PPS Energy Solutions

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Date: 31st Dec 2019

To,
The Principal,
Vidya Bharati Mahavidyalaya,
Amravati

This is to certify that, we M/s. **PPS Energy Solutions Pvt. Ltd, Pune** successfully conducted "**Detailed Energy Audit**' of Vidya Bharati Mahavidyalaya campus under Save Energy Program (SEP) of Maharashtra Energy Development Agency (MEDA) and submitted Detailed Energy Audit Report in **December 2019** consisting of Recommendations to implement Energy Conservation Measures (ECMs) to realise the savings in electrical consumption

Thanks & Regards,

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DETAILED ENERGY AUDIT REPORT

Vidyabharati Mahavidyalaya

C. K. Naidu Road, Camp,
Amravati - 444602, Maharashtra

December 2019

Conducted By

PPS Energy Solutions Pvt. Ltd.
Engineering Consultants
Plot No-18, Girish Housing Society
Warje, Pune – 411058, Maharashtra, India

PREFACE

Energy Audit is a key parameter of systematic approach for decision-making in the area of energy management. It attempts to determine how and where energy is used and to identify methods for energy savings. There is now a universal recognition of the fact that new technologies and much greater use of some that already exists provide the most hopeful prospects for the future. The opportunities lie in the use of existing renewable energy technologies, greater efforts at energy efficiency and the dissemination of these technologies and options.

As per the Energy Conservation Act, 2001, Energy audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

Present energy audit is a mare mile marker towards destination of achieving safe, healthy and energy efficient unit. We would like to emphasize that an electrical audit is a continuous process. We have compiled a list of possible actions to conserve and efficiently utilize our scarce resources and identified their savings potential. The next step would be to prioritize their implementation. Implementation of recommended measures can help consumes to achieve significant reduction in their energy consumption levels.

WHY ENERGY AUDIT?

An energy audit determines the amount of energy consumption affiliated with a facility and the potential savings associated with that energy consumption. Additionally, an energy audit is designed to understand the specific conditions that are impacting the performance and comfort in your facility to maximize the overall impact of energy-focused facility improvements.

An energy audit is a systematic review of the energy consuming installations in a facility to ensure that energy is being used sensibly and efficiently. An energy audit usually commences with the collection and analysis of all information that may affect the energy consumption of the building or premises, then follows with reviewing and analyzing the condition and performance of various facility services installations and facility management, with an aim at identifying areas of inefficiency and suggesting means for improvement.

Through implementation of the suggested improvement measures, facility owners can get the immediate benefit for paying less for energy bills. On the other hand, lowering of energy consumption in facility will lead to the chain effect that the power supply companies will burn less fossil fuel for electricity generation and relatively less pollutants and greenhouse gases will be introduced into the atmosphere, thus contributing to conserve the environment and to enhance sustainable development.

ACKNOWLEDGEMENT

We express our sincere gratitude to the authorities of Vidyabharati Mahavidyalaya, Amravati for entrusting and offering the opportunity. It is our immense pleasure to present the detailed energy audit report.

We acknowledge the support from management for their positive support in undertaking the task of energy efficiency assessment of all electrical system, thermal systems, utilities and other area and for continuous help and support before and during the audit.

We are also thankful to all field staff and agencies working with whom we interacted during the field studies for their wholehearted support in undertaking measurements and eagerness to assess the system / equipment performance and saving potential. We admire the help of all concerned staff for their active participation in completing official documentations.

We express our sincere gratitude to the authorities of Vidyabharati Mahavidyalaya, Amravati for entrusting PPS Energy Solutions Pvt. Ltd.

For PPS Energy Solutions Pvt. Ltd.

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About PPSES

M/s. PPS Energy Solutions Pvt. Ltd (PPSES) is an ambitious company, established by enterprising engineering professionals in the year 2009. The company offers services pertaining to Energy and Engineering to clients across the globe. Our team is based in Pune, a city known for its Software and Engineering talent in India. We are a rapidly growing company with a team of about 100 people which includes highly trained and experienced Techno-Managers, Analysts, and Engineers & Detailers.

We are presently working in India (Maharashtra, Assam, Madhya Pradesh, Gujarat, Andhra Pradesh, Delhi, Orissa, Chhattisgarh, Bihar, Andhra Pradesh, Telangana and Jharkhand) and Abroad (Bahrain, Stanford)

- We serve in majorly four areas,
  - Energy Audit, Management and System Evaluations
  - Power Distribution System Design, Evaluations and Monitoring
  - MEP Design and Project management
  - Research and Training

PPSES Team Members

Name	Role	Academics and Expertise
Dr. Ravi Deshmukh	ECM verification, Report verification and presentation	Accredited Energy Auditor, PhD, M tech, MBA (Power), Graduate E&TC Engineer with over 18 years of experience in Energy Management, Management of Power System, street light projects, Power Exchange Operations, Power Trading and Analysis, Electrical Automation. Has worked as Expert in Iron & Steel sector and Energy
Mr .Nilesh Saraf	Co-ordination with officers, project status review.	Expert in Energy sector with 16 years of experience in Energy efficiency assessment, Industrial engineering sector & Renewable Energy.
Mr. Vinayak Apte	Energy Audit Expert	Graduate Electrical Engineer with more than 10 years of experience in various sectors. He handled Energy Audits, Energy Conservation and Energy Efficiency projects in Industries, Commercial and Residential Buildings, Pump House
Mr. Vedmurthy Swamy	Field study, data tabulation and analysis, report preparation	Graduate Mechanical Engineer with 5 years of experience in project management, energy efficiency assessment
Mrs. Utkarsha Bharate	Data tabulation and analysis, report preparation	Graduate in Electrical & Electronics Engineering, Sr. Engineer, 3 years of experience in Energy & Power projects

1. EXECUTIVE SUMMARY

Detailed Energy Audit was undertaken in order to evaluate energy performance and identify potential energy conservation measures. Detailed Energy Audit was undertaken in three steps, i.e. document review of data and information initially provided by facility, site visit and preparation of this report.

Energy audit team conducted the site visit. The site visit includes interaction with staff, electricians of building, the collection/review of further data and a field inspection of the facilities and equipment.

The salient observations and recommendations are given below.

1. The average cost of energy is around **Rs. 5,94,812**/- per Annum
2. Average monthly units consumed is **3,659 kWh** equivalent to **Rs. 49,568/-**
3. Average electricity charges works out to be **Rs. 8**/-

This brief report has therefore sought to provide a high-level overview of the status of energy efficiency at building, combined with an illustration of areas where further, previously unidentified savings opportunities may exist.

Our survey has identified further potential opportunities, ranging from "no & low cost" measures, through to those that will require significant capital expenditure.

Note: Investment figures mentioned in are only indicative, further detailed study is recommended.

Summary of Recommended Energy Conservation Measures:

Sr. No.	ECM Details	Investment (Rs. Lacs)	Savings (kWh/year)	Carbon credit (Tons of Co2)	Saving (Rs. Lacs /Year)	Payback (Years)
1	Replacement of Conventional Lights with More Efficient Lights	2.32	4706.40	4.00	0.38	6.15
2	Replacement of Existing Fans with Energy Efficient Fans	7.40	10268.16	8.73	0.82	9.01
3	Optimize the temperature setting to 23-25 degree celsius	0.00	41.55	0.04	0.00	0.00
4	Replacement of No star ACs (1.5 T and 2.0 T) with 5 star Acs.	1.41	499.95	0.45	0.04	35.33
	Total	**11.13**	**15516.06**	**13.21**	**1.24**	**8.96**

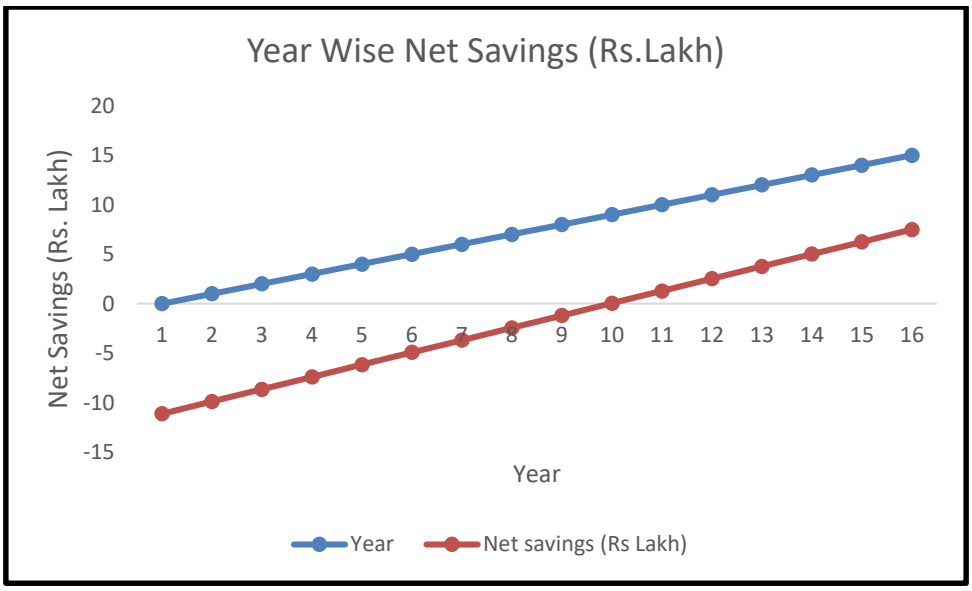
Note: Estimated savings may base on operating conditions

During the Energy Audit, Total Estimated Investment of Rs 11,13,000/- yields Total Estimated Savings of Rs. 1,24,000/- which 21 % of the Total Energy Cost of Rs. 5,94,812/-with an overall payback period of 9.41 Years.

Other Recommendations:

A. Regular cleaning and maintenance of equipment's is important to reduce energy losses.
B. Use of star rated equipment's is also strongly recommended specially in case of Fans and Air conditioning.
C. Cleaning of ceiling fan and exhaust fan blades will reduce the drag on the fan and intern will reduce energy loss.
D. Awareness amongst students and staff is very essential step to reduce wastage of electricity
E. Energy conservation awareness programs can be conducted once a year. Increasing energy awareness of employees and students motivates them to work as a team can lead to reductions in energy consumption and save the money.

Year	Investment (Rs. In Lacs)	Saving (Rs.In Lacs /Year)	Cum Savings(Rs Lakh)	Net savings (Rs Lakh)
0	-11	0	0	-11
1	0	1	1	-10
2	0	1	2	-9
3	0	1	4	-7
4	0	1	5	-6
5	0	1	6	-5
6	0	1	7	-4
7	0	1	9	-2
8	0	1	10	-1
9	0	1	11	0
10	0	1	12	1
11	0	1	14	3
12	0	1	15	4
13	0	1	16	5
14	0	1	17	6
15	0	1	19	7


Year Wise Net Savings (Rs.Lakh)
Net Savings (Rs. Lakh)
20
15
10
5
0
-5
-10
-15
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Year
Year
Net savings (Rs Lakh)

2. GENERAL AUDIT REVIEW

Building can implement faster payback energy conservation measures (ECMs) which have already been considered and for which the ECMs are fully developed.

Other General Points:

1. Energy conservation awareness programs can be conducted once a year. Increasing energy awareness of staff, students and motivating them to work as a team can lead to reductions in energy consumption and save the money. Savings estimates range in the order of 5 to 10%. When implemented effectively these savings can be realized quickly and cost effectively.
2. Most of the fans are of older design and not energy inefficient.
3. Most of the places the tube light installed are energy efficient and fittings are in healthy condition.
4. Natural day light is efficiently used in corridor and few classrooms and labs areas.

It is believed that with the current approach and organization of energy management, energy can be reduced in a systematic, cost effective manner. We hope that this report will help building to implement these changes and provide direction to the Energy Management Team.

3. ABOUT ENERGY AUDIT

Objective

The overall objective of the assignment is to quantify energy saving in existing system and achieve reduction in energy consumption pattern.

Hence the detail objectives are as under,

1. To calculate the energy consumption
2. To evaluate the performance of the equipment
3. To find out the energy saving opportunities
4. To quantify the total energy savings
5. To find out the ways to achieve energy efficiency

3.1. Scope of Work

Following is the scope of work envisaged for this assignment,

Data Collection
To collect the details of various electrical and mechanical system and their ratings, the available drawings and details shall be studied. Detail load list shall be prepared and checked.

A, B, C Analysis
With the details available from load list, analysis shall be carried out depending on the present usage trends. All the power consuming equipment's shall be classified in three categories depending on their ratings, condition and operating time. The area for larger potentials for savings shall be identified.

Field Study
The detail field study on site shall include the following as well as all other measures required for energy audit study,

a. Lay out the system and study of Electrical distribution
b. Study of area wise power distribution and Measurement of power consumption
c. Study of instrumentation provided
d. Measurement of motor currents, voltages, power etc. parameters by energy analyzer and measurement of water flow, pressures etc. parameters of pumps simultaneously and other measurements as needed to characterize the system and required for calculating efficiency at various combinations
e. Study of air conditioner operations and system requirements
f. Analysis of readings obtained from field with the standard consumption.

3.2. Approach and Methodology

1. Understanding the Scope of Work and Resource Planning

2. Identification of Key Personnel for the assignment/ project

3. Structured Organization Matrix

4. Steps in preparing and implementing energy audit assignment
   a) Discussions with key facility personnel
   b) Site visits and conducting "walk-through audit".
   c) Preliminary Data Collection through questionnaire before audit team's site visit
   d) Steps for conducting the detailed audit
      - Plan the activities of site data collection in coordination with the facility in-charge.
      - Study the existing operations involving energy consumption
      - Collect and collate the energy consumption data with respect to electricity consumption
      - Conduct performance tests to assess the efficiency of the system equipment/ electricity distribution, lighting, and identify energy losses.
      - Discuss with facility personnel about identified energy losses.

5. List proposed efficiency measures
   - Develop a set of potential efficiency improvement proposals
   - Baseline parameters
   - Data presentation
   - System mapping
   - List of potential Energy Savings proposals with cost benefit analysis.
   - Review of current operation & maintenance practices

6. Preparation of the Draft Energy Audit Report

7. Preparation and submission of final Energy Audit Report after discussion with concerned persons

4. ENERGY DETAILS

Maharashtra State Electricity Distribution Company Limited (MSEDCL) provides the electricity supply for College building. Billing is carried out with the help of Single meter. according to LT – II B Tariff.

Detailed Energy Auditwas conducted for the load connected to the mains supply used.

Mainly energy is used on this facility for the following purposes:

1) Lighting Load
2) Ceiling Fans

Based on above it is clear that followings buildings have highest potential for energy savings

Table 1 Name of Building

Sr. No.	Name of the Building
1	College Building
2	Girls Hostel

4.1. Electricity Bill Analysis

1. Consumer Details of Meter No. 366470780988

Consumer Details

Table 2 Consumer Details

Parameter	Details
Consumer No.	**366470780988**
Consumer Name	Shri Women Hostel Vidhya Bharti
Address	CMAP Amravati
Pin Code	444602
Sanction load (KW)	22
Tariff	LT – II B

Consumption Details

Table 3 Billing Data

Month	KWH	KVAH	RKVAH (Lag)	RKVAH (Lead)	Recorded MD	Billed MD	Demand Rate (Rs/KVA)	Billed PF	Unit rate (Rs/kWh)	Demand Charges (Rs)	Energy Charges (Rs)	PF Penal /Incentive (Rs)	Total Current Bill (Rs)
Dec-18	1759	1825	396	6	15	10	391	0.98	9.3	3,910	16,358	-367	29,620
Jan-19	1,083	1178	381	3	14	9	350	0.94	9.3	3,150	10,071	0	18,792
Feb-19	458	499	153	6	13	9	350	0.95	9.3	3,150	4,259	0	10,372
Mar-19	535	558	114	1	13	9	350	0.98	9.3	3,150	4,975	-137	11,039
Apr-19	627	643	99	5	12	9	391	0.99	9.3	3,191	5,831	-258	12,393
May-19	1,018	1040	147	5	14	9	391	0.99	9.3	3,519	9,467	-379	18,201
Jun-19	195	206	53	0	13	9	391	0.97	9.3	3,519	1,813	-58	6,954
Jul-19	1,368	1600	706	20	11	9	391	0.88	9.3	3,519	12,722	281	23,249
Aug-19	6,565	6868	1,624	26	19	12	391	0.97	9.3	4,692	61,054	-760	92,503
Sep-19	6,421	6682	1,429	44	19	12	391	0.98	9.3	4,692	59,715	-1,075	86,864
Oct-19	14,578	15058	80	2	17	11	391	1.00	9.3	4,301	47,690	-2,121	72,202
Nov-19	3,138	3231	680	8	19	12	391	0.98	9.3	4,692	29,183	-601	48,529

Month	"A" Zone Units	"A" Zone Demand	"B" Zone Units	"B" Zone Demand	"C" Zone Units	"C" Zone Demand	"D" Zone Units	"D" Zone Demand
Dec-18	502	12	665	15	248	13	343	14
Jan-19	307	12	416	11	127	13	232	12
Feb-19	89	9	152	12	92	13	126	13
Mar-19	0	0	469	9	67	12	0	0
Apr-19	0	0	596	11	25	10	6	6
May-19	0	0	991	14	25	10	1	0
Jun-19	0	0	187	13	6	7	2	5
Jul-19	514	9	472	10	127	8	255	10
Aug-19	2,188	19	2,304	16	844	18	1,228	16
Sep-19	2020	15	2370	16	846	18	1185	19
Oct-19	84	0	4897	0	77	0	69	0
Nov-19	724	17	1,329	17	496	18	589	19

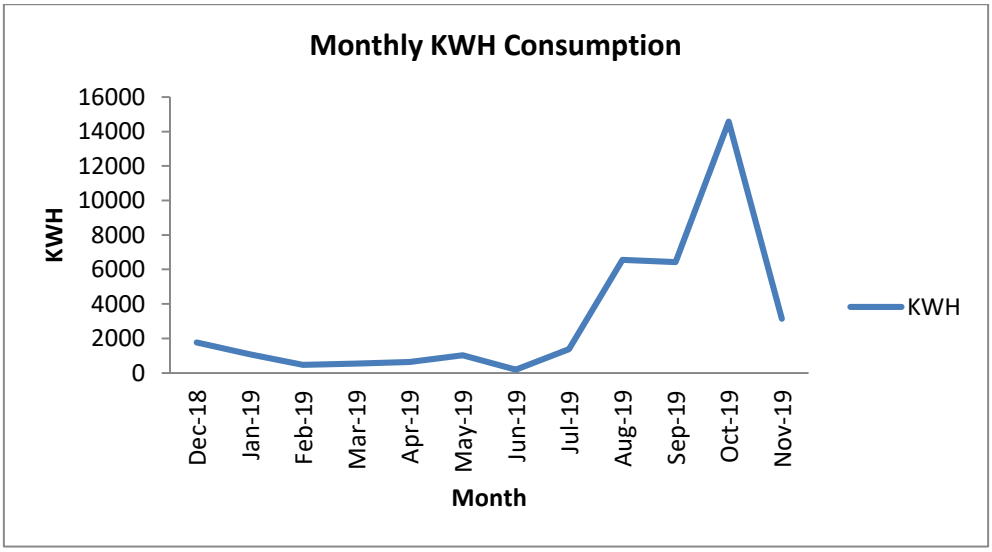


Figure 1 Monthly kWh Consumption

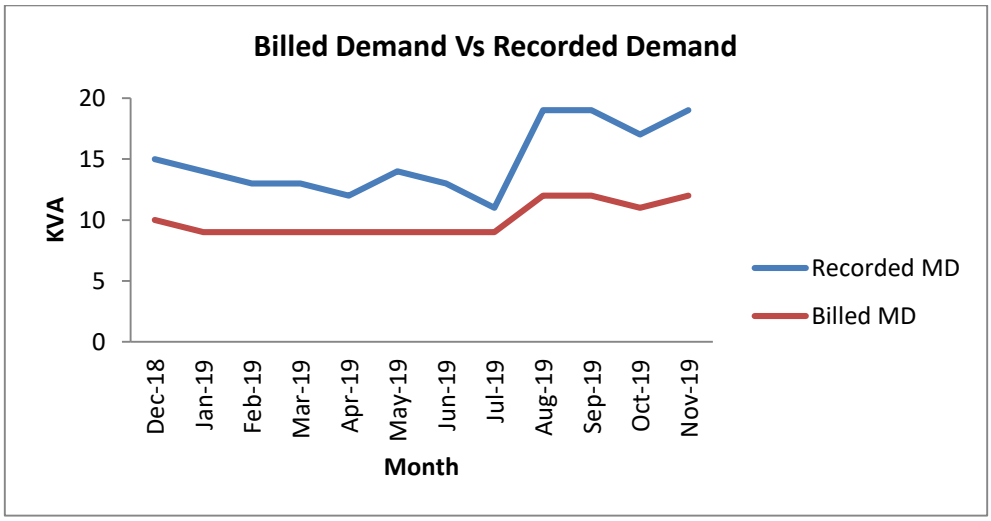


Figure 2 Billed Demand vs Recorded Demand

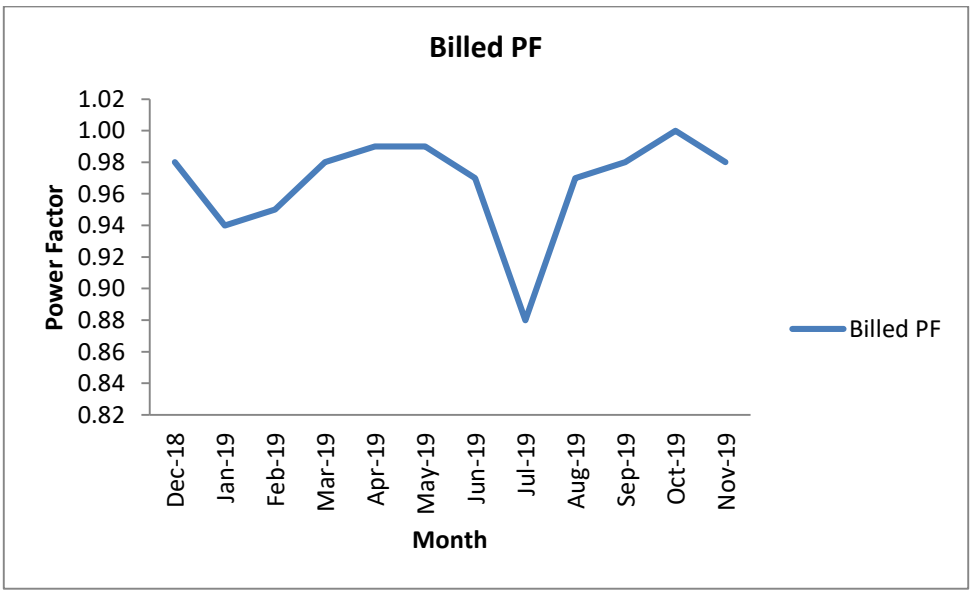


Figure 3 Billed PF vs Power Factor

2. Consumer Details of Meter No. 366470060225

Consumer Details

Table 4 Consumer Details

Parameter	Details
Consumer No.	**366470060225**
Consumer Name	The Sec Vidya Bharti Shikshanik Mandal
Address	Naidu RD Camp In front of reform Club H no 19-966
Pin Code	444602
Sanction load (KW)	50
Tariff	LT – X B II

Consumption Details

Table 5 Billing Data

Month	KWH	RKVAH (Lead)	Recorded MD	Billed MD	Demand Rate (Rs/KVA)	Billed PF	Unit rate (Rs/kWh)	Demand Charges (Rs)	Energy Charges (Rs)	PF Penal/ Incentive (Rs)	Total Current Bill (Rs)
Dec-18	280	0	22	25	351	0.88	6.8	8775	1904	173.92	11821
Jan-19	132	0	8	25	350	1.00	6.85	8750	904	-351	10224
Feb-19	188	250	0	25	350	0.92	6.85	8750	1287	0	10652
Mar-19	198	630	21	25	350	0.71	6.85	8750	1356	1065	11762
Apr-19	222	370	29	25	351	0.86	6.8	8753	1519	273	11249
May-19	260	326	20	25	351	0.89	6.8	8775	1768	113.3	11493
Jun-19	212	392	24	25	351	0.82	6.8	8775	1441	488.8	11392
Jul-19	202	404	33	25	351	0.90	6.8	8775	1373	0	10795
Aug-19	1,016	436	26	25	351	0.95	6.8	8775	6908	0	17778
Sep-19	1,366	428	30	25	351	0.96	6.8	8775	9288	-100.61	20282
Oct-19	1,776	0	41	27	351	0.97	6.8	9477	12076	-247.3	24824.5
Nov-19	308	0	29	25	351	0.93	6.8	8775	2094	0	11821

Month	"A" Zone Units	"A" Zone Demand	"B" Zone Units	"B" Zone Demand	"C" Zone Units	"C" Zone Demand	"D" Zone Units	"D" Zone Demand
Dec-18	0	0	0	22	0	0	280	0
Jan-19	0	0	0	0	0	0	132	0
Feb-19	0	0	0	0	0	0	188	0
Mar-19	0	0	0	1	0	0	198	0
Apr-19	0	0	0	1	0	0	222	0
May-19	0	0	0	0	0	0	260	0
Jun-19	0	0	0	1	0	0	212	0
Jul-19	0	0	0	1	0	0	202	1
Aug-19	0	3	784	26	0	23	232	7
Sep-19	0	2	1096	30	0	26	270	6
Oct-19	0	3	1420	41	0	37	356	9
Nov-19	0	4	0	29	0	22	308	6

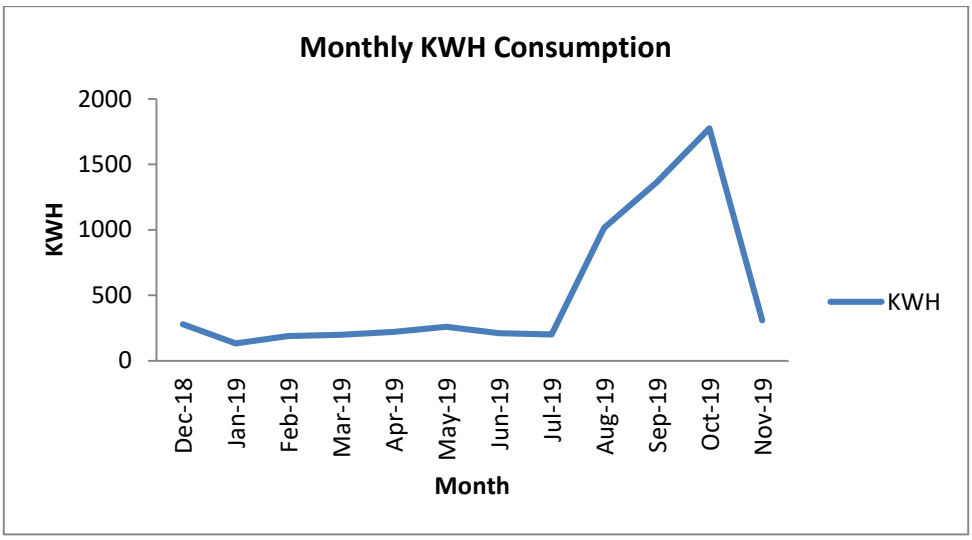


Figure 4 Monthly kWh Consumption

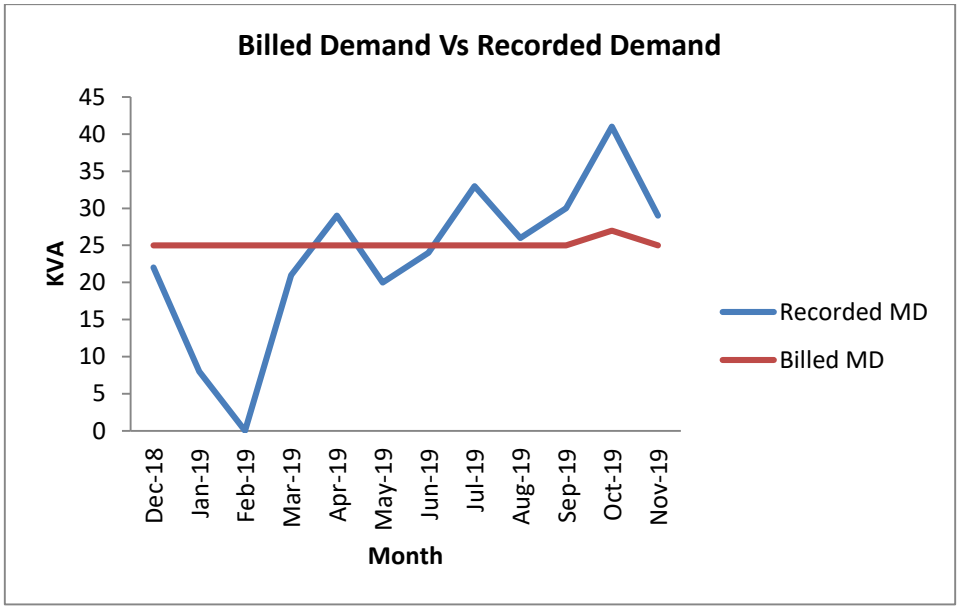


Figure 5 Billed Demand vs Recorded Demand

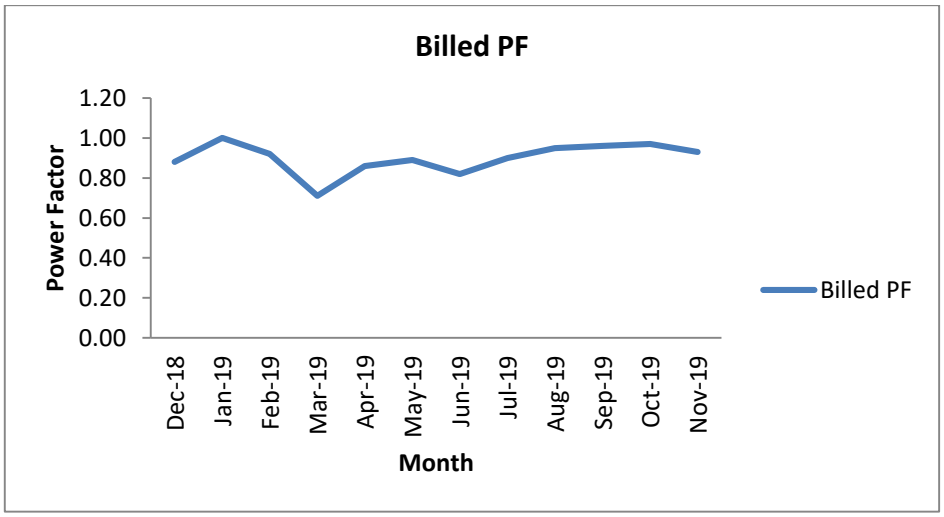


Figure 6 Billed PF vs Power Factor

4.2. Connected Load Quantity of Buildings

Table 4 Connected Load of College Building

Fixtures	Wattage	Ground Floor	First Floor	Second Floor	Third floor	Total Qty	Total Load kW
Ceiling Fan	75	97	87	40	56	280	21.00
Exhaust Fan	55	16		1		17	0.94
Wall Fan	55			12		12	0.66
LED Tube Light	18				3	3	0.05
Tube Light	28	36	88			124	3.47
Tube Light	40			3	6	9	0.36
LED Light	15	27	67	17		111	1.67
LED Light	20	119	20	51	49	239	4.78
LED Light	22	58	11		35	104	2.29
LED Light	50	10				10	0.50
CFL	18			10		10	0.18
CFL	36	6		14	12	32	1.15
Halogen	500				1	1	0.50
Air Cooler	150	3				3	0.45
Water Cooler	700	1	1	1	1	4	2.80
TV Lcd	60		1			1	0.06
Computer	150	30	26	127	5	188	28.20
Printer/scanner	150	26	7	4	3	40	6.00
Xerox M/C	700		1		1	2	1.40
AC Spilt (0*)	2500				3	3	7.50
AC Spilt (2*)	1709		3		6	9	15.38
AC Spilt (3*)	1566	3			13	16	25.06
AC Spilt (5*)	1490	1				1	1.49
Pump (5 HP)	3728.5	1				1	3.73
TOTAL							**129.61**

Table 4 Connected Load of Ladies Hostel Buildings

Fixtures	Wattage	HOSTEL I	HOSTEL II	Total Qty	Total Load kW
Ceiling Fan	75	75	27	102	7.65
Tube Light	28	86	27	113	3.16
LED Light	5		12	12	0.06
Halogen	500		1	1	0.50
Water Cooler	700	2		2	1.40
TV Lcd	60	2		2	0.12
Fridge	700	1		1	0.70
TOTAL					**13.59**

5. ACTUAL MEASUREMENTS

5.1. Study of Loading Pattern for College Building:

The Three-phase portable power analyzer was installed at incoming panel and data is recorded with Solar PV plant in running condition. Following graphs shows the loading pattern, Voltage, Current PF variation.

Parameter		R-Phase	Y-Phase	B-Phase	Total/Neutral
Voltage (V)	Avg	431.72	432.89	432.29	-
	Max	433.60	435.00	433.90	-
	Min	430.4	430.60	430.90	-
Current (A)	Avg	37.20	37.48	34.96	10.74
	Max	40.45	39.07	39.34	14.85
	Min	30.83	33.12	27.84	8.88
Active Power (W)	Avg	5214.25	5235.31	4351.27	14800.82
	Max	5889.00	5700.00	5475.00	17000.00
	Min	4289.00	4733.00	3085.00	13298.00
Power Factor	Avg	0.57	0.56	0.49	0.54
	Max	0.61	0.61	0.57	0.59
	Min	0.53	0.53	0.42	0.5
V % THD	Avg	2.30	2.48	2.61	-
	Max	2.51	2.70	2.87	-
	Min	1.89	2.06	2.18	-
I % THD	Avg	13.23	12.97	11.25	247.15
	Max	18.43	15.7	16.17	651.27
	Min	11.22	11.98	8.59	44.57

Comments:

1) Average, Maximum and Minimum variations for all the Phases is within the limit of +/- 6% i.e.,413 V to 467 V
2) The voltage unbalance between the Phases is Absent.
3) The current unbalance between the Phases is Absent.
4) Total Harmonic Distortion for voltage is within the limits of 5% whereas Total Harmonic Distortion forCurrent is more than 15%.

Recommendation:

It is recommended to install suitable size of Active Harmonic Filter to suppress Current Total Harmonic Distortion.

Voltage Variation:

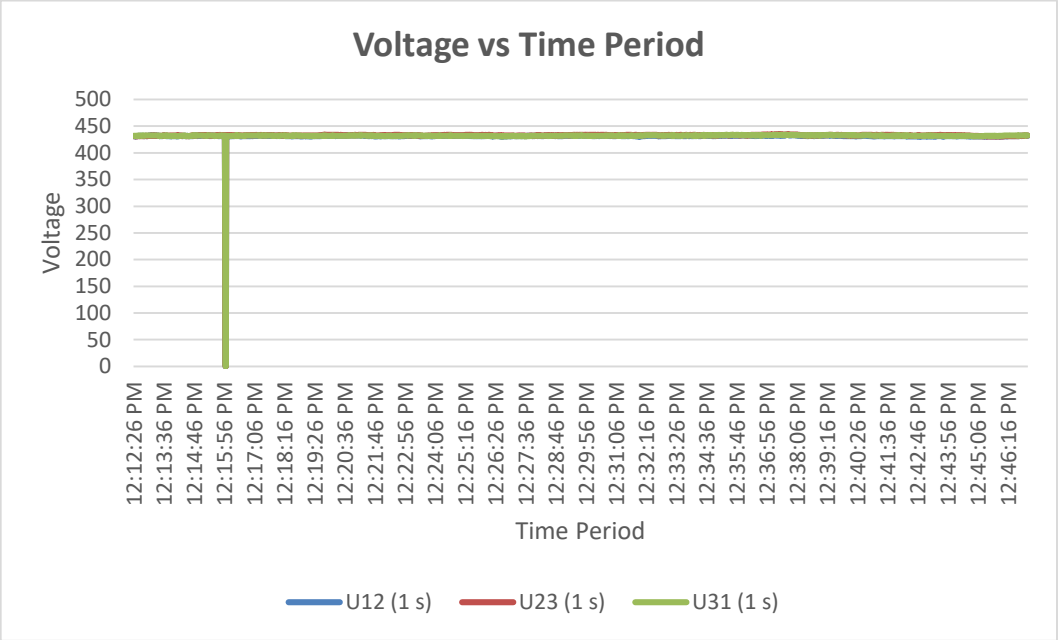


Figure 7 Voltage vs Time Period

Current Variation:

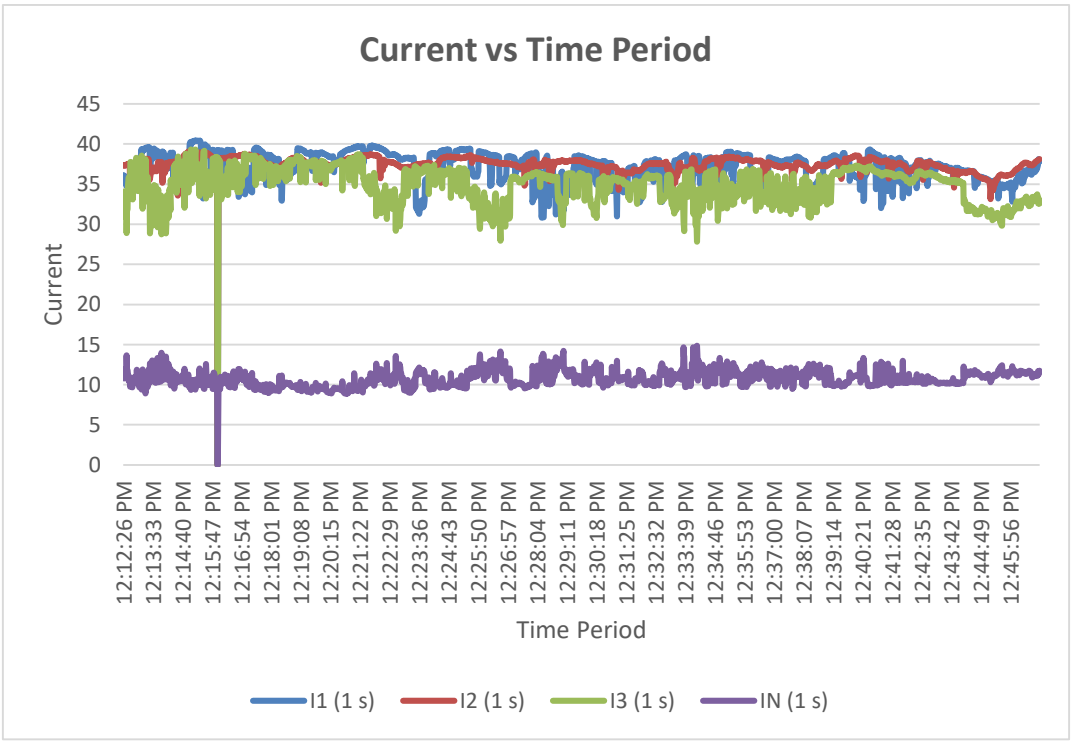


Figure 8 Current vs Time Period

Power Variation:

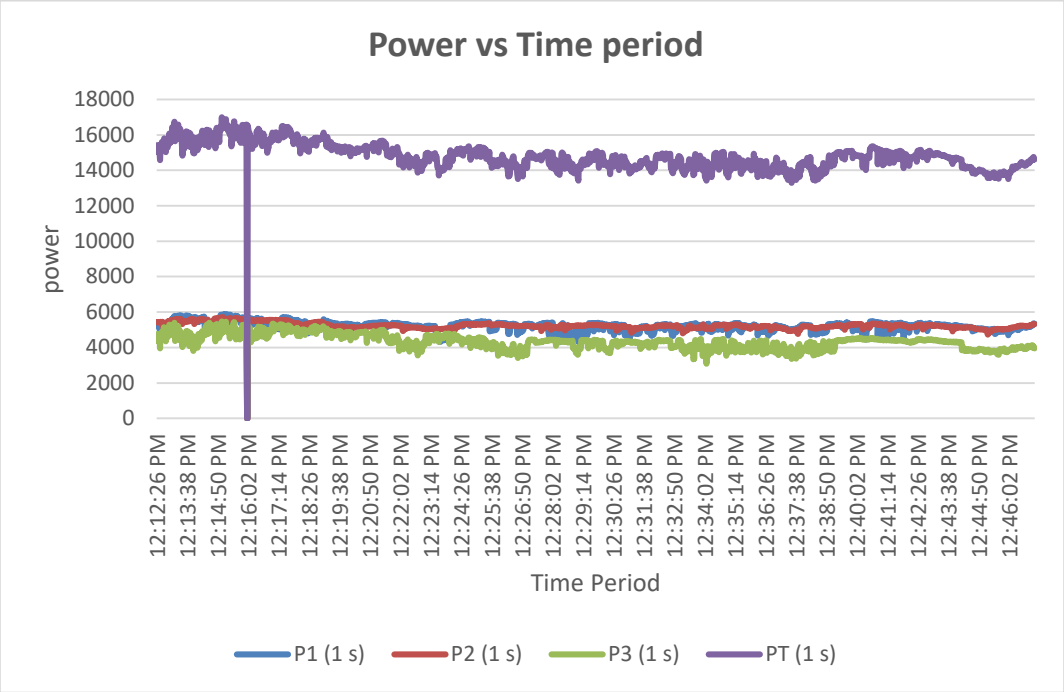


Figure 9 Power vs Time Period

Power Factor Variation:

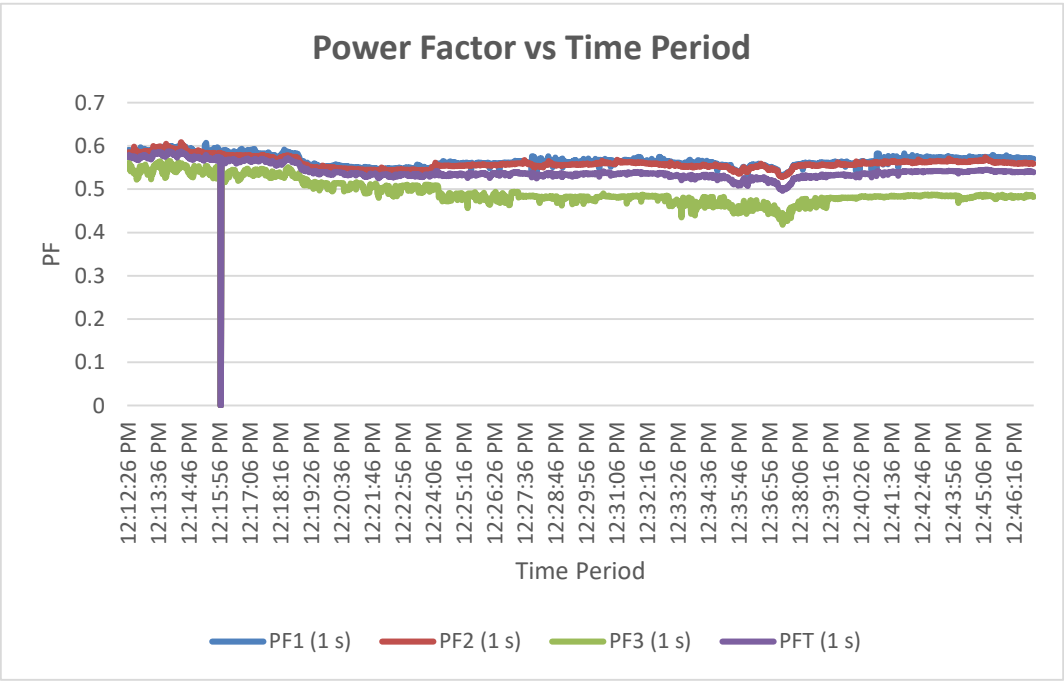


Figure 10 Power Factor vs Time Period

Voltage Total Harmonic Distortion Variation:

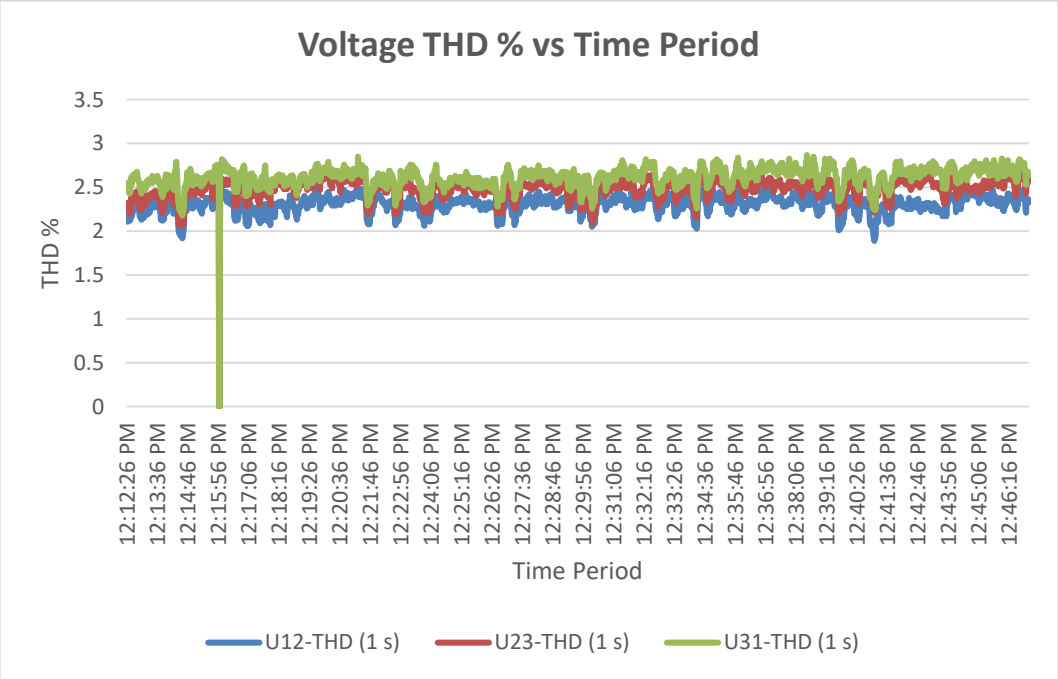


Figure 11 Voltage THD % vs Time Period

CurrentTotal Harmonic Distortion Variation:

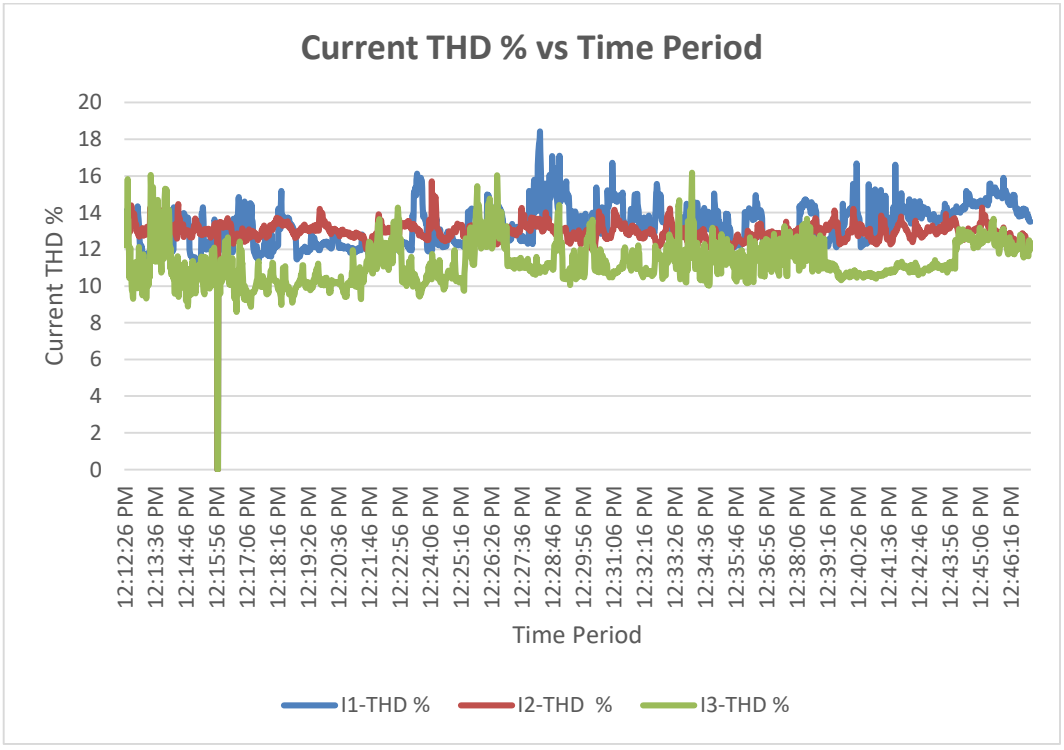
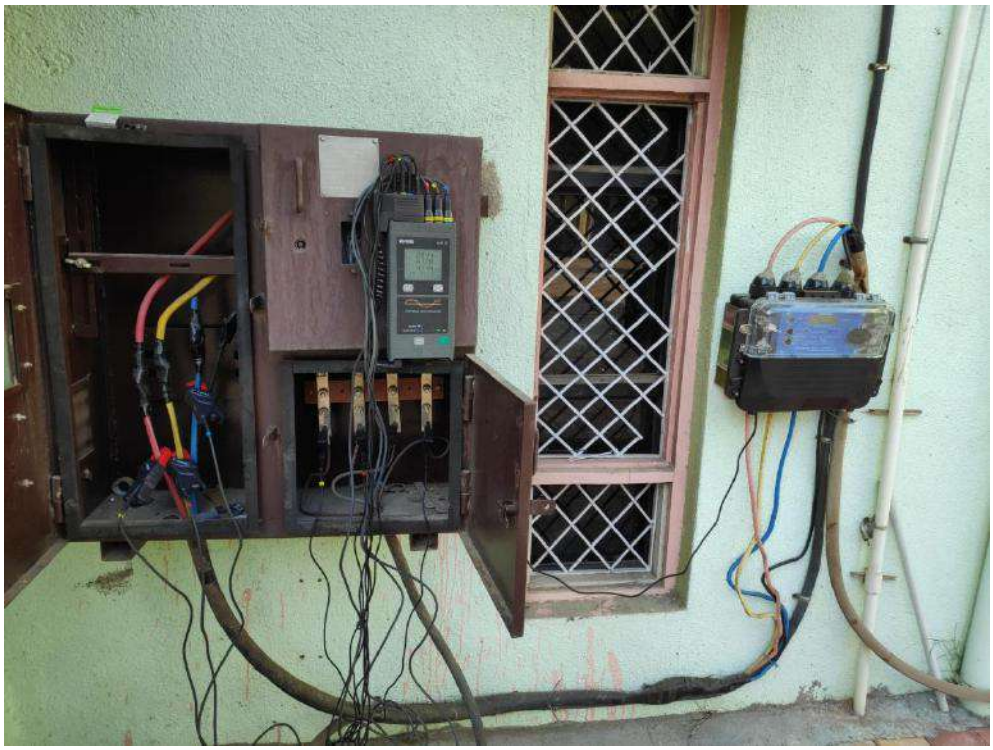


Figure 12 Current THD % vs Time Period

5.2. Study of Loading Pattern for Hostel Buildings:

The Three-phase portable power analyzer was installed at incoming panel and data is recorded. Following graphs shows the loading pattern, Voltage, Current PF variation.



Parameter		R-Phase	Y-Phase	B-Phase	Total/Neutral
Voltage (V)	Avg	427.17	426.49	426.98	-
	Max	429.40	428.20	429.40	-
	Min	424.5	424.00	423.40	-
Current (A)	Avg	5.52	10.45	8.83	4.77
	Max	13.58	19.18	18.07	8.37
	Min	2.51	6.67	4.73	3.21
Active Power (W)	Avg	1250.31	2381.10	2031.78	5663.17
	Max	2795.00	4303.00	4033.00	10679
	Min	613.00	1598.00	1139.00	3387.00
Power Factor	Avg	0.94	0.94	0.95	0.94
	Max	0.99	0.99	0.99	0.98
	Min	0.65	0.77	0.69	0.71
V % THD	Avg	2.42	2.51	2.28	-
	Max	2.64	2.85	2.56	-
	Min	1.94	2.04	1.82	-
I % THD	Avg	13.65	8.98	7.97	20.48
	Max	53.06	34.98	40.09	37.09
	Min	3.60	3.02	2.53	5.28

Comments:

1) Average, Maximum and Minimum variations for all the Phases is within the limit of +/- 6% i.e., 413 V to 467 V
2) The voltage unbalance between the Phases is Absent.
3) The current unbalance between the Phases is Present.
4) Total Harmonic Distortion for voltage is within the limits of 5% whereas Total Harmonic Distortion for Currents is more than 15%.

Recommendation: It is recommended to install sutaible size of Active Harmonic Filter to supress Current Total Harmonic Distortion.

Voltage Variation:

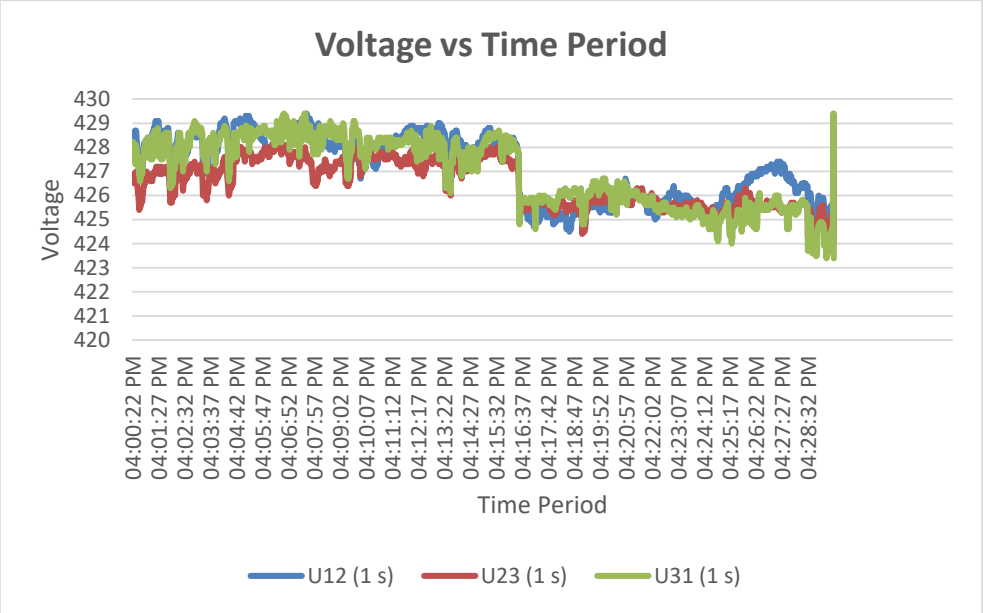


Figure 13 Voltage vs Time Period

Current Variation:

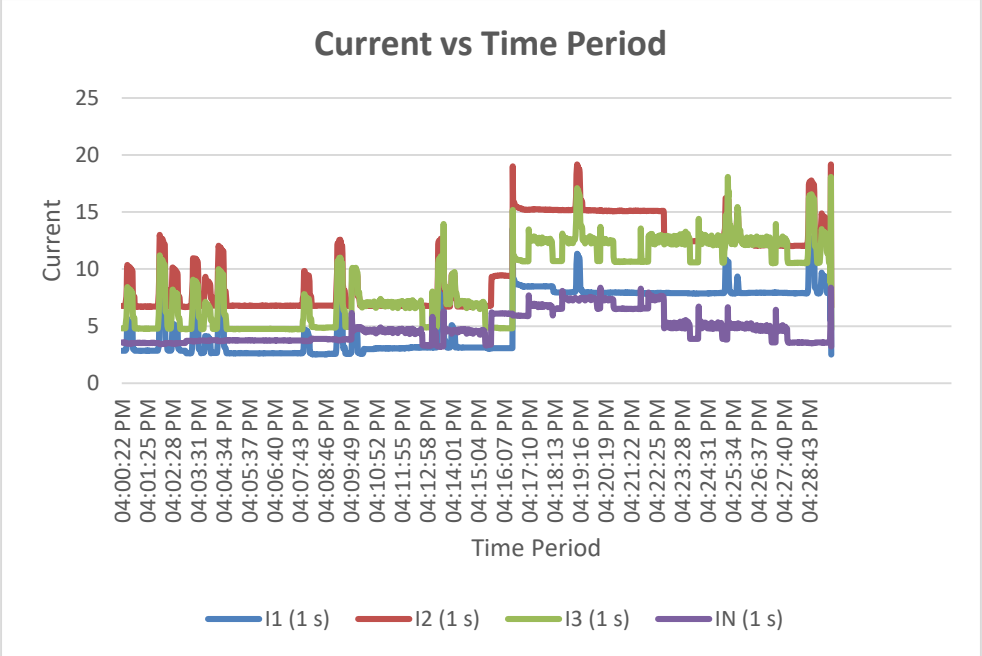


Figure 14 Current vs Time Period

Power Variation:

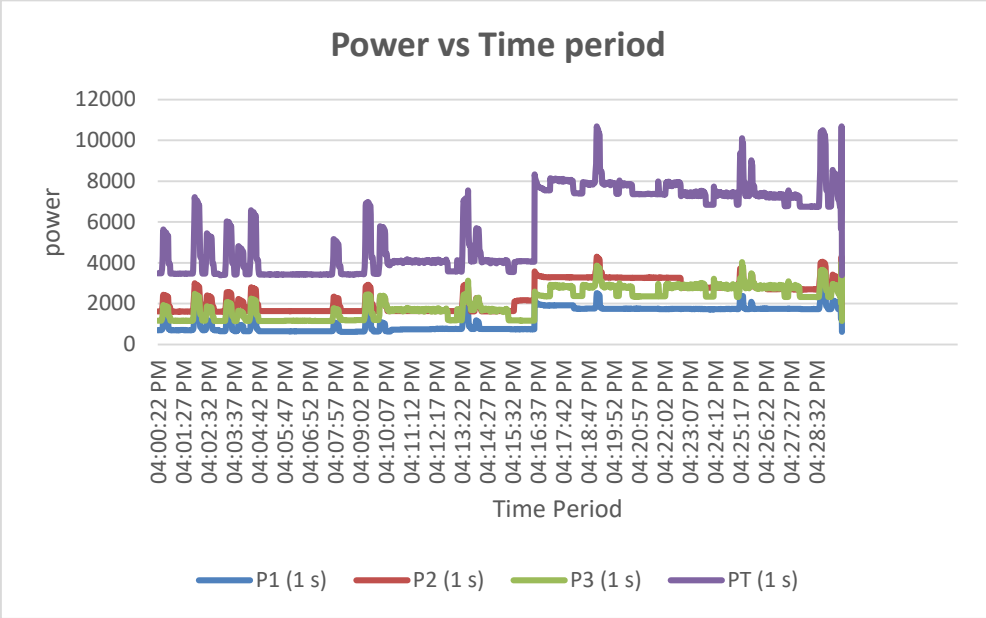


Figure 15 Power vs Time Period

Power Factor Variation:

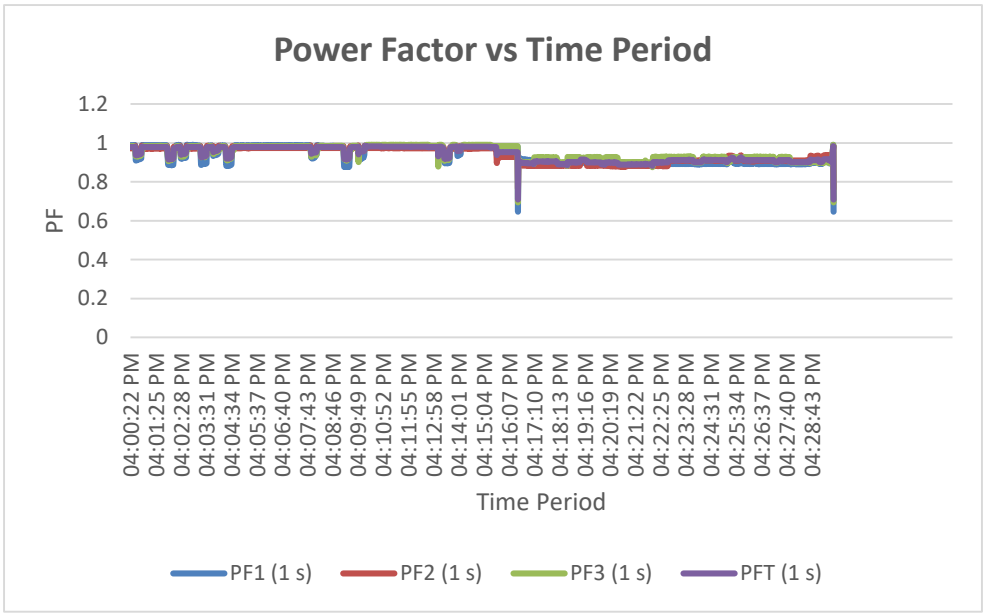


Figure 16 Power Factor vs Time Period

Voltage Total Harmonic Distortion Variation:

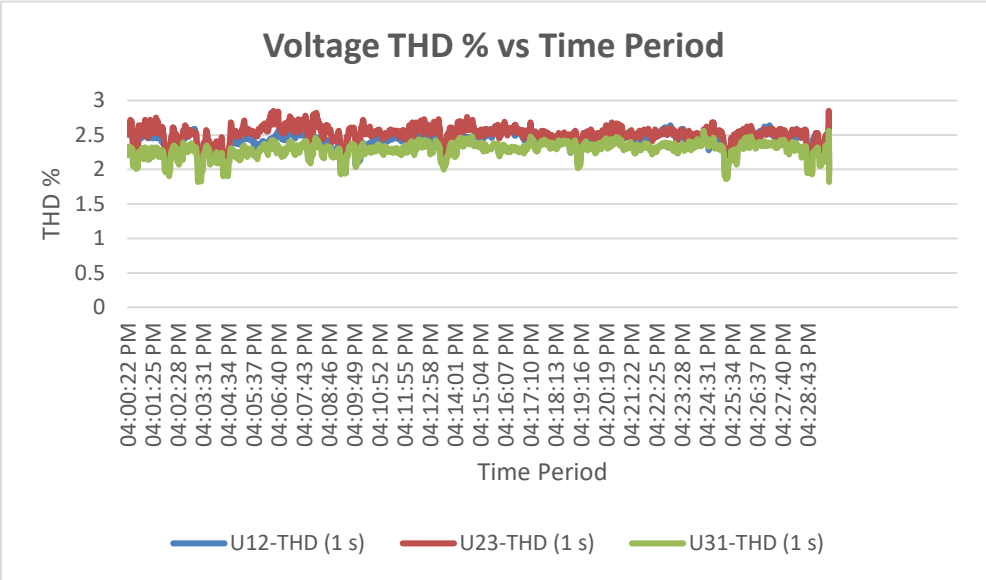


Figure 17 Voltage THD % vs Time Period

CurrentTotal Harmonic Distortion Variation:

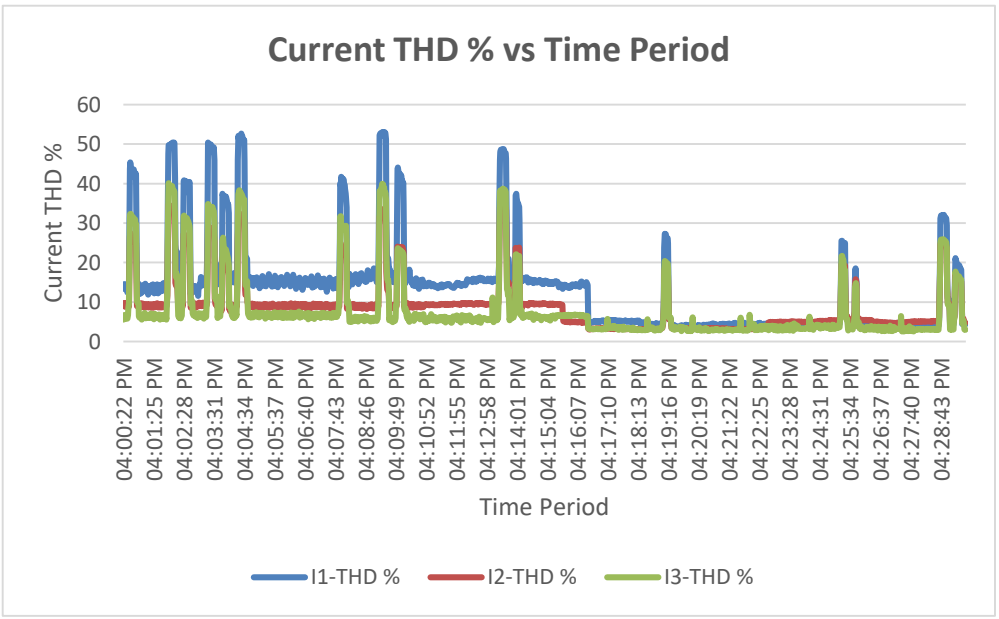


Figure 18 Current THD % vs Time Period

6. ENERGY CONSERVATION MEASURES

ECM 1: Replacement of Tube Lights with More Efficient Lights

ECM No.	Energy efficiency improvement measures	Investment Rs. In Lakh	Estimated saving		Estimated Savings Rs. In Lacs	Estimated Payback Years
			Electricity kWh	Carbon credit (Tons of CO_2)		
1	Replacement of Conventional Lights with More Efficient Lights	2.32	4706.40	4.00	0.38	6.15

Observations:

Facility has installed 28W, 40W Tubes and 18W, 36W CFL in the buildings

Recommendations:

During energy audit, it is observed that facility has installed T8tube lights, CFLs at some of the places in the facility Also energy team at facility has already replaced some of the CFLs with LEDs. The operating hours for these lightings are around 5 hours. T8 tube lights with equivalent LED fixture thereby achieving significant reduction in energy consumption. The LEDs could be replaced in such a manner that it has same fixture so there will not be retrofitting cost attached to the replacement. The replacement could be done in a phased manner. LED lights have better efficacy as well as better lifetime than conventionallights

Energy Saving Calculations:

Particular	Unit	Value
Energy Saving Calculation		
Power consumption of TL,CFL and Halogen lamps	KW	9.33
Power consumption of suitable LED	KW	5.41
Average power saving after replacement with LED lights	KW	3.92
Replacement of conventional lights with suitable LEDs	Nos	290
Average working hour per day	hrs	5
No. of working days in a year	Days	240
Cost Benefit Calculation		
Annual Energy Saving potential	kWh	4706
Electricity tariff	Rs/unit	8
Annual Cost Saving	Rs. Lakh	0.38
Total investment cost	Rs. Lakh	2.32
Annual Saving	Rs. Lakh	0.38
Simple Payback Period	Years	6.15

Type of Fitting	Wattage	Qty	Proposed LED W	Price - Rs/ Unit	Dismantling cost	Price with GST	Existing KW	Proposed KW	Saved kW	Investment Rs Lakh
Tube light	28	237	18	570	13	653	6.64	4.27	2.37	1.55
Tube light	40	9	20	878	13	998	0.36	0.18	0.18	0.09
Halogen	500	2	100	9504	13	10659	1	0.2	0.8	0.21
CFL	36	32	20	1212	13	1372	1.15	0.64	0.51	0.44
CFL	18	10	12	218	13	259	0.18	0.12	0.06	0.03
TOTAL	**622**	**290**	**170**	**12382**	**260**	**14159.04**	**9.33**	**5.41**	**3.92**	**2.32**

ECM 2: Replacement of Old Fan with Energy Efficient Super Fan

ECM No.	Energy efficiency improvement measures	Investment Rs. In Lakh	Estimated saving Electricity kWh	Carbon credit (Tons of CO_2)	Estimated Savings Rs. In Lacs	Estimated Payback Years
2	Replacement of Existing Fans with Energy Efficient Fans	7.40	10268.16	8.73	0.82	9.01

Observations:

During energy audit, it is observed that facility has old 75 watts' fan and its energy consumption is on higher side.

Recommendations:

During energy audit it is observed that facility has installed non star rated fan of 75 watts so we recommend to replace energy consuming fan with energy efficient super fan

Energy Saving Calculations:

Particular	Unit	Value
Existing energy consumption of Fan	kWh/year	27504
Fan Wattage	Watt	35
Energy consumption after replacing with Energy Efficient Super Fan	kWh/year	12835
Operating hrs/year	Hrs/year	960
Diversity factor	%	70%
Annual Saving	kWh/year	10268
Unit rate	Rs/kWh	8
Annual Saving	Rs. In Lacs	0.82

Category	Nos	Estimated Running kW
Ceiling Fan 75 W	382	28.65

ECM 3: Optimize the AC Temperature Setting to 23-25 Degree Celsius

ECM No.	Energy efficiency improvement measures	Investment Rs. In Lakh	Estimated saving		Estimated Savings Rs. In Lacs	Estimated Payback Years
			Electricity kWh	Carbon credit (Tons of CO2)		
3	Optimize The AC Temperature Setting To 23-25 Degree Celsius	0.00	41.55	0.04	0.00	0.00

Observations:

During Energy Audit, it is observed that ACs installed in facility run with lower temperature than the recommended temperatures.

Recommendations:

We recommend to keep the set temperature of AC between 23 to 25^0C to get the energy saving.

Standard:

It is known that a 1°C raise in AC temperature can help to save almost 3 % on power consumption (this can also be verified in BEE guideline: Chapter 4. HVAC and Refrigeration System).

The TR capacity of the same AC systems will also increase with the increase in evaporator temperature (AC set points), as given in Table below:

Effect of variation in Evaporator Temperature on Compressor Power Consumption			
Evaporator temperature(^{0}C)	Refrigeration Capacity* (tons)	Specific Power Consumption	Increase in kW/ton (%)
5	67.58	0.81	-
0	56.07	0.94	16
-5	45.98	1.08	33
-10	37.2	1.25	54
-20	23.12	1.67	106

* Condenser temperature 40°C

Present Energy Consumption Details:

Sr No	Type	Ton	Qty	Annual Consumption
1	Air Conditioner (Split) (1.5 Ton) (0*)	1.5	3	281.61
2	Air Conditioner (Split) (1.5 Ton) (2*)	1.5	9	887.922
3	Air Conditioner (Split) (1.5 Ton) (3*)	1.5	16	1501.92
4	Air Conditioner (Split) (1.5 Ton) (5*)	1.5	1	98.658
Total			**29**	**2770.11**

Energy Saving Calculations:

Particular	Unit	Value
Estimated consumption of ACs	kWh/hr	1385
Estimated Saving	%	3%
Operating Hrs per day	hrs/day	0.5
Operating days per year	Days/year	120
Estimated Saving	kWh/year	41.55
Unit Rate	Rs/kWh	8
Annual Saving	Rs Lakh/year	0.00

ECM 4: Replacement of No star rated AC with 5-starrated AC

ECM No.	Energy efficiency improvement measures	Investment Rs. In Lakh	Estimated saving		Estimated Savings Rs. In Lacs	Estimated Payback Years
			Electricity kWh	Carbon credit (Tons of CO2)		
3	Replacement of No star AC with 5 Star AC	1.41	499.95	0.45	0.04	35.33

Observations:

During Energy Audit, it is observed that facility has old No star ACs and its energy consumption is on higher side.

Recommendations: We recommend to replace No star ACs with 5 Star ACs

Energy Saving Calculations:

Particular	Unit	Value
A/C of 1.5 Ton with no star	Nos	3
wattage of 1.5 ton AC	Watt	2500
Total load of of 1.5 Ton AC	Kw	7.5
Total load of all no star installed AC's	Kw	7.5
Wattage of 1.5 Ton 5 star rated AC	Watt	1490
Estimated load of 1.5 ton ACs	kw	4.5
Total load of all 5 star Acs after replacement	kw	4.5
load reduction after replacement	kw	3.0
Diversity factor	%	55%
Operating Hrs per day	hrs/day	1
Operating days per year	Days/year	300
Estimated energy Saving	kWh/year	500
Unit Rate	Rs/kWh	8
Annual Saving	Rs Lakh/year	0.04

Investment Details:

Particular	Value	CSR No
A/C of 1.5 Ton	3	
Rate of 5 star Split ac 1.5 ton	141321	3-2-8

7. List of Instruments

POWER ANALYSER

Picture 1 ALM 20 Power Analyzer

ALM 20 Power Analyzer is designed for Measuring power network parameters

TECHNICAL SPECIFICATIONS

Number of channels	3U/3I
Voltage (TRMS AC + DC)	100V to 2000V ph-ph /50V to 1000V ph-N
Voltage ratio	Up to 650 kV
Current (TRMS AC + DC)	5mA to 10,000 Aac / 50 mA to 5,000 Adc (depending on Clamp)
Current ratio	Up to 25 kA
Frequency	42.5 - 69 Hz, 340 - 460Hz
Power values	W, VA, VAr, VAD, PF, DPF, cos ø, tanø
Energy values	Wh, VAh, VArh
Harmonics, THD	on V, U, I & In up to 50th order
Electrical safety	IEC 61010, 1000V CAT III / 600V CAT IV
Protection	IP54

DIGITAL CLAMP METER

Picture 2 MECO 3150 DIGITAL CLAMP METER

Power Clamp meter is a Portable Digital multi-functional measuring instrument. Designed for Measuring selected power network parameters, AC/DC Voltage, AC/DC current, Resistance, Continuity, Diode and Frequency.

TECHNICAL SPECIFICATIONS

DC VOLTAGE (Auto Ranging)	
Ranges	4V, 40V, 400V, 1000V
Overload Protection	1200V DC/800V AC
AC VOLTAGE (Auto Ranging) 40-500Hz	
Range	4V, 40V, 400V, 750V
Overload Protection	1200V DC/800V AC
RESISTANCE (Auto Ranging)	
Range	400Ω, 4KΩ, 40KΩ, 400KΩ, 4MΩ, 40MΩ
Test Current	0.7mA on 400Ω, 0.1mA on 4KΩ
Diode Test	
Measurement Current	1.0 ± 0.6 mA Approx
Open Circuit Voltage	0.4V Approx
Overload Protection	500V DC / AC
Frequency (Auto Ranging)	
Range	10.00Hz, 50.00Hz, 500.0Hz, 5.000kHz,
	50.00kHz, 500.0kHz
Sensitivity	3V
Overvoltage Protection	200V DC or AC peak

DIGITAL CLAMP METER

Picture 3 RISH POWER CLAMP 1000 A/400 A AC-DC

Power Clamp meter is a Portable Digital multi-functional measuring instrument. Designed for Measuring selected power network parameters, AC/DC Voltage, AC/DC current, Resistance, Continuity, Diode and Frequency.

TECHNICAL SPECIFICATIONS

Measuring function	Measuring range
kWh	9.999 kWh
	99.99 kWh
	999.9 kWh
	9999 kWh
Ahr	999.9 Ahr
Phase angle	0.0°….360.0°
Power Factor	-1…0…1
Harmonics (RMS & %)	1…13
	14…49
THD	0…99.9%
Crest Factor	1.0…2.9
	3.0…5.0
Power Clamp 1000A peak	1400 A/ 1400 V
Power Clamp 400A peak	100 A
	560 A/ 1000 V
Power Clamp 1000A INRUSH	999.9 A
Power Clamp 400A INRUSH	99.99 A
	400 A
Resistance	9999 Ohm
Continuity	Below 40 Ohm

THERMAL IMAGER

Picture 4 FLIR TG 167 Thermal imager

FLIR TG 167Thermal imager is designed to easily find unseen hot and cold spots in electrical cabinets or switch boxes, giving you quality image detail on even small connectors and wires.

TECHNICAL SPECIFICATIONS

Accuracy	±1.5% or 1.5°C (2.7°F)
Detector Type	Focal plane array (FPA), uncooled micro bolometer
IR Resolution	80 × 60 pixels
Laser	Dual diverging lasers indicate the temperature measurement area, activated by pulling the trigger
Memory Type	Micro SD card
Object Temperature Range	-25°C to 380°C (-13°F to 716°F)
Thermal Sensitivity/NETD	<150 mK
Display	2.0 in TFT LCD

INFRARED THERMOMETER

Picture 5 HTC IRX 64 Infrared thermometer

HTC IRX 64 infrared thermometer is useful instrument to measure the surface temperature. Infrared thermometers are ideal for taking temperatures need to be tested from a distance. They provide accurate temperatures without ever having to touch the object you're measuring (and even if your subject is in motion).

TECHNICAL SPECIFICATIONS

Specification	Range
IR	-50℃~1050 ℃
Contact	-50℃~1370 ℃
IR Temp. Resolution	0.1℃
Basic Accuracy	+/- 1.5% of reading
Emissivity	Adjustable 0.10 ~ 1.0
Optical resolution	30 : 1

LUX METER

Picture 6 Nishant NE 1010 Lux meter

Nishant NE 1010 Lux meter is used to measure the lux levels.

TECHNICAL SPECIFICATIONS

Measuring range	0 Lux ~200, 000 Lux/0 Fc~185, 806 Fc
Accuracy	± 3% rdg ± 0.5% f.s.(<10,000 Lux)
	± 4% rdg ± 10% f.s.(>10,000 Lux)
Digital Updates	2 times/s
Photometric sensor	Silicon diode
Battery life	18 hours (continuous operation)
Operating temperature and humidity	0°C ~ 40°C, 10% RH ~ 90% RH
Storage temperature and humidity	-20°C ~ 50°C, 10% RH ~ 90% RH
Power	9V battery
Unit Size	52.5 x 52.5 x 166 mm
Auto power off	After 5 minutes

8. ANNEXURE (SOLAR)

1) Introduction

The solar energy has a great potential as future source of energy. With its availability in large quantity almost in every corner of the country, solar power has the distinctive advantage of generating power at local and decentralized levels and being one of the prime factors for empowering people at grassroots level. The solar mission, which is part of the National Action Plan on Climate change has been set up to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy options. The solar photovoltaic device systems for power generation had been deployed in the various parts in the country for electrification where the grid connectivity is either not feasible or not cost effective as also some times in conjunction with diesel based generating stations in isolated places, communication transmitters at remote locations. With the downward trend in the cost of solar energy and appreciation for the need for development of solar power, solar power projects have recently been implemented. A significant part of the large potential of solar energy in the country could be developed by promoting solar photovoltaic power systems of varying sizes as per the need and affordability coupled with ensuring adequate return on investment.

2) Benefits of Solar Energy

a. Power from the sun is clean, silent, limitless and free.

b. Photovoltaic process releases no CO2, SO2, or NO2 gases which are normally associated with burning finite fossil fuel reserves and don't contribute to global warming.

c. Photovoltaic are now a proven technology which is inherently safe as opposed to other fossil fuel based electricity generating technologies.

d. Solar power shall augment the needs of peak power needs.

e. provides a potential revenue source in a diverse energy portfolio

f. Assists in meeting renewable portfolio standards goals.

This proposal is prepared for design, engineering, procurement / manufacture and installation of solar power generating system. The grid-tie solar photovoltaic power generation system is mainly composed of PV array, String Inverter, and PV mounting structure.

It also consists of supporting devices like AC / DC switchgears, Lighting Arrestor, Earth Electrodes, AC / DC cables. As there is no any battery, it’s maintenance cost is negligible and initial investment per KW is very low.

3) Objective

- Provide reliable, clean, regulated, un-interrupted power on demand to the pre-identified critical loads
- System to provide low life cycle cost and maximize savings to the beneficiaries.

- To save diesel in institutions and other commercial establishments including industry facing huge power cuts especially during daytime.

4) Design Assumptions

General

a. The Solar Radiation Data's are based on standard books & simulation software as NASA and Metronome. The Mean Hourly Radiation Data is considered.

b. The module rating considered is tentative. The exact module sizing and rating will depend on the availability of cell grade and site suitability.

c. Solar Panels are roof/ground mounted in one location. Environmentally protected, closed, ventilated, inverter room at minimum distance from PV modules.

d. Application: Self consumption, captive grid or NET metering.

e. Emergency Backup: Generator or any other source in absence of Grid.

5) System Description:

Solar Power Plant comprises of the main equipment and components listed below:

1. Solar PV Modules
2. String Inverter with MPPT
3. Module mounting system
4. Monitoring system
5. Cables & connectors

Each of the sub systems has been described for the functionality and operation modes. The physical construction of the system follows a modular approach, which is field-tested and is regularly used for delivery of power systems.

5.1 Solar PV Module (Electrical Features)

The PV modules convert the light reaching them into DC power. The amount of power they produce is roughly proportional to the intensity and the angle of the light reaching them. They are therefore required to be positioned to take maximum advantage of available sunlight within sitting constraints.

5.2 Solar PV Module (Mechanical Features)

Solar Module design will conform to following Mechanical requirements:

- Toughened,
- low iron content,
- High transmissivity from glass.
- Anodized Aluminum Frame.
- Ethyl Vinyl Acetate (EVA) encapsulating.

- Tedlar/Polyester trilaminate back surface.
- ABS plastic terminal box for the module output termination with gasket to prevent water & moisture.
- Resistant to water, abrasion hail impact, humidity & other environment of actors for the worst situation at site.

5.3 Module Mounting Structure

The structure shall be designed to allow easy replacement of any module and shall be in line with site requirement. Structure shall be designed for simple mechanical and electrical installation. It shall support SPV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly. There shall be no requirement of welding or complex machinery at site. The array structure shall have tilt arrangement to adjust the plane of the solar array for optimum tilt.

5.4 Junction Box

The junction boxes shall be dust, vermin and waterproof and made of FRP/ABS Plastic with IP65 protection. The terminals shall be connected to copper bus bar arrangement of proper sizes. The junction boxes shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Suitable marking shall be provided on the bus bar for easy identification and cable ferrules shall be fitted at the cable termination points for identification

5.5 String Inverter

The STRING INVERTER is A combination of Solar Charger (MPPT), Inverter and synchronization unit for two different AC supplies, all housed in a single unit. Maximum power point tracker (MPPT) shall be integrated into it to maximize energy drawn from the solar array. The Inverter converts the DC available from the array into an AC output. The output of the inverter is filtered to reduce the harmonics to an acceptable level (less than 5%). MPPT shall be microprocessor/micro controller based to minimize power losses and maximize energy utilization. The efficiency of MPPT shall not be less than 90% and shall be designed to meet the solar PV Array capacity.

5.6 AC /DC Cables

We use DC & AC cables of Lap, Apar, Polycab, Havels, Finolex or equivalent make to ensure minimum losses in transmission.

In order to complete the energy study that leads to the construction of a photovoltaic installation, hourly series of global horizontal irradiation values for a complete year are used, which resume the irradiation and other meteorological parameters behavior over a long term. We use PV. SYST. Software to workout optimum power production at site with minimum loses.

5.7 Grounding and Lighting Protection

- A protective earth (PE) connection ensures that all exposed conductive surfaces are at the same electrical potential as the surface of the Earth, to avoid the risk of electrical shock. It ensures that in the case of an insulation fault (a "short circuit"), a very high current flows, which will trigger an over current protection device as fuses and circuit breakers that disconnects the power supply.
- A functional earth connection serves a purpose other than providing protection against electrical shock. In contrast to a protective earth connection, a functional earth connection may carry a current during the normal operation of a device.
- Lightning protection is a very specialized form of grounding used in an attempt to divert the huge currents from lightning strikes. A ground conductor on a lightning arrester system is used to dissipate the strike into the earth.
- Lightning ground conductors must carry heavy currents for a short period of time. To limit inductance and the resulting voltage due to the fast pulse nature of lightning currents, lightning ground conductors may be wide flat strips of metal, usually run as directly as possible to electrodes in contact with the earth.
- In proposal, the entire system is fully provided with the required lighting and grounding protection.

6) Solar PV Locations

Buildings Considered for Solar Power Installation

Details of Building:

Average Unit Consumption / year of Buildings is **37745** Units (Ref. 12 months Electricity Bills)

Sr. No.	Name of Building	Area	Length (ft.)	Width (ft.)	Area (Sq. ft.)	Plant Installed (kW)
1	Hostel I	Area I	53	20	1060	13.25
		Area II	18	10	180	2.25
		Area III	10	8	80	1
Total					**1320**	**16.5**

Total Available Area = **1320 Sq. Ft.** & As per available shadow free Area maximum **16.5 KW** Plant can be installed on buildings as per details mentioned in above table.

7) Capacity Evaluation

Calculation for Required Solar Capacity plant to fulfill In-house Requirement

Calculation to Fulfill Building Total Load Requirement			
Sr. No.	**Details**	**Value**	**Unit**
1	Average electrical consumption per year	37745	KWh
2	Units generated per day per KWp	4.5	KWh/KWp/day
3	Units generated per Year per KWp (330 days / Year)	1485	KWh/KWp/Year
4	Solar KW capacity For 37745 KWh consumption / year	25.42	KWp

As per electrical consumption (Building Load), capacity of Solar Power Plant required is 25.42 KWp. As per shadow free space available on college building maximum 16.5 KWp plant can be installed which is more than the actual requirement of full Electrical Load.

It is suggested to install Solar Plant of Capacity 25.42 KWp, which can be installed on New building itself & it covers all required load.

The SPV power plant with proposed capacity of 25.42 KWp would be connected to the main electrical distribution panel. The system would meet full load requirement of the connected load during the day. Advance control mechanism in the Power Conditioning Unit will ensure that the maximum power generated by PV modules will be utilized first and the balance requirement of power will be met by either grid or DG set

The 25.42 KWp SPV Power Plant is estimated to afford annual energy feed of 37745 KWh/year (After considering all losses) considering efficiency of the solar module as 15.16%, Power Conditioning Unit (PCU) efficiency as 98.3% and losses in the DC and AC system as 3%.

8) Budgetary Estimation of the Project

Details	Value	Unit
Shadow free space required for approx. 1 KWp Solar Plant	80	Sq.Ft
Shadow free space available on college building	1320	Sq.Ft.
Solar Plant capacity to be Installed on college building	16.5	KWp
Solar Plant Requirement as per actual consumption	25.42	KWp
Installation Cost Per KW for 1 KWp Solar Plant	0.5	Rs. In Lakh
Gross Estimated System cost (For 25.42 KWp Grid Connected Solar Plant)	12.71	Rs. In Lakh
Unit generated per day per kWp	4.5	KWh
Electricity generation per day for 25.42 KWp Grid Connected Solar Plant	114.39	KWh/day
Electricity generation per year for 25.42 KWp Grid Connected Solar Plant (330 days/year)	37745	KWh/year
Average Electricity Unit Cost	9.3	Rs./KWh
Electricity cost saved per year	3.5	Rs. In Lakh
Simple payback period	**3.62**	**Years**