ENERGY, ENVIRONMENT & GREEN AUDIT REPORT
FOR

SHRI RAMDEOBABA COLLEGE OF ENGINEERING AND MANAGEMENT (RCEOM)
NAGPUR

From 7th to 9th February 2024

By

IRCLASS SYSTEMS AND SOLUTIONS PVT. LTD.

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1. Executive Summary

Shri Ramdeobaba College of Engineering and Management (RCOEM) was founded in 1984 by

Shri Ramdeobaba Sarvajanik Samiti, a registered charitable trust established in 1967 which has been involved in community service for over five decades. The Institute was granted progressive academic autonomy in 2011 and the self-financed university status on September 13, 2019. The governance of the Institute is reflective of transparent, supportive, responsive leadership which practices participative management and collective decision making in line with the vision and mission of the Institute. To strengthen the academic practices, innovation in governance is the distinguishing feature of the Institute.

This Assessment is mainly focused on Energy Savings, Water Management, Waste Management, Renewable Energy, Carbon Accounting , Green Belt / Landscaping/ Gardening.

Campus is steadily moving towards sustainability in electricity, water & uses of natural resources.

For eg:

- **100 % utilization of Sewage Treated Water**
- **Use of TSE water from STP Plant for Irrigation network.**
- **Pumps & Equipments selected on best energy efficient point.**
- **Use of low flow fixtures to reduce water flow & thereby control in water usage.**
- **Master switches installed in for each class rooms.**
- **Rain water harvesting & Recharge pits are provided at numerous locations of the campus.**
- **Solar PV rooftop is installed in the campus**.
- **Electrical Energy Load balance is maintained**
- **Carbon foot printing initiated.**
- **Canteen waste including vegetable cuttings and cooked food if any is hardly 5kg/day which is handed over to agency for cattle feeding.**
- **Garden waste generated 22.5kg/day is used in vermi composting**

CSR Activities:

REEF : RAMDEOBABA COLLEGE ENGINEERS FOR ENVIRONMENT FORUM

- The environment club of Shri Ramdeo Baba Collegof Engineering and Management REEF organized a tree plantation Day and sapling distribution drive on July 7, 2023, in association with MeriLife Tree Plantation. REEF has distributed 127 saplings.
- REEF Organized a trash collection drive from April 19 to April 21 ,2023 on the occassion of Earth Day. The volunteers of REEF collected various recyclable garbage, and the e waste .
- A cleanliness drive and analysis of upcoming summer problems for birds ecosystem was organized at ambazari biodiversity Bird Census campus was organized .
- Green Habits Ideas Camp Organized
- REEF participated in Swatchata League , Eco-friendly Ganpati Immersion Drive

Key Result Areas for Energy Savings & Estimated Potential along with Broad Cost Benefit Analysis

Sr. No.	Description	Energy Savings	Cost Savings	Investment	Simple Payback Period
		kWh/kVAh	Rs. Lakhs	Rs. Lakhs	Months
1	Improve Existing power factor	19248	2.57	2	9.32
2	Reduce harmonics level at main incomer side	33222.57093	3.46	5	17.37
3	Replace Geyser installed in hostel with solar water heater	60000	6.24	2	3.85
4	Solar Rooftop System	508000	22.9108	1	1.1
5	Provide automation system for chiller utility	99991	7.5	-	-
Total		**20,15,331**	**198**	**155**	**9**

2. Introduction

Shri Ramdeobaba College of Engineering and Management (RCOEM) founded in 1984 gives an idyllic setting where individuals are honed to be ethical professionals. RCOEM has been recognized for its commitment to excellence to technical education. The reputation that RCOEM has earned comes from the efforts, contributions and achievements of our thousands of stakeholders.

Our community of students, professors, staff and alumni shares a commitment to diligence and make sincere efforts towards the advancement of the society through creativity and innovation. RCOEM is the temple of knowledge devoted to innovative learning, creativity and effective application of knowledge and values for sustainable development.

The college has earned good name and is ranked amongst top colleges in India for Engineering and Management education. Today, RCOEM is one of the most sought after institutes in Central India.

We offer a unique blend of academic excellence, industry-focused curriculum, state-of-the-art infrastructure, and a vibrant campus life that sets us apart from other institutions. Our experienced faculty members, industry collaborations, and global academic partnerships ensure that our students receive the best education and exposure. Additionally, our focus on research and innovation helps our students develop an analytical and creative mindset that is highly valued in the industry.

Choose RCOEM for a fulfilling and rewarding college experience that prepares you for the challenges of the real world.

Highlights:

- RCOEM positioned in the **151-200** Rank band of Engineering Category and **51-200** Rank band in Innovation Category by National Institutional Ranking Framework 2023.
- RCOEM has got INDIA RANKING **'146'** by National Institutional Ranking Framework 2022.
- RCOEM has got INDIA RANKING **'119'** by National Institutional Ranking Framework 2021.
- RCOEM has got 20th rank in India Today Ranking 2021 in All India Private Engineering Colleges Category
- RCOEM **Centers of Excellence**:
    - RCOEM-TATA-CIIIT Center of Invention, Innovation, Incubation and Training.
    - NVIDIA – Center of Excellence in the area of "Artificial Intelligence & Machine Learning".
    - Centre for Microsystems with Intellisense
    - Energy Research Centre (ERC)
    - RCOEM-QCFI Centre of Human Excellence.
- RCOEM has been ranked 26th as per CSR Magazine Survey 2020
- RCOEM has got 50th rank in India Today Ranking 2020 in All India Private Engineering Colleges Category
- RCOEM has been ranked 28th in Outlook's India's Best Professional Colleges 2020 Survey.
- **RCOEM-TATA-CIIIT** Center of Invention, Innovation, Incubation and Training was inaugurated at the hands of Honourable Union Minister Shri Nitin Gadkari.
- RCOEM has got INDIA RANKING **'113'** by National Institutional Ranking Framework 2020.
- RCOEM signed a Memorandum of Understanding for clinical collaboration with Kingsway Hospitals in the field of Bio-Medical Engineering.

Ramdeobaba College of Engineering and Management is a authorised partner institute of "Study in India" an initiative by the Ministry of HRD, Government of India for the admission cycle of 2019-2020. The

- Ministry of Human Resources Development (HRD) has approved 'Study in India' programme to attract foreign students to pursue higher education in India.
- RCOEM is known for excellent and well qualified faculty. College boasts of 134 faculty members who hold doctorate that is Ph.D degree in their respective subjects. Students are groomed under the expert guidance of the faculty members in academic and co-curricular areas.
- RCOEM has got INDIA TODAY RANKING of **23** in All India Private Engineering Colleges Category.
- RCOEM ranked **'27th'** among all Private Engineering Colleges of India as per Outlook survey 2019. AND ranked **'53rd'** among all Engineering Colleges of India as per Outlook survey 2019.
- RCOEM has got INDIA RANKING **'112'** by National Institutional Ranking Framework 2019.
- RCOEM hosted the 1 st , 2 nd and 3 rd Smart India Hackathon in 2017, 2018, 2019 respectively organized by Ministry of HRD, Govt. of India.
- RCOEM has got INDIA RANKING in the range of '101-150' by National Institutional Ranking Framework 2018.
- RCOEM has got INDIA RANKING '**64**' by National Institutional Ranking Framework 2017.
- RCOEM ranked 49 th in Outlook's India's Best Professional Colleges 2017 Survey.
- Approved Autonomous status By UGC as well as by RTM Nagpur University.
- Approved by All India Council of Technical Education (AICTE) and affiliated to Nagpur University, Nagpur.
- RCOEM has been awarded "A" Grade by NAAC for a period of 5 years from Dec,2014.
- NBA accredited Engineering departments, including NBA-tier I accreditation for five years.
- World-class sporting facilities at New Campus, Mohali, Katol Road, Nagpur.
- Many faculty members have brought laurels to the institute by way of awards, honours and prizes at National and International level.

- RCOEM won the KC Bajaj Trophy for Best College in Sports Promotion from Sports Journalist Association of Nagpur and Raisoni Achievers in Annual Award 2016.
- MoUs with highly reputed International Universities of USA, UK, and Australia.
- Implementation of Choice Based Credit System (CBCS) for PG Programmes since 2016-17 academic session.
- RCOEM has earned the distinction of having highest placements in Maharashtra and it is the most sought after Technical Institute in Central India.
- RCOEM has been selected as the top institution in Maharashtra by Rajiv Gandhi Science and Technology Commission for the implementation of scheme of Technology Information, Forecasting, and Assessment Council (TIFAC), by RGSTC, Govt. of Maharashtra and MSME Internship scheme for the consecutive second year..
- Ongoing consultancy of more Rs 1 Crore received under MoUs signed with 30 industries.
- RCOEM was selected as the top institution in Maharashtra by RGSTC for the implementation of scheme of Technology Information, Forecasting, and Assessment Council (TIFAC), by Rajiv Gandhi Science and Technology Commission (RGSTC), Government of Maharashtra.
- Incorporation of dynamic TBI Foundation, a Section 8 Company founded by College to give momentum to innovation, entrepreneurship and incubation support related activities.
- Implementation of Visvesvaraya PhD Scheme of Department of Electronics and Information Technology (DeitY).
- RCOEM selected as Knowledge Management Partner Institution (KMPI) of Consultancy Development Centre (CDC), DSIR (Dept of Scientific and Industrial Research), Government of India.
- Highest Placements in Central India.
- RCOEM compete with the likes of IITs and top government and non-government educational institutions as well as well-established consultancy firms of India to attain this milestone.
- Over 500 students have done or are doing their MS from prestigious institutes in USA and UK.
- RCOEM students excel in competitive examinations like CAT, GRE, GMAT, CET, GATE etc and Students after graduation have been admitted to reputed institutions as IIT's, IISc-Bangalore, BITS-Pilani, VJTI and various Regional Engineering Colleges.
- Shri Ramdeobaba College Engineers for Environment Forum (REEF) of RCOEM is the recipient of Earthian Award-2015.
- Established in 1984, one of the oldest institutes of the central India.
- Institute level Admissions (Management quota) on merit and transparent basis.
- RCOEM has received grants of more than 2 crore rupees from various Government agencies such as Department of Science & Technology (DST), Department of Information Technology (DIT), AICTE etc. for conducting research activities.
- Well Placed Alumni. Strong tie with Alumni. The alumni association is giving scholarship to bright students in addition to Tuition fee Waiver scheme of Institute. Association also donates technical education aid.
- Vibrant Entrepreneurship Development Cell (OASIS) and Business Incubation Centre (First Step).
- As per the compulsory internship scheme of the curriculum, MCA final semester students are working as interns in reputed firms to ensure guaranteed placements.
- Former students have been selected in Civil Services, Engineering Services, etc.

International Collaboration:

With globalization and increasing need for international exposure to academia, RCOEM has forged ties with various universities of USA, UK and other countries. The primary aim of these collaborations is to foster advancement in teaching, research and academic collaboration and to create avenues for enhancing student and faculty experience, enhanced employability with development of curriculum, practical approach, soft skill development and creativity. The collaborations aim to achieve these through development of short-term programs, sharing of best practices, innovative or creative concepts, and student and faculty exchange. Collaborative development of teaching and research methodology and continued education programs are also part of the collaboration.

Current Memorandum of Understanding (MOU) with Foreign Universities:

- University of North Florida
- RWTH AACHEN Academy, Germany
- TEESIDE University, UK
- Nplus Engineering Institute, France
- Rochester Institute of Technology, USA
- University of Massachusctts, Lowell, USA

RCOEM Courses/Departments –

1. Courses:

Civil Engineering, Industrial Engineering, Electrical Engineering, Electronics Engineering , Electronics Design Technology, Electronics and Communication, Information Technology, Computer Science and Engineering, Mechanical Engineering, M. Tech - Geo- Technical Engineering (Part Time), M. Tech - Industrial Engineering, M. Tech - VLSI Design, M. Tech - Structural Engineering, M. Tech - Computer Science and Engineering, M. Tech - Power Electronics Power Systems, M. Tech - Heat Power Engineering, Masters of Computer Applications, Masters of Business Management,

2. Civil Engineering:

The Civil Engineering Department offers testing and consultancy services in the field of:

- Geotechnical Engineering
- Water and Waste water Engineering,
- Concrete and Non-destructive Testing
- Transportation Engineering,
- Quantity Surveying and Costing
- Structural Engineering
- Survey

Software's Available:

- AutoCAD 2016
- STAAD Pro v8i
- PRIMAVERA V6.0
- Ansys
- SAP
- Bentley Bundle (Water Gems)
- ArcGIS

Major Equipment Available:

Digital Universal Testing Machine (UTM), Micro Processor Based Compression Testing Machine, Ultrasonic flow meter, Ultrasonic Pulse Velocity meter, Benkelman beam test setup, Total Station, Hand held GPS, SPT setup, Pressure meter for SBC of soil, Tri-axial shear test setup, Direct Shear test setup, Abrasion Testing machine, CBR test setup, Spectrophotometer, water quality analyzer etc.

3. Computer Science, IT & MCA

The Computer Science & Engineering, Information Technology and Computer Application Department offers testing and consultancy services in the field of:

Natural Language Processing

- Artificial Intelligence
- Machine Learning
- Image Processing
- Data Science

Software's Available:

- MATLAB
- Netsim
- Java
- Python
- Visual Studio 6.0 education +
- Additional 5 user License
- Rational Rose Suite Enterprise

Major Equipment Available :

- **AIX Server, HPE 380 Gen 9 Server :** Intel XE non S-2620V4/64 GB/4* 1TB
- server 2 U 2T 2.1GHz/ 8 Core, **Fire Bird**

4. Electrical Engineering:

Offers testing and consultancy services in the field of:

- Electrical System Design up to 33kV level
- Reactive Power Compensation Solutions
- Industrial Automation
- Energy Bill analysis
- High Voltage Testing
- Power Electronics controller design

Softwares Available:

- PSIM
- ETAP
- MATLAB
- DSA Tools

Major Equipment Available:

Power Quality Analyzer (HIOKI), Impulse Generator, Oil Test Kit, High Voltage AC and DC Test Set, Inclined Plane Tracking Test Equipment, Relay Test Kit, Digital Storage Oscilloscope (200MHz) with Current and High voltage Probes, Mixed Domain Oscilloscope (MDO), Solar PV array Analyzer, Battery Capacity Tester.

5. Electronics Engineering

Department of Electronics Engineering, Electronics Communication and Electronic Design and Technology offers testing and consultancy services in the field of:

- PLC, SCADA training
- Electronics system design
- Industry automation
- Sensor Design
- PCB prototyping
- Antenna Design
- 3D printing Services

Softwares Available:

- Mentor graphics CAD tool for IC design
- COMSOL Multi-physics
- Matlab
- XILINX Vivado
- Orcad Suite
- Xilinx ISE
- Tanner Tool
- HFSS antenna Design
- NIELVISII+

Major Equipment Available:

- DSO 4 channel, 200MHz,1 4 Hz
- Spectrum analyzer, 1GHz , 3 GHz
- Logic analyzer cum pattern generator 48 channel, 100mhz
- Arbitrary function generator
- LCR meter
- 3D Printer, rapid PCB prototyping set up

6. Industrial Engineering

Industrial Engineering provides us the way of thinking about continual all-round improvement. It develops a mindset of progress for every real-life situation. It deals with the optimization of complex processes, systems, or organizations. Industrial engineers work to eliminate waste of time, money, materials and other non-value adding resources. Industrial engineering is concerned with the development, improvement, and implementation of integrated systems of man, machine and materials.

Major Equipment:

- Fully equipped workshop for all kind of fabrication work.
- Spirometer.
- Sound Level Measurement Apparatus.
- Illumination Measurement (Dark Room)
- Anthropometric Measurement Kit.
- Motion Camera for Work Study.
- Treadmill Test.
- Body Fat Measurement.
- Blood Pressure & Heart Rate Measurement.
- Vibration Signature Monitoring.
- CNC Machine.
- Electric Discharge Machine (EDM).

Softwares Available:

- SIMUL 8
- MINITAB
- SIMIO
- TECHNOMATIX
- SPSS
- MDAT

7. Mechanical Engineering

The Mechanical Engineering Department offers consultancy services in the field of :

- Mechanical System Design
- Elevator selection & installation
- Finite Element Analysis
- EOT Crane Design
- Additive manufacturing & 3-D Printing
- Solar Energy Applications
- Machine Condition Monitoring, diagnostic & vibration signature Analysis
- Design of orthopedic & dental implants
- Design of hydraulic & pneumatic systems
- Mechanical Roll Over Protection devices
- Material Testing
- Precision Manufacturing

Software's:

- AutoCAD 2016
- Creo
- Solid Modeling Software
- ANSYS 14.5
- MS Project
- PRIMAVERA
- SIMUL-8

Major Equipment Available:

Stratagem make Julia dual 3-D Printer, CNC Machine, Izod-Charpy impact testing machine, HMT Machines.

Vision: To be a leading institute committed to excellence in technical and management education, research, and innovation to meet societal, national, and global needs.

Mission:

- Providing quality education that builds a foundation for life-long learning
- Striving continuously for creating an intellectually stimulating environment for research, innovation, and entrepreneurship
- Developing professionals and future leaders with ethical values to serve the society

Autonomy: RCOEM was granted progressive academic autonomy from the session 2011-12. Various statutory bodies such as Board of Management, Academic Council, Board of Studies, and Finance Committee have been constituted and an industry need-based syllabus has been introduced.

Quality Policy:

Shri Ramdeobaba College of Engineering and Management is committed to achieve exemplary standards in Engineering and Management Education.
We aim at continuous improvement of all our processes and will strive to provide an environment conducive to the pursuit of knowledge and overall personality development.
We encourage all to adhere to the highest ethical standards and professional integrity and aim to enhance the satisfaction level of all stakeholders.

Core Values:

Excellence: The Institute strives to excel in knowledge assimilation, research and innovation.
Integrity: The Institute upholds high values of rationalism, professional ethics, human values and practice of equality.

Transparency:

Transparency is maintained in all the processes and decisions taken in the Institute.
Social and Moral Responsibilities: The Institute commits itself to issues of national importance and global concern as a part of social and moral responsibilities.
Service to the Nation: The Institute pledges to serve the nation by developing technically trained human resource in the field of engineering and management.

Other Green, Environment related Initiatives & Recognitions:

- Solar PV rooftop is installed in the campus.
- About 90 % lights are replaced by LED, balanced are being replaced in phase manner.
- Most of Split Air conditioners are of 2 or 3-star rating. Temperature setting is kept at around 25-26^0 C.
- Contract demand is upgraded to 750 KVA from 350 KVA considering future demand in advance. Erection/commissioning of 1200KVA transformer for future load increment is in progress.
- Load Balance is maintained
- Sustainability approach is visible
- Many recognitions and awards for environmental work initiatives.
- Lot of greenery in the campus.
- 100% reuse of treated water from STP.
- Flora fauna sighted.
- Garden waste is treated in vermi composting chambers previously it was in the green bags.
- Carbon foot printing initiated.

3. *Gene*ral Introduction and Objectives of Environmental, Energy & Green Assessment Process

The Environmental, Energy & Green Assessment is a process of systematic Identification, Quantification, Recording, Reporting and Analysis of components of environmental diversity of various establishments. It aims to analyze Environmental, Energy Conservation & Green practices within and outside of the concerned sites, which will have animpact on the eco- friendly ambiance.

Objectives in brief:

- To ensure that the performance of the institution with respect to environmental activities they are involved in, is in compliance with existing laws and regulations.
- To check the functionality and their operating success including water supply, energy related matters and other similar matters that are related to green operations in the campus
- To measure the environmental impact of operational process related to green activities in the campus.
- To measure the performance of each green related operations and actions in the campus.
- To generate a database of green activities for continuous monitoring to assess the success of each of them.
- To identify future potential liabilities.
- To align the institution's developmental and day to day activities with the stated vision, mission, strategies, etc.
- To identify possible ways to reduce expenditure and running costs on equipment's, appliances, etc. or try enhance revenue income.
- To improve process and materials efficiency, and in response to stakeholder requests for increased disclosure.

4. General Steps and Scope of the Assessment

1. Data collection based on questionnaire.
2. Visit to the campus by audit team.
3. Data analysis and evaluation.
4. Discussion on the findings.
5. Report preparation.

5 . ENERGY MANAGEMENT ASSESSMENT

Objective of Energy Audit:

- Identifying the quality and cost of various energy inputs.
- Assessing present pattern of energy consumption in different cost centers of operations.
- Relating energy inputs and production output. Identifying potential areas of thermal and electrical energy economy.
- To achieve and maintain optimum energy procurement and utilization, throughout the organization
- To minimize energy costs / waste without affecting production & quality.
- To minimize environmental effects.
- To undertake an electrical Safety audit and energy audit so as to identify the deviation in installation practice being followed at premise and that of recommended as per applicable standard & areas for energy saving, both without and with investment.
- To prioritize distinct areas identified for energy savings depending upon saving potential, skills, and time frame for execution, investment cost, paybacks etc.

Scope of Work

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

Table 1 : Instrument Used by Audit Team

Sr. No.	Instrument Name	Specification
1.	Demand Analyzer	Suitable for 1φ, 3φ. 156 electrical parameters like voltage, current, frequency, harmonics, active & reactive power, power factor etc.
2.	Clamp-on Power Meter	0 - 1200 kW 0 - 600 Voltage, AC 0 - 800 Voltage, DC 0 - 2000 A, Current, AC / DC
3.	Power Quality Analyzer	3 Ph 4 Wire Recording Parameters: Voltage, Current, Frequency, Harmonics/ Inter harmonics up to 50th, THD of V, I and KW with K Factor, Transients, Voltage Sag- Swells, All Power Parameters, Inrush current, Load Unbalance, Flicker Recording etc. enabling graphical, vectorial, numerical representation, trending of data, monitoring of events etc.
4.	Lux Meter	0 - 50,000 lux level Non Contact Type
5.	Digital Thermo Anemometer	0 - 45 m / sec. ± 3%
6.	Relative Humidity and Temperature Indicator	RH – 10% to 95% Temp. – 0 – 100 °C Handheld unit
7.	Infrared Thermometers	40 ^{0}C to 500 ^{0}C
8.	Portable Temperature Indicator	50 ^{0}C to 1200 ^{0}C

5.1: OVERVIEW OF ENERGY CONSUMPTION:

Energy Sources:

The Power is supplied to RCOEM by Maharashtra State Electricity Distribution Company Ltd. (MSEDCL), Nagpur Zone.

There are two energy sources to the RCOEM, Nagpur.

1. 475 KVA Power supply at 11 KV for main campus including boys' hostel and other facilities (commercial Type)
2. 200 KVA supply for girls' hostel infront of the main gate. (residential type)

Supply scheme – SLD:

Electricity

- Power supply at plant is received from MSEDCL, Maharashtra. The Plant premises comprise of three connections of 11 kV input with contract demand of 475 kVA, 72 kVA.
- The power received at 11 kV is stepped down to 415 V by 2 no's of 630 kVA transformers and one 200 kVA transformer

Electrical Distribution Systems

Facility Description:

i. Power is supplied at 11 KV voltage Level stepped down to 415 V and distribution.
ii. 3 nos standby DG Sets are installed, 2 nos at substation and 1 no at new building.
iii. Roof top Solar PV panels are installed.
   - Stage-1 = 90 KWp, at Admin building
   - stage-2 = 250 KWp, at ME+IT+FY building
   - stage-3 = 120 KWp, at EN+MCA building
     Total = 460 KWp

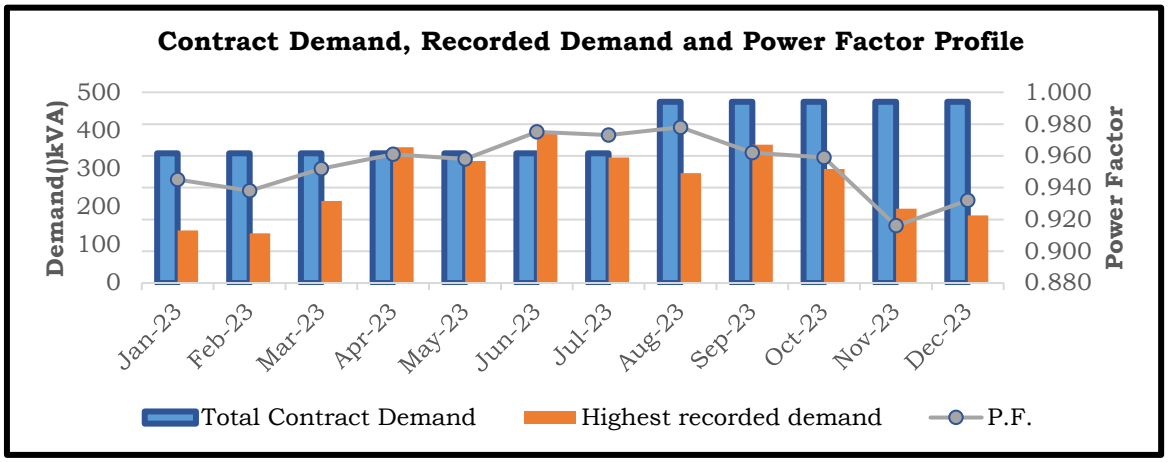
Table 2 : Monthly Electricity Consumption for 630 TR Connection

Month	Sanctioned Load	Total Contract Demand	Billing Demand	Highest recorded demand	P.F.	Energy Consumption	Charge/ kWh	Demand Charges	Energy Charges
	kVA	KVA	kVA	KVA		kWh	Rs.	Rs. lakhs	Rs. Lakhs
Dec-23	380	475	332.5	177	0.932	27041	10.40	1.66	3.01
Nov-23	380	475	332.5	195	0.916	21803	10.40	1.66	2.47
Oct-23	380	475	332.5	299	0.959	50006	10.40	1.66	5.42
Sep-23	380	475	332.5	363	0.962	65722	10.40	1.81	7.10
Aug-23	380	475	332.5	288	0.978	55767	10.40	1.64	5.93
Jul-23	406	340	238	329	0.973	61870	10.40	1.64	6.61
Jun-23	406	340	238	397	0.975	64607	10.40	1.98	6.89
May-23	406	340	238	320	0.958	39768	10.40	1.59	4.31
Apr-23	406	340	238	356	0.961	40760	10.40	1.77	4.41
Mar-23	406	340	221	215	0.952	22843	8.96	1.39	2.14
Feb-23	406	340	221	130	0.938	8797	8.96	1.39	0.84
Jan-23	406	340	221	138	0.945	13462	8.96	1.39	1.27
Average			**273**	**267**	**0.95**	**39371**	**10.40**		**4.20**

Observations for EB 1 Connection:

- Contract demand is 380 kVA and minimum billing demand is 70% of contract demand, 332kVA or recorded demand whichever is higher. Average unit cost incurred is Rs. 10.40/kVA.
- Power factor is maintained at 0.95 which is lower side and can be further augmented to maintain near unity.
- Average demand recorded for the year 2023 is 267 kVA

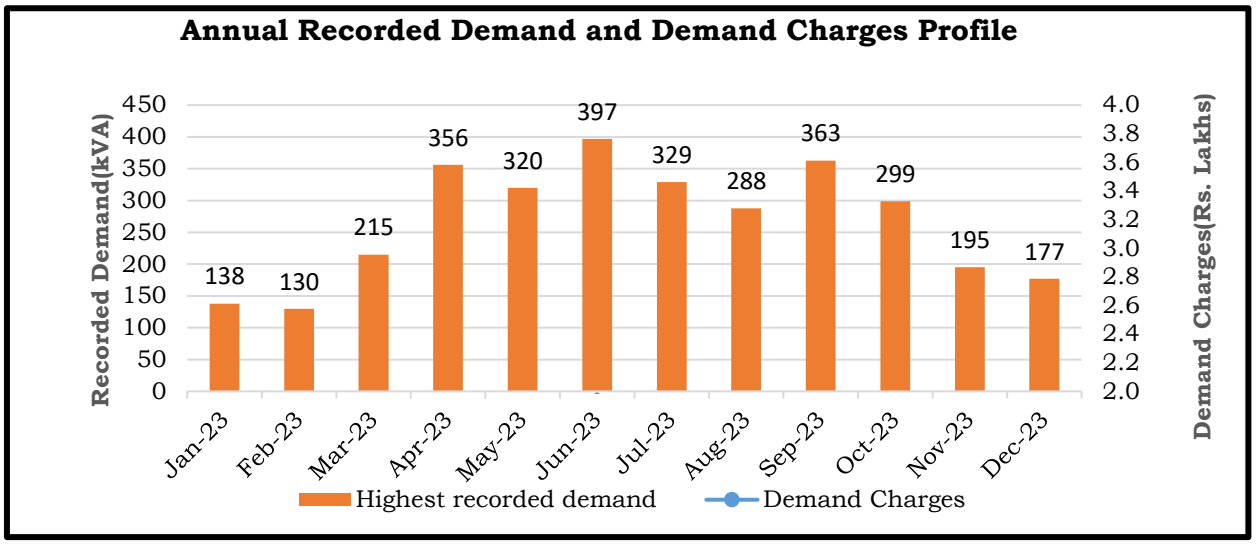
Figure 1. Annual Contract Demand, Recorded Demand and Power Factor profile



Observation on PF:

Power Factor maintained near 0.97 which is highest in year and 0.92 is lower side recorded. Same has scope for improvement to near unity levels by fine tuning the Capacitor Banks

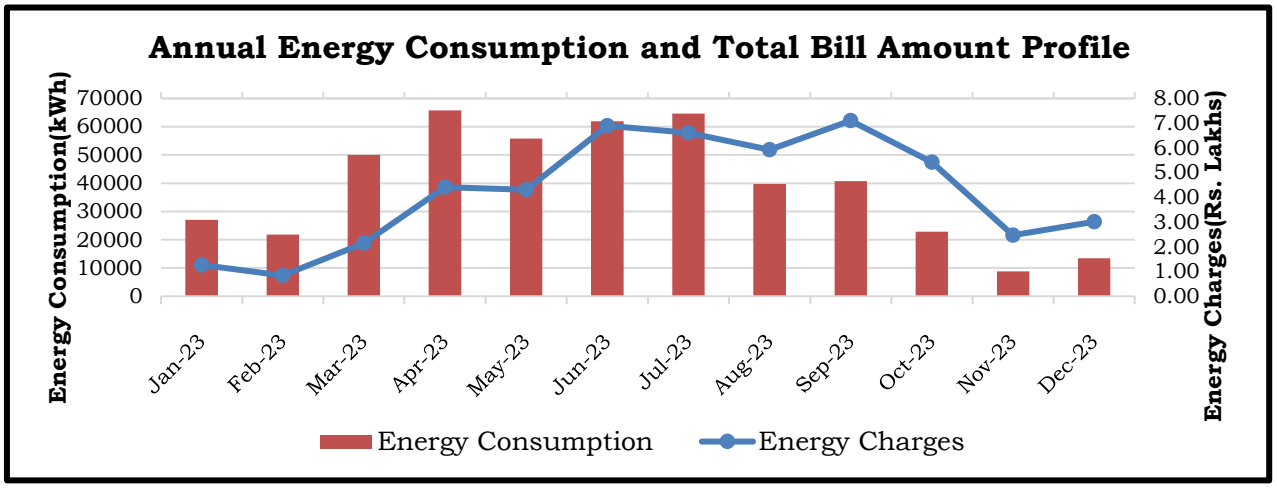
Figure 1 : Annual Recorded Demand and Demand Charges profile



Observation on Recorded Demand & Demand Charges:

Recorded demand is maximum in the month of June 23 which is 397 kVA and minimum in the month of Feb 23 which is 130 kVA. Same can be attributed to Summer and Winter months respectively. Demand has not exceeded the minimum billing demand slab of 80% and is satisfactory.

Figure 2 : Annual Energy Consumption and Energy Charges profile



Observation:

- Total and average energy consumption for the year 2023 is 4.91 lakh kVAh and 0.40 lakh kVAh respectively.

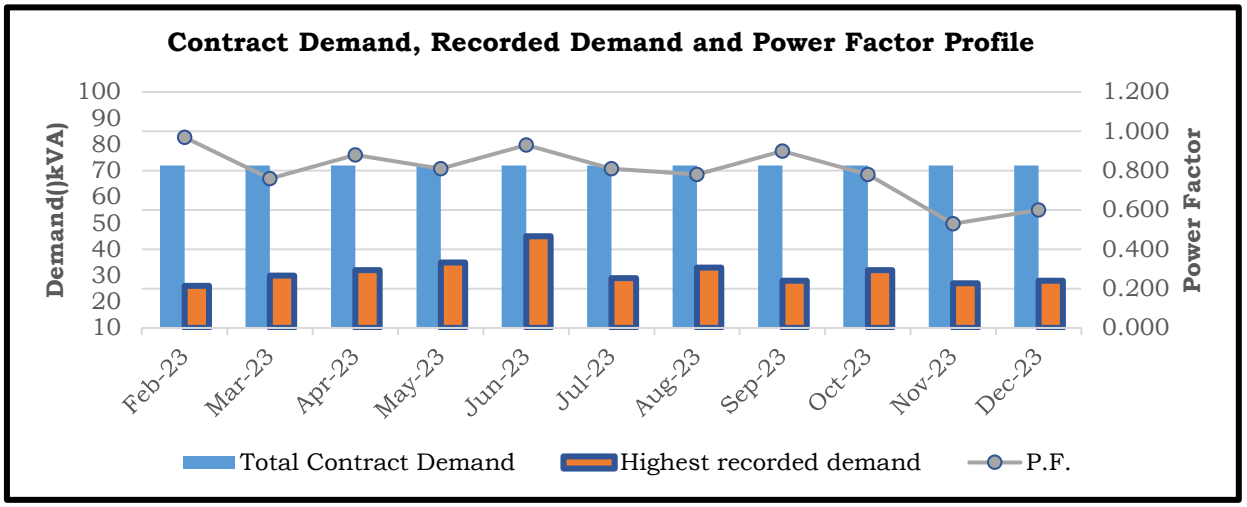
Table 3 : Monthly Electricity Consumption of EB-2 connection

Month	Sanctioned Load	Total Contract Demand	Billing Demand	Highest recorded demand	P.F.	Energy Consumption	Charge/kWh	Demand Charges	Energy Charges	Total Bill Amount
	kVA	kVA	kVA	KVA		kWh	Rs.	Rs. lakhs	Rs. Lakhs	Rs. Lakhs
Dec-23	90.00	72	28.8	28	0.600	6595	9.74	0.12	0.64	1.02
Nov-23	90.00	72	28.8	27	0.530	5309	9.74	0.12	0.51	0.87
Oct-23	90.00	72	28.8	32	0.780	7558	9.74	0.12	0.73	1.03
Sep-23	90.00	72	28.8	28	0.900	1319	9.74	0.12	0.12	0.27
Aug-23	90.00	72	28.8	33	0.780	9164	9.74	0.12	0.89	1.20
Jul-23	90.00	72	28.8	29	0.810	9752	9.74	0.12	0.94	1.25
Jun-23	90.00	72	28.8	45	0.930	12169	9.74	0.12	1.18	1.45
May-23	90.00	72	28.8	35	0.810	8995	9.74	0.12	0.87	1.16
Apr-23	90.00	72	28.8	32	0.880	11169	9.74	0.12	1.08	1.36
Mar-23	90.00	72	28.8	30	0.760	9006	7.49	0.11	0.67	1.12
Feb-23	90.00	72	28.8	26	0.970	6623	7.49	0.11	0.49	0.79
Average			**28.8**	**31.36**	**0.80**	**7969.00**	**9.33**	**0.12**	**0.74**	**1.05**

Observations for EB 2 Connection:

- Contract demand is 72 kVA and minimum billing demand is 40% of contract demand, 28.80kVA or recorded demand whichever is higher. Average unit cost incurred is Rs. 9.74/kVA.
- Power factor is maintained at 0.80 which is lower side and can be further augmented to maintain near unity.
- Average demand recorded for the year 2023 is 31.36 kVA.
- Average monthly energy consumption is 0.079 lakh kWh.

Figure 3 : Annual Contract Demand, Recorded Demand and Power Factor profile



Observation:

- Recorded demand is maximum in the month of Jun 23 which is 48 kVA and minimum in the month of Feb 23 which is 20 kVA.
- Average PF is 0.8.

Figure 5 : Annual Recorded Demand and Demand Charges profile

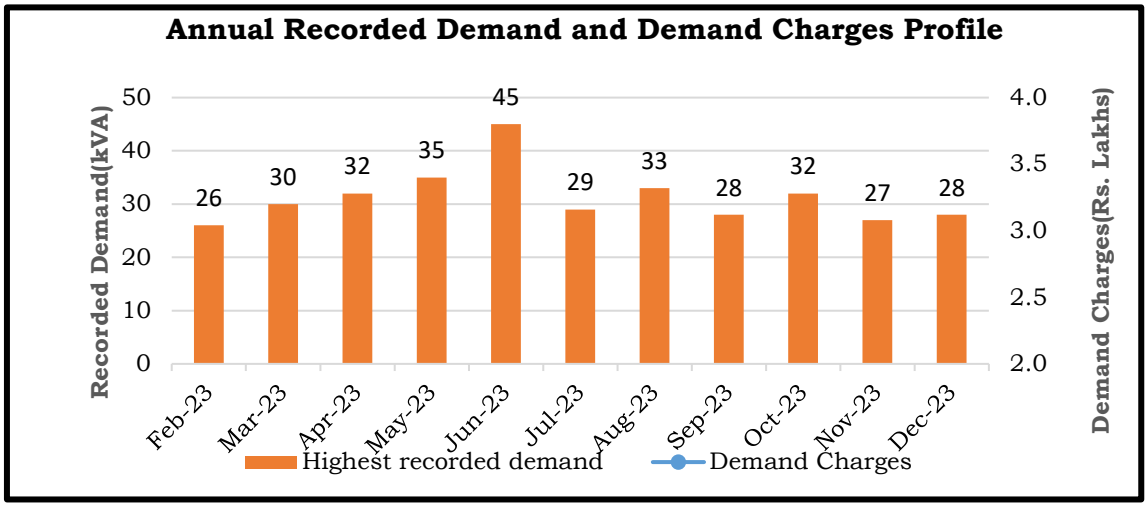


Figure 4:Annual Energy Consumption and Energy Charges profile

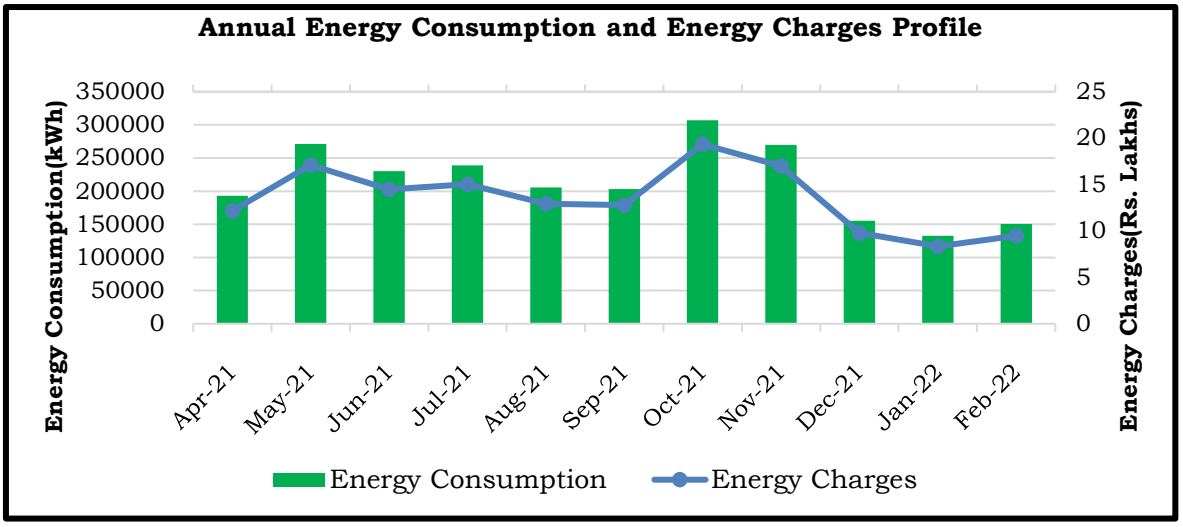
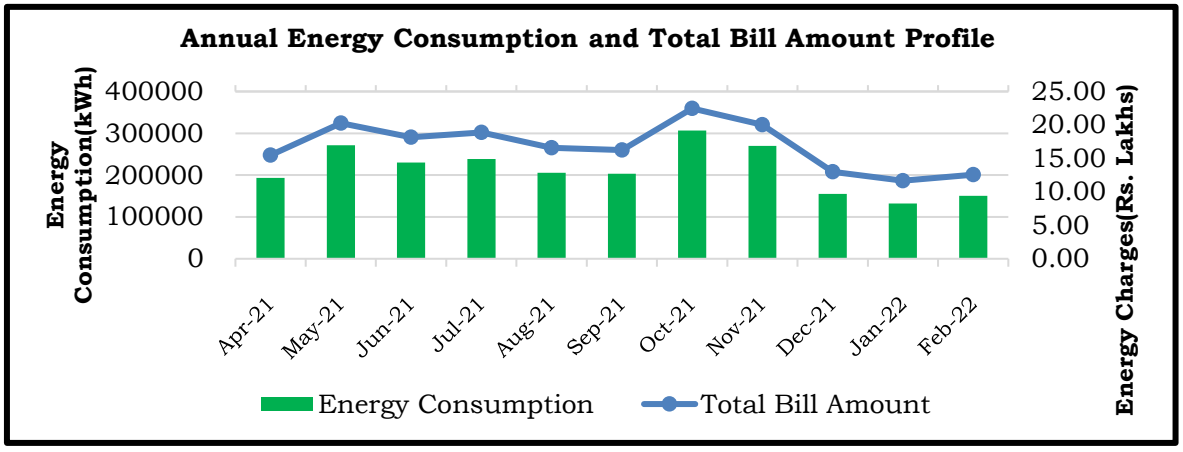


Figure 7 : Annual Energy Consumption and Total Bill Amount



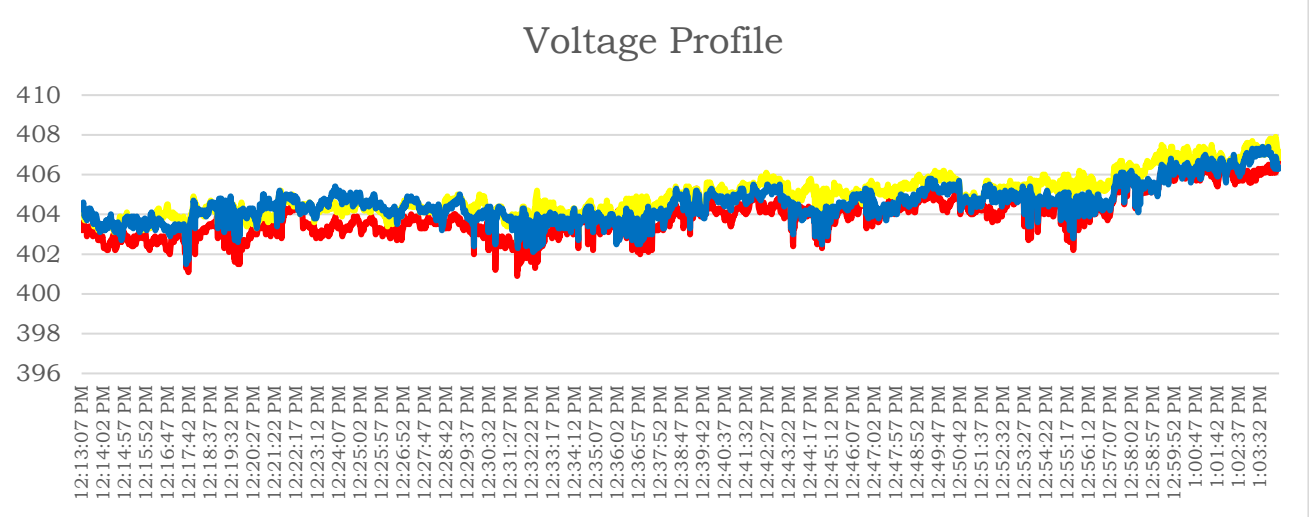
5.2 : Transformer Load Review

- The power factor at each transformer and estimated loss at each transformer is computed based on present loading pattern.
- Performance assessment of transformers is presented in table below.

Table 4: Details for 630 kVA Transformer

630 kVA Transformer details			
Parameters	**Minimum**	**Average**	**Maximum**
Voltage (V)			
U12 rms	400.9	403.9	406.8
U23 rms	402.3	404.9	407.9
U31 rms	401.5	404.5	407.4
Current			
L1 (A)	182.7	216.6	262.4
L2 (A)	185.1	200.3	240.3
L3 (A)	177.5	202.7	247.5
Active Power			
Total (KW)	124.3	141.0	162
Apparent Power			
Total (KVA)	128.5	144.9	168
Power Factor			
Total	0.95	0.97	0.98
Harmonics			
Voltage THD %	2.4	2.6	2.8
Current THD%	10.4	15.9	19.7

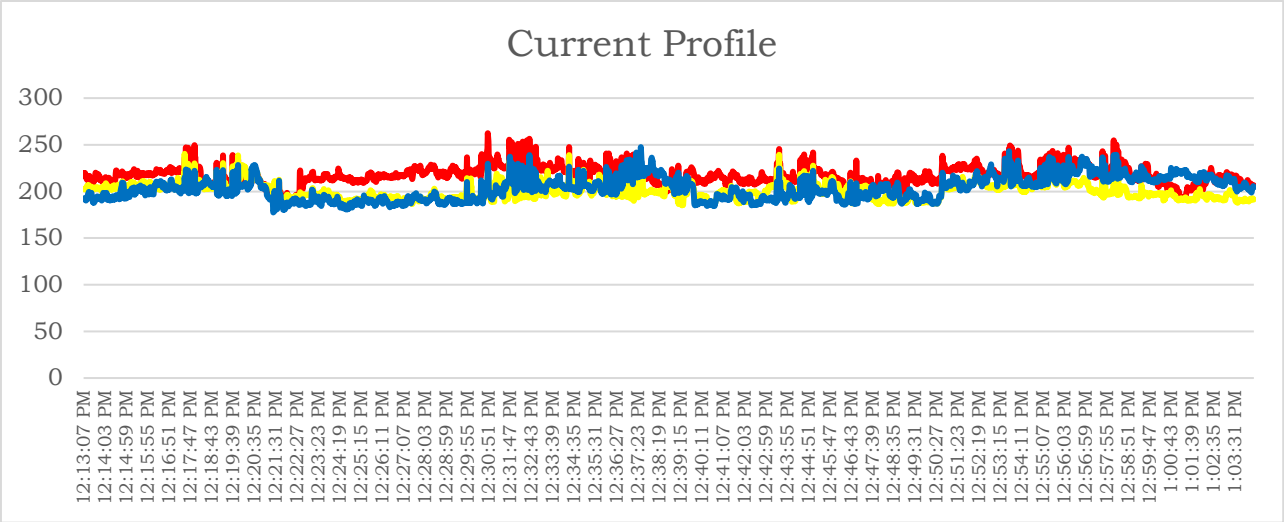
Figure 5 : Voltage Profile of Main Incomer



Observation:

- The average R-Phase voltage recorded is 403 V.
- The average Y-Phase voltage recorded is 404 V.
- The average B-Phase voltage recorded is 404 V.
- There is no such variation in voltage or no any fluctuation recorded during audit

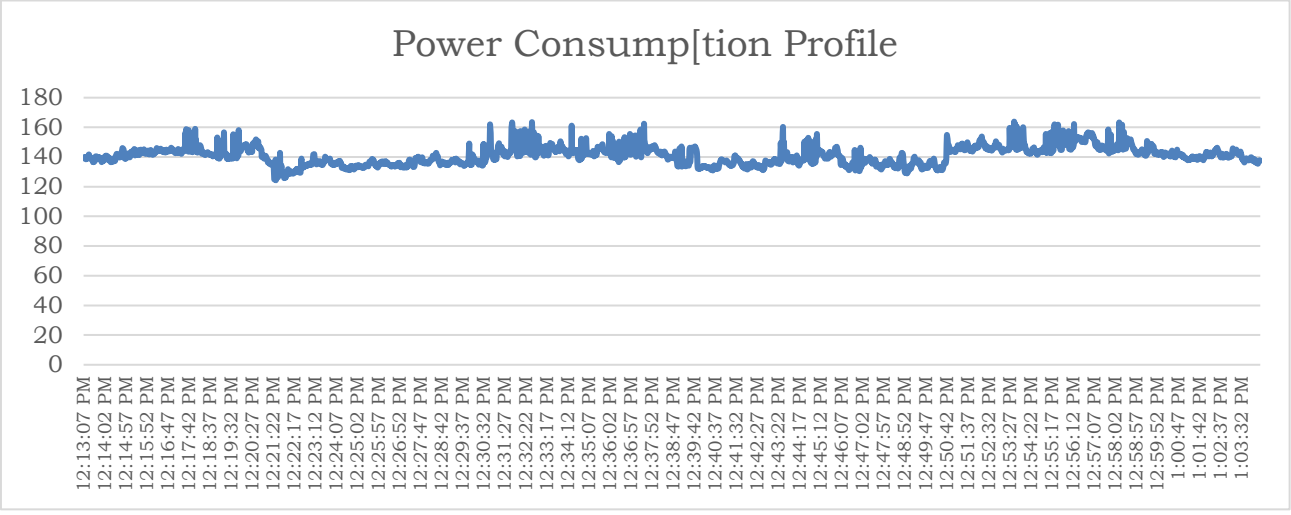
Figure 6 : Current Profile of Main Incomer



Observation:

- The average R-Phase current recorded is 216 A.
- The average Y-Phase voltage recorded is 200 A.
- The average B-Phase voltage recorded is 202 A.
- All three phases are equally distributed hence no such imbalance of load recorded during audit.

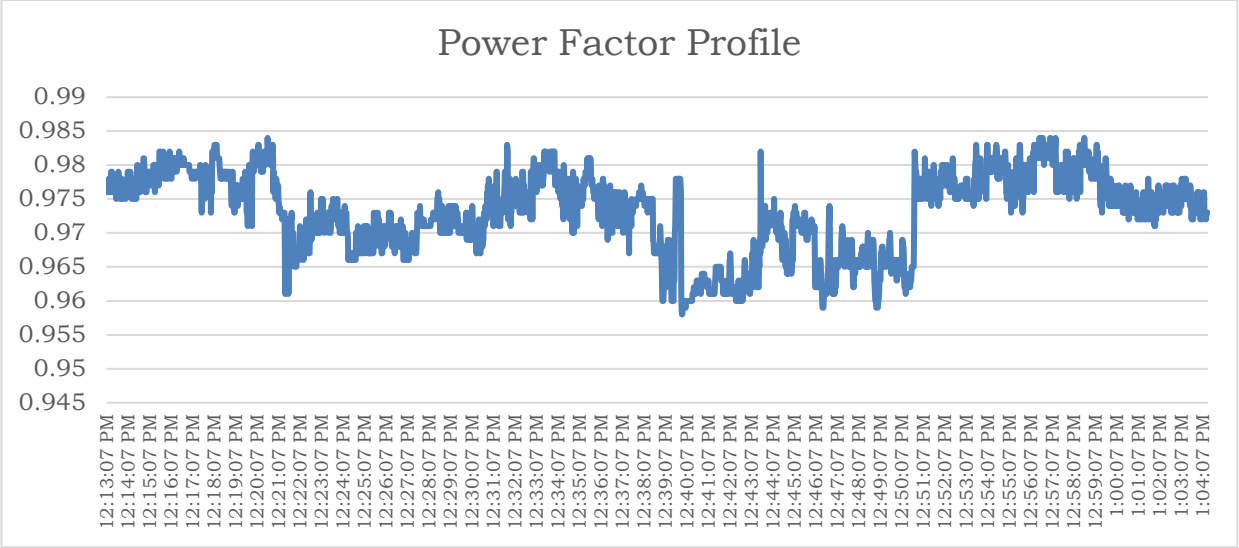
Figure 10 : Power Consumption Profile of Main Incomer



Observation:

- The maximum and minimum power recorded is 160 kW and 124 kW.
- The average power recorded is 141 kW.

Figure 7 : Power Factor Profile of Main Incomer



Observation:

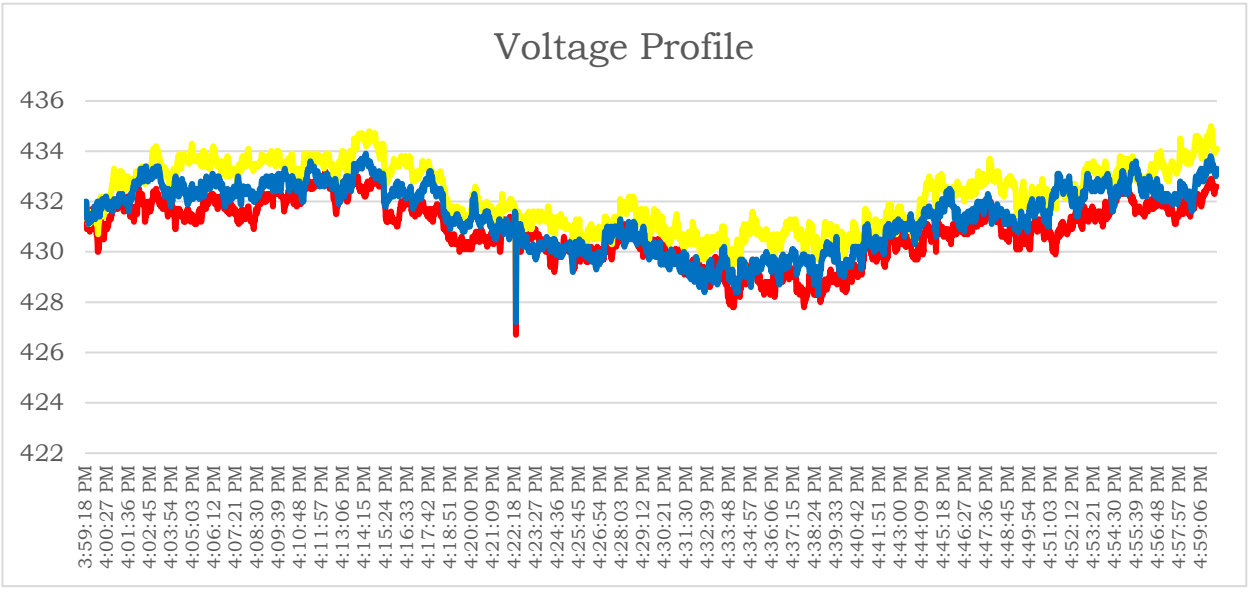
- The maximum and minimum power factor recorded is 0.98 and 0.95.
- The average power factor recorded is 0.97.
- The power factor is on lower side need to install capacitor bank to minimise the reactive power.

200 kVA Transformer

Table 4. Details of 200 kVA transformer

200 kVA Transformer details			
Parameters	**Minimum**	**Average**	**Maximum**
Voltage (V)			
U12 rms	427	431	433
U23 rms	428	432	435
U31 rms	427	431	434
Current			
L1 (A)	26.3	30.3	37.6
L2 (A)	15	16.1	16.9
L3 (A)	17	18.4	22.6
Active Power			
Total (KW)	8.2	11.7	14
Apparent Power			
Total (KVA)	14.8	16.4	18
Power Factor			
Total	0.54	0.70	0.92
Harmonics			
Voltage THD %	2.3	2.5	2.8
Current THD%	7.2	11.9	16.5

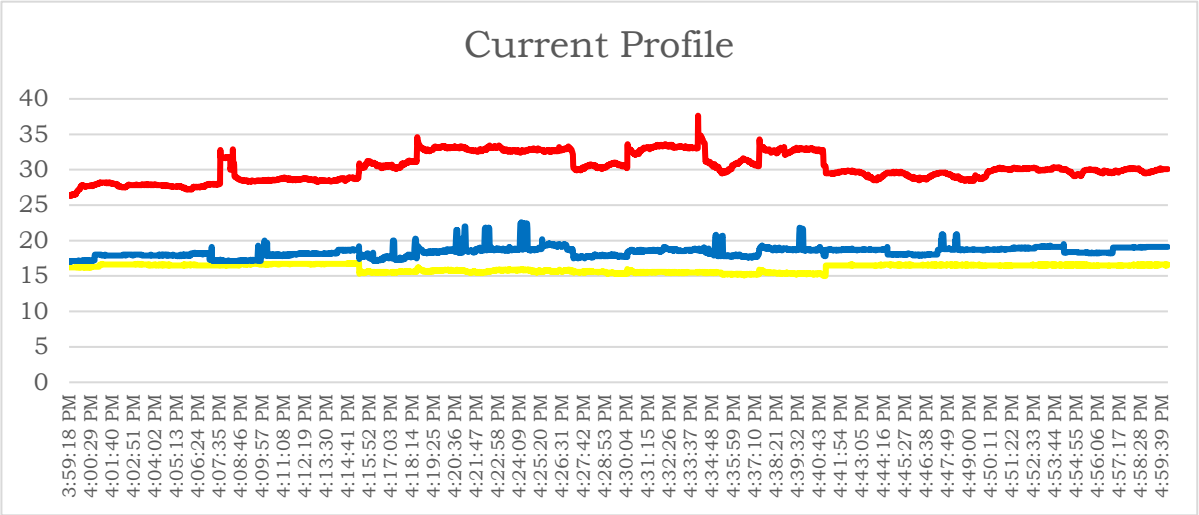
Figure 8 : Voltage Profile of 200 kVA Main Incomer



Observation:

- The average R-Phase voltage recorded is 431 V.
- The average Y-Phase voltage recorded is 432 V.
- The average B-Phase voltage recorded is 431 V.

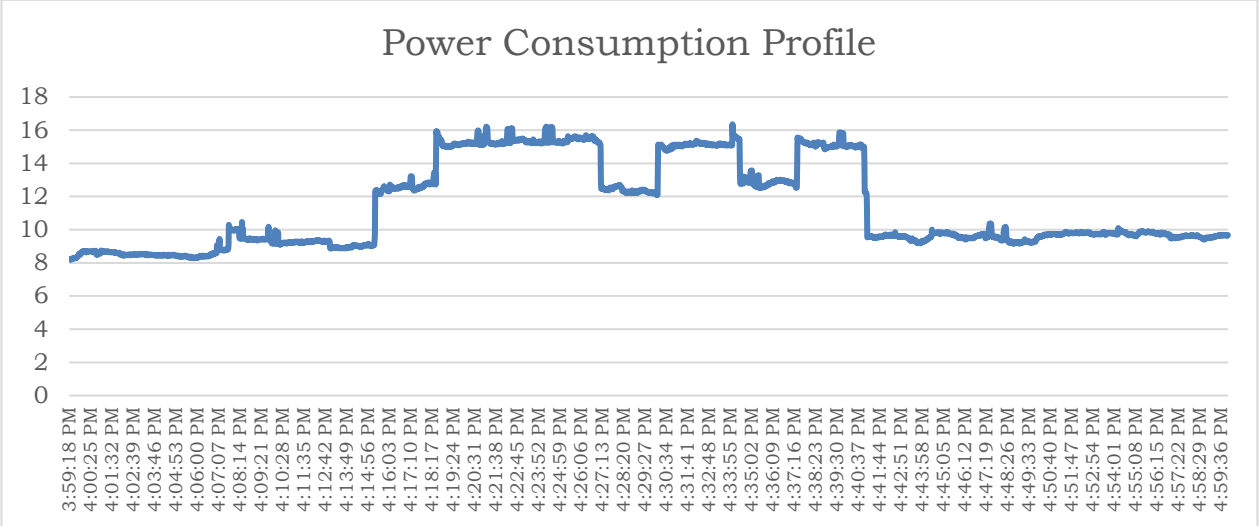
Figure 13 : Current Profile of 200 kVA Main Incomer



Observation:

- The average R-Phase current recorded is 30 A.
- The average Y-Phase voltage recorded is 16 A.
- The average B-Phase voltage recorded is 18 A.
- All three phases are equally distributed hence no such imbalance of load recorded during audit.

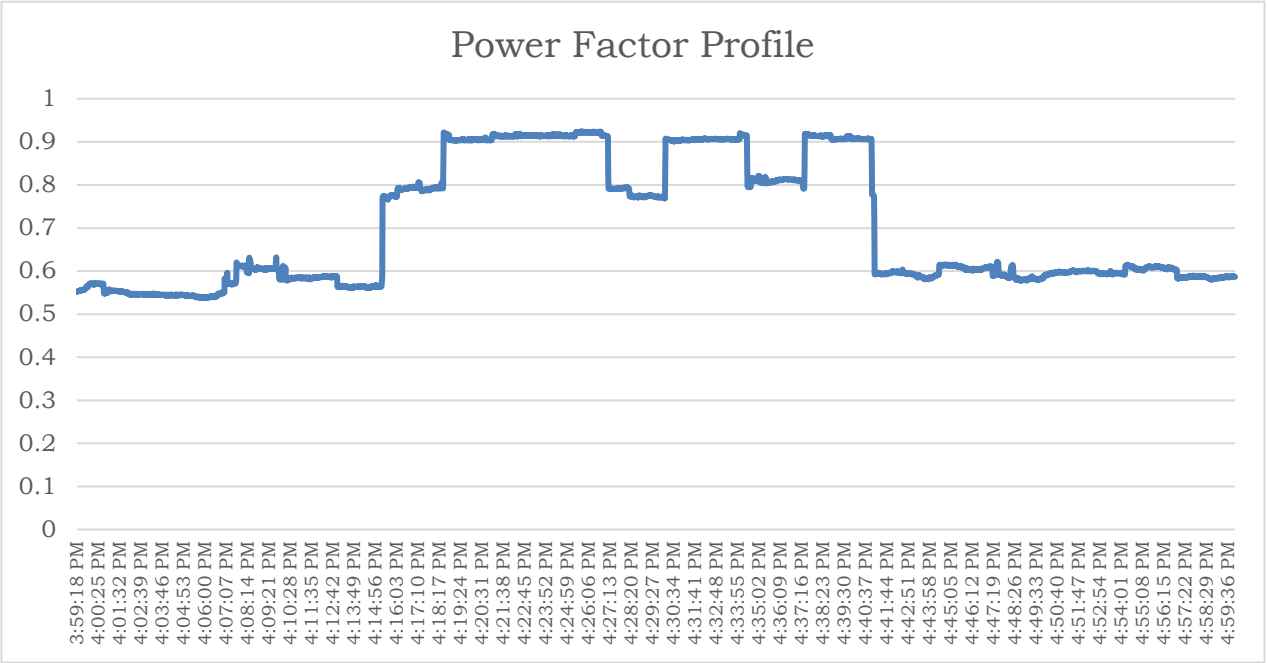
Figure 9 : Power Consumption Profile of Shed 4 Main Incomer



Observation:

- The maximum and minimum power recorded is 14 kW and 8.2 kW.
- The average power recorded is 11.7 kW.

Figure 15 : Power Factor Profile of 200 kVA Main Incomer



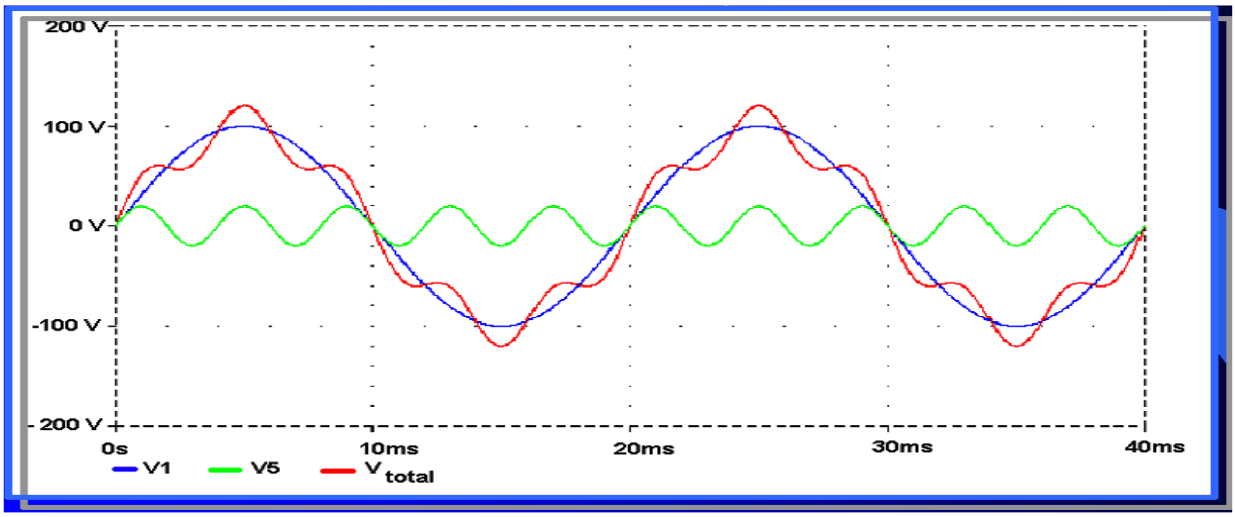
Observation:

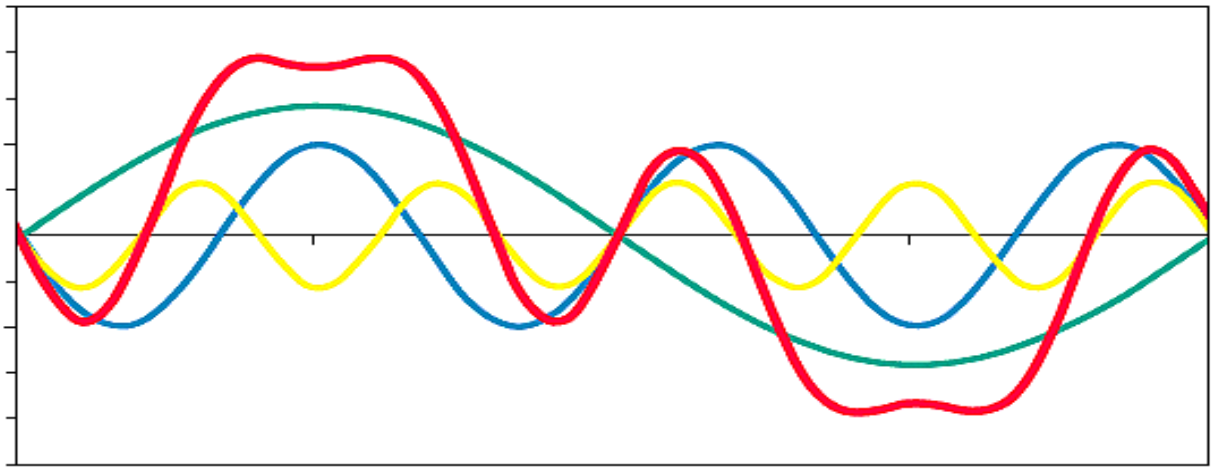
- The maximum and minimum power factor recorded is 0.92 and 0.54.
- The average power factor recorded is 070
    - The drop in power factor will increase the penalty amount indicated in electricity bills.

5.3 : Harmonics study

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

Figure 10 : Harmonics





V_1 –1st Harmonic (Fundamental wave)

V_5 –5th Harmonic

V_3 – 3rd harmonic

V total – Resultant Wave form

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

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

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

Current Harmonics

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

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

Voltage Harmonics

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

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

- The reason for harmonic current is the wave chopping of non-linear loads. As mentioned earlier the reason for harmonic current is the wave chopping phenomena in various non-linear loads. Some of the potential sources for harmonic current distortions are as follows:

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

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

Problems caused by harmonic voltages

- Voltage distortion
- Additional losses in induction motor
- Zero crossing noise

Problems caused by harmonic currents

- Overloading of neutrals
- Overheating of transformers
- Nuisance tripping of circuit breakers
- Overstressing of power factor correction capacitors
- Skin effect

Some of the main effects are briefed below.

Effects on transformers

- Harmonics affect the transformers in mainly two ways- one is eddy current and the other is triple N harmonics. Eddy losses are normally about 10% of the full load losses. It increases with the square of the harmonic number. Triple-N harmonics when reflected to the delta winding of transformers, they are all in phase so that they will circulate in the winding. The triple-n harmonics are effectively absorbed in the winding and do not propagate into the supply, so delta transformers are useful as isolating transformers. But all the other non-triple-n harmonics will pass through.

Nuisance tripping of circuit breakers

- Residual circuit breakers operate by summing the phase currents and neutral currents and if they are not within the rated limit, disconnecting the power from the load. Harmonics are the higher frequency components which may or may not make difficulty to RCCB to properly sum the currents and to trip unnecessarily. In addition to this, equipment which generate harmonics may generate switching noise which has to be filtered at the equipment power connection. The filters normally for this purpose will have a capacitor from line and neutral to ground, so leak a small current to earth. When a series of filters are connected to the circuit, the leakage current is large enough to trip the RCCB. More circuits with smaller loads will avoid this problem. Due to the presence of harmonics, error may calculation of current in the circuit which will lead to the tripping of circuit miniature circuit breakers.

Overstressing of power factor correction capacitors

- Power factor correction capacitors will inject a leading current to minimize the effect of lagging current in the system by presence of inductive loads such as induction motors. Impedance of capacitor is inversely proportional to the frequency and the source impedance which is inductive in nature is proportional to the frequency. When frequency increases, capacitor impedance decreases whereas the source impedance increases which will results in flow of large harmonic currents through the capacitor leads to damage.

- If the capacitor and the stray inductance of the supply can resonate at particular harmonic frequency, a very large voltages and currents can be generated leading to the complete failure of the capacitor system.

Skin effect

- Alternating current tends to flow on the outer surface of a conductor, known as skin effect. Skin effect is more severe at higher frequencies. At supply frequencies, effect of skin effect is nullified. But above 350Hz i.e., at the seventh harmonic and above, the effect will become severe causing additional losses and heating. The skin effect will increase the effective resistance of the conductors and consequently I^2R losses in the conductors will increase manifold. Increase loss generates excess heat in the conductors, terminations, switchgears and may cause nuisance tripping of breakers.

Insulation stress and Thermal stress

- The insulating stress depends primarily on the instantaneous voltage magnitude & rate of change of voltage (or dV / dT). The presence of voltage harmonics can result in an increase of Peak value of the voltage and thus increased insulation stress. In most of the cases, the increase in peak is not of concern for most power system apparatus because they are insulated for much higher voltage levels than those usually encountered from harmonics.

Effect on Capacitors

- The major effect of higher voltage distortion is on the power capacitors power electronics used in the network. The presence of higher voltage distortion will increase the di-electric stress in the capacitors and consequently the life of the capacitor will reduce drastically.

- The capacitive reactance of the capacitor is inversely proportional to the applied frequency. Consequently, the magnitude of the capacitive reactance will reduce with frequency due to which the capacitor will act as a Sink for higher harmonic currents and absorb the harmonic current into it. The flow of higher harmonic current in the capacitor will increase the losses and consequently the di-electric will undergo higher thermal stress along with the voltage stress. As the life of the insulation is inversely proportional to the thermal stress, premature failures of capacitors are common.

Harmonic Loss due to skin effect

- Skin effect is a phenomenon in which, the high frequency AC current will tend to flow in the outer periphery of the conductor due to internal inductance effect, leaving the central portion of the conductor empty. Due to skin effect, the current will tend to flow in the outer periphery of the conductor. The skin effect will increase the effective resistance of the conductors and consequently I2R losses in the conductors will increase manifold. Increase loss generates excess heat in the conductors, terminations, switchgears and may cause nuisance tripping of breakers.

Effect of harmonics on rotating machines (such as Induction motors, Alternators etc.

The Iron loss in any AC rotating machines depends on the applied voltage, frequency of magnetic flux in the core and the Flux density itself. The Iron loss is proportional to the Frequency to the power N (where N is a number), and maximum flux density. The presence of harmonic voltage in the applied voltage will alter the Wave shape of the magnetic field in the rotating machine's magnetic circuit. The magnetic circuit will be subjected to high frequency magnetic fields due to which the Eddy current and the Hysteresis losses will increase. The other loss in the rotating machines is due to skin effect

Effect of harmonic distortion on Sensitive Electronics

- The sensitive automation equipment used in the process industries are designed for a given rate of change of voltage (dV/dT) and are also programmed to work with reference to zero crossover of the voltage waveform. The presence of higher harmonic distortion will create a significant magnitude of dV/dT, which may result in mal-function, and/or failures of sensitive electronics used in the Automation system.
- The presence of higher harmonic distortion may shift the zero crossover of the applied voltage waveform. This may result in mis-firing of thyristors used in DC / AC drives, UPS, Rectifiers etc. due to which the system may mal-function and/or damage permanently.

Outcome of Harmonics

- Blinking of Incandescent Lights - Transformer Saturation
- Capacitor Failure - Harmonic Resonance
- Circuit Breakers Tripping - Inductive Heating and Overload
- Computer Malfunction or Lockup - Voltage Distortion
- Conductor Failure - Inductive Heating
- Electronic Equipment Shutting down - Voltage Distortion
- Flickering of Fluorescent Lights - Transformer Saturation
- Fuses Blowing for No Apparent Reason - Inductive Heating and Overload
- Neutral Conductor and Terminal Failures - Additive Triplen Currents
- Overheating of Metal Enclosures - Inductive Heating

Amplification of Harmonics

- Power factor capacitors are sensitive to harmonic and shunt connected capacitors to forms a parallel resonance circuit with the load & series resonance circuit with power transformers. Shunt connected power factor correction capacitor amplifies the harmonics to a higher level, due to the combination of series and parallel resonance. This amplification of harmonics leads to damaging effects on the total distribution system. In this type of harmonics loads, the effectiveness of power factor correction by the power capacitors is not possible and the distribution deterioration including capacitors will be faster.

Harmonic Mitigation Measures

Need of harmonic mitigation

- To meet local harmonic emission levels
- To reduce overloading of cables, transformers etc.
- To improve resilience of equipment by reducing voltage wave form distortion

Methods of harmonic mitigation

- Passive filters
  - Passive shunt filters
  - Passive series filters
- Isolation and harmonic reduction transformers
- Active harmonic filters

Limits for harmonics

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

Table 5 : Harmonics Distortion Limits: – IEEE – 519C:2014

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

Table 6 : Current distortion limits for systems rated 120 V to 69 kV – User's responsibility

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)						
I_{sc}/I_L	3≤h<11	11≤h<17	17≤h<23	23≤h<35	35≤h<50	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12
100<1000	12.0	5.5	5.0	2.0	1.0	15
>1000	15.0	7.0	6.0	2.5	1.4	20

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

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

Table 7 : Current distortion limits for systems rated 69kV to 161 kV – User's responsibility

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)						
I_{sc}/I_L	3≤h<11	11≤h<17	17≤h<23	23≤h<35	35≤h<50	TDD
<20*	2.0	1.0	0.75	0.3	0.15	2.5
20<50	3.5	1.75	1.25	050	0.25	4.0
50<100	5.0	2.25	2.0	0.75	0.35	6.0
100<1000	6.0	2.75	2.5	1.0	0.5	7.5
>1000	7.5	3.5	3.0	1.25	0.7	10.0

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

- Odd harmonics are represented as % of fundamental at PCC

- Even harmonics are limited to 25% of odd harmonic's limits.

Table 8 : Current distortion limits for systems rated above 161 kV – User's responsibility

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)						
I_{sc}/I_L	3≤h<11	11≤h<17	17≤h<23	23≤h<35	35≤h<50	TDD
<25*	1.0	0.5	0.38	0.15	0.1	1.5
25<50	2.0	1.0	0.75	0.3	0.15	2.5
≥50	3.0	1.5	1.15	0.45	0.22	3.75

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

- Odd harmonics that result in a DC offset, e.g., half-wave converters, are not allowed.

- Even harmonics are limited to 25% of odd harmonic's limits at the PCC under normal load operating conditions

Table 10 : Voltage distortion Limit –Utility's Responsibility

Bus voltage at PCC	Individual harmonics (%)	Total Harmonics Distortion THD (%)	Remarks
V≤1.0 kV	5.0	8.0	
1 kV< V ≤ 69 kV	3.0	5.0	HV System may have up to 2% THD as in HVDC terminal that attenuates while tapped for a user
69 kV<V ≤ 161 kV	1.5	2.5	
161 KV<V	1.0	1.5*	

Harmonics Analysis

- During Audit harmonics analysis is carried out at each transformer side and the details of harmonics level at each transformer is given in below

Figure 11 : Current Harmonics profile at 630 kVA Main Incomer

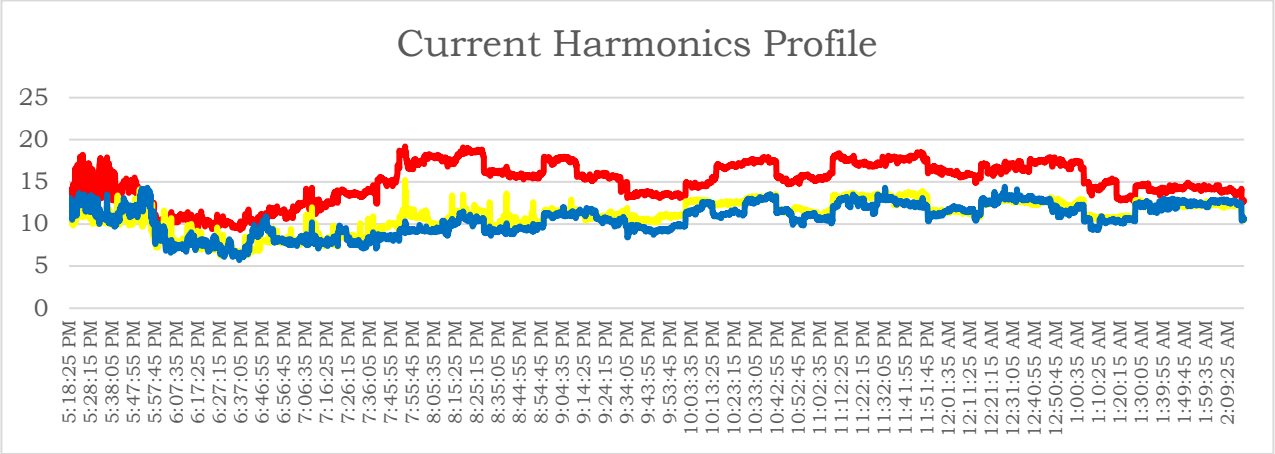
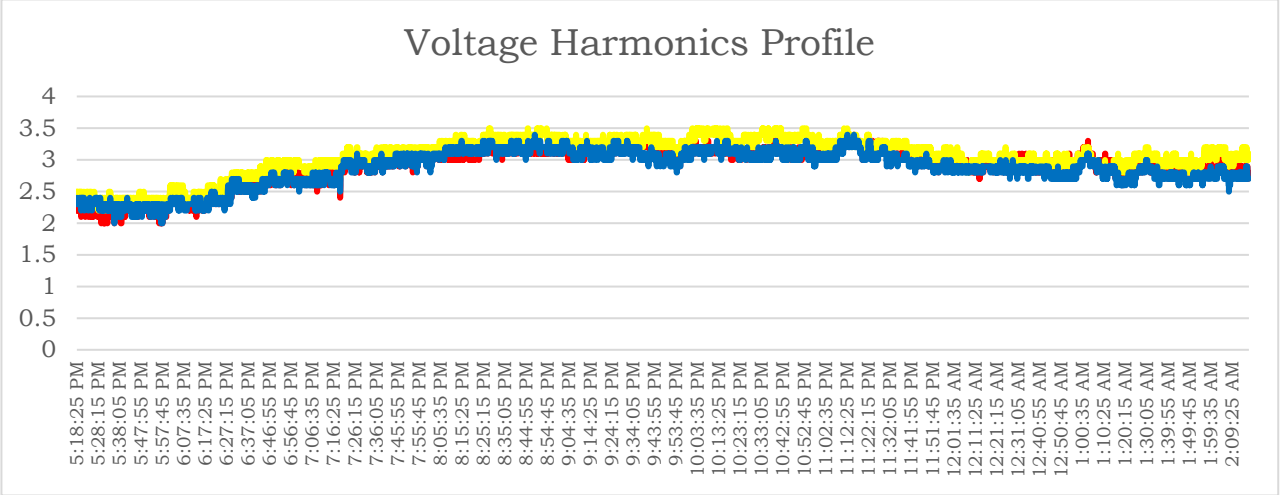


Figure 12 : Voltage Harmonics Profile of 630 kVA Main Incomer



Observation:

- Harmonic audit is carried out at main incomer side.
- During the operations, voltage harmonics (V_{THD} %) are noted to be within limit as per IEEE 519:2014 standard of 8%.
- Current harmonics (I_{THD} %) are noted to be slightly on higher side as per IEEE 519:2014 standard of 5%.

Harmonics Analysis of Shed 4 Main Incomer

Figure 13 ; Current Harmonics Profile of 200 kVA Main Incomer

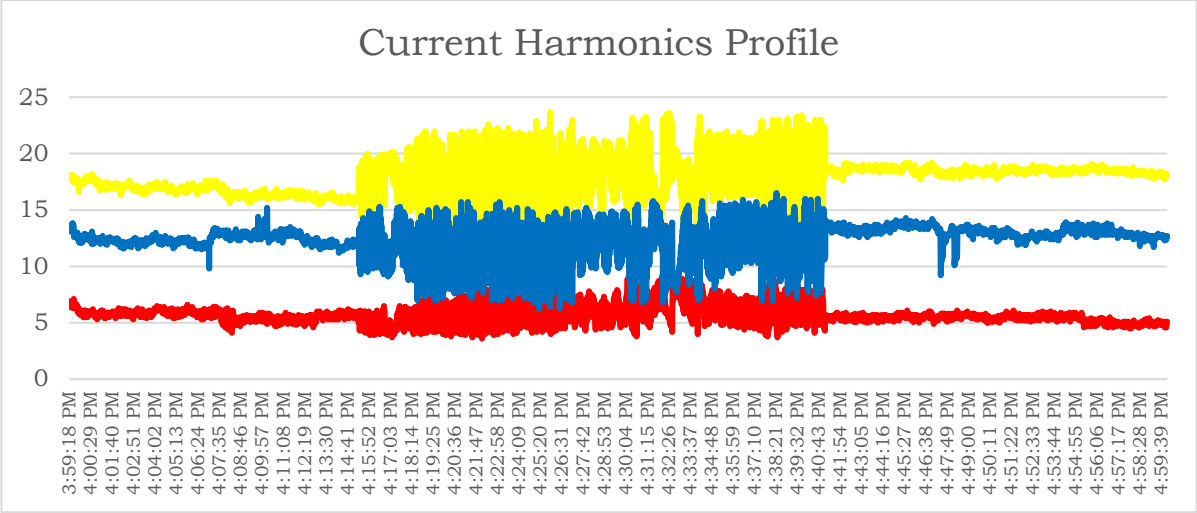
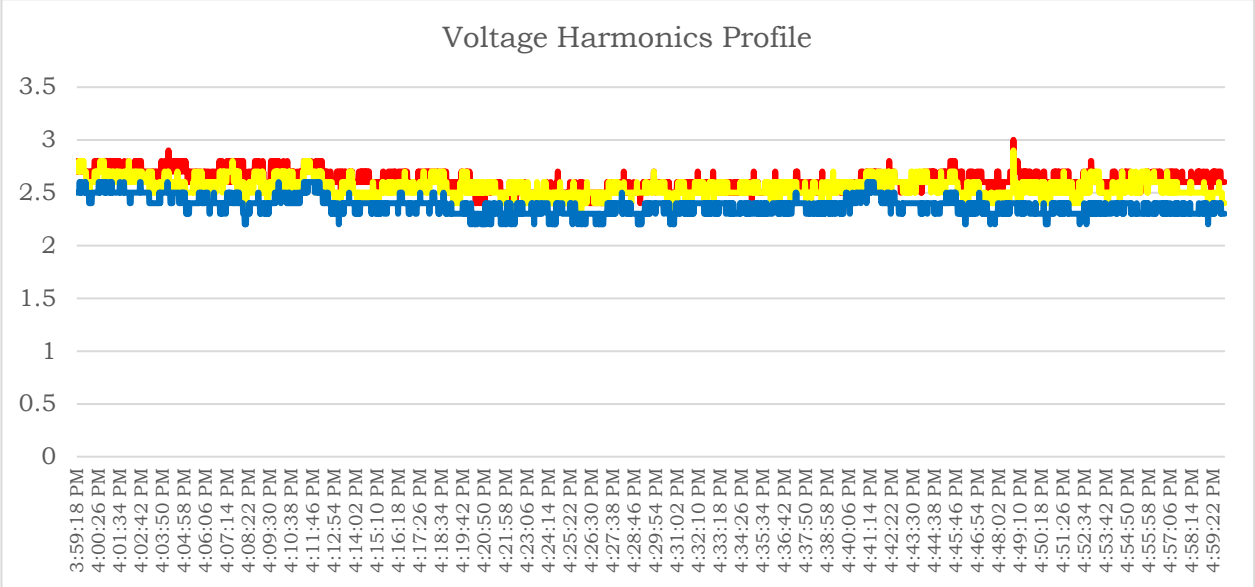


Figure 14 : Voltage Harmonics Profile of 200 kVA Main Incomer



Observation:

- Harmonic audit is carried out at main incomer side.
- During the operations, voltage harmonics (V_{THD} %) are noted to be within limit as per IEEE 519:2014 standard of 8%.
- Current harmonics (I_{THD} %) are noted to be within limit as per IEEE 519:2014 standard of 5%.

5.4 : Energy Conservation Opportunities

5.4.1 Improve power Factor for both Transformers

Two transformers are installed in college premises to cater the need of electricity. Transformer with capacity of 630 kVA is having average power factor of 0.95 and for 200 kVA transformer average power factor is 0.8.

No capacitor banks are installed in panel room area to compensate the reactive power. It is suggested to installed power factor for both transformer side to avoid penalty.

The cost saving benefit is presented in below table

Table 9. Cost saving benefit by installation of APFC for 630 kVA transformer

Month	Billing Demand	Highest recorded demand	P.F.	Energy Consumption		Difference	Charge/kWh	Cost Saving
	kVA	KVA		kWh	kVAh		Rs.	Rs. Lakhs
Dec-23	332.5	177	0.932	27041	29014	1973	10.40	0.21
Nov-23	332.5	195	0.916	21803	23802	1999	10.40	0.21
Oct-23	332.5	299	0.959	50006	52144	2138	10.40	0.22
Sep-23	332.5	363	0.962	65722	68318	2596	10.40	0.27
Aug-23	332.5	288	0.978	55767	57021	1254	10.40	0.13
Jul-23	238	329	0.973	61870	63587	1717	10.40	0.18
Jun-23	238	397	0.975	64607	66264	1657	10.40	0.17
May-23	238	320	0.958	39768	41511	1743	10.40	0.18
Apr-23	238	356	0.961	40760	42414	1654	10.40	0.17
Mar-23	221	215	0.952	22843	23995	1152	8.96	0.10
Feb-23	221	130	0.938	8797	9378	581	8.96	0.05
Jan-23	221	138	0.945	13462	14246	784	8.96	0.07
Total								**1.97**

Table 10. Cost saving benefit by installation of APFC for 200 kVA transformer

Month	Billing Demand	Highest recorded demand	P.F.	P.F. Penalty
		KVA		Rs. Lakhs
Dec-23	28.8	28	0.600	0.14
Nov-23	28.8	27	0.530	0.14
Oct-23	28.8	32	0.780	0.0622
Sep-23	28.8	28	0.900	0.00
Aug-23	28.8	33	0.780	0.07
Jul-23	28.8	29	0.810	0.06
Jun-23	28.8	45	0.930	0.00
May-23	28.8	35	0.810	0.05
Apr-23	28.8	32	0.880	0.02
Mar-23	28.8	30	0.760	0.08
Feb-23	28.8	26	0.970	-0.01
Average	**28.8**	**31.36**	**0.80**	
Total				**0.61**

5.4.2 Reduce the harmonics level at main incomer

Presently the harmonics level at main incomer observed is 20%. Current harmonics (I_{THD} %) are noted to be slightly on higher side as per IEEE 519:2014 standard of 8%.
The cost saving benefit by maintaining harmonics level is presented in below table.

Table 11. Cost saving benefit by reducing harmonics level

Description	Unit	TR1
Transformer rating	kVA	630
% loading	%	25%
Average current on transformer	A	200
Average power consumption	kW	141
Fundamental Current	A	194.38
Actual current loss	A	5.62
Actual power loss	kWh	3.85
Total running hours per day	Hrs	24
Operating days	Days	360
Annual power loss	kWh/annum	33223
Unit rate	Rs./kWh	10.4
Annual Cost Saving	Rs. Lakhs	3.46
Investment	Rs. Lakhs	5
Simple payback period	Months	17.37

5.4.3 : Replace the geyser installed in hostel area with solar water heaters

Two hostels buildings are available in building premises. Both hostels are having electric geyser installed for hot water requirement. Each room is having geyser installed.

It is recommended that to install solar water heater in place of geysers. The cost saving benefit after geyser replacement is presented in below table.

Table 12. Cost saving benefit by solar water heater installation.

Description	Unit	Geysers
Total Number of geysers installed	No	20
Rated Power of each geyser	kW	2
Total power consumption of geyser	kW	40
Expected power consumption after solar water heater with heaters	kW	10
Actual savings in power consumption	kW	30
Annual operating days	Days	200
Total running hours per day	Hrs	10
Annual power savings	kWh/annum	60000
Unit rate	Rs./kWh	10.4
Annual Cost Saving	Rs. Lakhs	6.24
Investment	Rs. Lakhs	2
Simple payback period	Months	3.8

5.4.4 : Solar rooftop system

University premises is having numbers of buildings with solar PV installed in 6 numbers of buildings. This solar system is installed in 3 stages mentioned below.

Stage 1 – 90 kW – Admin Building

Stage 2 – 250 kW – ME+IT+FY building

Stage 3 – 120 kW – EN+MCA Building.

Stage 1 and stage 2 is having net-meter connection so excess energy generated by solar system can directly sell to MSEDCL. But stage 3 solar system is not having net-meter connection so whatever energy is generated that is directly wasted.

The Stage 1 solar system, almost 60-65 numbers of solar panels are damaged and those panels are not replaced solar the energy generation by these panels are lesser than the installed solar plant.

Stage 2 solar system, the panel is having automated cleaning system by water spray installed. But due to improper cleaning of panel the power generation by these system is less than the installed one.

It is recommended that clean the solar panels in periodically manner and replace the damaged solar panels with new panel.

The cost saving benefit is presented in below table:

Table 13. Cost saving benefit by solar system improvement

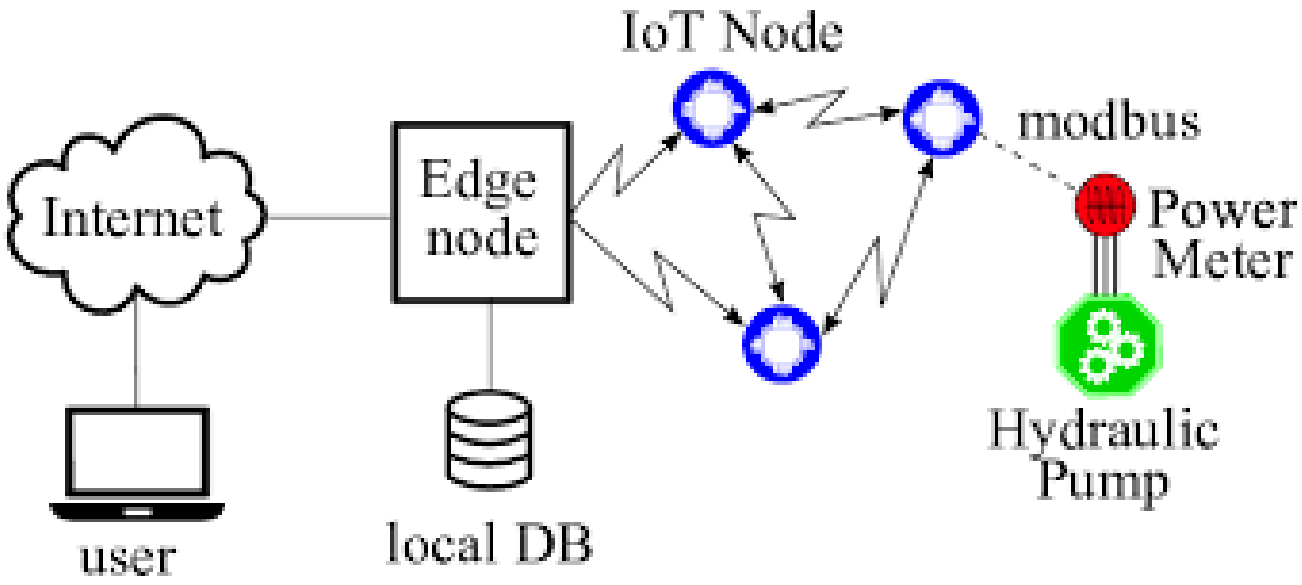
Description	Unit	Stage 2	Stage 1	Stage 3
Total Capacity of solar plant	kW	250	90	120
Total Power generation of plant	kW	140	26	0
Total operating hours	Hrs	8	8	8
Expected power generation from solar plant	kW	230	80	110
Actual Generation gap	kW	90	54	110
Annual operating days	Days	250	250	250
Annual energy savings	kWh/annum	180000	108000	220000
Unit rate	Rs./kWh	4.51	4.51	4.51
Annual Cost Saving	Rs. Lakhs	8.118	4.8708	9.922
Investment	Rs. Lakhs	-	-	-
Simple payback period	Months	-	-	-

5.5 : Energy Monitoring System

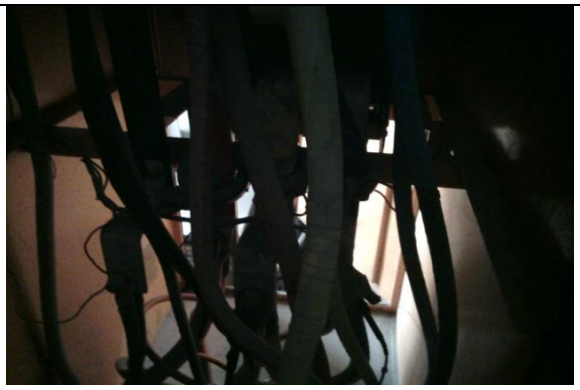
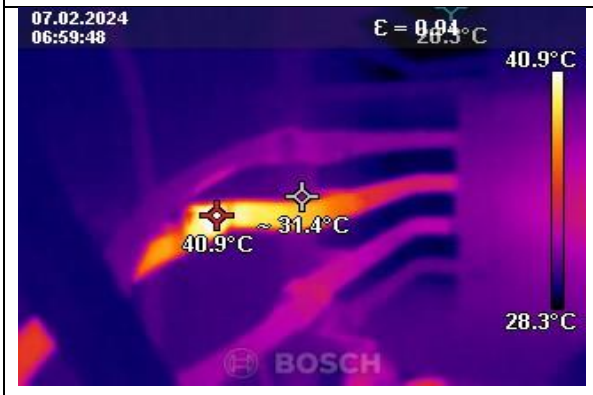
- Plant has installed energy meter to each feeder of SHED. Each SHED has own energy meter and there is not segregation of connected load.

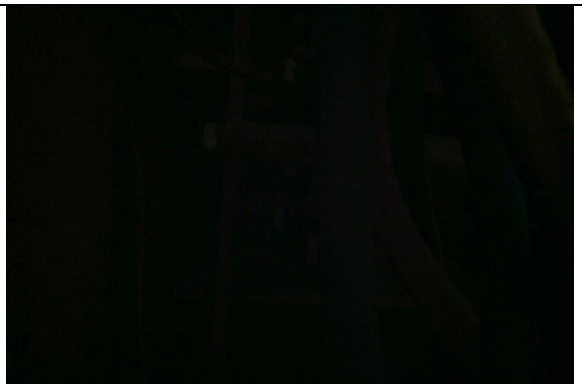
- For better understanding and detailed consumption of process it is recommended that to install Schneider or Honeywell meter with RS 485 with 0.2 class connectivity for data storage and analysis. Each compressor feeder, AHU Feeder with ODU required energy meters for understanding of load pattern. The Details of EMS is given in below.

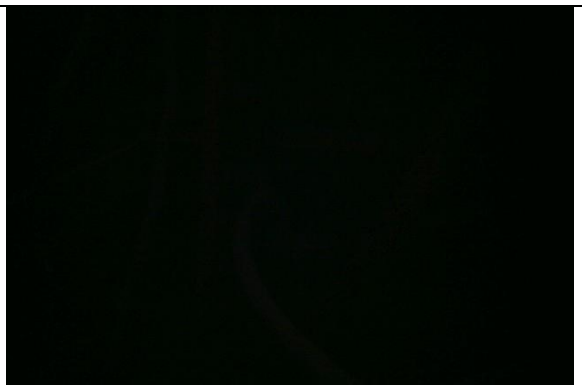
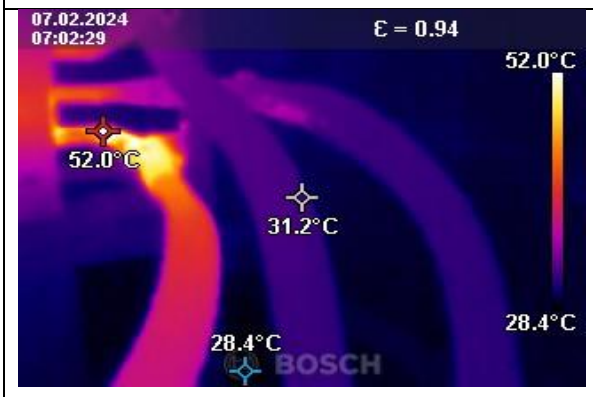
- EMS can also refer to a system designed to achieve energy efficiency through process optimization by reporting on granular energy use by individual pieces of equipment. Newer, cloud-based energy management systems provide the ability to remotely control HVAC and other energy-consuming equipment; gather detailed, real-time data for each piece of equipment; and generate intelligent, specific, real-time guidance on finding and capturing the most compelling savings opportunities.



5.6 Thermography Survey

Main Incomer	
Thermal Images	**Real Images**
	
No issues all connection is okay	
Admin Block	
Thermal Images	**Real Images**
	
Y phase required tightening.	
C1 IT AC	
Thermal Images	**Real Images**

	
All connections are okay	
Boys Hostel Feeder	
Thermal Images	**Real Images**
	
All Okay	
G block/EC/EN/EDT/MBA Dept.	
Thermal Images	**Real Images**
	
R Phase required Tightening	
CS/IT	
Thermal Images	**Real Images**

	
B phase temp is 50 Degree required tightening	
Work Shop	
Thermal Images	**Real Images**
	
All Okay	
Admin Block Main	
Thermal Images	**Real Images**
	
B phase Heated required tightening	

6 Environment Management Assessment

6.1 : WATER MANAGEMENT

Details of borewells

Sr. No.	Location of borewell	Water level/depth of well
1	Near Practice Cricket Pitch	150 ft
2	Near Gym	150 ft.
3	Near Girls Hostel	250 ft.

Details of Open wells

Sr. No.	Location of Natural/Open Well	Water level/depth of well
1	Near Boys Hostel	45 ft

Details of Taps:

Data of No. of Taps with locations is Not available with the Institute currently.

Maintenance is prompt.

No leaked taps found in the institute.

Water storage facilities

Over Head Tank Details

Sr. No.	Tank No.	Location of Tank	Tank Capacity (m^3)
1	RKNEC/Temple/1	Ramdeobaba Temple	27.5
2	RKNEC/B Hostel/2	Boys Hostel B	12.5
3	RKNEC/B Hostel/2	Boys Hostel B	12.5
4	RKNEC/B Hostel/2	Boys Hostel B	12.5
5	RKNEC/B Hostel/2	Boys Hostel B	12.5
6	RKNEC/A Hostel/3	Boys Hostel A	12.5
7	RKNEC/A Hostel/3	Boys Hostel A	12.5
8	RKNEC/A Hostel/3	Boys Hostel A	12.5
9	RKNEC/A Hostel/3	Boys Hostel A	12.5
10	RKNEC/Mess/4	Boys Mess	5
11	RKNEC/Mess/4	Boys Mess	3
12	RKNEC/ADM/5	ADM Building	2
13	RKNEC/ADM/5	ADM Building	2
14	RKNEC/ADM/5	ADM Building	5
15	RKNEC/ADM (Fire)/5	ADM Building	30
16	RKNEC/ADM (Fire)/5	ADM Building	30
17	RKNEC/CS/IT/6	CS/IT Building	5
18	RKNEC/CS/IT/6	CS/IT Building	5
19	RKNEC/CS/IT/6 (Fire)	CS/IT Building	25
20	RKNEC/MCA/7	MCA Building	5
21	RKNEC/MBA/8	MBA Building	22
22	RKNEC/MBA/8	MBA Building	32.5
23	RKNEC/Elec./9	Electrical Building	5
24	RKNEC/Elec./9	Electrical Building	5
25	RKNEC/Elec./9	Electrical Building	5
26	RKNEC/GS G- block/10	G-Block	5
27	RKNEC/GS G- block/10(Fire)	G-Block	25
28	RKNEC/B- block/11	Electronic Building	5
29	RKNEC/B- block/11	Electronic Building	5
30	RKNEC/WS./12	Work Shop	3
31	RKNEC/Hostel./13	Girls Hostel	5
32	RKNEC/Hostel./13	Girls Hostel	5
33	RKNEC/Hostel./13	Girls Hostel	5
34	RKNEC/Hostel./13	Girls Hostel	2
35	RKNEC/Overhead/17 RCC	Main Water Tank	100
		TOTAL	**474**

Underground Tank

Sr. No.	Tank No.	Location of Tank	Tank Capacity (m3)
1	RKNEC/ADM (sump)/5	ADM Building	5
2	RKNEC/CS/IT (Sump)/6	CS/IT Building	36.5
3	RKNEC/MBA(sump)/8	MBA Building	45
4	RKNEC/Hostel.(sump)/13	Girls Hostel	16.5
5	RKNEC/Sump./16	Main Water Tank	150
6	RKNEC/Sump./15	Main Water Tank	200
7	RKNEC/A Hostel/3	Boys Hostel A	12.5
		TOTAL	**453**

Water Consumption

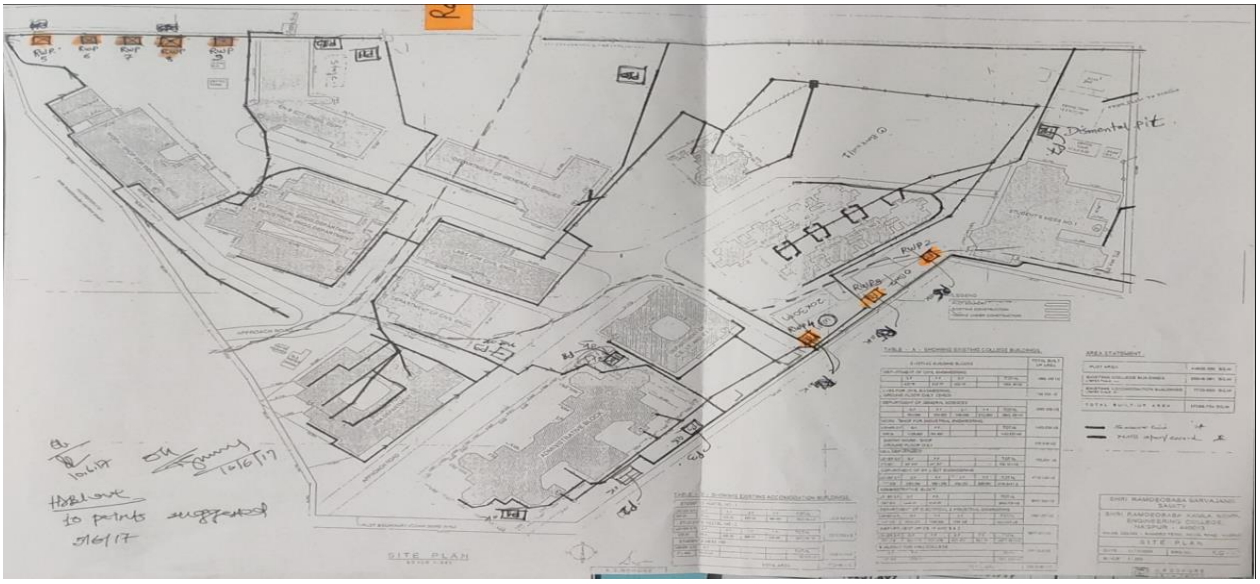
BOREWELL WATER LINE & UG WATER TANK

Building Name/Activity	Consumption of water during Year 2022 in Klit	Consumption of water during Year 2023 in Klit
Total	99573	135323

Rain Water Harvesting

Eight groundwater recharge points are created across the campus. In this, the surface runoff water during monsoon is directed to a designated area which then percolates in the ground resulting in groundwater recharge. Ultimately rise in borewell and open well water observed. Many such recharge points are being planned across the campus in the coming years.

Location of Rainwater Harvesting Pits



Rain Water Collection Pits:

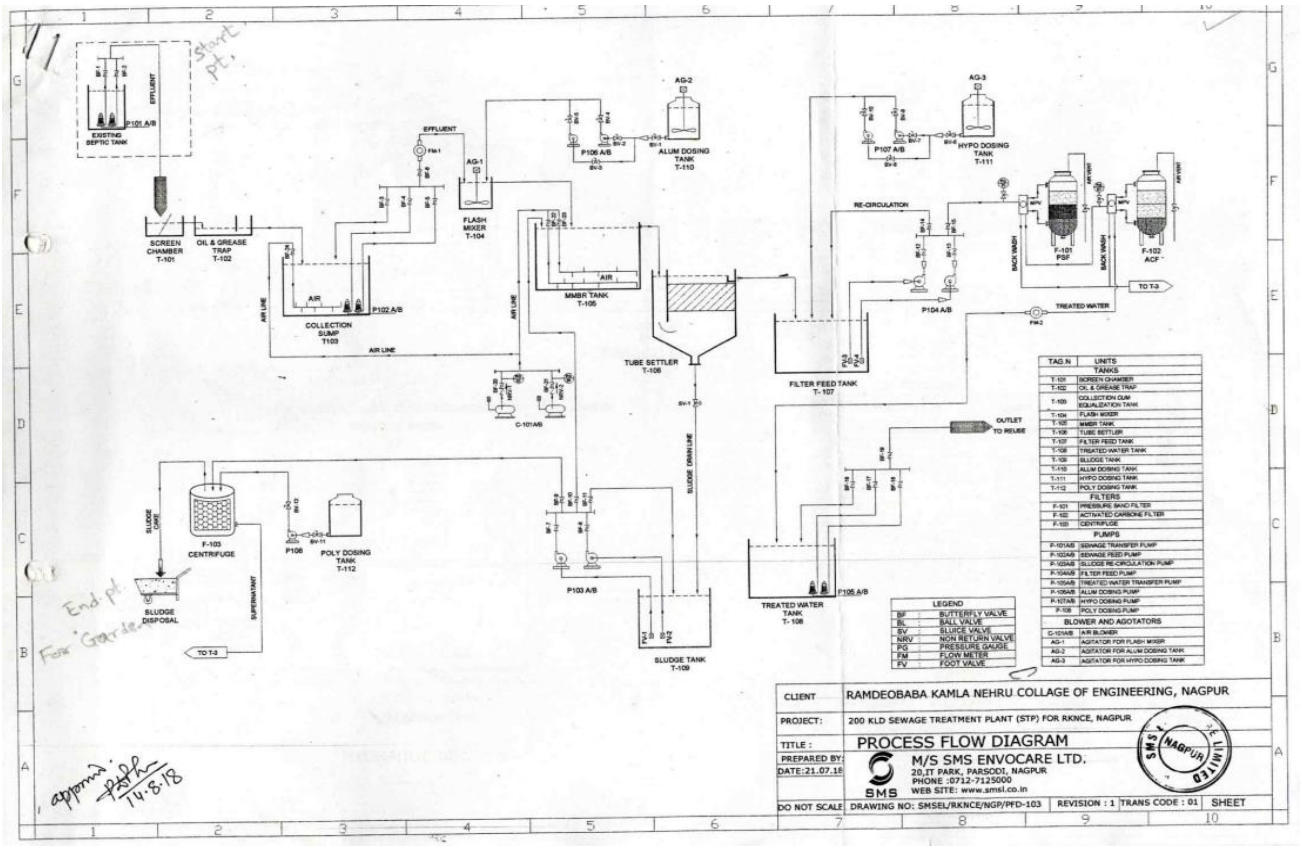
Water requirement for irrigation

Irrigation water for landscape use within the campus is a domestic quality and it sourced from in house STP and has acceptable parameter as per governing requirement, using it to maintain lush green garden.

Recycling of Water through STP

Domestic waste generated in the campus at residences, hostels, messes, etc. is diverted to the STP through channelized pipeline.

- To maintain natural balance in the environment and make optimum utilization of water available, the domestic sewage is getting treated in STP.
- The Sewage Treatment Plant (STP) with the capacity of 200KLD is working round the clock to treat sewage generated by residents of the campus.
- The Treated sewage is used only for gardening after tertiary treatment at STP.
- Treated water is odorless and is acceptable as per the Maharashtra Pollution Control Board Norms chemical /bacteriological parameters.



Process Flow of STP

STP water analysis for last three years:

			Inlet Value			Outlet Value		
S.N.	Parameters	Unit	Date 27.02.20	Date 12.03.21	Date 14.1.22	Date 27.02.20	Date 12.03.21	Date 14.1.22
1	PH	--	7.45	8	7.85	7.16	7.8	7.7
2	Total Dissolved Solid	mg/Lit.	422	240	194	279	188	194
3	Suspended Solids	mg/Lit.	24	130	62	4	16	12
4	COD	mg/Lit.	188	232	118	74	28.7	26.4
5	BOD	mg/Lit.	35	38.4	20.7	8.5	9	5.8
6	Oil & Grease	mg/Lit.	1.2	7	6	0.1	4	5
7	Cloride	mg/Lit.	95	18.6	13.8	75	12.4	10.2
8	Sulphate	mg/Lit.	30	16.3	10.4	17	11.1	12.6

Positive points:

- ➢ 100 % utilization of Sewage Treated Water
- ➢ Use of TSE water from STP Plant for Irrigation network.
- ➢ Pumps & Equipments selected on best energy efficient point.
- ➢ Use of low flow fixtures to reduce water flow & thereby control in water usage.
- ➢ Master switches installed in for each class rooms.
- ➢ Rain water harvesting & Recharge pits are provided at numerous locations of the campus.

6.2 : WASTE MANAGEMENT

Non-Biodegradable waste categorized as sellable waste

Sr. No.	Category	Qty in Kg/Day	Disposal Process
1	Dry Wastes - Papers, Boxes, Cartons etc.	47	Dispose through Private Contractor
2	Plastic wastes - covers, Bottles, Containers etc.	8	Dispose through Private Contractor
3	Chemical Waste (from Labs)	0.1	The Liquid waste collected in separate Sintex tank. After Every 15 Days water is analyse for TDS/Alkalinity/hardness & these parameters if in permissible limit then water is release in drainage.
4	Metal scraps - Tins etc.	13.70	Cell to vendor

Biodegradable waste

Mainly includes canteen waste and garden waste.
Canteen waste including vegetable cuttings and cooked food if any is hardly 5kg/day which is handed over to agency for cattle feeding.

Garden waste generated 22.5kg/day is used in **vermi composting**.
Due to this activity saved Rs. 80000/- on manure.

E waste generation and discarding

.

E-waste is handed over to authorized vendors.
In the year 2022 – 4050kgs handed over to vendor
In the year 2023 – 1300kgs handed over to vendor.
Around 200 units of computers donated to Needy organizations.

7.0 GREEN CAMPUS MANAGEMENT

7.1: Assessment of Green Cover of the Campus

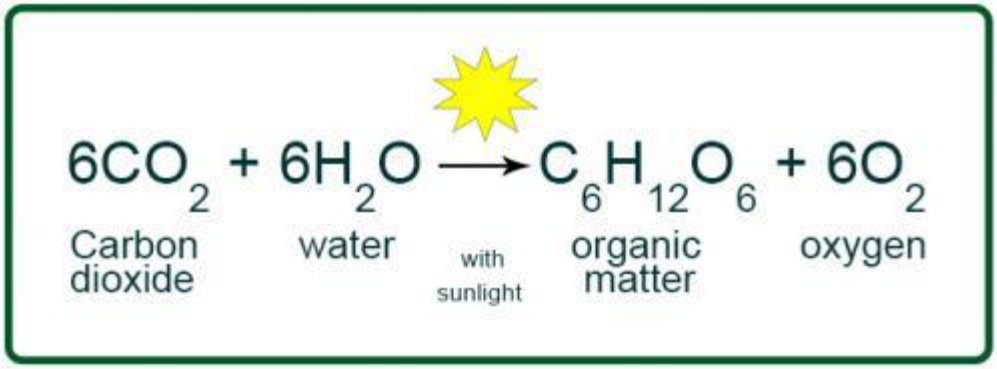
Trees play an important ecological role within the urban environment, as well as support improved public health and provide aesthetic benefits to campuses. In one year, a single mature tree will absorb up to 48 pounds of carbon dioxide from the atmosphere, and release it as oxygen. The amount of oxygen released by the trees of the campus is good for the students and staff in the campus. We need to realize the importance of trees in and around the campus as they significantly contribute towards making the air cleaner for us. The RCOEM campus sustains a luxuriant plant diversity ranging from trees, grasses, herbs, shrubs, creepers ornamental plants, palm and seasonal flowers.

Benefits of plants

- Lowers levels of anxiety. Constantly seeing and being around plants helps people feel more calm and relaxed, thus decreasing levels of anxiety.
- Increases attentiveness and memory. ...
- Increases productivity. ...
- Reduces stress levels and boosts mood. ...
- Sparks creativity.

The ultimate benefit of plants is the air we breathe. Our ancient Earth likely contained very little free oxygen, but scientists estimate that about 2.5 billion years ago the evolution of photosynthesis, whose by-product was oxygen, was the ultimate cause of the rise of oxygen levels in our atmosphere (Photo 1). Modern levels of oxygen in the atmosphere allow us to breathe easy, thanks to photosynthesis.

Today, the levels of oxygen in our atmosphere are not much of a concern, but the rapid rise of carbon dioxide is. However, another benefit of photosynthesis is the absorption of carbon dioxide from the air which ultimately transforms into carbon (organic matter) stored in plant tissues (Photo 1). If the carbon is stored long-term, such as in trunks of long-lived trees, this process is called “carbon sequestration.” Many scientists are looking at ways to use plants to sequester carbon in order to mitigate or defer global warming.



The chemical formula of photosynthesis showing how six carbon dioxide molecules and six water molecules in the presence of sunlight are converted into one molecule of organic matter and six molecules of oxygen.

Some specific Benefits of Plants:

Indoor plants are commonly used for their aesthetics benefits but they also have vital role reducing airborne pollution. The right choice of plants can be an excellent way of improving indoor air quality and general health. Local landscape contractor can be contacted for supply and rotation of these plants


Central Administra
His Excellency Banwarilal Purohit
Sunday, 4th July 2021

Details of Plants in the Campus

Biodiversity is abandoned in the campus of the institute.
More than 1300 types of shrubs, herbs, tress and climbers can spot.
Some of them as follows

Nilgiri	Aawala
Chafa	Neem
Sagwan	Bakul
Kanchan	Mango
Badam	Sisam
Ficus	Amrut
Gulmohor	Bel
Ashok	Kaner
Umbar	Saptaparni
Casia	Amaltash
Wad	Hibiscus
jamun	Peltafarm
Pimpal	Karanj
Nimbu	Parijat
Royal Palm	Musanda
Nariyal	Santra
Madhumalati	Kund
Jasmine	Roses

Various types of snakes, chameleon, frogs, birds, microbes are also traced in the campus

7.2 Carbon Foot Print Assessment

Fossil fuels (such as petrol, diesel) contribute significantly to environmental pollution through emission of greenhouse gases into the atmosphere mainly as carbon dioxide. Vehicular emission is the main source of carbon emission in the campus, hence to document the various means of transportation that is practiced by the university members is important.

Carbon foot print analysis :

Data of Year 2022-2-23 - Vehicular movements & Foot fall inside the Campus per day

Category	Count
Staff Movement	**180**
Visitors Movement	**52**
Four Wheelers	**150**
Two Wheelers	**3500**

Initiatives:

- Cycle movement encouraged. All students are allowed only to use the Cycles.
- To minimize the traveling time and distance the hostels are within the premises only.
- Car Pooling is encouraged

7.3 Routine Green Practices:

The college has initiated '**The Green Campus 'program** two years back and has actively promoted the various projects for the environment protection and sustainability. Awareness and sensitivity towards protection of environment is an important part of value education. Keeping the mission of RCOEM of providing value education and social responsibility in mind, **REEF (Shri Ramdeobaba College Engineers for Environment Forum)** was set up as an environment club of the college The club, founded on 25th January 2012, is hosted by the Department of Chemistry of RCOEM . It works to achieve the following objectives:

- To create awareness and take up various activities for the conservation of various aspects of the environment.
- To establish active association with various organizations working for environmental conservation.
- To take up various activities for underprivileged children and in the process initiate and ingrain the value of environmental conservation.
- To encourage the development and execution of ideas on role of technology for protection of environment**.**

Some of the Activities done by REEF:

- Water Tap Survey Initiated for a noble cause, the “Digital Water Tap Survey” started on 28th September 2019. It aimed at conserving water, by identifying various leaking taps throughout the campus, and repairing them. The Survey was conducted in an eco-friendly manner, using online forms. The gateway was circulated through social media. The Club multiple reports and complaints, which were directed to the maintenance department for repair.
- Poster Making Competition After declaration of “Nation-wide Plastic Ban”, it was time to spread awareness. As an interactive activity, A “Poster Making Competition” was organized on 22nd October 2019. The theme was selected as : “Plastic Ban: Harmful effects of Plastic”. The event took place at the Open Air Theatre. It saw participation of some very talented artists of our college.
- Guest Lecture on Noise Pollution A prominent NEERI (National Environmental Engineering Research Institute, Nagpur) engineer, Er. Satish Lokhande, was invited to deliver a speech on “Noise Pollution”, organized on 21st December 2019, in the Main Auditorium. He has developed a “Noise Tracker” mobile application, which measures real-time noise level and indicates, whether it is within permissible limits or is exceeding it.
- Nylon Removal Drive Nylon “Manjas” are still used during the Makar Sankranti. It is a hazard to nature, and poses a serious threat to birds. A Nylon removal drive, “Clean the GREENS”, was organized by GroWill Foundation on 19th January 2020. REEF participated and contributed towards this cleaning drive. Various urban jungles were parsed, and large amount of Nylon Manja was collected. The Bharat Van jungle, Ambazari backwaters, and various other places were selected. Teams were made and sent to each such location to collect Manja. This Manja was then used to manufacture recycled products, and was even used to stuff inside soft toys.

Some of the Activities…….2020-21

A year of great apprehensions and Uncertianities . Nevertheless many online activities related to environment were conducted like Elocution competition, Activities like Making of Bird Feeders, Photography competition, etc were conducted.

8 RECOMMENDATIONS

Energy Savings & Cost benefit recommendations:

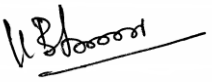
- Power factor is maintained at around 0.97 and thus gets penalized in the Electricity Board billing. Appropriate capacitors may be provided for the pf improvement
- Harmonics level is high to the tune of 16% as compared to recommended value of ≤ 8%. Action needs to be taken to control these harmonics.
- Many hot spots in thermal imaging of the panels. Needs maintenance. Regular thermography may be done.
- Solar water heating system may be provided in hostels and canteen/mess.
- Old Ceiling fans may be replaced with BLDC technology fans for getting energy saving

Other Improvement Opportunities:

1. New RMU is being installed in the switchyard for future expansion plan. The switchyard area needs dressing with proper routing of the DG set cables once the construction activities are over. Housekeeping needs to be improved.
2. Minor oil leakages are observed from 630KVA transformer radiation drain plugs. Needs to be arrested by providing gaskets or may be stopped temporarily by applying suitable sealant till you get the transformer outage opportunity. Water leakage from the tap is also observed. Needs immediate attention.
3. Transformer oil needs regular filtration which is not done since long. Breather also needs maintenance. Cable dressing at distribution panels is required. Rubber mats in front of all 440 V electrical panels are mandatory as per Electricity safety regulation 2010.
4. Energy meters are to be provided for energy accounting and control either on major distribution panels or in each building.
5. Rooftop solar panels are installed on 3 buildings. At Admin building, it is observed that the solar power generated is not connected to the net-metering of MSEDCL. The supply system at present here is such that whenever MSEDCL supply fails, solar power also gets off. Thus, benefit of solar power during MSEDCL power failure is lost. Also, you are not getting benefit of net metering. Supply scheme needs modification till you get the net metering facility in future.

6. Sprinkler system at rooftop solar panels is provided. However, panels are to be wiped to remove dust accumulation during dusty atmospheric conditions especially during the ongoing construactivities in the vicinity of the panels. This results in low generation to the tune of 60% only.

7. Many cells of Solar PV panel installed on Admin building are not operative and this panel is giving only 23KWp output as on today. As this panel is having net metering provision, cells from other panel (250KWp) may be replaced so as to get net metering advantage

Name of the Client	Date of Audit	Audit Team		Date and Signature
		Name	Role	
RCEOM Nagpur	**From 7th to 9th February 2024**	**V. Balakrishnan**	**Team Leader**	**V. Balakrishnan**  **19.02.2024**
		Keshvraj Athavale	**Lead Auditor – Energy Management**	
		Radhika Buwa	**Environment & Green Audit**	
		Sunny Subhash Pangire	**Energy Auditor**	
			Energy Auditor	