DETAILED ENERGY AUDIT REPORT

AEF Ashoka Business School

Urjayant Plaza, Next to Suman Petrol Pump,
Mumbai-Agra Highway CIDCO 422009

January 2022

Conducted By

PPS Energy Solutions Pvt. Ltd.

Plot No-18, Girish Housing Society
Warje, Pune – 411058, Maharashtra, India

PPS ENERGY SOLUTIONS PVT. LTD. PPS

Dr. Ravi G. Deshmukh
Energy Auditor Class - A
MEDA/ECNCR-05/2018-19/EA-05

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 energy 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 building 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 facility, then follows with reviewing and analyzing the condition and performance of various 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 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 AEF Ashoka Business School, Nashik for entrusting and offering the opportunity. It is our immense pleasure to present the detailed energy audit report.

We acknowledge the positive support from management in undertaking the task of Detailed Energy Audit of all electrical system, thermal systems, utilities and other area and for continuous help and support before and during the Detailed Energy 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 AEF Ashoka Business School, Nashik 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

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 facility, the collection/review of further data and a field inspection of the facility and equipment.

The salient observations and recommendations are given below.

1. The total cost of energy is around **Rs. 145280/-** per Annum
2. Average monthly units consumed are **661 kWh** equivalent to **Rs. 12096.3**/-
3. Average electricity charges work out to be **Rs. 18.3**/-

This brief report has therefore sought to provide a high-level overview of the status of energy efficiency at facility, 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.	Equipment Name	ECM Details	Investment (Rs. In Lakh)	Savings (kWh/year)	Carbon credit (Tons of Co2)	Saving (Rs. In Lakh /Year)	Payback (Years)
1	Tube Lights	Replacement of conventional lights with suitable LEDs	0.63	340.20	0.29	0.06	10.15
2	Fans	Replacement of existing fans with energy efficient Super fans	2.00	560.84	0.48	0.10	19.44
3	AC	Replacement of No star ACs with 5-star ACs.	5.16	473.40	0.42	0.09	59.52

Sr. No.	Equipment Name	ECM Details	Investment (Rs. In Lakh)	Savings (kWh/year)	Carbon credit (Tons of Co2)	Saving (Rs. In Lakh /Year)	Payback (Years)
4	AC	Optimize the temperature setting to 23-25 degree Celsius	0.00	132.84	0.12	0.02	0.00
5	APFC	Optimize the Power Factor	0.05			0.05	0.09
Total			**7.84**	**1507.28**	**1.31**	**0.33**	**23.99**

Note: Estimated savings may base on operating conditions

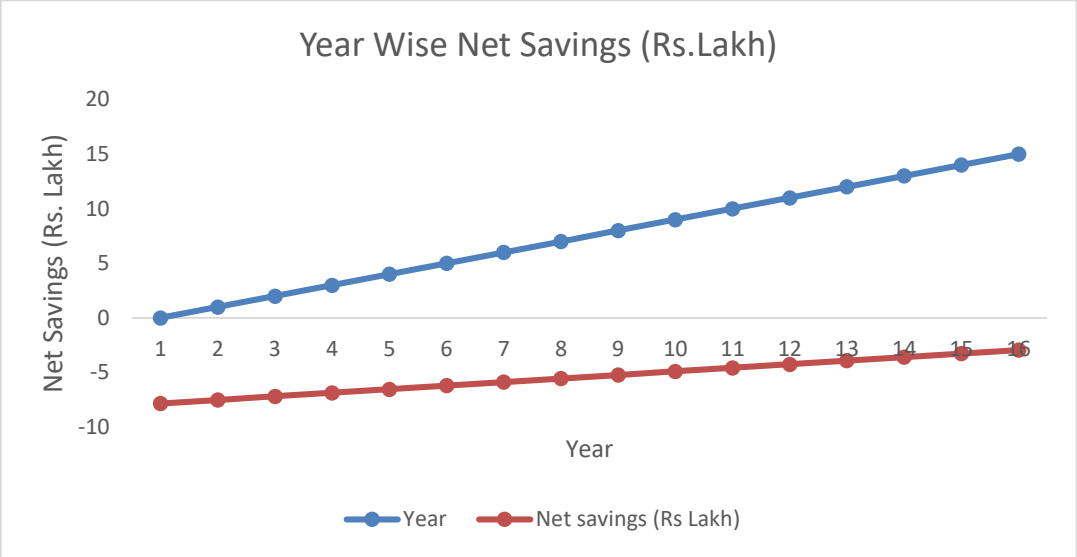
During the Energy Audit, total estimated investment of Rs 7,84,000/- yields total estimated savings of Rs. 33,000/- which 22.71 % of the total energy cost of Rs. 145280/- with an overall payback period of 23.99 years.

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 energy users is very essential step to reduce wastage of electricity
E. Energy conservation awareness programs can be conducted once a year. Increasing energy awareness of energy users motivates them to work as a team can lead to reductions in energy consumption and save the money.

Year	Investment (Rs. in Lakh)	Saving (Rs. in Lakh /Year)	Cum Savings(Rs Lakh)	Net savings (Rs Lakh)
0	-8	0	0	-8
1	0	0	0	-8
2	0	0	1	-7
3	0	0	1	-7
4	0	0	1	-7
5	0	0	2	-6
6	0	0	2	-6
7	0	0	2	-6
8	0	0	3	-5
9	0	0	3	-5

10	0	0	3	-5
11	0	0	4	-4
12	0	0	4	-4
13	0	0	4	-4
14	0	0	5	-3
15	0	0	5	-3



Net Savings (Rs. Lakh Vs Year)

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2. GENERAL AUDIT REVIEW

Facility 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 efficient.
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 facility 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 facility. Billing is carried out with the help of 055-XF429638 meter according to 88 LT-VII B I Tariff.

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

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

1) Air conditioning
2) Lighting Load
3) Ceiling Fans

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

Table 1 Name of Area

Sr. No.	Name of the Area
1	Air conditioner
2	Ceiling fans

4.1. Electricity Bill Analysis

1. Consumer Details of Meter No. 049084721297

Consumer Details

Table 2 Consumer Details

Parameter	Details
Consumer No.	**049084721297**
Consumer Name	AEF's Ashoka Business School
Address	Urjayant Plaza, Next to Suman Petrol Pump, Mumbai-Agra Highway CIDCO
Pin Code	422009
Connected load (KW)	40
50% of con. Demand (KVA)	20.0
Sanctioned Load (KW)	40
Sanct. Demand (KVA)	40
Tariff	88 LT-VII B I
Bu/ Circle No	4670

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)
Jan-21	820	1775	205	234	8	8	362	0.970	7.44	5792	6100.80	131.15	13140.38
Feb-21	491	1760	118	218	7	9	362	0.980	7.44	5792	3653.04	160.46	10630.12
Mar-21	662	2179	115	283	11	11	362	0.980	7.44	5792	4925.28	182.14	12086.68
Apr-21	591	1945	48	191	15	16	373	0.990	7.28	5968	4302.48	293.40	11555.29
May-21	560	1994	67	159	7	8	373	0.990	7.28	5968	4076.80	285.84	11254.38
Jun-21	487	1751	70	216	7	8	373	0.990	7.28	5968	3545.36	268.03	10545.81
Jul-21	538	2108	94	566	11	11	373	0.950	7.28	5968	3916.64	0.00	11321.32
Aug-21	493	1993	188	341	9	9	373	0.970	7.28	5968	3589.04	107.80	10765.75
Sep-21	505	1984	50	564	7	7	373	0.950	7.28	5968	3676.40	0.00	10992.95
Oct-21	575	2203	36	976	20	20	373	0.910	7.28	5968	4186.00	0.00	11689.48
Nov-21	938	2043	28	958	8	9	373	0.900	7.28	5968	6828.64	0.00	14297.88
Dec-21	1277	2038	44	994	7	7	373	0.890	7.28	5968	9296.56	-165.91	17000.17
Avg	**661**	**1981**	**89**	**475**	**10**	**10**	**370**	**0.956**	**7.32**	**5924**	**4841**	**105**	**12107**
Max	**1277**	**2203**	**205**	**994**	**20**	**20**	**373**	**0.990**	**7.28**	**5968**	**9297**	**293**	**17000**
Min	**487**	**1751**	**28**	**159**	**7**	**7**	**362**	**0.890**	**7.28**	**5792**	**3545**	**-166**	**10546**
Sum	**7937**	**23773**	**1063**	**5700**						**71088**	**58097**	**1263**	**145280**

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
Jan-21	334	7	0	8	0	6	486	8
Feb-21	0	6	0	8	0	9	491	7
Mar-21	101	7	0	11	0	5	561	9
Apr-21	0	6	0	16	0	6	591	8
May-21	0	6	0	8	0	8	560	6
Jun-21	0	6	0	8	0	4	487	7
Jul-21	0	6	0	11	0	7	538	7
Aug-21	0	6	0	9	0	8	493	6

Sep-21	0	6	0	7	0	6	505	6
Oct-21	0	6	0	20	0	9	575	13
Nov-21	386	6	0	9	0	7	552	8
Dec-21	674	5	80	7	0	4	523	7
Avg	**125**	**6**	**7**	**10**	**0**	**7**	**530**	**8**
Max	**674**	**7**	**80**	**20**	**0**	**9**	**591**	**13**
Min	**0**	**5**	**0**	**7**	**0**	**4**	**486**	**6**
Sum	**1495**		**80**		**0**		**6362**	

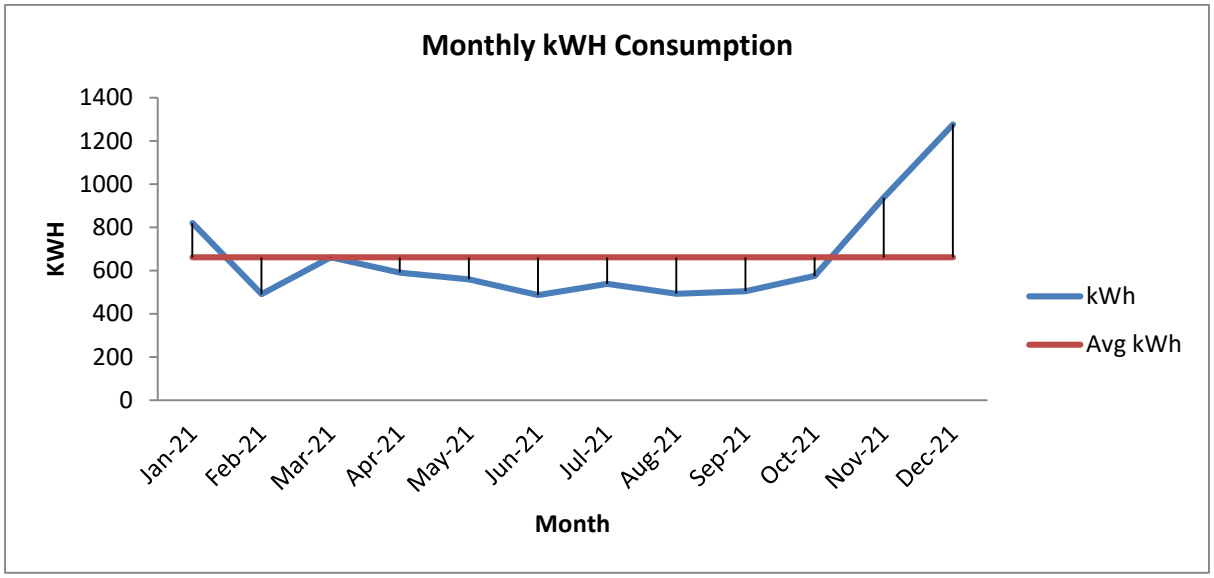


Figure 1 Monthly kWh Consumption

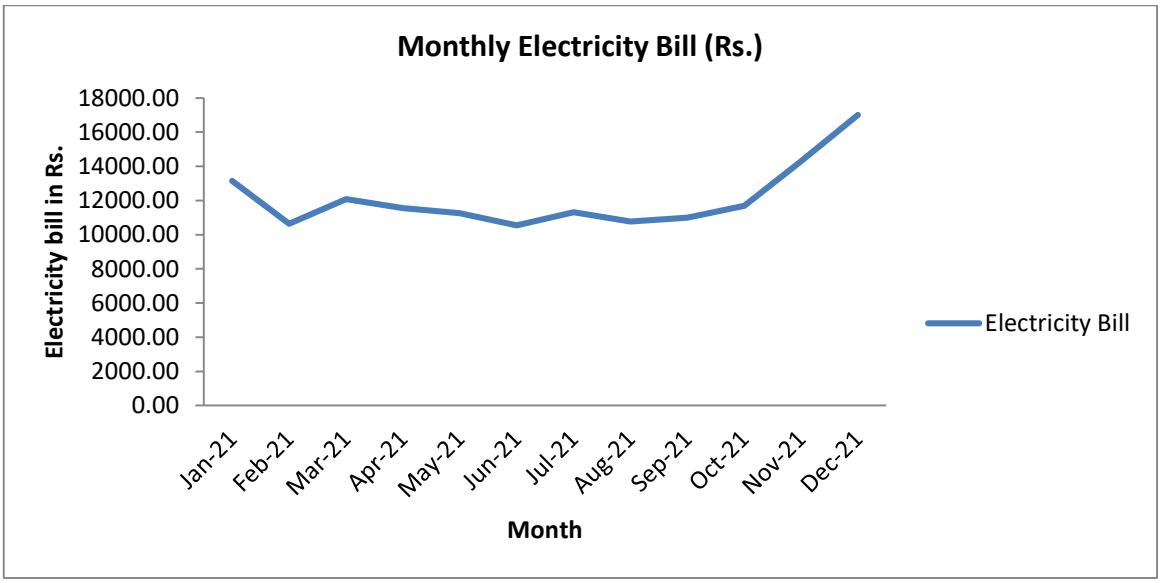


Figure 2 Monthly Electricity Bill

Comments:

1. Average monthly units consumed is 661kWh equivalent to Rs. 12096.3/-

2. Average electricity charges work out to be Rs.18.3/-

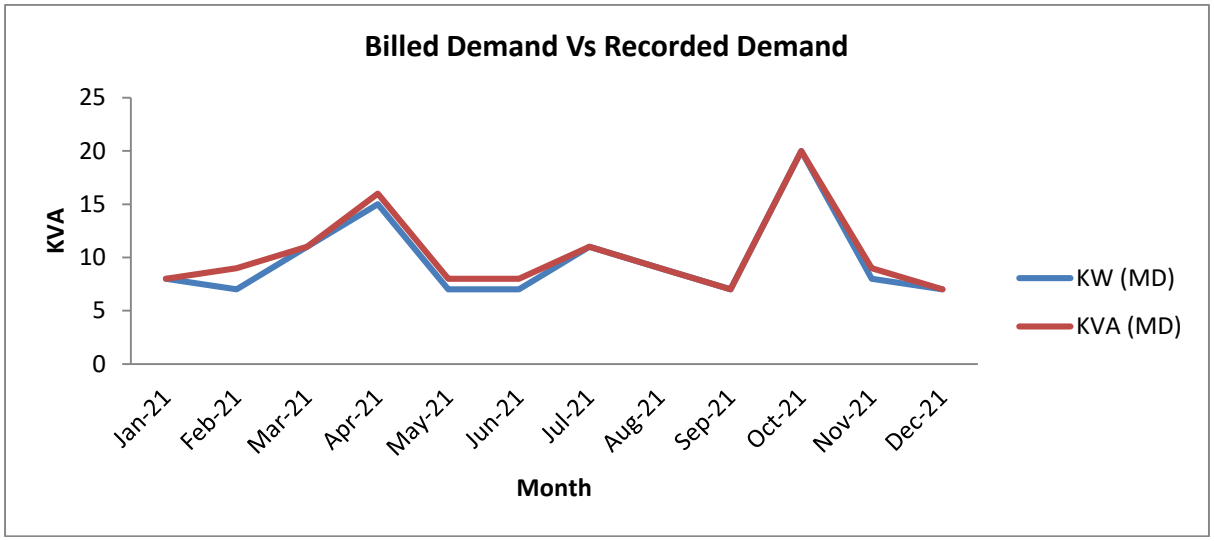


Figure 3 Billed Demand vs Recorded Demand

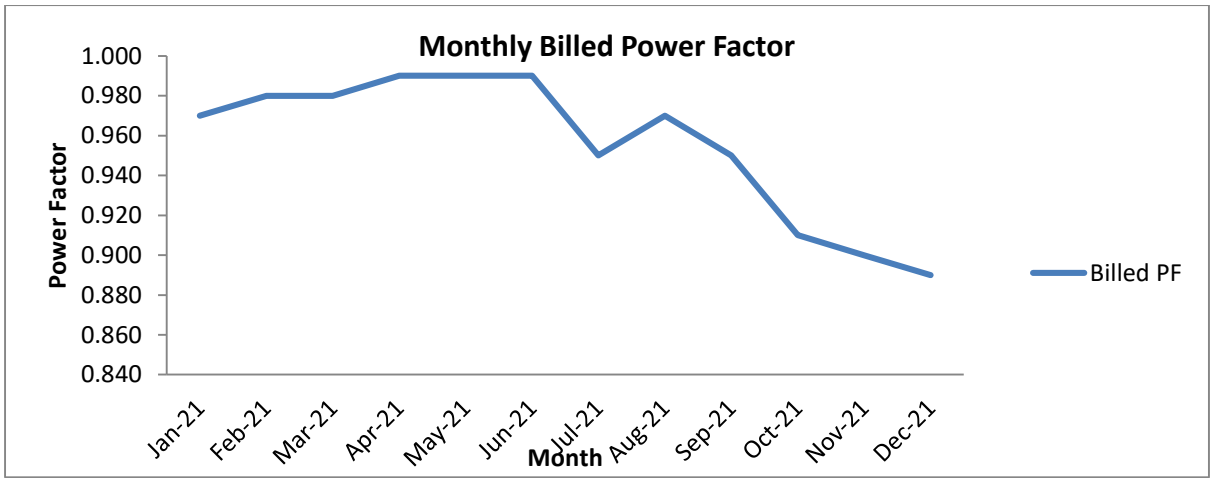


Figure 4 Billed PF

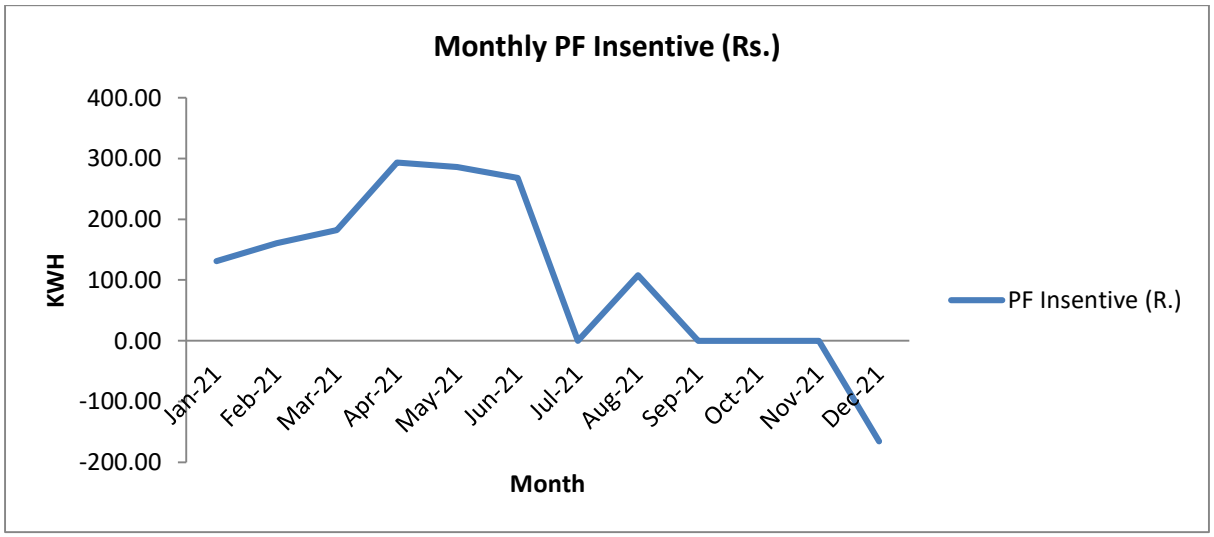


Figure 5 PF Incentive

4.2. Connected Load Quantity of Buildings

Table 4 Connected Load of Facility

Fixtures	Wattage	Total number of fixtures	Total KW
Tube-light	18	84	1.51
Ceiling Fan	75	103	7.73
LED round	18	110	1.98
LED sq.	3	6	0.02
LED sq.	18	24	0.43
LED sq.	43	300	12.90
CFL	72	41	2.95
CFL	10	2	0.02
CFL	20	16	0.32
AC (cassette)	1800	25	45
Air conditioning VRF load (First floor)	70	-	23.9
Air conditioning VRF load (second floor)	125	-	34.3
AC (No-star) (Ground floor)	2	4	12
AC (No-star) (Ground floor)	1.5	2	5
AC (5-star) (Ground floor)	1.5	2	3.46
AC (1.5 Ton 3 star)	1.5	4	6.93
TV	60	2	6
Computer	150	136	23.5
Printer/scanner	150	9	
Xerox M/C	700	1	
Focus	18	32	0.58
Projector	210	10	2.1
Pump	1 HP	1	0.75
Fire pump	12.5 HP	1	9.33
Jockey pump	40 HP	2	18.65
Total			**219.02**

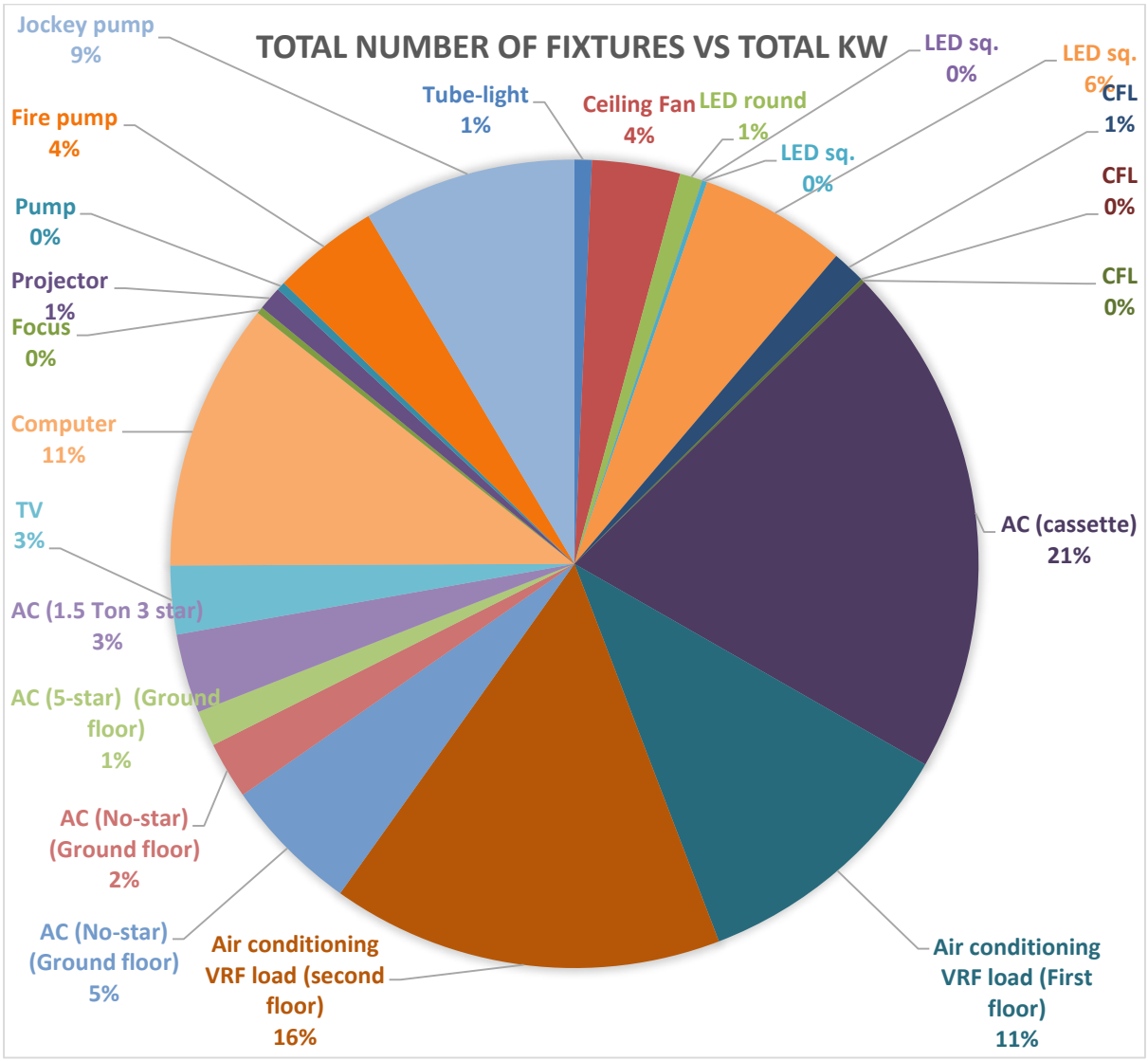


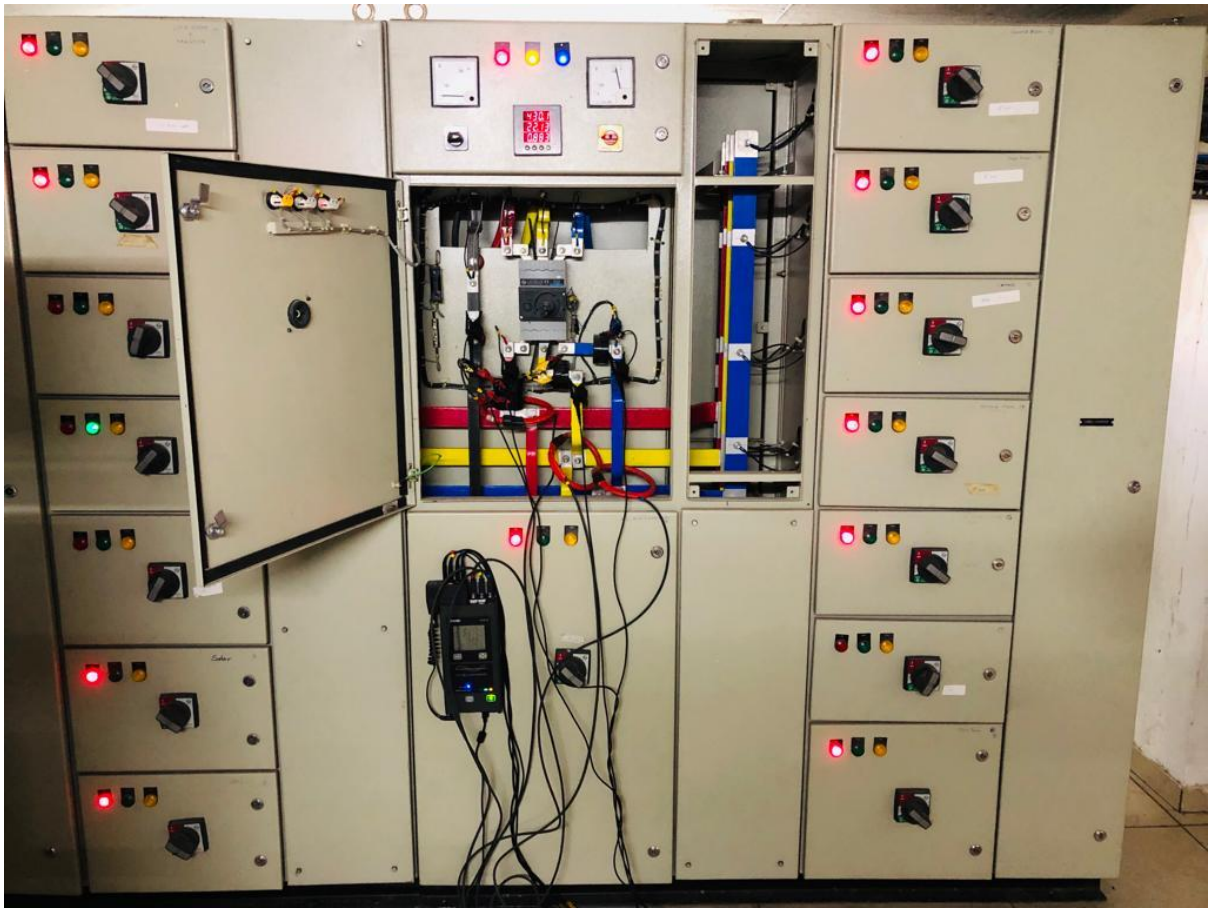
Figure 6 Distribution of Connected Load

5. ACTUAL MEASUREMENTS

5.1. Study of Loading Pattern for Facility:

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	427.19	433.40	429.93	
	Max	436.30	442.70	439.60	
	Min	422.80	428.60	425.30	
Current (A)	Avg	37.37	34.59	27.99	17.76
	Max	63.15	57.47	48.75	30.34
	Min	20.91	22.30	19.14	7.17
Active Power (W)	Avg	8831.37	8235.51	6579.33	23646.23
	Max	13922.00	12854.00	10289.00	37065.00
	Min	4564.00	5047.00	3986.00	13744.00
Power Factor	Avg	0.96	0.95	0.93	0.95
	Max	0.99	0.97	0.97	0.98
	Min	0.88	0.91	0.83	0.88
V % THD	Avg	1.84	1.74	1.81	
	Max	2.27	2.15	2.28	
	Min	1.57	1.42	1.48	
I % THD	Avg	25.26	27.84	35.55	89.23
	Max	49.39	44.69	64.17	648.76
	Min	12.70	18.24	18.45	31.05



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 current is more than 15%.

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

Voltage Variation:

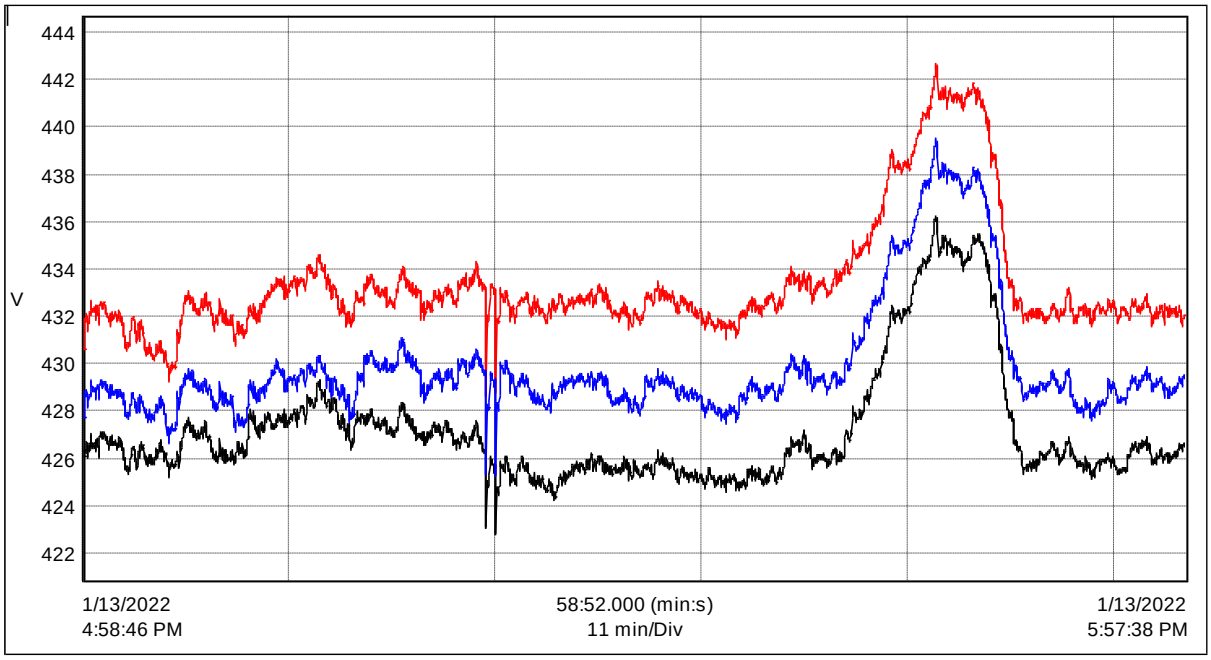


Figure 6 Voltage vs Time Period

Current Variation:

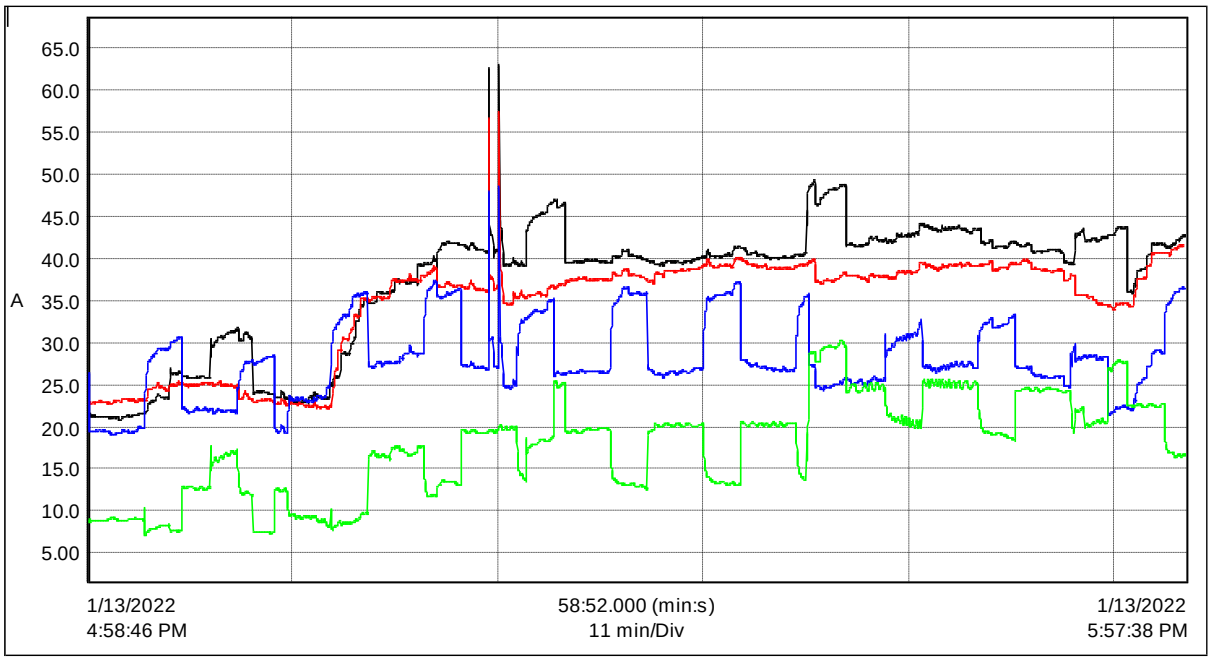


Figure 7 Current vs Time Period

Power Variation:

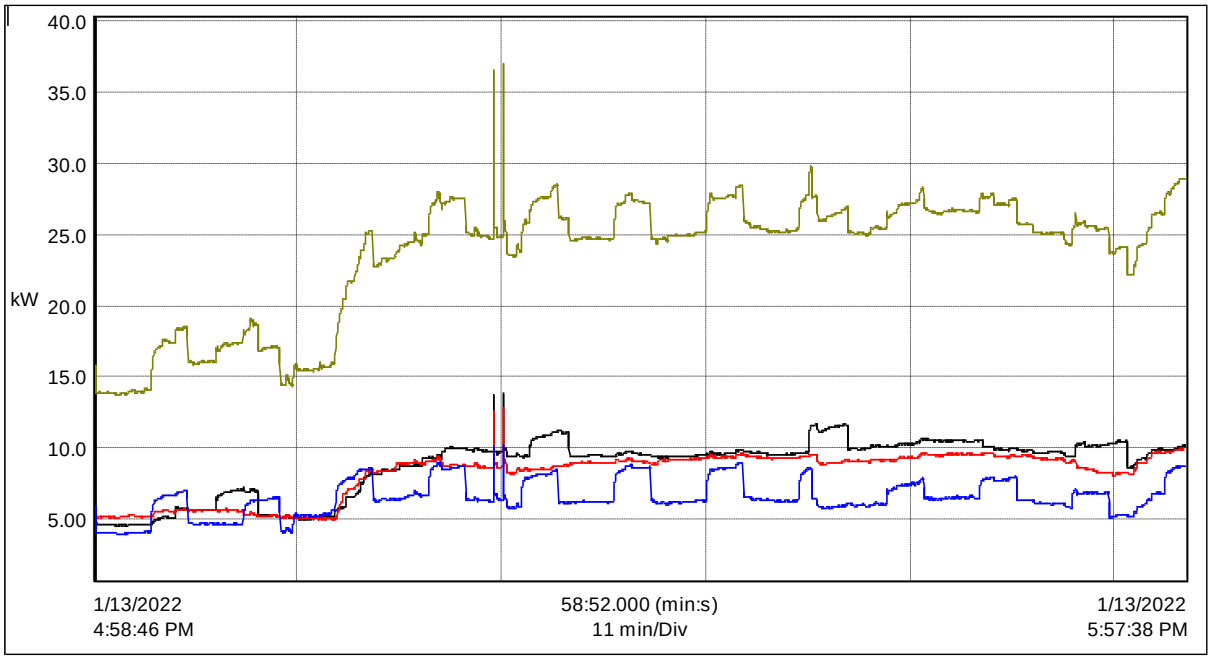


Figure 8 Power vs Time Period

Power Factor Variation:

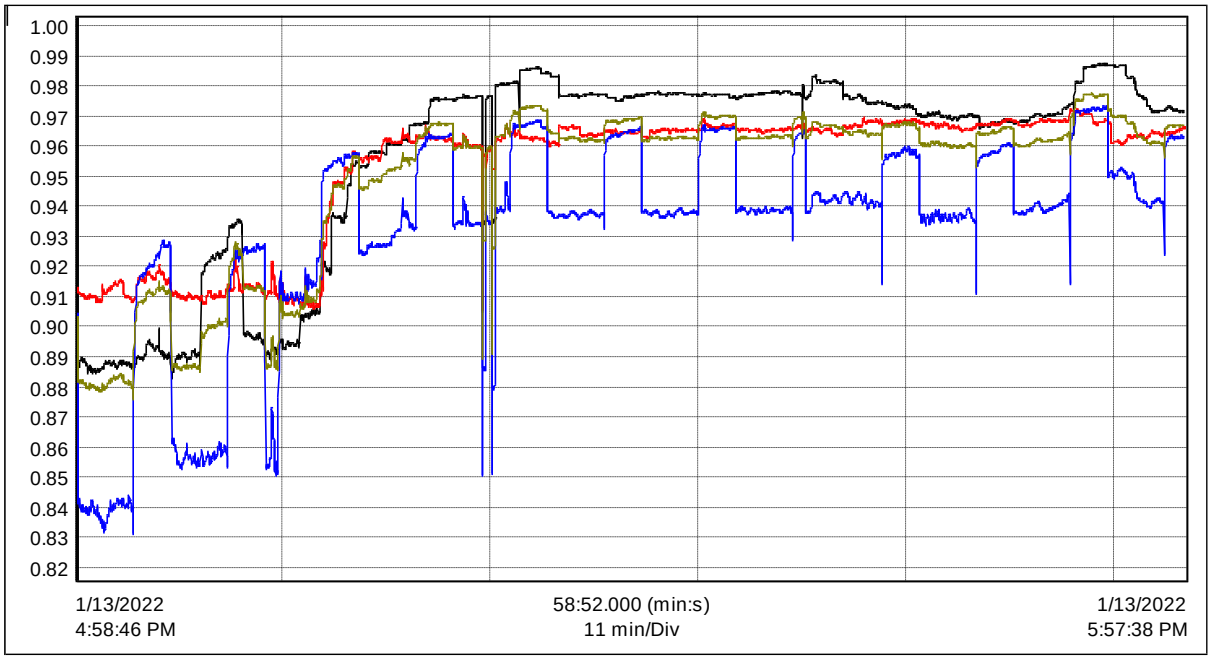


Figure 9 Power Factor vs Time Period

Voltage Total Harmonic Distortion Variation:

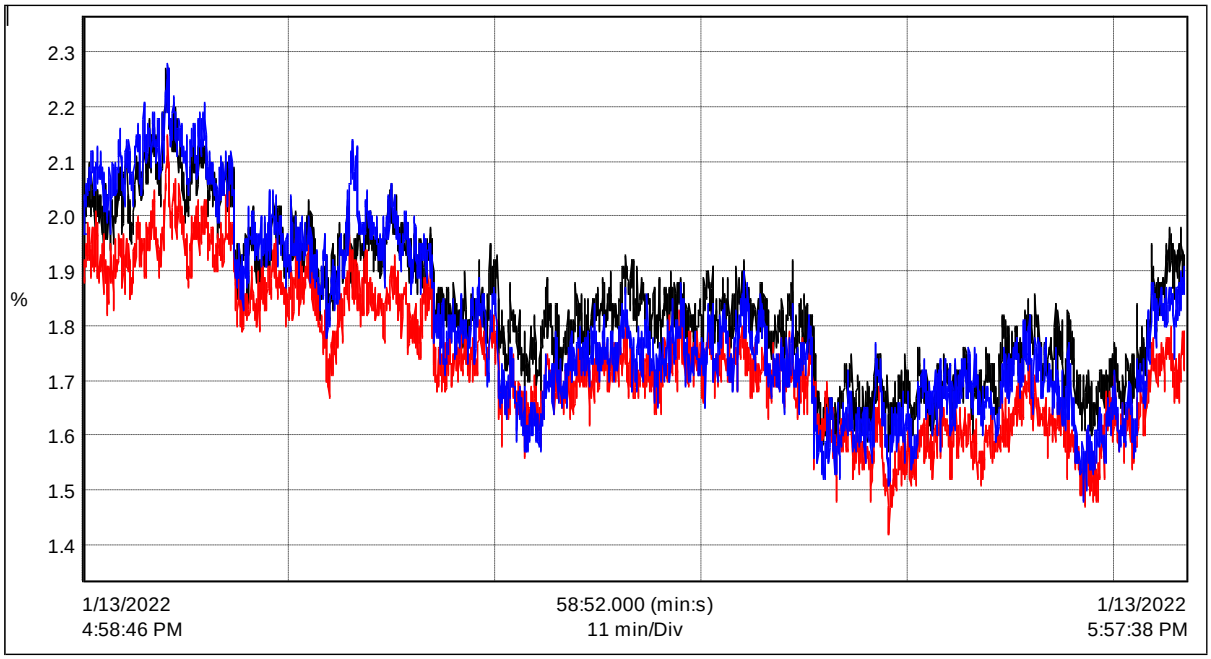


Figure 10 Voltage THD % vs Time Period

CurrentTotal Harmonic Distortion Variation:

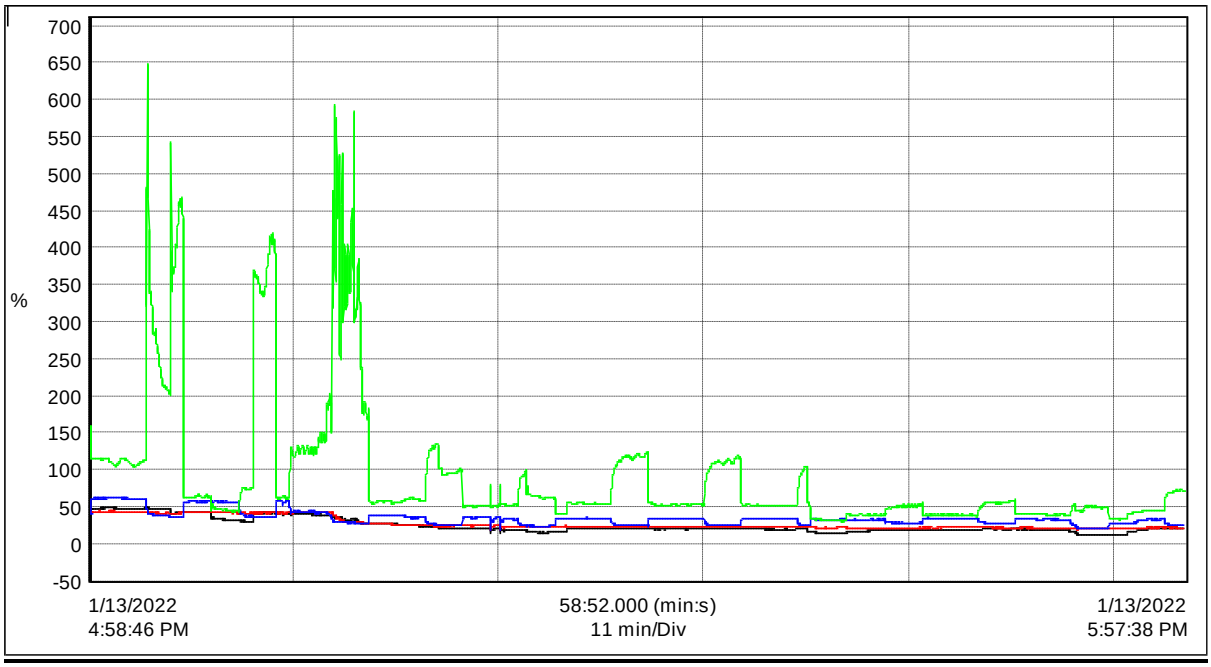
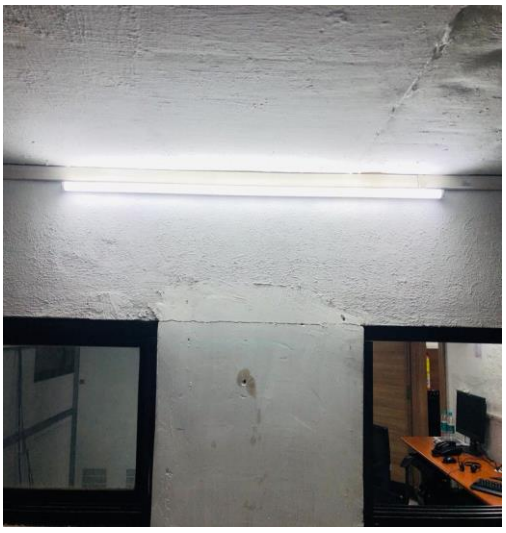


Figure 11 Current THD % vs Time Period

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 Lakh	Estimated Payback Years
			Electricity kWh	Carbon credit (Tons of CO_2)		
1	Replacement of conventional lights with suitable LEDs	0.63	340.20	0.29	0.06	10.15



Observations:

Facility has installed different type of light fittings in their premises which are shown in following table. At few places tube lights are available.

Fixtures	Wattage	Total number of fixtures
Tube-light	18	84
LED round	18	110
LED sq.	3	6
LED sq.	18	24
LED sq.	43	300
CFL	72	41
CFL	10	2
CFL	20	16

Recommendations:

During energy audit, it is observed that facility has installed Type of Fixture and Wattage at some of the places in the facility Also energy team at facility has already replaced some of the lights with LEDs. At few places CFLs are available. The operating hours for these lightings are around 3 hours. Type of Fixture and Wattage 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 conventional lights.

Energy Saving Calculations:

Particular	Unit	Value
Energy Saving Calculation		
Power consumption of Tube lights	KW	1.51
Power consumption of suitable LED light	KW	0.76
Average power saving after replacement with LED light	KW	0.76
Replacement of conventional lights with suitable LEDs	Nos	84
Average working hour per day	Hrs	3
No. of working days in a year	Days	150
Cost Benefit Calculation		
Annual Energy Saving potential	kWh	340
Electricity tariff	Rs/unit	18.3
Annual Cost Saving	Rs. Lakh	0.06
Total investment cost	Rs. Lakh	0.63
Annual Saving	Rs. Lakh	0.06
Simple Payback Period	Years	10.15

Type of Existing Fitting	W	Qty	Proposed LED W	Total Cost	Existing KW	Proposed KW	Saved kW	Investment Rs
Tube light	18	84	9	63168	1.51	0.76	0.76	63168
TOTAL	**18**	**84**	**9**	**63168**	1.51	0.76	0.76	**63168**

Sr. No	Item	C.S.R No.	Rate	Unit
1	9 W LED	2-1-3.	739	Each
2	Dismantling of fluorescent fittings	2-14-1.	13	Each

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

ECM No.	Energy Efficiency Improvement Measures	Investment Rs. In Lakh	Estimated saving		Estimated Savings Rs. In Lakh	Estimated Payback Years
			Electricity kWh	Carbon credit (Tons of CO_2)		
2	Replacement of existing fans with energy efficient Super fans	2.00	560.84	0.48	0.10	19.44

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	1912
Wattage of Energy Efficient Super Fan	Watt	35
Energy consumption after replacing with Energy Efficient Super Fan	kWh/year	892
Operating hrs/day	Hrs/day	3
No. of working days in a year	Days	150
Diversity factor	%	55%
Annual Saving	kWh/year	561
Unit rate	Rs/kWh	18.3
Annual Saving	Rs. In Lakh	0.10

Category	Nos	Estimated Running kW
Ceiling Fan 75 W	103	7.73
Total	**103**	**7.73**

ECM 3: Replacement of No star AC with 5 star AC.

ECM No.	Energy Efficiency Improvement Measures	Investment Rs. In Lakh	Estimated Saving			
			Electricity kWh	Carbon Credit (Tons of CO_2)	Estimated Savings Rs. In Lakh	Estimated Payback Years
3	Replacement of No star ACs with 5 star ACs.	5.16	473.40	0.42	0.09	59.52

Observations:

Facility has installed different type of ACs in their premises.

Fixtures	Wattage	Total number of fixtures	Total KW
AC (cassette)	1800	25	45
Air conditioning VRF load (First floor)	70	-	23.9
Air conditioning VRF load (second floor)	125	-	34.3
AC (No-star) (Ground floor)	2	4	12
AC (No-star) (Ground floor)	1.5	2	5
AC (5-star) (Ground floor)	1.5	2	3.13
AC (1.5 Ton 3 star)	1.5	4	6.93

Recommendations:

It is recommended to install no star as well as 3-star rated ACs with 5-star ACs. Here for calculation of replacement of ACs, 3-star ACs are not mentioned for calculation (only no star ACs are considered for calculation of replacement of ACs). It is recommended to replace ACs with phase manner. Also due to less occupancy/ less usage of ACs payback is huge but with normal/ full capacity use of ACs will show small payback.

Energy Saving Calculations:

Particular	Unit	Value
Quantity of 1.5 Ton AC with 3-star	Nos	4
Wattage of 1.5 Ton AC with 3-star	Watt	1566
Quantity of 1.5 Ton AC with no star	Nos	2
Wattage of 1.5 Ton AC with no star	Watt	2500
Quantity of 2 Ton AC with no star	Nos	4
Wattage of 2 Ton AC with no star	Watt	3000
Total load of 1.5 Ton AC with 3-star	kW	6.264
Total load of 1.5 Ton AC with no star	kW	5
Total load of 2 Ton AC with no star	kW	12
Total load of all no star installed AC	kW	17
Wattage of 1.5 Ton 5-star AC	Watt	1490
Wattage of 2 Ton 5-star AC	Watt	1732
Total load of 1.5 Ton 5-star AC	kW	2.98
Total load of 2 Ton 5-star AC	kW	6.928
Total load of all 5-star AC	kW	13.844
Load reduction after replacement	kW	3.156
Diversity Factor	%	50%
Operating Hrs per day	hrs./day	2
Operating days per year	Days/year	150
Estimated energy Saving	**kWh/year**	**473**
Unit Rate	Rs/kWh	18.3
Annual Saving	**Rs Lakh/year**	**0.09**

Investment Details

Particular	Value	Unit	CSR No
Quantity of 1.5 Ton Split AC (3*)	4	Nos.	
Quantity of 1.5 Ton Split AC	2	Nos.	
Quantity of 2 Ton Split AC	4	Nos.	
Rate of 1.5 Ton 5 star Split AC	51676	Rs.	3-2-9.
Rate of 2 Ton 5 star Split AC	62944	Rs.	3-2-7.
Dismantling Cost for Split AC	743	Rs.	3-12-3.
Total Investment for 1.5 Ton Split AC	104838	Rs.	
Total Investment for 2 Ton Split AC	254748	Rs.	
Total Investment for All AC	**515625**	**Rs.**	

ECM 4: Optimization of Set Temperature of ACs

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)		
4	Optimize the temperature setting to 23-25 degree Celsius	0.00	132.84	0.12	0.02	0.00

Observations:

Facility has installed different type of ACs in their premises which is explained in earlier ECM.

Recommendations:

During assessment, it was observed that set point of ACs was 20-22^0 C. Hence, it is recommended to increase set temperature setting to 23-24 ^{0}C as well as improve maintenance of AC frequency.

It is also recommended to reduce idle running (night and weekend use) of ACs.

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

The TR capacity of the same refrigeration will also increase with increase in the evaporator temperature, as given in table below:

Effect of variation in Evaporator Temperature on Compressor Power Consumption			
Evaporator Temperature (°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*

Energy Saving Calculations:

Particular	Unit	Value
Estimated Annual Consumption of ACs	kWh/hr	4428
Estimated Saving	%	3%
Operating Hours per day	hrs/day	2
Operating days per year	Days/year	150
Estimated Saving	kWh/year	133
Unit Rate	Rs/kWh	18.3
Annual Saving	Rs Lakh/year	0.02

Sr No	Type	Ton	Qty	Annual Consumption
10	Air Conditioner (Split) (1.5 Ton) (3*)	1.5	4	1008
1	Air Conditioner (Split) (1.5 Ton) (0*)	1.5	2	504
2	Air Conditioner (Split) (2 Ton) (0*)	2	4	1344
3	AC (cassette)	1800 W	25	900
4	Air Conditioner (Split) (2 Ton) (5*)	2	2	672
Total				**4428**

ECM 5: Optimize the Power Factor

ECM No.	Energy efficiency improvement measures	Investment Rs. In Lakh	Savings Rs. In Lakh	Payback Year
5	Optimize the Power Factor	0.053	0.051	0.09

Observations:

The facility is maintaining PF around = 0.956.

Recommendations:

Power factor correction capacitors act as a reactive power generator, and provide needed power to accomplish kW of work. Due to this total current in the system is reduced at the source end which reduces I2R losses. It helps to increase voltage level at load end. High power factor can help in utilizing full capcacity of the electrical system. To get the PF incentive, it is recommended to check the operation of each capacitor bank installed once in a month and maintain the PF to unity.

Calculation for KVAR Required based on Desired Unity PF:

Particular	Value	Unit
Total Annual Consumption	7937	kWh/Year
Unit Rate	18.3	Rs./kWh
Total Annual Energy Charges	145247.1	Rs./year
With Operation of all Capacitor banks, Annual Energy Saving	5083.65	Rs./year
Annual Energy Saving	0.05	Rs (Lakhs)/year
Present Billed Power Factor	0.956	
Desired Billed Power Factor	1	
Multiplying Factor	0.329	
Total Connected Load	40	kW
Size of required Capacitor Bank	13.16	kVAR
Rate of Capacitor Bank	400	Rs./KVAR
Total Investment	5264	Rs.
Payback	0.09	Years

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^{o}….360.0^{o}
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

PPS ENERGY SOLUTIONS PVT. LTD.

Dr. Ravi G. Deshmukh
Energy Auditor Class - A
MEDA/ECNCR-05/2018-19/EA-05