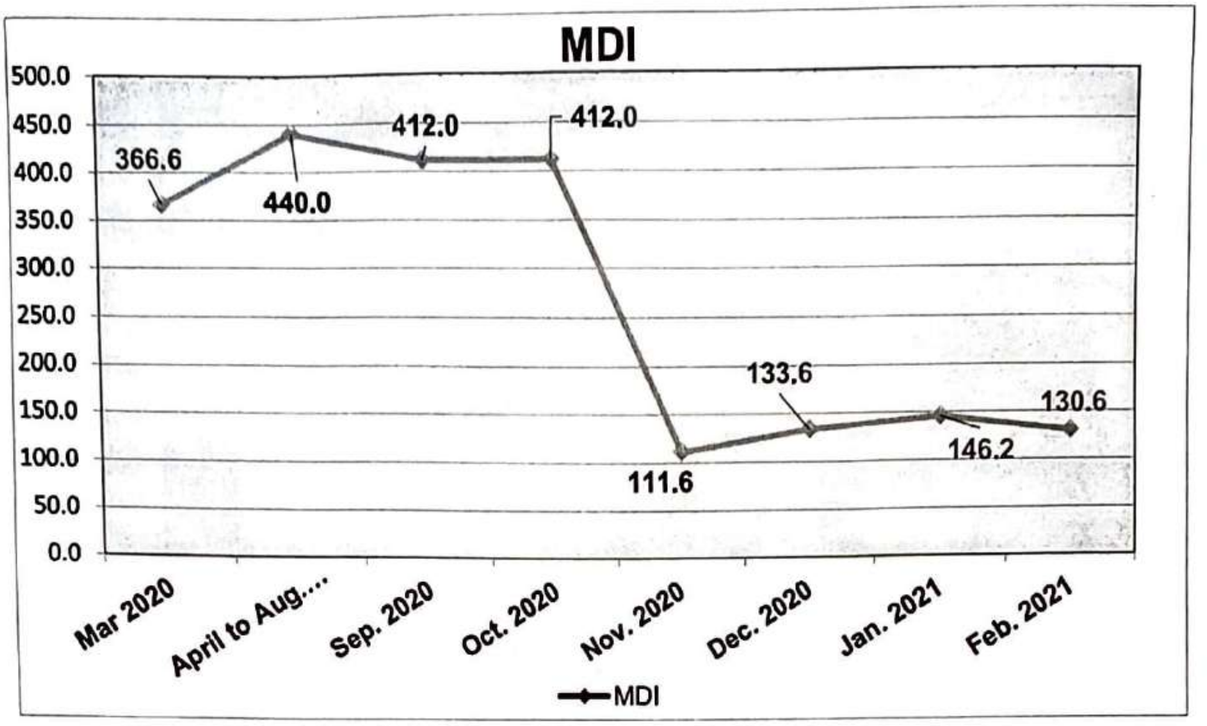

Figure 17.4: Historical MDI variation

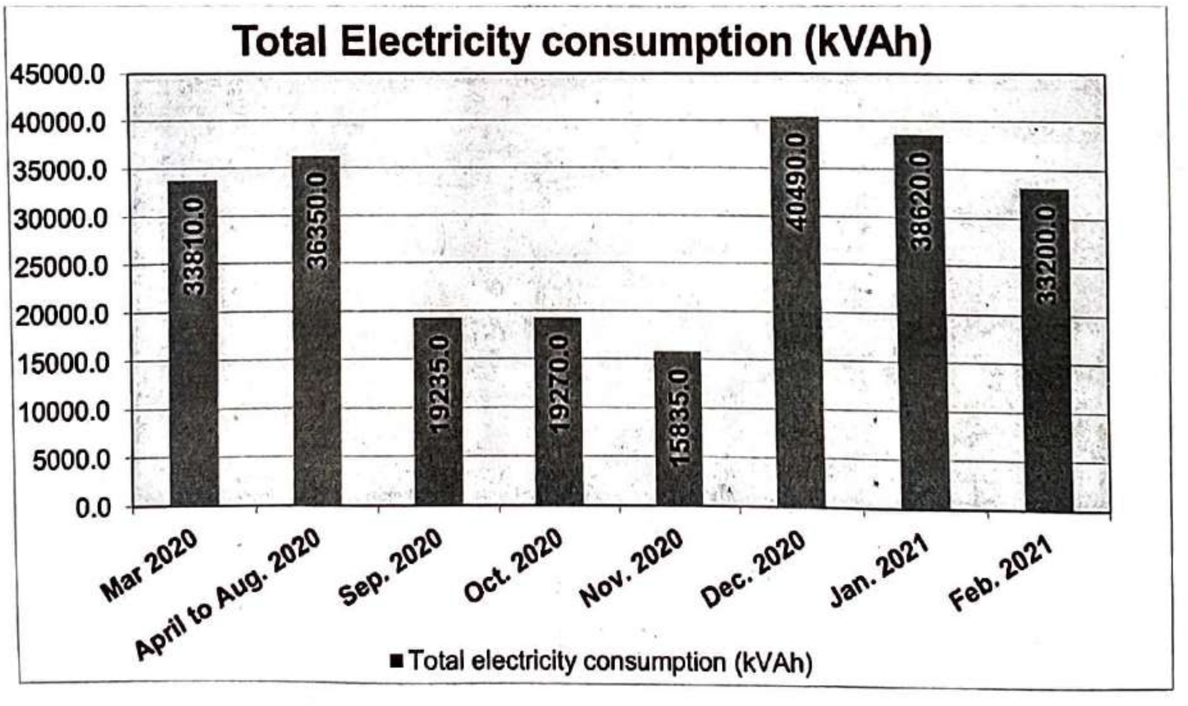

Figure 17.5: Historical trends of Reactive Power Consumption

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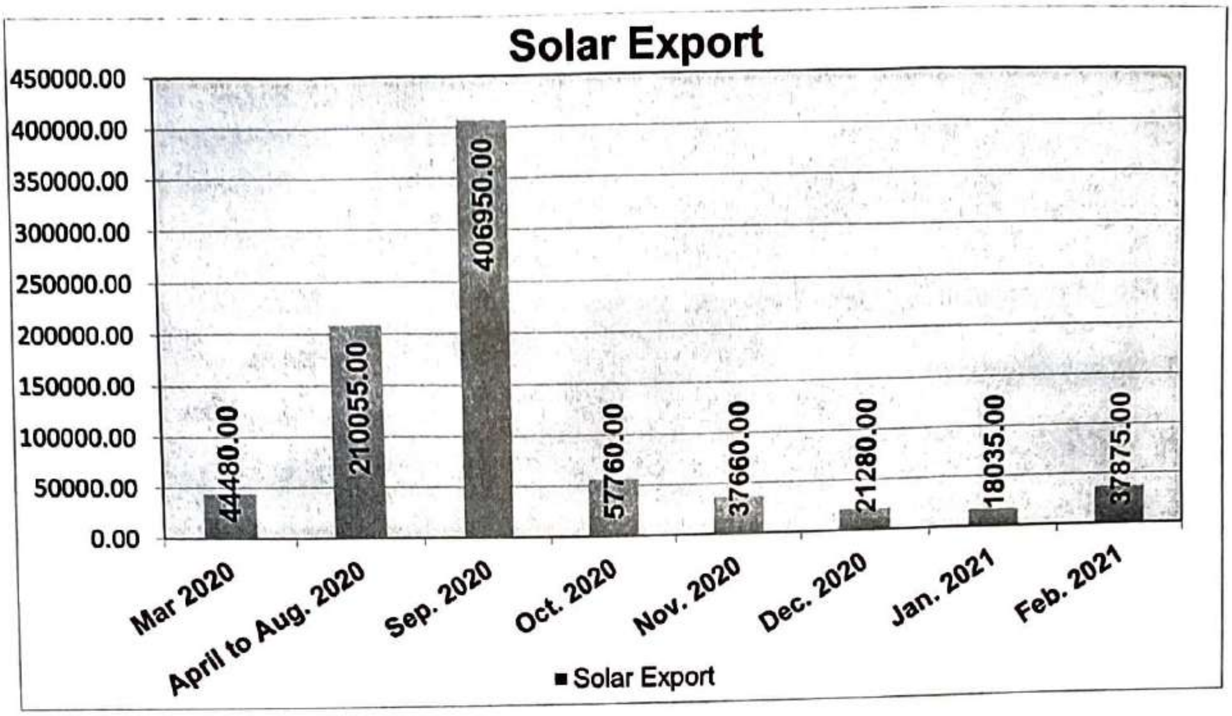

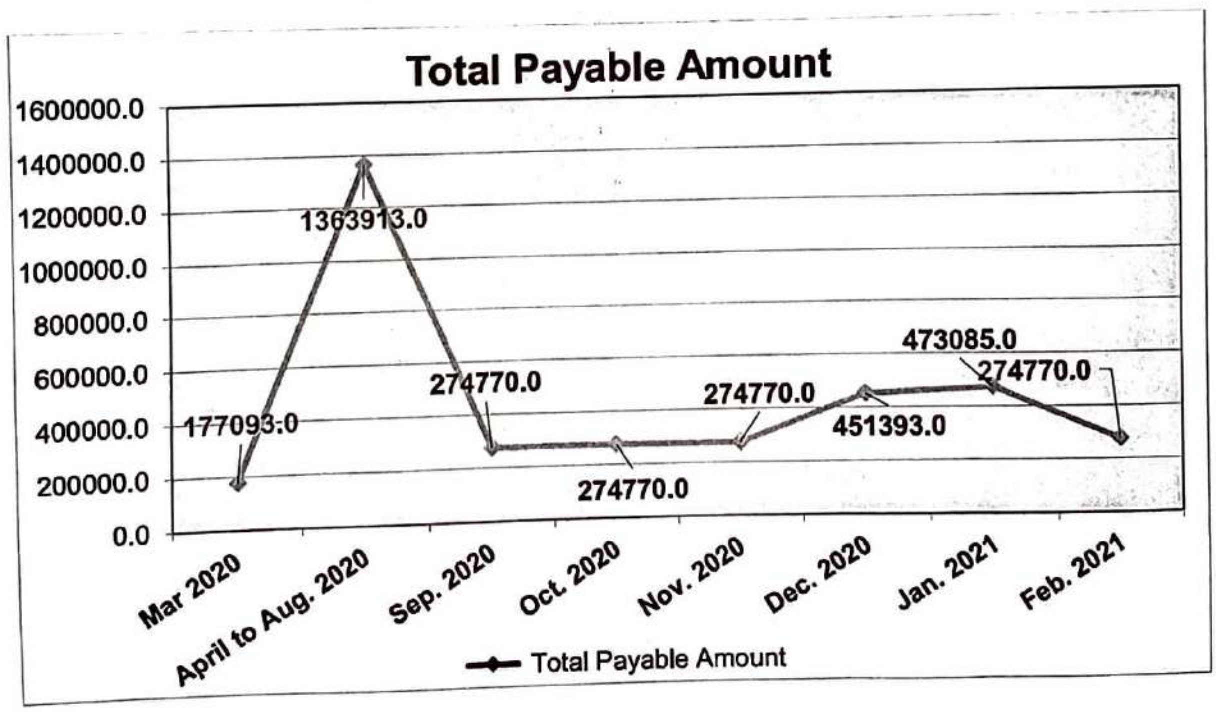

Figure 17.6: Historical Trends of Electricity cost

- Total yearly consumption from grid of the premises is 2.37 Lakhs kVAh in the month of Mar 2020 to Feb 2021 and Export electricity to grid 8.34 Lakhs KVAh in the month of Mar 2020 to Feb 2021, for fulfilling energy needs campus has been paying annually campus is paying Rs 35.65 Lakhs.

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- Incoming supply voltage is 11 kV which is further stepped down to 433 V with the help of transformer.
- Average demand of the premises is 111.6 KVA, while variation of M.D. is within 111.6 to 440 KVA respectively.

NOTE

It is suggested the demand of the Industry to reduce Electricity cost. This can be achieved as below:

a. Re-schedule the load

b. Staggering of motor load

c. Shedding of non-essential load.

d. Operation of captive power generation

e. To install reactive power compensator

f. Use demand controller

g. Switching off non-essential loads.

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18. Illumination & LUX Levels

To study, analyze and identify energy conservation options in lighting, a study of the unit lighting load was conducted. The purpose of the study was to determine the lighting load and its distribution in various sections of the buildings, determine the quality of illumination provided, and recommend measures to improve illumination and reduce electricity consumption.

A high quality and accurate digital LUX meter was used to measure the illumination level at various sections of the building during working hours. Other performance indicators such as type of lamps used, luminaries, mounting height, physical condition of lamps, use of day lighting, etc. were also noted down.

Major reasons for poor illumination levels at selected locations of the building are as follows:

- Poor reflectors/no reflector installed for the tube lights.
- Large height of installed fittings from the working plane.
- Reduction in illumination due to ageing.
- Very old fittings and dust deposition on luminaries

Table 16: Table of assessment of lighting Load

Sr. No	Location	Lux Level
1	**New Building**	
	Civil Lab-1	150-190
	Chemistry Lab-1	120-270
	Chemistry Lab-2	140-260
2	**Engineering Block**	
	Room-9	260-340
	Room-8	250-330
	Room-3	270-375
	Room-13	
3	**Management Block**	
	Room-1	211-370
	Room-7	208-334
	Room-4	200-320
4	**Computer Block**	
	Lab-2	80-120

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Sr. No	Location	Lux Level
	Lab-3	80-135
	Lab-1	70-110
5	**Admin. Block**	
	Office	140-200
	Account office	130-220
6	**Work Shop**	
	Work shop	130-190
	Workshop-Lab	140-260
7	**University Building**	
	Room-15	260-300
	Room-16	241-370
	Room-17	230-320
	Room-30	210-300
	Room-31	190-350
	Room-20	220-360
	Room-26	200-310
	Room-25	190-330
	Room-26	210-330
	Room-51	220-335
	Room-24	210-340
8	**Boys Hostel**	
	Room	130-170
	Room	120-160

Assessment of Lighting System

Example : Room

Lux Measured = Average Lux = 286

287	284

Length of the Room = 18ft.

Width of the Room = 14ft

Working Place Height = 10ft

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STEP 1	Measure the Floor area of the interior :	Area = 18 x 14 = 252 sqft
STEP 2	Calculate the Room Index 18 x 14 / 10 (18 + 14) = .78	RI = .78

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STEP 3	Determine the total circuit watts of the installation by a power meter if a separate feeder for lighting is available. If the actual value is not known a reasonable approximate can be obtained by totaling up the lamp wattage including the ballasts	Total Circuit watts 54 W x 16 = 864 32 W x 4 = 128 TOTAL = 992W
STEP 4	Calculate Watts per square meter, Value of Step 3 ÷ Value of Step 1	W/m^2 = 3.9
STEP 5	Ascertain the average maintained luminance by using Lux Meter, Eav. Maintained	Eav.maint = 286
STEP 6	Divide 5 by 4 to calculate Lux per Watt per square Meter	Lux/W/m^2 = 72.77
STEP 7	Obtain target Lux/W/M^2 lux for type of the type of interior/ application and RI (2)	Target Lux/W/m^2 = 36
STEP 8	Calculate Installed Load Efficacy Ratio (6 ÷ 7)	ILER = 2.02

ILER 0.75 or over = Satisfactory to Good

Measuring Units Light Level – illuminance

Illuminance is measured in foot candles (ftcd, fc, fcd) or lux in the metric SI system). A foot candle is actually one lumen of light density per square foot, one lsux is one lumen per square meter.

- 1 lux = 1 lumen / sq meter = 0.0001 phot = 0.0929 foot candle (ftcd, fcd)
- 1 phot = 1 lumen / Sq centimeter = 10000 lumens / sq meter = 10000 lux
- 1 foot candle (ftcd, fcd) = 1 lumen / sqft = 10.752 lux

Common Light Level Outdoor

Common light levels outdoor at day and night can be found in the table below :

Table 17: Lux level of different natural occasions

Condition	Illumination	
	(ftcd)	(lux)
Sunlight	10,000	107,527
Full Daylight	1,000	10,752
Overcast Day	100	1075
Very Dark Day	10	107
Twilight	1	10.8
Deep Twilight	.1	1.08
Full Moon	.01	.108
Quarter Moon	.001	.0108
Starlight	.0001	.0011
Overcast Night	.0001	.0001

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Quarter Moon	.001	.0108
Starlight	.0001	.0011
Overcast Night	.0001	.0001

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Common and Recommended Light Levels Indoor

The outdoor light level is approximately 10,000 lux on a clear day. In the building, in the area closes to windows, the light level may be reduced to approximately 1,000 lux. In the middle area its may be as low as 25- 50 lux. Additional lighting equipment is often necessary to compensate the low levels.

Earlier it was common with light levels in the range 100 -300 lux for normal activities. Today the light level is more common in the range 500 – 1000 lux – depending on activity. For precision and detailed works, the light level may even approach 1500 – 2000 lux.

The table below is a guidance for recommended light level in different work spaces:

Table 18: Required lux level for various activities

Activity	Illumination (lux, lumen/m^2)
Public areas with dark surroundings	20 -50
Simple orientation for short visits	50 -100
Working areas where visual tasks are only occasionally performed	100 -150
Warehouse, Homes, Theaters, Archives	150
Easy Office work, classes	250
Normal Office work, PC work, Study library, Groceries, show room, laboratories	500
Supermarkets, Mechanical workshops, Office landscapes	750
Normal Drawing work, very detailed mechanical works	1000
Detailed drawing work, very detailed mechanical works	1500 -2000
Performance of visual tasks of low contract and very small size for prolonged periods of time	2000 -5000
Performance of visual tasks of low contract and very small size for prolonged period of time	2000 -5000
Performance of very prolonged and exacting visuals tasks	5000 – 10000
Performance of very special visual tasks of extremely low contract and small size	10000 - 20000

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19. Energy Balancing

Energy balancing starts from energy accounting and it is one of the principal activities integrated with energy management system aimed to help the energy manager in preparation of an energy balance sheet. Energy balance sheet helps to identify and fix energy guzzlers and take corrective measures. ***It is not possible to prepare an energy balance sheet without metering set-up at important nodes. It is an important activity for the management to initiate and install such metering facilities at least at selected important nodes*** of electrical distribution network starting from transformers outgoing point to motor end. Energy accounting could be done either by manual process or with the aid of data acquisition system supported by menu driven specially software packages to monitor, record and control the process sequences and thereby energy. The diesel storage and distribution system has no measurement, records and monitoring system. The diesel consumed by individual DG set are not measured and recorded, which is not proper practice both for energy efficiency and economic prospective.

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20. Transformers and load profile

20.1 Transformers

The Campus is getting electrical power supply from Dakshin Haryana Bijli Vitran Nigam (DHBVN) at 11 kV supply.

There are three step down transformers of 630 kVA x 2 Nos., & 400 kVA (11kV / 0.415kV) to meet the demand of whole complex. During the audit TR-1 (630 KVA) on load and another both Transformer (630 KVA & 400 KVA) are stand by. The premise is also having two diesel generators to provide power backup during day/night. Load profile of power shown in below graphs.

Table 19: Technical Specifications of transformers

Name Plate Data		TRF-1	TRF-2	TRF-3
Rated	kVA	630	400	630
Voltage	H.V	11000	11000	11000
	L.V	433	433	433
Amp.	H.V	33.33	21	33.33
	L.V	840	5333.33	840
Impedance Volt	%	4.75	4.75	4.75
Phase		3	3	3
Frequency	HZ	50	50	50
Cooling Type		ONAN	ONAN	ONAN
Vector Group		Dyn11	Dyn11	Dyn11
Mfg.	Year	2011	2002	2011
Make		R.K Industries	R.K Industries	R.K Industries

20.2 Load profile for Main Incomer (Transformer)

The load profile of the electrical parameters was recorded by using a portable 3-phase power analyzer. During the recording, the power analyzer recorded all the electrical parameters for further detailed analysis. The analysis of the different parameters recorded 24 hours reading at the L.T. incoming main supply is given below.

20.2.1 Real power (kW) and apparent power (kVA) profile

Load (real power) profile and apparent power profile is the variation in the electrical load versus time. In any electrical system, the vector sum of the active power (kW) and reactive power (kVAR) make up the total (or apparent) power (kVA) used. This is the power generated by a generation station for the user to perform a given amount of work. The total power is measured in kVA (Kilo Volts-Amperes) and the load or active power is measured in kW (kilowatts) and

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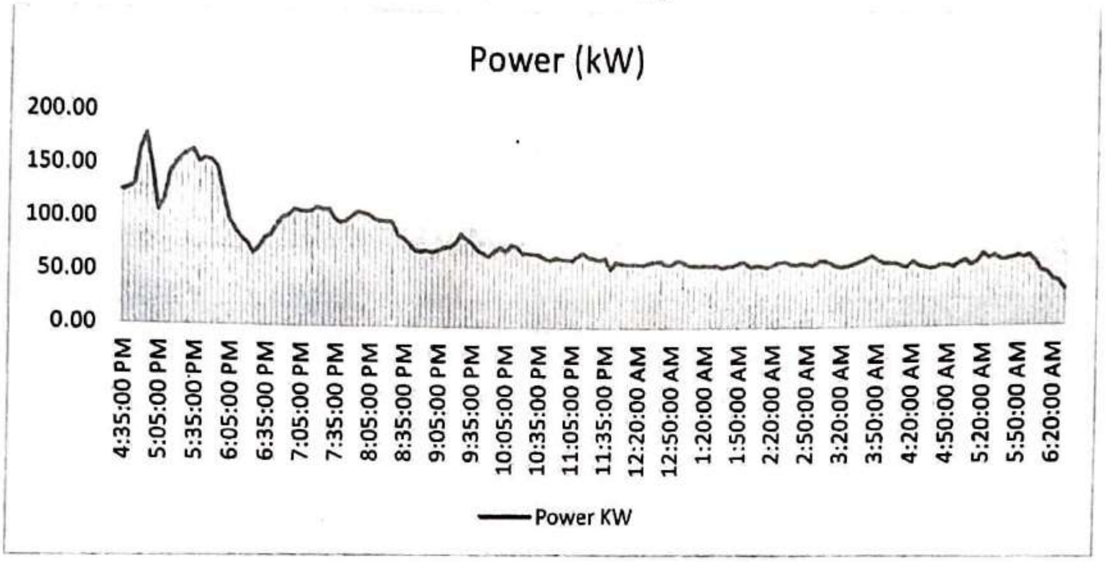
they become equal as and when the power factor approaches unity. Total electricity charges (units and demand) are based on the load or active power (kW) and apparent power (kVA).

During the energy audit studies, the total operating load at the transformer was recorded to find out the variation in the load at different times of the day. The following graph depicts the variation in the load and apparent power of the premises:

Load Profile Real power (kW & kVA) profile of main incomer



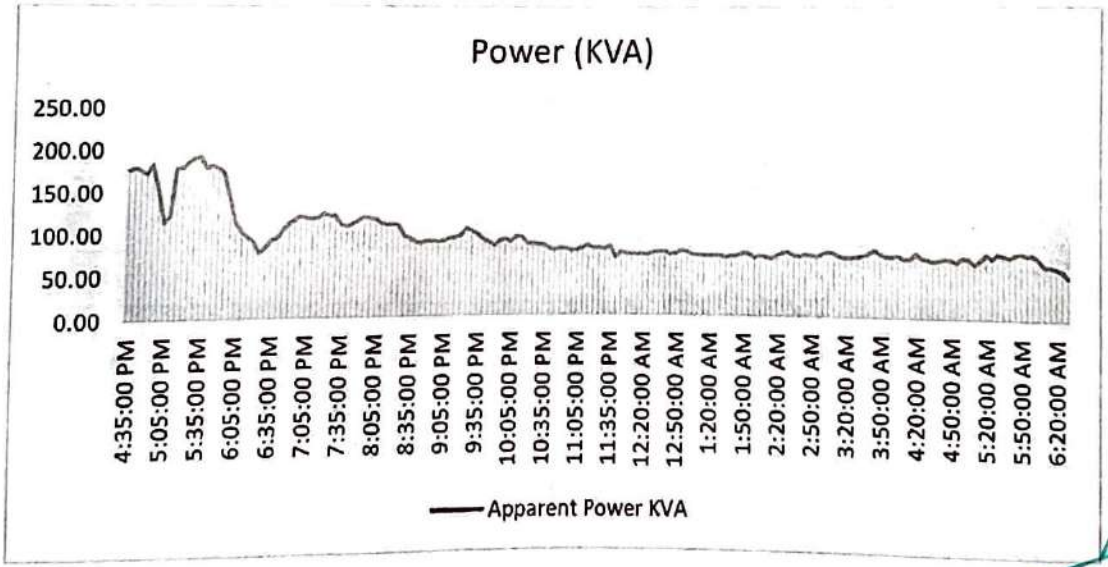


Figure 20.7: Trends of active and reactive power

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The observations taken from the graph:

- The load (kW) variation ranges from 34.35 kW to 178.93 kW during the Load hours of measurement period and Average 79.27.
- The apparent power (kVA) varies from 50.62 kVA to 191.36 kVA during the Load hours of measurement period and Average 92.09.

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Table 20: Maximum and minimum Values of active and reactive Power

	Power (KW)	Apparent Power (KVA)
Max.	178.93	191.36
Min.	34.35	50.62
Ave.	79.27	92.09

20.2.2 Power factor profile

Under the current tariff system, the billed units are in kVAh and the demand charges for apparent power (kVA) depend on the power factor. If the facility has a low power factor, then the demand drawn from the grid will increase and consequently the facility will incur more demand charges. The variation in the power factor was recorded to explore opportunities for improvement. The graph below presents the variations in the power factor of the power supply to the building:

Power factor profile for the main Incomer

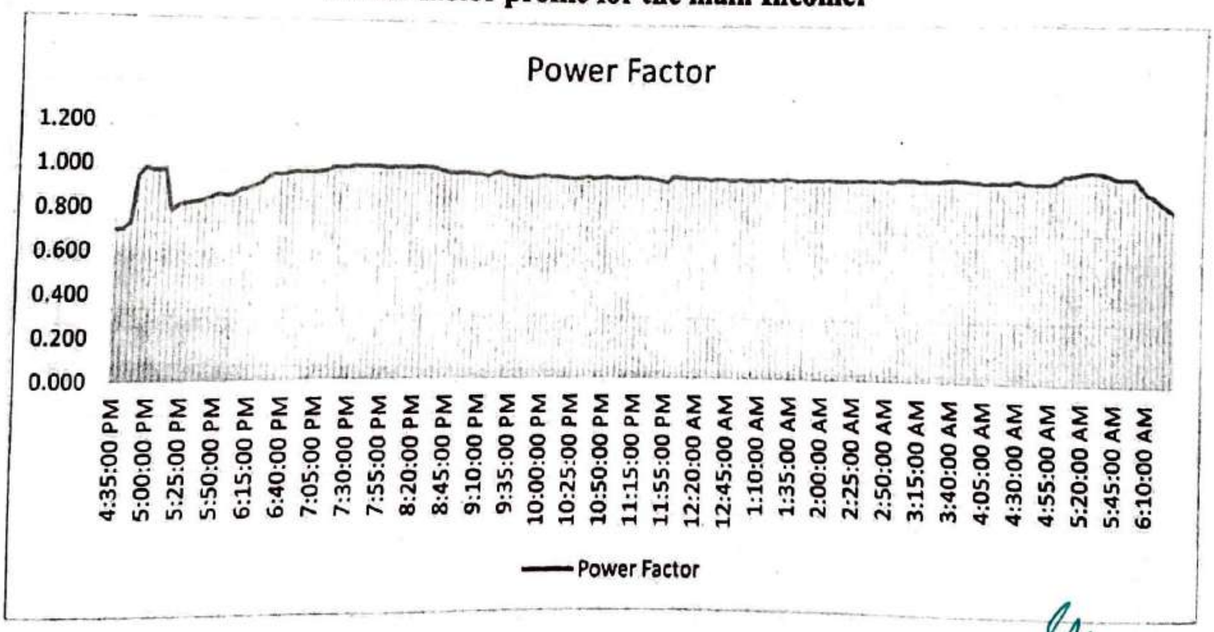

Figure 20.8: Trends of Power Factor Variation

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The observations taken from the above graphs:

- The power factor varied from 0.695 to 0.991 during the load hours of measurement period and Average 0.938.

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20.2.3 Current profile

Current profile is the variation in the electrical current versus time. The current variations in all the three phases (R, Y and B) were recorded at the main panel of the transformer. The graphs below present the variations in the current:

Current Profile- Phase wise of the main Supply

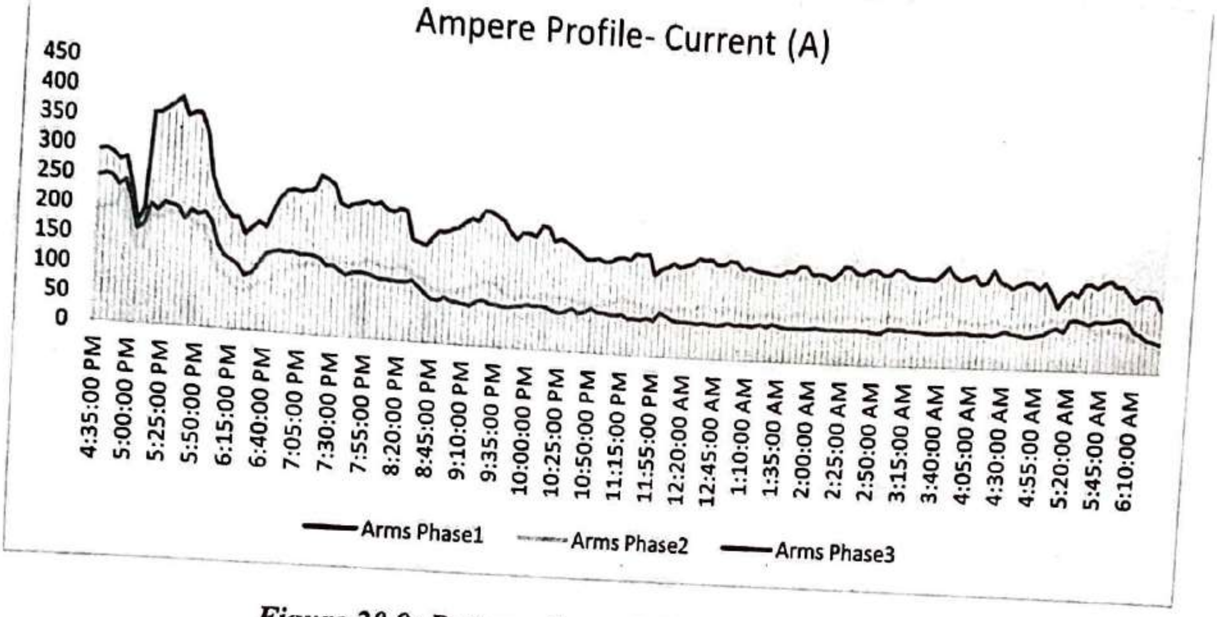

Figure 20.9: Pattern of recorded current Profile

The observations taken from the above graphs:

- There is a considerable current variation in the different phases and hence the phase-to-phase load is not balanced. The Current variation ranges. during the load hours of measurement period.

Table 21: Maximum and minimum values of current

	Amp. Phase (R)	Amp. Phase (Y)	Amp. Phase (B)
Max.	388.1	228.2	251.3
Min.	110.4	40.1	52.1
Ave.	192.2	100.4	93.1

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20.2.4 Voltage profile

All electrical equipment has a designed range of operating voltage. Therefore, it is important to operate all electrical equipment, within the specified voltage range. The voltage variations in all the three phases (R, Y and B) were recorded at the main Supply. The graphs below depict the variations in the voltage

Voltage Profile- Phase wise (V)

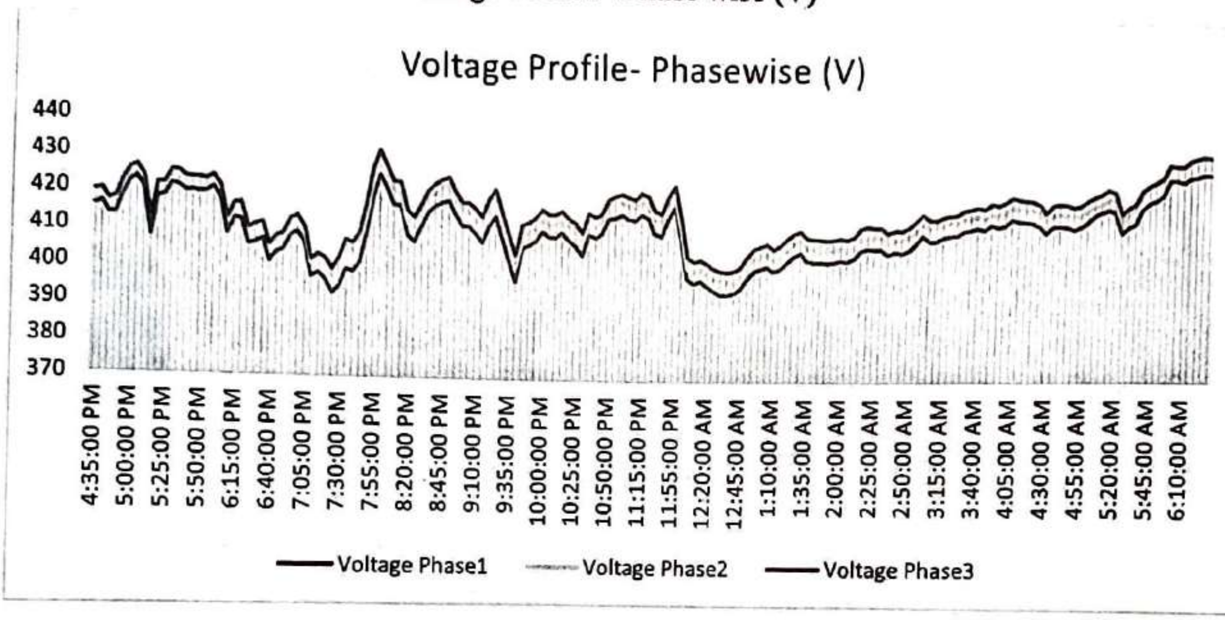

Figure 20.10: Pattern of voltage Variation

The observations taken from the above graphs:

- There was a slight variation in phase-to-phase voltage.
- The average voltage recorded

Table 22: Maximum and minimum values of recorded voltage

	Voltage (R) Phase	Voltage(Y) Phase	Voltage(B) Phase
Max.	426.6	432.0	431.8
Min.	392.9	397.3	399.5
Ave.	410.2	414.0	415.9

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20.2.5 Frequency profile

The variations recorded in the frequency during the 24 hours of measurement period are provided below:

Frequency profile of the main Incomer for load hours

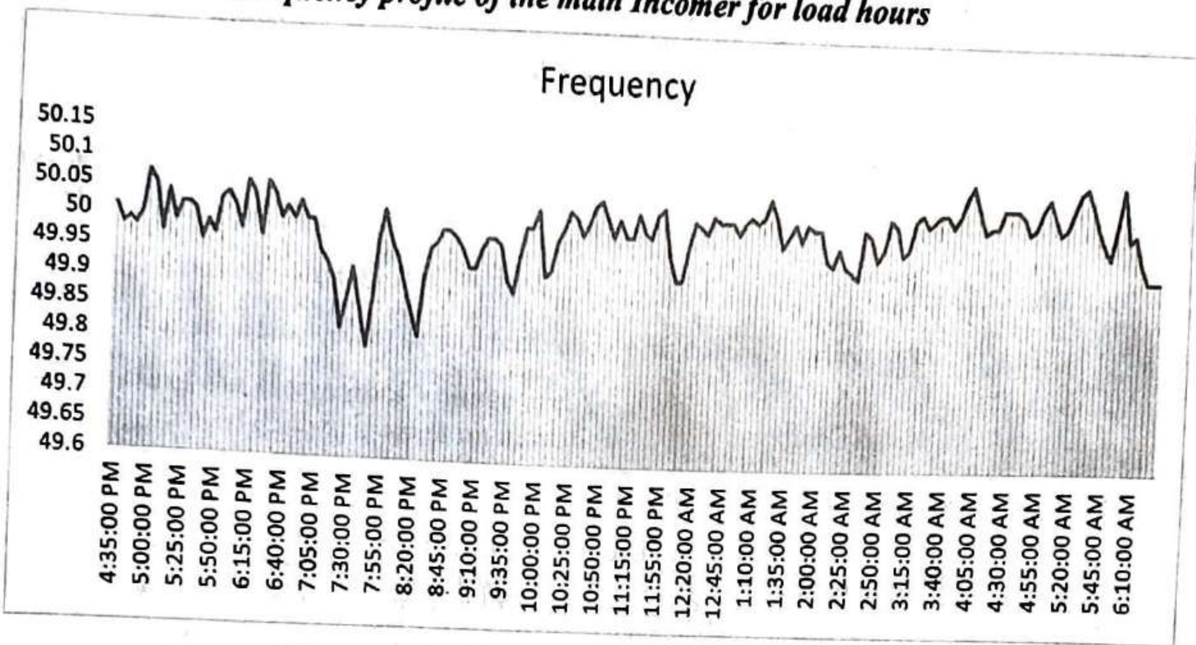

Figure 20.11: Trends of frequency variations

The observations taken from the above graphs:

- There was a minimal variation in the recorded frequency during the measurement period.
- The frequency varied from 49.8 Hz to 50.1 Hz and the average frequency recorded was 50.0 Hz.

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20.2.6Harmonies

Harmonics are the periodic steady-state distortions of the sine wave due to equipment generating a frequency other than the standard 50 cycles per second as now a day's equipment became more sophisticated and with the proliferations of non-linear loads, harmonics have become a pronounced problem on many power systems. Now a-days in many areas non-linear load are approaching significantly.

The Effects of the Harmonics current are:

- Additional copper losses
- Increased core losses
- Incresed electromagnetic interference with communication circuits.

The Effects of the Harmonics Voltage are:

- Incresed dielectric stress on insulation
- Electro static interference with communication circuits
- Resnance between reactance and capcitance

- **Causes:** There are many sources of harmonics in Power system but all harmonics sources share a common characteristic. This is a non-linear voltage current operating relationship and any device that alters the sinusoidal wave form of voltage or current is harmonics producer. The following are the source of harmonics: **Electronic ballasts; non—linear loads; variable frequency drives, diodes, transistors, thyristors, rectifier output, frequency conversion, Transformers; circuit breakers; phone systems; capacitor banks; motors, Computers (power supplies) PC, laptop, mainframe, Servers, Monitors, Video display, Copiers, scanners, FAX machines, printers, plotters, lighting controls, UPS systems, battery charges & data centers etc. etc.**
- **Effects:** Overheating of electrical equipment; random breakers tripping, High Neutral current due to 3rd Harmonics, interference with communication, non-proper recording of metering, increase in cooper loss, heating of equipment's such as transformer & generators, breakers & fuse operation occur.

Harmonics contents can place serious Burden on power distribution system. If harmonics distortion may suppose 35%, the distribution of harmonics then will be 5th order 27% 7th order 5%, 11th order – 2 % and 13th order 1%.

Solutions: Harmonics filters employ the use of power electronic technology, which monitors the nonlinear load and dynamically corrects a wide range of harmonics, such as the 3rd to 51st harmonics orders. By the injection of a compensating current into the load, the waveform is restored which dramatically reduce distortion to less than 5% THD, meeting IEEE 519 standards.

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Further to meet other power quality demand surge protection, metering, relay protection, control, SCADA and communication can be one of the solution. Solution can range from simply tightening connections in a switchboard to help overheating of conductors, to use of a 200% rated neutral in a panel board:

The percentage of total current and voltage harmonic distortion in all the three phases (R, Y and B) were recorded at the main incoming panel. The graphs below depict the percentage of total harmonic distortion in the electrical distribution system:

Percentage of Total Harmonic Distortion (THD) - Phase wise voltage

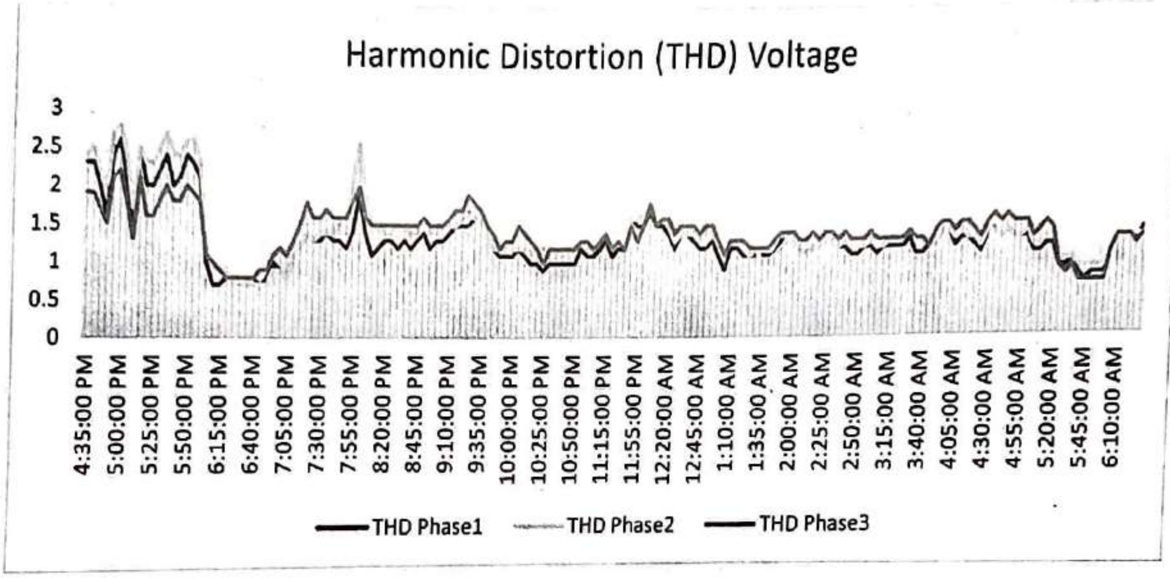

Figure 20.12: Pattern of harmonics levels in voltage

Percentage of Total Harmonic Distortion (THD) - Phase wise current

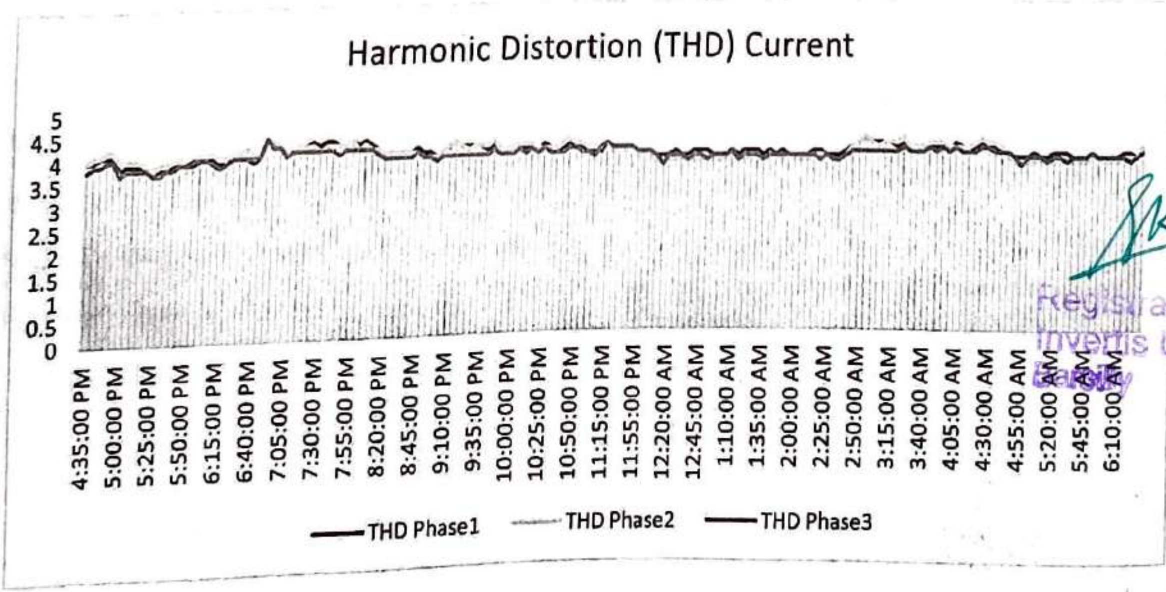

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Figure 20.13: Patterns of harmonics levels in current

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	Voltage Harmonics %			Current Harmonics %		
Max.	2.6	2.8	2.2	4.4	4.4	4.4
Min.	0.7	0.7	0.7	3.8	3.6	3.6
Ave.	1.3	1.4	1.4	4.0	4.0	3.9

Table 23: Measured Harmonics levels

The observations taken from the above graphs:

- The percentage of average voltage THD is in the range of 0.7 % to 3.5 %. This is well within the recommended limits as per IEEE Standards i.e. 4% variation for voltage & 15% variation for current.
- The percentage of average current THD is in the range of 3.8 % to 4.4 %. The current harmonics in the system are more than the recommended limits as per IEEE Standards. So, it is recommended to install the harmonics controller in the system to bring the Voltage harmonics with in limit & current THD levels within limits.

The Observations Taken From The Above as:

- Transformer temperature is Normal
- Silica Gel need to be replace.
- Oil level ok.
- Harmonics Level with in limit

Overall Power Quality

The analysis of various power quality parameters given above indicates that the overall quality of power received by the facility is good and most of the parameters are within the desired range except the current harmonics in the system.

It is recommended that regular de-hydration of transformer oil should be carried out to remove the moisture. This de-hydration should be got done at regular interval based on condition monitoring.

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Transformer Losses And Efficiency

The efficiency of the transformer not only depends on the design, but also on the effective operating load. Transformer losses consist of two parts No-Load loss and Load loss.

1. No-Load loss (also called core loss): These losses occur whenever the transformer is energized. It does not vary with load.
2. Load-Loss (also called copper loss): It is the power lost in the primary and secondary winding of the transformer. Whenever the transformer remained energized and it varies with square of the current.

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21. Capacitor

Capacitor is a device that generates reactive current and consumes very less power. Installing capacitor will improve the power factor, will also reduce the kVA demand of the system and will increase the capacity of the network. Capacitor is passive equipment very useful to reduce the load current by improving PF.

There are two APFC Panels installed i.e. 205 KVAr & 400 nos. The power factor shown in the APFC panel is 0.99.

Table 24: Status of capacitors

APFC PANEL-01						
Sr. No.	Capacity (kVAr)	Rated Current (amp)	Measured			Remark
			Measured-R	Measured-Y	Measured-B	
1	6	7.87	-	-	-	Capacitor Panel Not Working
2	6	7.87	-	-	-	
3	10	13.1	-	-	-	
4	10	13.1	-	-	-	
5	10	13.1	-	-	-	
6	15	19.6	-	-	-	
7	15	19.6	-	-	-	
8	15	19.6	-	-	-	
9	15	19.6	-	-	-	
10	20	26.2	-	-	-	
11	12.5	16.4	-	-	-	
12	15	19.6	-	-	-	
13	20	26.2	-	-	-	
14	5	6.6	-	-	-	
15	10	13.1	-	-	-	
16	20	26.2	-	-	-	
Total	**205**					

APFC PANEL-02						
Sr. No.	Capacity (kVAr)	Rated Current (amp)	Measured			Remark
			Measured-R	Measured-Y	Measured-B	
1	10	13.1	0.0	0.0	0.0	De-Rated
2	20	26.2	0.0	0.0	0.0	De-Rated
3	20	26.2	0.0	0.0	0.0	De-Rated
4	20	26.2	0.0	0.0	0.0	De-Rated
5	25	32.8	10	11	11	De-Rated
6	50	65.6	0.0	0.0	0.0	De-Rated

7	50	65.6	**0.0**	**0.0**	**0.0**	**De-Rated**
8	20	26.2	**0.0**	**0.0**	**0.0**	**De-Rated**
9	20	26.2	**24.0**	**23.0**	**24.0**	**OK**
10	20	26.2	**19.0**	**18.5**	**19.2**	**OK**
11	20	26.2	**25.0**	**24.0**	**25.0**	**OK**
12	25	32.8	**33.0**	**31.0**	**33.0**	**OK**
13	50	65.6	**7.0**	**5.0**	**7.0**	**De-Rated**
14	50	65.6	**0.0**	**0.0**	**0.0**	**De-Rated**
Total	**400**					

The advantages of Power Factor improvement by capacitor

- A Reactive component of the network are reduced and so also the total current in the system from the source end.
- I2R power losses are reduced in the system because of reduction in current.
- Voltage level at the load end is increased.
- kVA loading on the source generators as also on the transformers and line upto the capacitors reduces giving capacity relief. A high power factor can help in utilities the full capacity of the electrical system.

Cost benefits of Power Factor improvement

- Reduced kVA (Maximum Demand) charges in electricity bill
- Reduced distribution losses (kWh) within the plant network
- Better voltage at motor terminals and improved performance of motors
- A high power factor eliminates penalty charges imposed when operating with low power factor
- Investment on system facilities such as transformers, cables, switchgears etc for delivering load is reduced.

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22. Earthing

The electricity rules clearly specify that two independent earths to the body and neutral should be provided to give adequate protection to the equipment in case if an earth fault, and also to drain away any leakage of potential voltage from the equipment to the earth for safe working. As there is no standard of earth resistance value, it varies on different type of soil resistivity, ideally it should be Zero but for different kind of soil for electrical equipment it should be better to below .8 Ohm and for electronics equipment it should be below .4 Ohm but best value is .1 Ohm.

Table 25: Details of Earth Resistance at various locations

Sr. No.	Location	Ohm
1	TRANSFORMER -630	3.8
2		4.3
3	TRANSFORMER -400	4.2
4		2.7
5	TRANSFORMER -630	3.9
6		2.8
7	DG SET – 750 KVA (Body)	4.7
8	DG SET – 750 KVA (Body)	4.5
9	DG SET – 750 KVA (NEUTRAL GROUNDING)	4.6
10	DG SET – 380 KVA (Body)	4.2
11	DG SET – 380 KVA (Body)	2.6
12	DG SET – 380 KVA (NEUTRAL GROUNDING)	2.1
13	L.T Panel	1.4
14	L.T Panel	2.3
15	L.T Panel	3.4

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23. General Tips for Energy Conservation

23.1 Electricity

- Schedule your operations to maintain a high load factor
- Minimize maximum demand by tripping loads through a demand controller
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.99 under rated load conditions.
- Set transformer taps to optimum settings.
- Shut off unnecessary computers, printers, and copiers at night.

23.2 Motors

- Properly size to the load for optimum efficiency.
- (High efficiency motors offer of 4 - 5% higher efficiency than standard motors)
- Check alignment.
- Provide proper ventilation
- (For every 10°C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)
- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply.
- (An Imbalanced voltage can reduce 3 - 5% in motor input power)
- Demand efficiency restoration after motor rewinding.

23.3 Drives

- Use variable-speed drives for large variable loads.
- Use high-efficiency gear sets.
- Use precision alignment.
- Check belt tension regularly.
- Eliminate variable-pitch pulleys.
- Use flat belts as alternatives to v-belts.
- Use synthetic lubricants for large gearboxes.
- Eliminate eddy current couplings.
- Shut them off when not needed.

23.4 Fans

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- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.

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- Clean screens, filters, and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimize fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimize bends in ductwork
- Turn fans off when not needed.

23.5 Blowers

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimize blower inlet and outlet obstructions.
- Clean screens and filters regularly.
- Minimize blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable blower loads.
- Use energy-efficient motors for continuous or near-continuous operation.
- Eliminate ductwork leaks.
- Turn blowers off when they are not needed.

23.6 Pumps

- Operate pumping near best efficiency point.
- Modify pumping to minimize throttling.
- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- Stop running both pumps -- add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.
- Increase fluid temperature differentials to reduce pumping rates.
- Repair seals and packing to minimize water waste.
- Balance the system to minimize flows and reduce pump power requirements.
- Use siphon effect to advantage: don't waste pumping head with a free-fall (gravity) return.

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23.7 Chillers

- Increase the chilled water temperature set point if possible.
- Use the lowest temperature condenser water available that the chiller can handle.
- (Reducing condensing temperature by 5.5°C, results in a 20 - 25% decrease in compressor power consumption)
- Increase the evaporator temperature
- (5.5°C increase in evaporator temperature reduces compressor power consumption by 20 - 25%)
- Clean heat exchangers when fouled.
- (1 mm scale build-up on condenser tubes can increase energy consumption by 40%)
- Optimize condenser water flow rate and refrigerated water flow rate.
- Use water-cooled rather than air-cooled chiller condensers.
- Use energy-efficient motors for continuous or near-continuous operation.
- Specify appropriate fouling factors for condensers.
- Do not overcharge oil.
- Install a control system to coordinate multiple chillers.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest operating costs to serve base load.
- Avoid oversizing -- match the connected load.
- Isolate off-line chillers and cooling towers.
- Establish a chiller efficiency-maintenance program. Start with an Energy & Safety Audit and follow-up, then make a chiller efficiency-maintenance program a part of your continuous energy management program.

23.8 HVAC (Heating / Ventilation / Air Conditioning)

- Tune up the HVAC control system.
- Consider installing a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Balance the system to minimize flows and reduce blower/fan/pump power requirements.
- Eliminate or reduce reheat whenever possible.
- Use appropriate HVAC thermostat setback.
- Use building thermal lag to minimize HVAC equipment operating time.
- In winter during unoccupied periods, allow temperatures to fall as low as possible without freezing water lines or damaging stored materials.
- In summer during unoccupied periods, allow temperatures to rise as high as possible without damaging stored materials.
- Improve control and utilization of outside air.
- Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.

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- Reduce HVAC system operating hours (e.g. -- night, weekend).
- Optimize ventilation.
- Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g. -- computer rooms).
- Provide dedicated outside air supply to kitchens, cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- Use evaporative cooling in dry climates.
- Clean HVAC unit coils periodically and comb mashed fins.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Check HVAC filters on a schedule (at least monthly) and clean/change if appropriate.
- Check pneumatic controls air compressors for proper operation, cycling, and maintenance.
- Isolate air conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Install ceiling fans to minimize thermal stratification in high-bay areas.
- Relocate air diffusers to optimum heights in areas with high ceilings.
- Consider reducing ceiling heights.
- Eliminate obstructions in front of radiators, baseboard heaters, etc.
- Check reflectors on infrared heaters for cleanliness and proper beam direction.
- Use professionally-designed industrial ventilation hoods for dust and vapor control.
- Use local infrared heat for personnel rather than heating the entire area.
- Use spot cooling and heating (e.g. -- use ceiling fans for personnel rather than cooling the entire area).
- Purchase only high-efficiency models for HVAC units.
- Put HVAC window units on timer control.
- Don't oversize cooling units. (Oversized units will "short cycle" which results in poor humidity control.)
- Install multi-fueling capability and run with the cheapest fuel available at the time.
- Consider dedicated make-up air for exhaust hoods. (Why exhaust the air conditioning or heat if you don't need to?)
- Minimize HVAC fan speeds.
- Consider desiccant drying of outside air to reduce cooling requirements in humid climates.
- Seal leaky HVAC ductwork.
- Seal all leaks around coils.
- Repair loose or damaged flexible connections (including those under air handling units).
- Eliminate simultaneous heating and cooling during seasonal transition periods.
- Zone HVAC air and water systems to minimize energy use.
- Inspect, clean, lubricate, and adjust damper blades and linkages.
- Establish an HVAC efficiency-maintenance program. Start with an Energy & Safety Audit and follow-up, then make an HVAC efficiency-maintenance program a part of your continuous energy management program.

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23.9 Lighting

- Reduce excessive illumination levels to standard levels using switching,de-lamping, etc. (Know the electrical effects before doing de-lamping.)
- Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
- Install efficient alternatives to incandescent lighting, mercury vapor lighting, etc. Efficiency (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent.
- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete fluorescent systems to Compact fluorescents and electronic ballasts
- Consider lowering the fixtures to enable using less of them.
- Consider day-lighting, skylights, etc.
- Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type, and control. Control it aggressively.
- Change exit signs from incandescent to LED.

23.10DG Sets

- Optimize loading
- Use waste heat to generate steam/hot water /power an absorption chiller or preheat process or utility feeds.
- Use jacket and head cooling water for process needs
- Clean air filters regularly
- Insulate exhaust pipes to reduce DG set room temperatures
- Use cheaper heavy fuel oil for capacities more than 1MW

23.11Buildings

- Seal exterior cracks/openings/gaps with caulk, gasketing, weatherstripping, etc.
- Consider new thermal doors, thermal windows, roofing insulation, etc.
- Install windbreaks near exterior doors.
- Replace single-pane glass with insulating glass.
- Consider covering some window and skylight areas with insulated wall panels inside the building.
- If visibility is not required but light is required, consider replacing exterior windows with insulated glass block.
- Consider tinted glass, reflective glass, coatings, awnings, overhangs, draperies, blinds, and shades for sunlit exterior windows.

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- Use landscaping to advantage.
- Add vestibules or revolving doors to primary exterior personnel doors.
- Consider automatic doors, air curtains, strip doors, etc. at high-traffic passages between conditioned and non-conditioned spaces. Use self-closing doors if possible.
- Use intermediate doors in stairways and vertical passages to minimize building stack effect.
- Use dock seals at shipping and receiving doors.
- Bring cleaning personnel in during the working day or as soon after as possible to minimize lighting and HVAC costs.

23.12Water & Wastewater

- Recycle water, particularly for uses with less-critical quality requirements.
- Recycle water, especially if sewer costs are based on water consumption.
- Balance closed systems to minimize flows and reduce pump power requirements.
- Eliminate once-through cooling with water.
- Use the least expensive type of water that will satisfy the requirement.
- Fix water leaks.
- Test for underground water leaks. (It's easy to do over a holiday shutdown.)
- Check water overflow pipes for proper operating level.
- Automate blow-down to minimize it.
- Provide proper tools for wash down -- especially self-closing nozzles.
- Install efficient irrigation.
- Reduce flows at water sampling stations.
- Eliminate continuous overflow at water tanks.
- Promptly repair leaking toilets and faucets.
- Use water restrictors on faucets, showers, etc.
- Use self-closing type faucets in restrooms.
- Use the lowest possible hot water temperature.
- Do not use a heating system hot water boiler to provide service hot water during the cooling season -- install a smaller, more-efficient system for the cooling season service hot water.
- If water must be heated electrically, consider accumulation in a large insulated storage tank to minimize heating at on-peak electric rates.
- Use multiple, distributed, small water heaters to minimize thermal losses in large piping systems.
- Use freeze protection valves rather than manual bleeding of lines.
- Consider leased and mobile water treatment systems, especially for de-ionized water.
- Seal sumps to prevent seepage inward from necessitating extra sump pump operation.
- Install pretreatment to reduce TOC and BOD surcharges.
- Verify the water meter readings. (You'd be amazed how long a meter reading can be estimated after the meter breaks or the meter pit fills with water!)
- Verify the sewer flows if the sewer bills are based on them.

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23.13 Miscellaneous

- Meter any unmetered utilities. Know what is normal efficient use. Track down causes of deviations.
- Shut down spare, idling, or unneeded equipment.
- Make sure that all of the utilities to redundant areas are turned off -- including utilities like compressed air and cooling water.
- Install automatic control to efficiently coordinate multiple air compressors, chillers, cooling tower cells, boilers, etc.
- Renegotiate utilities contracts to reflect current loads and variations.
- Consider buying utilities from neighbors, particularly to handle peaks.
- Leased space often has low-bid inefficient equipment. Consider upgrades if your lease will continue for several more years.
- Adjust fluid temperatures within acceptable limits to minimize undesirable heat transfer in long pipelines.
- Minimize use of flow bypasses and minimize bypass flow rates.
- Provide restriction orifices in purges (nitrogen, steam, etc.).
- Eliminate unnecessary flow measurement orifices.
- Consider alternatives to high-pressure drops across valves.
- Turn off winter heat tracing that is on in summer.

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ANNEXURES

Annex I –Certification

This part shall indicate certification by Accredited Energy Auditor stating that:

(i) The data collection has been carried out diligently and truthfully;

(ii) All data monitoring devices are in good working condition and have been calibrated or certified by approved agencies authorized and no tempering of such devices has occurred

(iii) All reasonable professional skill, case and diligence had been taken in preparing the energy audit report and the contents thereof are a true representation of the facts;

(iv) Adequate training provided to personnel involved in daily operations after implementation of recommendations; and

(v) The energy audit has been carried out in accordance with the Bureau of Energy Efficiency (Manner and Intervals of Time for the Conduct of Energy Audit) Regulations, 2010.

(Dr. P.P. Mittal)
Accredited Energy Auditor AEA-011

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Annex II –Certificate of Accreditation

BUREAU OF ENERGY EFFICIENCY

Examination Registration No. : ....EA-6851........

Accreditation Registration No.: ....AEA-0011........

Certificate of Accreditation

This is to certify that Mr./Ms.........Prem Prakash Mittal..........having its trade/registered office at Delhi.................. has been given accreditation as accredited energy auditor. The certificate shall be effective from ..26th... day of ...February 2013...

The certificate is subject to the provisions of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010.

This certificate shall be valid until it is cancelled under regulation 9 of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010

On cancellation, the certificate of accreditation shall be surrendered to the Bureau within fifteen days from the date of receipt of order of cancellation.

Your name has been entered at AEA No...0011... in the register of list of accredited energy auditors. Your name shall be liable to be struck out on the grounds specified in regulation 8 of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010.

Given under the seal of the Bureau of Energy Efficiency, Ministry of Power, this ......26th....... day of May 2014.

Secretary,
Bureau of Energy Efficiency
New Delhi

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ANNEXURE III–Venders List

The details of suppliers/manufacturers of energy efficient technologies are provided below.

Srl.	Product / Equipment	Agency Name / Address
1	DG Synchronization, Automation and capacitors	SGS Industrial Controls & Solutions Pvt. Ltd. Floor-II, MadanpurKhadar, SaritaVihar, New Delhi Tel. 011-29942516, 41402992
2	Eco-Ventilators	Nu Plast Pipes &profilies SCF – 124, Sector – 17 Market, Faridabad - 121002 Tel. 0129-6456217, 4070023
3	Electrical measurement Instrument	Riken Instrument Ltd. 369, Industrial Area, Phase –II, Panchkula Haryana Tel. : 0172-2591651, 2592028 www.rikeninstrumentation.com
4	Energy Management & Control System	Manaco Energy Solutions (P) Ltd. A-6, Shanti Apts. 21 & 22,1st Cross St.TTKRoad, Alwarpet Chennai-18, Tel. 044-42316164 www.mesco.co.in
5	Energy Saving Products	Gautam Enterprises 205, VinayIndl. Est. ChicholiBunder Link Road, Malad(W) Mumbai – 6, India
4	Energy Saving Products	Techmark Engineers & Consultants K-1/28, Ground Floor, Chittaranjan Park, New Delhi – 110019Tel. 011-26238349
5	Flue Gas Analyzer/ Oxygen Analyzer	Nevco Engineers Pvt. Ltd. 90A, (2nd Floor) Amritpuri B, main Road, East of kailash, Opp. Iskcon Temple, New Delhi – 110 065 Tel. 26226328, 26213009 www.nevco.co.in

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6	Flue Gas Analyzer/ Oxygen Analyzer	ACE Instruments & Controls 1 Birandari, Above Kashi Dairy MG Road, Ghatkopar (W) Mumbai – 400 086 Tel. 5125153, 5122762
7	FRP Blades & Cooling Tower accessories	Eneertech Engineers SCO 144 – 145, Sector – 34A, Chandigarh Tel. 0172-5018077, 9876022225
8	HVAC related instruments Thermocouples pipe fittings pressure gauges	Waaree, 36 Damjishamji Industrial Complex, Off Mahakali caves Road, Andheri (E) Mumbai tel. 02266963030, 26874778
9	Infrared Temperature Meters (600 °C to 1800 °C	Toshniwal Industries Pvt. Ltd. Industrial Area MahU.Pupura, Ajmer – 305 002 Tel. 91145 2695171, 91145 2695205
10	Infrared Temperature Meters (upto 1500 °C)	KusamMeco, G-17, Bharat Industrial Area, T.J. Road, Sewree Mumbai – 400015 Tel. 02224156638, 24124540
11	AC Drives	Rockers Control System SCO 819 2nd Floor, NAC Manimajra, Chandigarh – 160101 Tel. 0172-2730900, 5071627
12	AC Drives	Allen Bradley India Ltd. C – 11, Industrial Area, Site – IV, Sahibabad, Ghaziabad
13	AC Drives	Asea Brown Boveri Ltd. Guru Nanak Foundation Building, 15 – 16, Qutab Institutional Area, SaheedJeet Singh Sansnwal Marg, New Delhi 110 067
14	AC Drives	Crompton Greaves Ltd. Machine 3 Division, A – 6 / 2, MIDC Area, Ahmednagar
15	Automation, Panel Meters	Conzerv System 44P, Electronic City Phase –II, East Hosur Road, Banglore – 560100

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16	Automation, Panel Meters	Selec controls Pvt. Ltd. E-121 Ansa Industrial Estate, Saki Vihar Road, Mumbai 400072 Tel.: 022-28471882, 28476443 www.selecindia.com
17	Building Automation, sensors, twilight Switches	Electro Art Plot No. K-11, MIDC Area, Ambad, Nasik – 422010 Tel. 0253-5603954, 2380918, www.electronicswitchesindia.com
18	Burners	Wesman Engineering (P) Ltd. 503-504 Eros Apartments, 56, Nehru Place, New Delhi – 110019 Tel. : 26431723, 26434577
19	Burners, Furnace RecuperatorsHor air Generation, Heating & Pumping unit Laddle pre-heating	ENCON 12/3, Mathura Road, Faridabad – 121003 Tel. : 0129-25275454 www.encon.co.in
20	Capacitors	Asian Electronics Ltd. Plot No. 68, MIDC, Satpur, Nasik – 422 007
21	Capacitors	Shreem Capacitors Pvt. Ltd. /39, VikramVihar, Lajpat Nagar-IV, New Delhi – 110024
22	Capacitors & APFC Panels	Matrix Controls & Engineers Pvt. Ltd. E-725, DSIDC Industrial Complex, Narela, GT Road, Delhi – 011-27786945 / 46 / 47 Rajeev Batra 9811624440, Rajeev@matrixcapacitor.com
23	Capacitors & APFC Panels	Standard Capacitors B-70/43, DSIDC Complex, Lawrence Road, Industrial Area,, Delhi – 110035Tel: 011-27181490, 27151027 www.standardcapacitors.com
24	Capacitors & APFC Panels	Saif Electronics 174, Hira Building, 1st Floor, Carnac Road, Opposite Police Commissioner Officer Mumbai Tel. 022-22064626, 22086613 www.saifel.com

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25	Insulations	Llyod Insulations (India) Ltd. PB NO. 4321, Kalkaji Industrial Area, Punj Sons Premises, New Delhi Tel. : 26430746-7
26	Insulations	Hirnal Supply (India) Ltd. 168, Rajagarden, New Delhi – 110015 Tel: 011-25438602, 25448602
27	Insulations	Technical & Management Consultancy Center SCO – 324, 2nd Floor, Cabin – 203, Sector – 9, Panchkula Ry_tmcc@yahoo.com
28	LED Lighting	Synergy Solar (P) Ltd. SCO 133, Sector 28D, Chandigarh Tel. : 0172-6451133, www.synergysolars.com
29	Lighting system	Philips India Ltd. Regional Office-North, 9th Floor Ashoka Estate, 24, Barakhamba Road, New Delhi – 110 001 Tel. : 3353280, 3317442
30	Lighting system	Crompton Greaves Ltd. Lighting Business Group, 405, Concorde, RC Dutt Road, Baroda – 390 007
31	Lighting system	Osram India Ltd. Signature Towers, 11th Floor, Tower B, South City-I, Bareilly -122001Tel.: 0124-6526175, 6526178, 6526285
32	Lighting system	Asian Electronics Surya Place, First Floor, K-185, Sarai Julena New Friends Colony, New Delhi – 110 025
33	Lighting system	Philips India Limited, Technopolis Knowledge Park, Nelco Complex, Mahakali Caves Road, Chakala, Andheri (E) Mumbai – 400 093 Tel
34	Lighting system Director Administration Invertis University	Surya Roshni Ltd. Padma Tower_I, Rajendra Palace, New Delhi – 110 006 Registrar Invertis University Bareilly

35	Lighting system	Wipro Limited SCO – 196-197, Sector – 34-A, Chandigarh – 160 022
36	Lighting Voltage Control Systems	Jindal Electric & machinery Corporation C – 57, Focal Point, Ludhiana – 141010 Tel. : 2670250, 2676890
37	Lighting Voltage Control System	ES Electronics (India) Pvt. Ltd. Plot No. 82, KIADB Industrial Area, Bommasandra – Jigani Link Road, JiganiHobli Banglore – 562 106

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