ENERGY AUDIT REPORT

Kanpur Institute of Technology

A-1, UPSIDC Industrial Area, Rooma
Kanpur-208001 (Uttar Pradesh)

Estd. 2004

KIT

July-2022

CONDUCTED BY:

PCRA

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Petroleum Conservation Research Association
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Acknowledgement

Petroleum Conservation Research Association (PCRA) places on record its sincere gratitude to Kanpur Institute of Technology, Kanpur (KIT, Kanpur) for giving an opportunity for Energy Audit of their Institute.

The study team is thankful to the Dr Brajesh Varshney, Director of the KIT, Kanpur, Dr R. K. Pandey, Dean Administration and Mr Faraz Khan (Assistant Professor) for their whole hearted support in providing data related to Energy Audit work and providing access to all Electrical equipment. We are also great full to electrical staff, who took pain along with us to gather data and cooperation in carrying out of work.

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INDEX

CHAPTER-1

EXECUTIVE SUMMARY

1.1 An executive summary provides an overview of the energy audit report. The purpose of an executive summary is to summarize the key points of the energy audit study such as energy saving potential, recommendations, cost savings, investment requirement etc. for each sub system for which energy audit done.

1.2 The study was carried out based on various data provided by KIT, Kanpur, however depending upon the requirement, additional measurements using various measuring instruments, were taken during the study. Various Energy Conservation measures were explored and possible saving in energy is also listed in Table-1.1

1.3 Observations & Possible Energy Saving

The institute was visited and discussions were held with officers/staff regarding institute's equipment and process. Some records such as Energy bills, log book and log sheets were also studied. After those measurements of parameters of various equipment were recorded. Based on records and measurements, it was found that there is scope of energy savings in following fields:

1. Lighting accessories
2. Air conditioners

1.4 Cost Benefit Analysis

Sr No	Name of Activity	Quantity	Energy saved (KWH) / Year	Cost of Energy saved/Year @ Rs 8.50 per unit (Rs)	Cost of replacement (Rs)	Payback period (Year)
1	Saving of Demand charges by Reduction of Sanctioned Load from 450 KVA to 350 KVA		Nil	32250	NIL	Immediate
2	Replacement of 36 W FTL with 20 W LED Tube light	320	12288	104448	160000	1.53
3	Replacement of 36 W CFL by 20 W LED Tube Light	740	28416	241536	222000	0.92
4	Replacement of Window AC 2 Ton capacity non star year 2008 by Window AC 2 Ton capacity Five-Star rating	3	3510	29835	126000	4.22
5	Replacement of Split AC 2 Ton capacity non star 2012 by Split AC Five Star 2 Ton capacity	5	6630	56355	260000	4.61
	Total		**50844**	**464424**	**768000**	

Table-1.1 Summary of EE Strategy

1.5 Electricity consumption of year 2021

Sr. no.	Year	Net billed units (KVA)	Solar Gen. (KWH)	Total unit consumed (KWH)
1	2021	227190	236043	463233

Table-1.2: Electricity consumption of year 2021

Table-1.3 Summarize the various sources of energy and their usage in KIT, Kanpur during Year 2021.

Sl. No.	Particulars	Quantity
1	Electricity (kWh)	227190
2	Electricity Solar (kWh)	236043
3	Diesel (Litres)	5590

Table-1.3: Total Energy Consumption

1.6 Savings in TOE basis:

Percentage Saving has been shown in Table-1.4 to Table-1.5

1) Electricity:

Annual Consumption			Savings Identified			Percentage Saving Identified (%)		
(kWh)	(TOE) (*)	Amount @ Rs 8.50/ unit (Rs)	(kWh)	(TOE)	Amount @ Rs 8.50/ unit (Rs)	(kWh)	(TOE)	Amount (Rs)
463233	39.838	3937480	50844	4.373	464424	10.98	10.98	11.79

Table-1.4: Percentage Saving in Electricity

2) Diesel Energy

Annual Consumption			Savings Identified			Percentage Saving Identified (%)		
Diesel (Liter)	TOE (*)	Amount @ Rs 90.60 (Rs)	Diesel (Liter)	TOE	Amount @ Rs 90.60 (Rs)	Diesel	TOE	Amount
5590	4.808	506454	0	0.00	0	0.00	0.00	0.00

Table-1.5: Percentage Saving in Diesel Energy

***Note:** 1 kWh=860 Kcal and **1 TOE = 10^7 k Cal**

CHAPTER 2

INTRODUCTION

2.1 Introduction

Kanpur Institute of Technology (KIT) is counted among the top-rated technical institutes of North India. Kanpur Institute of Technology runs B. Tech, MBA, MCA and M. Tech courses. The institute is affiliated to Dr. A.P.J. Abdul Kalam Technical University, Lucknow (formerly U.P.T.U., Lucknow) with College Code 165. The courses are approved by the All-India Council for Technical Education (AICTE) and Pharmacy Council of India (PCI). The institute is ISO 9001:2008 certified for it's up to the mark quality systems and best practices in technical and professional education. The institute is very easily accessible; it is located in Rooma, on Kanpur – Allahabad Highway, 6 Kilometers away from Rama Devi Chauraha.

The sprawling lush campus spreads over 10 acres of landscape with Total Built up Area: 24500 m2 lodged with all modern amenities and basic infrastructure to run the professional courses in Engineering & Management domains. The campus has separate hostels for boys and girls. The wi-fi campus has a library and a student activity center for co-curricular and extracurricular activities. KIT boasts a conference and seminar halls. The institute has three academics & and administrative block. Apart from there are Lecture Theatre, AC Fitted Class Rooms, Tutorial Rooms, Faculty Rooms, Office for the HODs, director's office, administrative office, registrar's office, maintenance office, Reprographics Room, Strong Room, Reception Lounge and the Visitor's Room.

2.2 Address of Institute: A1, UPSIDC Industrial Area, Rooma, Uttar Pradesh 208001

2.3 Location of Institute

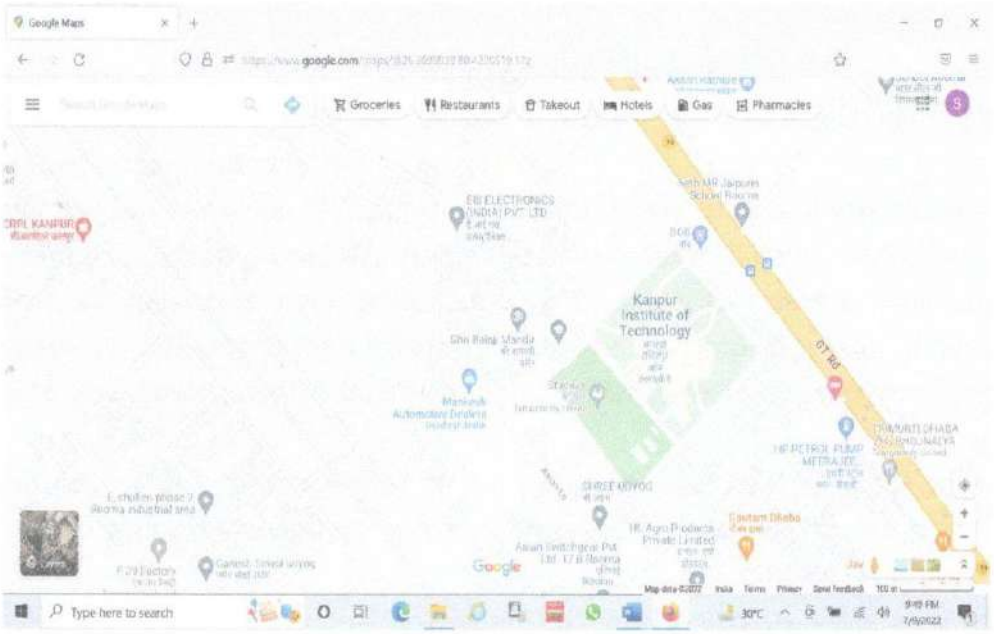


Fig-2.1: Location of Institute

2.4 Campus View of KIT, Kanpur

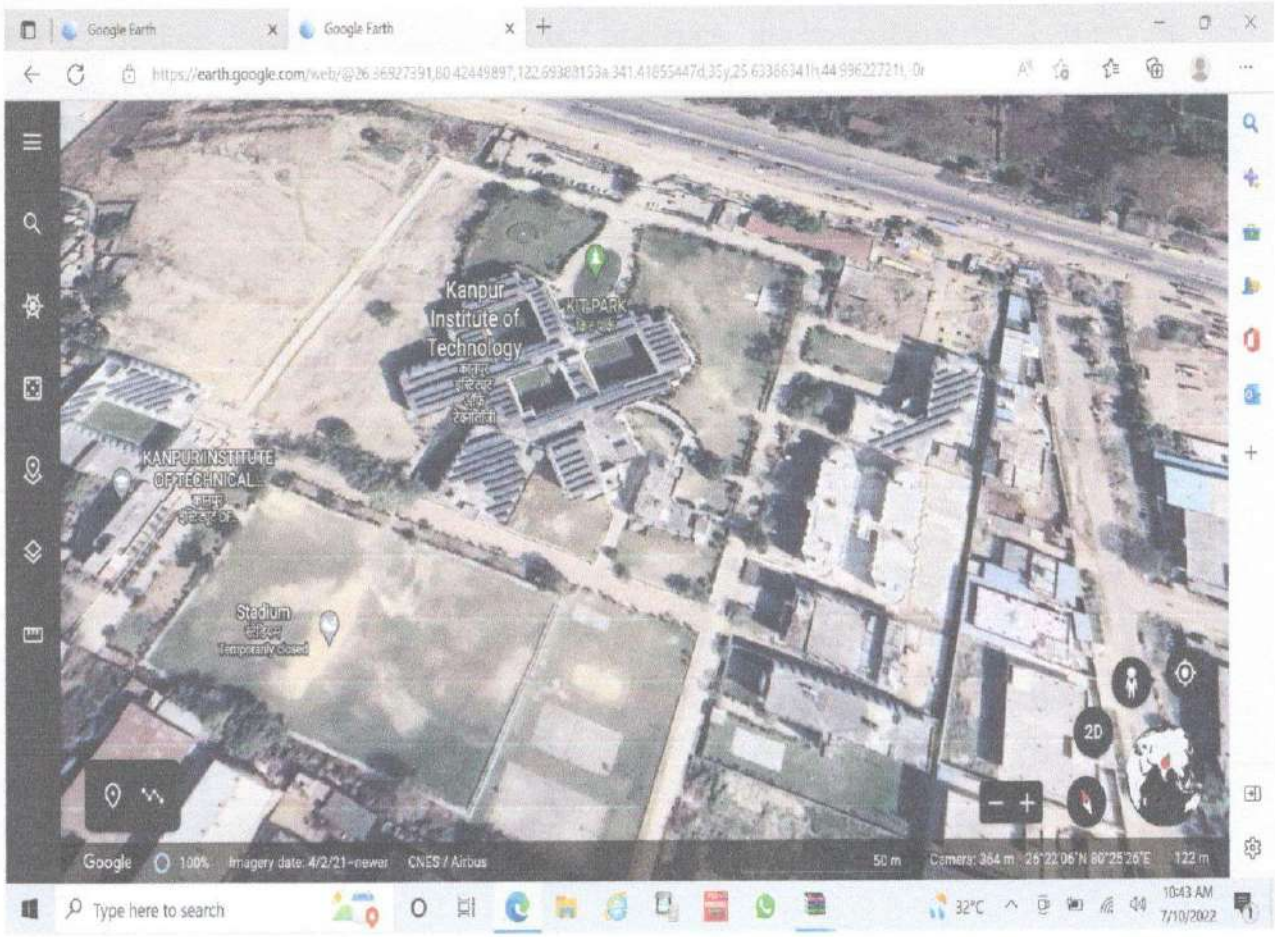


Fig-2.2: Campus View of KIT, Kanpur

2.5 Scope of Work

1. Review of Electricity Bills, Contract Demand and Power Factor: For the last one-year, in which possibility will be explored for further rationalization of contract demand and improvement of P.F.

2. Electrical System Network: Which would include study of Transformer operations, their operational pattern, Loading, Harmonic level measurement, Sufficiency and performance of capacitors bank (consider only LT Capacitor panel). Measurement on the Main Power Distribution Boards and scope for improvement, if any. The study would also cover possible improvements in energy metering systems for better control and monitoring.

3. Air Conditioners: Performance shall be evaluated as regards, their input power vis-à-vis TR capacity and performance will be compared to improve to the best in the category.

4. **Illumination**: Study of the illumination system, LUX level in various areas, area lighting etc. and suggest measures for improvements and energy conservation opportunity wherever feasible.

5. DG Set: Study the operations of DG Sets to evaluate their average cost of Power Generation, Specific Energy Generation and subsequently identify areas wherein energy savings could be achieved after analyzing the operational practices etc. of the DG Sets.

2.6 General Details:

Brief description of assignment	:	Energy Audit
Name & Address	:	Kanpur Institute of Technology, Kanpur
Contact Officials	:	Dr Brajesh Varshney Director, Kanpur Institute of Technology
Name of PCRA Team Leader	:	Mrs. Puja Prasad Dy. Director & Field Engineer (NR) nrfe4@pcra.org
Address of communication of PCRA	:	Petroleum Conservation Research Association, Sanrakshan Bhawan, 10, Bhikaji Cama Place, New Delhi – 110 066 Ph: 011 – 2619 8856; Fax: 011 – 2610 9668 e-mail: crcnr@pcra.org Website: http://www.pcra.org
Operational Days	:	300
No. of Shifts	:	1

CHAPTER 3

METHODOLOGY ADOPTED FOR ENERGY AUDIT

3.1 Energy Audit Methodology

A team of certified energy auditors and domain experts were involved in the energy study at KIT, Kanpur, with primary focus on identification of areas of energy conservation within the existing set-up. During the study, all the facilities within the complex were visited and surveyed for techno-commercial analysis. The analysis includes not only the energy savings' estimation through recommended energy conservation measure, but also simple payback calculations where investments shall be required to achieve the energy savings as estimated, in order to high-light the individual ECM economic viability. The major areas of study are: -

- Electrical Distribution
- Illumination & Lighting system
- Diesel Generators
- Air Conditioning System

Audit study used latest, sophisticated, portable, diagnostic and measuring instruments to support our energy audit investigations and analyses, for carrying out various measurements and analyses.

The following methodology was adopted for this Study:

1. Familiarization with KIT, Kanpur and understanding of its operation
2. Interaction and discussion with concerned stakeholders' Visual inspection and preliminary data collection with respect to various end use application (as available with KIT, Kanpur)
3. Identification and collection of energy consumption data (as available with KIT, Kanpur)
4. End use application wise necessary measurement taken using required instruments
5. Analysis of measured Data
6. Identification of potential Energy

3.2 Audit Team

College Work Group

- Dr Brajesh Varshney, Director,
- Dr R. K. Pandey, Dean Administration
- Mr. Faraz Khan (Assistant Professor)

PCRA Audit Team

- Mr. Umesh Prasad Singh, Additional Director & CRC (NR)
- Mrs. Puja Prasad Dy. Director & Field Engineer (NR)

CHAPTER-4

ELECTRICAL SYSTEM NETWORK

4.1 Sources of Energy being used in the Institute

The Institute is using both conventional and non-conventional sources of energy.

4.2 Electricity Distribution System:

The electric supply of KIT, Kanpur is fed from Kanpur Electric Supply Company (KESCO) through 11 KV feeder. The details of Distribution Transformer are as shown in Table-4.1. Sanctioned Load is 450 KW.

Sl. No.	Transformer No.	Rated Voltage Ratio	Make	Rated Capacity (KVA)	Winding Material	No Load Current (A)	Full Load Current (A)	Year of Manufacture
1	T/F-1	11KV/433 volt	Kirloskar	650	copper	Rewound		

Table-4.1: Details of 11/0.4 KVA Transformers installed in the premises

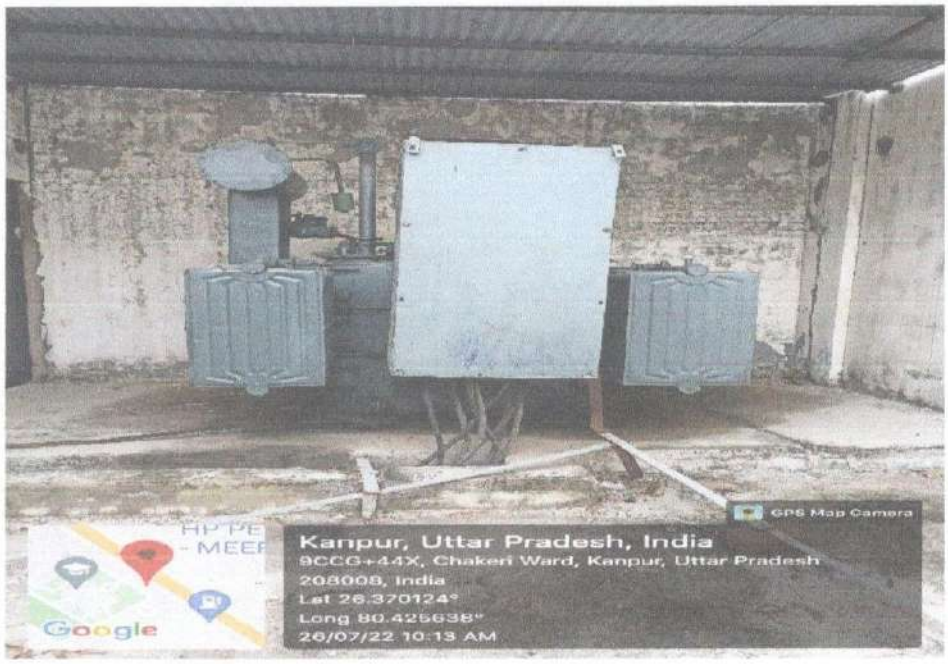


Fig-4.1: 11/0.4 Transformer (650 KVA)

4.3 Study of operational pattern and quality of Power Supply of Transformers

Power Analyzer was installed on Main Bus bar of incoming Distribution Panels of Distribution Transformer of 650 KVA from 12.00 at noon to 13.00 PM to on dated 26.07.2022.

Fig-4.2: Checking Load & Electrical Parameters through Load Analyzer

The energy parameter except THD and only THD were as per Table-4.2.

Time:	V1 rms	V2 rms	V3 rms	A1 rms	A2 rms	A3 rms	AN rms	P1 (W)	P2 (W)	P3 (W)	PT (W)	PFT
	V	V	V	A	A	A	A	W	W	W	W	
12:00:00 PM	228	231.6	226	194.4	276.9	214	97.7	33664	55667	39556	128887	0.82
12:01:00 PM	228	231.8	226.1	180.3	268.4	208	101.6	29596	53136	37664	120396	0.80
12:02:00 PM	228	231.8	226.1	164.8	255.3	195.5	104	25047	49380	34077	108504	0.77
12:03:00 PM	228.1	231.8	226.2	151.4	246.4	177.9	111.1	20803	47229	29055	97086	0.74
12:04:00 PM	228.1	231.9	226.3	142.9	234.9	168.9	109.5	18222	44405	26543	89169	0.71
12:05:00 PM	228	231.6	226	140.9	231.6	166.1	108.9	17928	43780	26129	87837	0.71
12:06:00 PM	228.2	231.7	226.1	138.8	225.1	161.6	108.8	15902	41528	24121	81550	0.68
12:07:00 PM	228.4	232	226.4	130.6	208	149.9	107.2	11034	36228	19416	66678	0.59
12:08:00 PM	228.7	232.1	226.7	126.7	201.6	142.9	108.8	9307	34729	17424	61460	0.56

Time:	V1 rms	V2 rms	V3 rms	A1 rms	A2 rms	A3 rms	AN rms	P1 (W)	P2 (W)	P3 (W)	PT (W)	PFT
	V	V	V	A	A	A	A	W	W	W	W	
12:09:00 PM	228.7	232.2	226.7	113	166.1	121.1	105.6	-547	24257	8470	32180	0.35
12:10:00 PM	228.9	232.3	226.8	119.9	156.9	119	106.3	-4889	19799	2845	17755	0.19
12:11:00 PM	228.8	232.2	226.8	130.1	141.5	119.7	106.1	-12766	11926	-3629	-4469	-0.05
12:12:00 PM	228.8	232.2	226.9	143.4	137.3	125.6	106.5	-17961	6777	-8045	-19229	-0.20
12:13:00 PM	228.5	232	226.6	135.2	142.7	122.4	106.4	-14132	10618	-3081	-6595	-0.07
12:14:00 PM	228.2	231.7	226.1	115.8	180.2	127.8	108.1	3910	29295	12649	45854	0.47
12:15:00 PM	227.9	231.5	225.9	127.9	211.3	148.8	104.8	14463	39222	21952	75637	0.68
12:16:00 PM	227.6	231.1	225.5	141.5	230.7	161.5	108.7	18852	44077	25636	88566	0.73
12:17:00 PM	227.1	230.5	225.1	147.1	238.4	168.1	111.4	20117	45720	27168	93005	0.74
12:18:00 PM	227.2	230.9	225.4	124.9	186.7	135.9	99.9	6959	29727	14045	50731	0.49
12:19:00 PM	226.7	230.3	224.9	120.8	185	131.4	103.4	6321	29958	13312	49592	0.50
12:20:00 PM	227	230.6	225.2	122.4	162.4	122.2	104.8	-3183	20551	4350	21718	0.23
12:21:00 PM	226.7	230.1	224.9	127.2	180.4	133.5	102.7	3540	26753	10952	41245	0.39
12:22:00 PM	226.2	229.6	224.3	125.6	199.7	141.6	104.3	10740	34523	18267	63530	0.60
12:23:00 PM	226.2	229.6	224.4	120.7	195.1	138.7	106.5	8578	33174	17094	58846	0.57
12:24:00 PM	227.2	230.7	225.4	118.5	167.3	124.9	105.7	-649.5	23407	8720	31478	0.33
12:25:00 PM	228.8	232.2	227	115.9	175.1	127	104.5	2942	26912	11707	41561	0.43
12:26:00 PM	230	233.5	228.3	120.1	184.6	134.9	97.4	7364	30025	15156	52546	0.51
12:27:00 PM	230.3	233.8	228.5	132.6	207.8	148.7	96.8	15315	37518	21431	74265	0.66
12:28:00 PM	230.4	233.9	228.7	140.4	214.8	159.5	94.7	17710	39134	24662	81506	0.68
12:29:00 PM	230.5	234.1	229	140.7	203.7	162.6	82.3	17837	36129	25389	79355	0.68
12:30:00 PM	230.5	234.1	229	132.6	195.4	160.6	83.2	15115	34044	24728	73888	0.65
12:31:00 PM	230.2	233.7	228.7	140.5	206.7	173.8	82.4	18687	37733	28879	85298	0.71
12:32:00 PM	229.9	233.3	228.5	148.5	219.1	179.8	83.1	21829	41493	30797	94119	0.74
12:33:00 PM	229.7	233.2	228.3	156.2	228.4	184.7	85.1	24167	43896	32158	100221	0.76
12:34:00 PM	229.4	232.9	227.9	168.2	240.7	189	85.9	27786	47209	33497	108492	0.79
12:35:00 PM	229.6	233	228.1	176.7	241.5	194.6	75.9	30493	47620	35216	113329	0.80
12:36:00 PM	229.5	233	228	178.1	248.9	196.2	82.5	31153	49807	35867	116827	0.81
12:37:00 PM	229.5	232.9	227.9	181.2	249.8	200.8	80.2	31641	49669	36814	118124	0.81
12:38:00 PM	229.7	233.1	228.1	162.4	225.9	182.8	76.6	26153	43338	31828	101319	0.77
12:39:00 PM	229.7	233.2	228.3	138.4	200	158.7	81.3	17551	36037	24216	77803	0.68
12:40:00 PM	229.6	233.2	228.2	161.4	228.1	182.4	80.3	26153	44282	31939	102374	0.78
12:41:00 PM	229.4	232.9	228	165.8	235.2	187.5	80.7	28428	46789	34081	109298	0.81
12:42:00 PM	229.4	233	228.1	153.4	220.8	175.8	76.2	26132	43908	31814	101855	0.80
12:43:00 PM	229.4	233	228.2	150.3	215.3	166.9	75.9	25197	42226	29499	96922	0.79
12:44:00 PM	229.7	233.2	228.3	147.7	221	162.6	87.7	24095	43774	28329	96199	0.78
12:45:00 PM	229.5	233.1	228.2	154.1	228.8	172.8	87.9	25988	45913	31263	103164	0.80
12:46:00 PM	229.6	233.1	228.2	152.7	230.9	178.7	90	25501	46408	32575	104485	0.81
12:47:00 PM	229.4	232.8	227.9	145.3	222.6	170.4	90.9	22903	43887	30124	96914	0.78
12:48:00 PM	229.9	233.4	228.4	116.4	152.5	126.5	81	2133	19999	11896	34028	0.34
12:49:00 PM	230.1	233.6	228.6	118.8	139.9	120	86	-5018	13317	6817	15117	0.17
12:50:00 PM	230	233.7	228.6	121.3	136.3	118.5	85.9	-7575	10503	4835	7764	0.09
12:51:00 PM	230.2	234	229	131.4	129.1	115.4	86	-14465	3710	-2970	-13725	-0.16
12:52:00 PM	230.6	234.4	229.4	133.5	126.6	115.4	86.1	-16455	1980	-5659	-20134	-0.22
12:53:00 PM	230.7	234.4	229.4	116.5	136	113.1	93.6	-7737	12987	3222	8473	0.10
12:54:00 PM	230.3	234.2	229.1	116.2	164	133.7	82.2	6110	24721	15708	46539	0.48

Time:	V1 rms	V2 rms	V3 rms	A1 rms	A2 rms	A3 rms	AN rms	P1 (W)	P2 (W)	P3 (W)	PT (W)	PFT
	V	V	V	A	A	A	A	W	W	W	W	
12:55:00 PM	230.6	234.3	229.2	125.5	183.2	146.2	87.6	10788	30509	20173	61470	0.58
12:56:00 PM	231.2	234.9	229.8	122.6	186.6	141.5	94.2	11330	32700	19884	63914	0.61
12:57:00 PM	231.8	235.4	230.4	118.8	173.2	132.2	90.2	8263	28106	16539	52908	0.53
12:58:00 PM	232.5	236.3	231.2	114.5	151.2	123.5	83.8	1631	19697	11747	33076	0.36
12:59:00 PM	232.9	236.7	231.6	119.6	176.7	141.1	90.3	8847	29052	19331	57230	0.56

Table-4.2: Energy parameters (Except THD) of 650 KVA Transformer

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
A1 rms	7/26/2022	12:00:00 PM	140.1	99.50	229.5	A	1:00:00	(h:min:s)
A2 rms	7/26/2022	12:00:00 PM	202.4	116.5	306.0	A	1:00:00	(h:min:s)
A3 rms	7/26/2022	12:00:00 PM	155.8	101.0	243.5	A	1:00:00	(h:min:s)
AN rms	7/26/2022	12:00:00 PM	94.95	71.20	123.9	A	1:00:00	(h:min:s)

Table-4.3: Current Profile

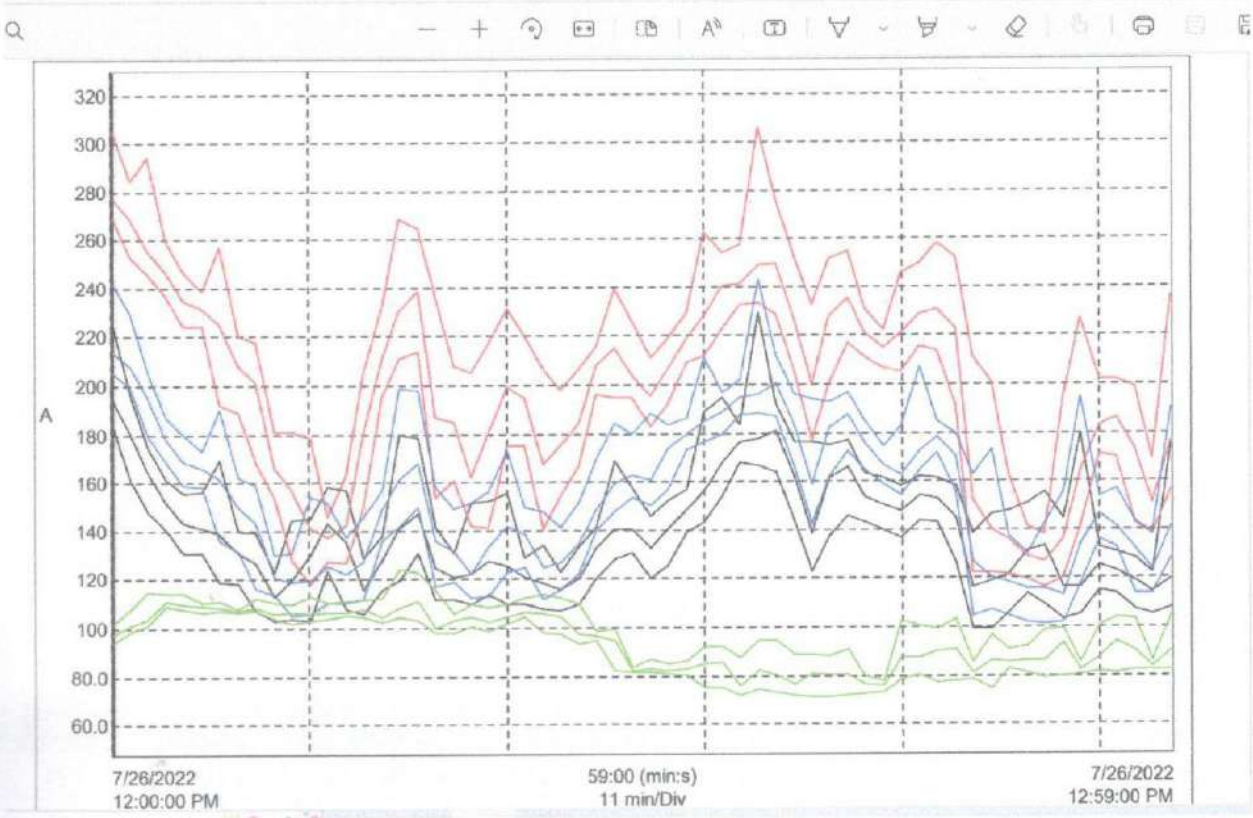


Fig-4.3: Current Profile Graph

From Table-4.3, it is observed that Load on all the three phases 229.5 ampere, 306 Ampere and 243.5 Ampere respectively which is unbalanced and need balancing by redistribution of load. It will stop energy drain through neutral.

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
U12 rms	7/26/2022	12:00:00 PM	399.9	386.3	409.3	V	1:00:00	(h:min:s)
U23 rms	7/26/2022	12:00:00 PM	398.3	379.7	407.5	V	1:00:00	(h:min:s)
U31 rms	7/26/2022	12:00:00 PM	396.0	370.0	405.1	V	1:00:00	(h:min:s)

Table-4.4: Voltage Profile (Phase to Phase)

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
V1 rms	7/26/2022	12:00:00 PM	229.2	217.3	234.5	V	1:00:00	(h:min:s)
V2 rms	7/26/2022	12:00:00 PM	232.7	225.7	238.2	V	1:00:00	(h:min:s)
V3 rms	7/26/2022	12:00:00 PM	227.5	212.5	233.1	V	1:00:00	(h:min:s)

Table-4.5: Voltage Profile (Phase to Neutral)

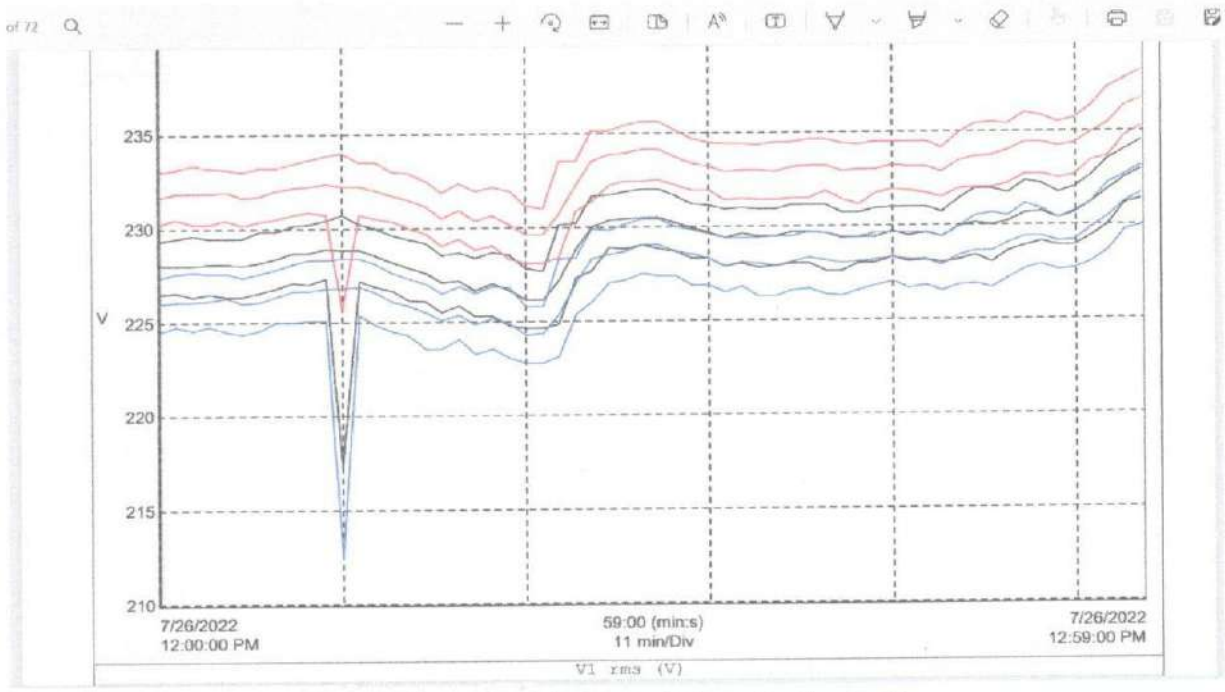


Fig-4.4: Voltage Profile Graph (Phase to Neutral)

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
PF1	7/26/2022	12:00:00 PM	0.347	-0.544	0.761		1:00:00	(h:min:s)
PF2	7/26/2022	12:00:00 PM	0.693	0.062	0.867		1:00:00	(h:min:s)
PF3	7/26/2022	12:00:00 PM	0.533	-0.280	0.817		1:00:00	(h:min:s)
PFT	7/26/2022	12:00:00 PM	0.543	-0.224	0.821		1:00:00	(h:min:s)

Table-4.6: Power Factor during Measurement

4.4 Harmonic Distortion and Total Harmonic Distortion (THD)

The individual current Harmonics distortion have been shown in Table-4.7

Time:	A1 H4	A2 H4	A3 H4	A1 H5	A2 H5	A3 H5	A1 H6	A2 H6	A3 H6	A1 H7	A2 H7	A3 H7
	% f	% f	% f	% f	% f	% f	% f	% f	% f	% f	% f	% f
12:00:00 PM	5.3	2.2	4.1	10.2	9.1	13	1.4	0.1	0	9.4	6.4	8.2
12:01:00 PM	5.7	2.2	4.1	10.8	9.3	13	1.4	0.1	0.1	10.1	6.8	8.4
12:02:00 PM	6.2	2.4	4.5	12	9.9	14.1	1.6	0.2	0	11	7.1	9.1
12:03:00 PM	6.8	2.5	5.1	13.4	10.1	15.5	1.8	0.2	0.1	12.2	7.3	10.4
12:04:00 PM	7.3	2.6	5.5	14.5	10.7	16.5	2	0.3	0.1	13	7.7	11
12:05:00 PM	7.4	2.7	5.5	15.1	11	17	2	0.3	0.1	13.4	7.9	11.2
12:06:00 PM	7.6	2.7	5.5	15.4	11.3	17.7	1.9	0.2	0.1	13.6	7.9	11.4
12:07:00 PM	8.2	2.9	6	17	12.6	19.9	2	0.1	0.2	14.5	8.5	12.1
12:08:00 PM	8.5	3.1	6.5	17.7	12.7	20.2	2.3	0.3	0.2	15.1	8.6	12.7
12:09:00 PM	9.8	3.9	8.1	20.5	16.1	24.7	2.6	0.5	0.3	16.7	10.2	14.5
12:10:00 PM	9.1	3.9	8.2	18.9	16.7	24.2	2.3	0.4	0.1	15.6	11.2	15.1
12:11:00 PM	8.4	4.3	8.1	17.8	19.4	24.9	2	0.4	0.3	13.8	12.3	14.3
12:12:00 PM	7.7	4.5	7.7	16.1	20.2	24.1	1.8	0.4	0.3	12.9	12.8	13.9
12:13:00 PM	8.2	4.4	8	16.5	18.5	23.8	2	0.5	0.2	13.8	12.3	14.2
12:14:00 PM	9.6	3.5	7.7	19.4	14.7	23.2	2.3	0.3	0.1	16.5	10	14
12:15:00 PM	8.5	2.9	6.4	16.9	12.2	18.9	2.1	0.3	0.1	14.6	8.4	12.1
12:16:00 PM	7.6	2.7	5.7	14.9	11.2	17	2	0.3	0.1	13.5	7.9	11.4
12:17:00 PM	7.2	2.6	5.4	14.8	11.2	16.6	1.8	0.2	0.1	13	7.6	10.8
12:18:00 PM	8.6	3.4	6.9	17.4	14	20.9	2.3	0.4	0.1	15.4	9.6	13.1
12:19:00 PM	8.9	3.3	7.2	18.4	14.3	22	2.3	0.3	0.1	15.9	10	13.7
12:20:00 PM	8.8	3.7	7.7	18.2	16.1	23.6	2.1	0.4	0.1	15.2	11.2	14.5
12:21:00 PM	8.4	3.4	7	17.4	14.9	21.7	2	0.4	0.1	14.2	9.9	12.8
12:22:00 PM	8.6	3.1	6.6	16.9	12.7	19.5	2.2	0.4	0.2	15.2	9.2	12.6
12:23:00 PM	8.9	3.2	6.8	16.7	12.1	19.4	2.4	0.5	0.4	15.1	9	12.6
12:24:00 PM	8.9	3.8	7.5	16.9	14.7	21.8	2.4	0.6	0.3	14.9	10.2	13.6
12:25:00 PM	9.3	3.5	7.5	17.2	14.6	21.6	2.3	0.4	0.2	15.7	10.2	13.9
12:26:00 PM	9	3.3	7	17.1	13.9	20.4	2.1	0.3	0.1	15.5	9.9	12.5
12:27:00 PM	8.3	2.9	6.3	15.5	12.4	18.5	1.9	0.2	0.1	13.9	8.7	11.3
12:28:00 PM	7.7	2.9	6	14.9	12	17.2	1.9	0.2	0.1	13.4	8.5	10.7
12:29:00 PM	7.9	3.3	6.1	14.6	12.9	17.2	1.8	0.3	0.1	13.5	9.3	10.7
12:30:00 PM	8.4	3.5	6.2	15.7	13.3	17	2	0.3	0.1	14	9.4	10.6
12:31:00 PM	7.9	3.3	5.5	15.4	13.2	16.2	1.8	0.2	0	13.1	8.7	9.5
12:32:00 PM	7.5	3	5.2	14	12.1	15.4	1.8	0.2	0	12.5	8.4	9.5
12:33:00 PM	7	2.8	5.1	13.1	11.9	14.8	1.7	0.3	0.1	11.7	8.1	9
12:34:00 PM	6.4	2.6	5	12.2	11.4	14.4	1.5	0.3	0.1	10.8	7.6	9
12:35:00 PM	6.1	2.6	4.9	11.7	11	14	1.4	0.3	0.1	10.5	7.8	8.9

Time:	A1 H4	A2 H4	A3 H4	A1 H5	A2 H5	A3 H5	A1 H6	A2 H6	A3 H6	A1 H7	A2 H7	A3 H7
12:36:00 PM	6	2.5	4.8	11.5	11.1	14.1	1.4	0.3	0	10.4	7.9	9
12:37:00 PM	5.9	2.5	4.7	11.2	11.2	14	1.4	0.3	0.1	10.5	7.7	8.7
12:38:00 PM	6.6	2.7	5.2	13	12.5	15.7	1.5	0.2	0.1	11.8	8.5	9.4
12:39:00 PM	8.1	3.1	5.8	15	13.9	17.9	1.7	0.3	0.2	13.7	9.6	10.9
12:40:00 PM	6.7	2.7	5.1	13	12.2	15.5	1.5	0.2	0.1	11.7	8.5	9.5
12:41:00 PM	6.6	2.6	5.1	12.8	11.8	15	1.6	0.2	0.1	11.3	8.3	9.4
12:42:00 PM	7.3	2.9	5.7	14.1	12.3	16	1.8	0.3	0	12.7	8.9	10.2
12:43:00 PM	7.5	3.1	6	14.3	12.4	16.9	1.8	0.3	0.1	12.9	9.2	10.8
12:44:00 PM	7.5	2.9	6	14.2	12.3	17.2	1.8	0.2	0.1	13	8.8	11
12:45:00 PM	7.3	2.7	5.5	13.8	11.9	16.3	1.7	0.2	0.2	12.4	8.5	10.4
12:46:00 PM	7.2	2.7	5.3	14.3	12.6	16.2	1.7	0.2	0.2	12.7	8.6	10.2
12:47:00 PM	7.8	2.9	5.7	15	13.1	17	1.9	0.2	0.1	13.5	9	10.8
12:48:00 PM	9.8	4.6	8.1	20	19.4	24.3	2.3	0.5	0.2	16.8	12.8	14.2
12:49:00 PM	9.5	4.8	8.5	19.2	20.6	24.9	2.2	0.6	0.2	16.7	13.6	14.9
12:50:00 PM	9.2	4.9	8.4	18.3	21.3	25.3	2.1	0.6	0.2	16.1	13.8	14.9
12:51:00 PM	8.4	5.1	8.5	17.1	22.1	25.1	1.9	0.5	0.2	14.7	14.8	15
12:52:00 PM	8.2	5.1	8.6	16.8	22.5	24.6	1.8	0.4	0.2	14.4	15.2	15
12:53:00 PM	9.6	4.9	8.8	18.8	21.2	25.1	2.1	0.6	0.2	16.8	14.3	15.7
12:54:00 PM	9.8	4.2	7.6	19.2	17.2	21.6	2.2	0.5	0.1	17.2	12.2	13.7
12:55:00 PM	9	3.7	6.8	17.5	15.3	19.3	2.1	0.5	0.2	15.8	10.7	12.5
12:56:00 PM	9.2	3.6	7	17.8	15.3	20.1	2.1	0.4	0.1	15.9	10.4	12.9
12:57:00 PM	9.6	3.9	7.5	18.2	16.4	21.9	2	0.3	0.2	16.5	10.9	13.4
12:58:00 PM	10.2	4.6	8.1	19	18.7	24.1	2	0.3	0.3	17.3	12.1	14
12:59:00 PM	9.6	3.9	7.2	17.3	15.3	19.9	2	0.4	0.1	16.6	10.6	12.4

Table-4.7: Individual current Harmonics distortion

From Table-4.7, it is observed that individual current Harmonics are highest at 5th Harmonics.

Total Harmonic Distortion (THD) have been tabulated in Table-4.8.

Time:	V1 THDf	V2 THDf	V3 THDf	U12 THDf	U23 THDf	U31 THDf	A1 THDf	A2 THDf	A3 THDf
	% f	% f	% f	% f	% f	% f	% f	% f	% f
12:00:00 PM	0.7	0.9	0.9	0.8	0.9	0.8	16.9	13.1	17.1
12:01:00 PM	0.7	0.8	0.8	0.7	0.9	0.7	18.2	13.6	17.2
12:02:00 PM	0.7	0.9	0.9	0.7	0.9	0.7	20	14.4	18.5
12:03:00 PM	0.7	0.9	0.9	0.8	0.9	0.8	22.2	14.7	20.7
12:04:00 PM	0.7	0.9	0.9	0.8	0.9	0.8	23.8	15.6	22.1
12:05:00 PM	0.8	0.9	0.9	0.8	0.9	0.8	24.6	15.7	22.5
12:06:00 PM	0.8	0.9	0.9	0.8	0.9	0.8	25.2	16.1	23.2

Time:	V1 THDf	V2 THDf	V3 THDf	U12 THDf	U23 THDf	U31 THDf	A1 THDf	A2 THDf	A3 THDf
	% f	% f	% f	% f	% f	% f	% f	% f	% f
12:07:00 PM	0.8	0.9	0.9	0.8	0.9	0.9	27.2	17.7	25.6
12:08:00 PM	0.8	0.9	0.9	0.8	0.9	0.8	28.3	17.8	26.5
12:09:00 PM	0.8	0.9	1	0.9	1	0.9	32.1	22	32
12:10:00 PM	0.8	0.9	0.9	0.8	0.9	0.8	29.9	23.2	32
12:11:00 PM	0.8	1	1	0.9	1	0.9	27.4	26.8	32
12:12:00 PM	0.8	1	1	0.9	1	0.9	24.9	27.8	31
12:13:00 PM	0.7	0.9	0.9	0.8	0.9	0.8	26.3	26.2	31.1
12:14:00 PM	0.7	0.9	0.8	0.7	0.9	0.7	31.1	20.7	30.1
12:15:00 PM	0.8	0.9	0.9	0.8	1	0.8	27.3	17.4	24.9
12:16:00 PM	0.7	0.9	0.9	0.8	0.9	0.8	24.6	16.1	22.6
12:17:00 PM	0.8	0.9	0.9	0.8	0.9	0.8	23.8	16.5	21.9
12:18:00 PM	0.8	0.9	0.9	0.8	1	0.8	28.2	20.3	27.4
12:19:00 PM	0.8	0.9	0.9	0.8	0.9	0.8	29.4	20.6	28.8
12:20:00 PM	0.8	0.9	0.9	0.8	1	0.8	28.9	23.4	30.7
12:21:00 PM	0.9	1	1.1	0.9	1.1	1	27.3	21.4	27.9
12:22:00 PM	0.8	0.9	0.9	0.8	0.9	0.8	27.7	18.7	25.9
12:23:00 PM	0.7	0.9	0.9	0.8	1	0.8	27.9	18.2	25.9
12:24:00 PM	0.8	1	1.1	0.9	1.1	0.9	28	22.7	28.8
12:25:00 PM	0.6	0.8	0.8	0.7	0.9	0.7	29	22.1	28.8
12:26:00 PM	0.6	0.7	0.8	0.6	0.8	0.7	28.6	20.2	26.8
12:27:00 PM	0.6	0.7	0.8	0.6	0.8	0.6	25.8	17.7	24.3
12:28:00 PM	0.6	0.7	0.8	0.6	0.8	0.6	24.7	17.2	22.7
12:29:00 PM	0.6	0.7	0.8	0.6	0.8	0.6	24.6	18.8	22.8
12:30:00 PM	0.7	0.8	0.9	0.7	0.9	0.8	26.1	19.4	22.6
12:31:00 PM	0.7	0.9	1	0.7	0.9	0.8	24.8	18.7	21.1
12:32:00 PM	0.7	0.9	0.9	0.7	0.9	0.8	23	17.5	20.2
12:33:00 PM	0.6	0.9	1	0.7	1	0.8	21.6	17.9	19.5
12:34:00 PM	0.6	0.9	0.9	0.7	1	0.8	20.1	17.4	19
12:35:00 PM	0.6	0.8	0.8	0.6	0.8	0.7	19.2	16	18.6
12:36:00 PM	0.6	0.7	0.8	0.6	0.8	0.7	19	16.6	18.8
12:37:00 PM	0.6	0.8	0.8	0.6	0.8	0.7	18.8	16.5	18.4
12:38:00 PM	0.6	0.8	0.9	0.6	0.9	0.7	21.4	18.1	20.5
12:39:00 PM	0.6	0.8	0.8	0.7	0.9	0.7	25.2	20.9	23.5
12:40:00 PM	0.6	0.8	0.8	0.6	0.8	0.7	21.5	18.5	20.4
12:41:00 PM	0.6	0.8	0.8	0.6	0.8	0.7	21	17.8	19.9
12:42:00 PM	0.6	0.7	0.8	0.6	0.8	0.7	23.2	18	21.3
12:43:00 PM	0.6	0.7	0.8	0.6	0.8	0.7	23.6	18.3	22.7
12:44:00 PM	0.6	0.8	0.8	0.6	0.8	0.6	23.8	18.4	22.9
12:45:00 PM	0.6	0.7	0.8	0.6	0.8	0.7	23	17.8	21.6

Time:	V1 THDf	V2 THDf	V3 THDf	U12 THDf	U23 THDf	U31 THDf	A1 THDf	A2 THDf	A3 THDf
	% f	% f	% f	% f	% f	% f	% f	% f	% f
12:46:00 PM	0.6	0.7	0.8	0.6	0.8	0.7	23.4	18.8	21.3
12:47:00 PM	0.6	0.7	0.8	0.6	0.8	0.7	24.7	19.5	22.4
12:48:00 PM	0.8	0.9	1	0.7	1	0.8	31.7	26.9	31.5
12:49:00 PM	0.6	0.8	0.8	0.7	0.8	0.7	30.9	28.7	32.7
12:50:00 PM	0.6	0.8	0.8	0.7	0.8	0.7	29.6	29.6	33.1
12:51:00 PM	0.7	0.8	0.8	0.7	0.8	0.7	27.2	31.3	33.1
12:52:00 PM	0.6	0.7	0.8	0.6	0.8	0.6	26.8	33	32.7
12:53:00 PM	0.6	0.8	0.8	0.7	0.8	0.6	30.8	33	33.5
12:54:00 PM	0.6	0.7	0.8	0.6	0.8	0.7	31.4	24.6	28.7
12:55:00 PM	0.6	0.7	0.7	0.6	0.7	0.6	28.7	22.3	25.9
12:56:00 PM	0.6	0.7	0.7	0.6	0.8	0.6	29.4	23.1	26.8
12:57:00 PM	0.6	0.7	0.7	0.6	0.7	0.6	30.3	24.1	28.9
12:58:00 PM	0.6	0.7	0.7	0.6	0.7	0.6	31.7	26.3	31.4
12:59:00 PM	0.5	0.7	0.6	0.6	0.7	0.5	29.9	22.8	26.6

Table-4.8: Total Harmonic Distortion (THD) of 650 KVA Transformer

The abstract of Current and Voltage THD have been shown in Table-4.9.

Name	Date	Time	AVG	MIN	MAX	Units	DURATION	UNITS
A1 THDf	7/26/2022	12:00:00 PM	25.76	16.90	32.10	% f	1:00:00	(h:min:s)
A2 THDf	7/26/2022	12:00:00 PM	20.48	13.10	33.00	% f	1:00:00	(h:min:s)
A3 THDf	7/26/2022	12:00:00 PM	25.19	17.10	33.50	% f	1:00:00	(h:min:s)
U12 THDf	7/26/2022	12:00:00 PM	0.707	0.600	0.900	% f	1:00:00	(h:min:s)
U23 THDf	7/26/2022	12:00:00 PM	0.873	0.700	1.100	% f	1:00:00	(h:min:s)
U31 THDf	7/26/2022	12:00:00 PM	0.738	0.500	1.000	% f	1:00:00	(h:min:s)
V1 THDf	7/26/2022	12:00:00 PM	0.678	0.500	0.900	% f	1:00:00	(h:min:s)
V2 THDf	7/26/2022	12:00:00 PM	0.827	0.700	1.000	% f	1:00:00	(h:min:s)
V3 THDf	7/26/2022	12:00:00 PM	0.857	0.600	1.100	% f	1:00:00	(h:min:s)

Table-4.9: THD Profile

4.5 Installation of Harmonic Filters

The value of (ISC/IL) can be taken as 50<100) in Table of Fig 4.5 for current Distortion.The maximum individual harmonics as per Table-4.7 were found at 5th order. The measured Maximum Current harmonics of all the three phases were 32.1% to 33.5% as shown in Table-4.9, which, are not in limit of 10% as per IEE Std 519-2014, followed in India. Harmonic distortions are usually caused by the use of nonlinear loads. Nonlinear loads, a vast majority of

which are loads with power electronic devices, draw current in a non-sinusoidal manner. Higher the use of such devices, THD will increase. It is recommended to install Harmonic Filters in consultation of any Harmonic Expert.

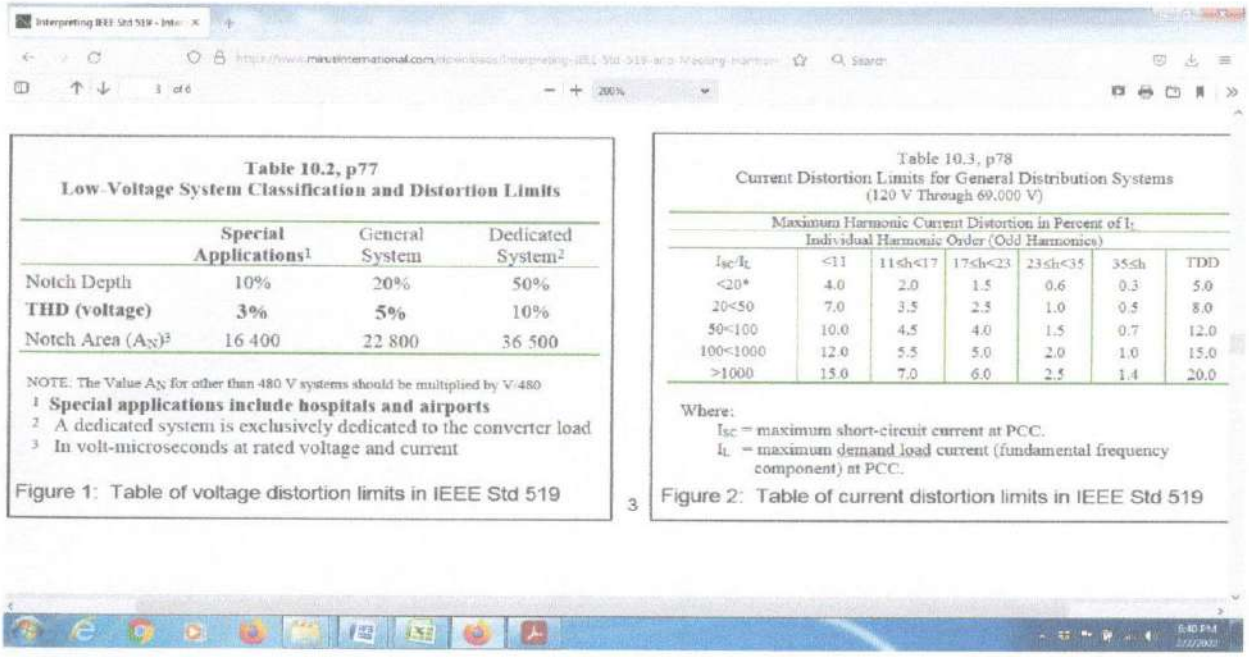


Table 10.2, p77
Low-Voltage System Classification and Distortion Limits

	Special Applications[1]	General System	Dedicated System[2]
Notch Depth	10%	20%	50%
THD (voltage)	**3%**	**5%**	10%
Notch Area (A_N)[3]	16 400	22 800	36 500

NOTE. The Value A_N for other than 480 V systems should be multiplied by V/480
1 **Special applications include hospitals and airports**
2 A dedicated system is exclusively dedicated to the converter load
3 In volt-microseconds at rated voltage and current

Figure 1: Table of voltage distortion limits in IEEE Std 519

Table 10.3, p78
Current Distortion Limits for General Distribution Systems
(120 V Through 69,000 V)

	Maximum Harmonic Current Distortion in Percent of I_L Individual Harmonic Order (Odd Harmonics)					
I_{SC}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Where:
I_{SC} = maximum short-circuit current at PCC.
I_L = maximum demand load current (fundamental frequency component) at PCC.

Figure 2: Table of current distortion limits in IEEE Std 519

Fig-4.5: Recommended Harmonic Current &Voltage Limits

4.6 Capacitor Banks

4.6.1 Installed Capacity & Rated Performance of Capacitors

Installed Capacity Rated Performance of Capacitors as per Manufacturer on 440 V is as per Table-4.10.

Sl No	Capacity of Capacitor at 440 V (KVAR)	Make	Nos	Total Rated Capacity at 440 V (KVAR)	Effective Capacity at 400 V (KVAR)	Total Effective Capacity at 400 V (KVAR)	Rated current at 400 Volt (A)
1	20	L&T	7	140	16.5	115.5	23.6
2	15	L&T	1	15	12.38	12.38	17.7
3	7.5	L&T	1	7.5	6.2	6.2	8.8
4	4	L&T	2	8	3.3	6.6	4.7
5	2	L&T	2	4	1.65	3.3	2.35
6	1	L&T	1	1	0.83	0.83	1.17
	Total		14	**175.5**		**144.81**	

Table-4.10: Specifications of Capacitors of Transformer 650 KVA

4.6.2 Performance Measurement of Capacitor Bank

Performance of all 14 no Capacitors was checked by measuring current drawn by individual units with respect to rated current. The results were found satisfactory.

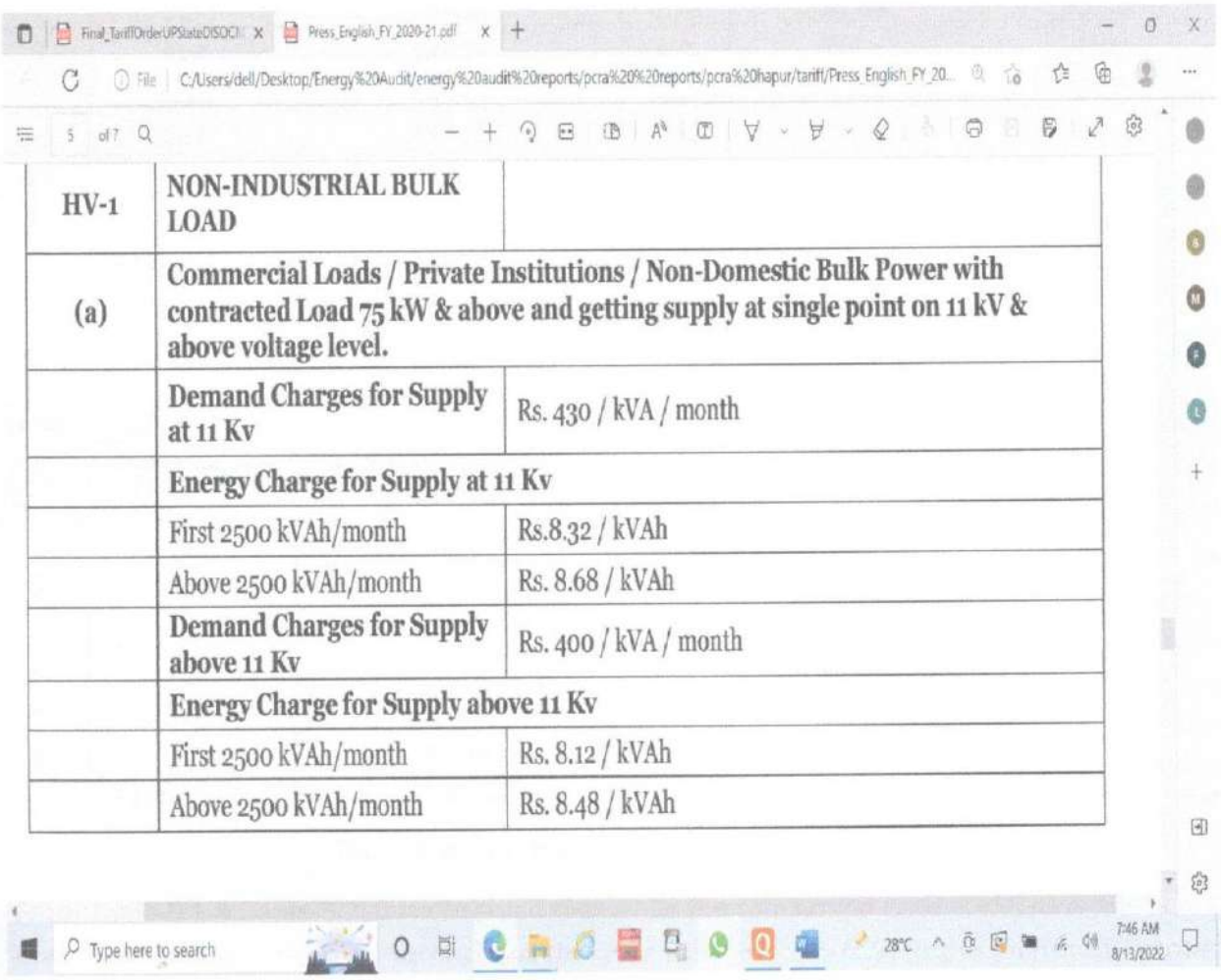
Fig-4.6: Capacitor Bank

CHAPTER-5

REVIEW OF ELECTRICITY BILLS, CONTRACT DEMAND

5.1 Electrical Energy Consumption from Grid

The power is supplied to KIT, Kanpur by Kanpur Electricity Company (KESCO). The Tariff applicable for KIT, Kanpur is under HV-1 category and shown in Fig-5.1. The fixed charges are Rs 8.12 to 8.48 per KVAH depending upon consumption and Demand charges are Rs 430/KVA.



HV-1	**NON-INDUSTRIAL BULK LOAD**	
(a)	**Commercial Loads / Private Institutions / Non-Domestic Bulk Power with contracted Load 75 kW & above and getting supply at single point on 11 kV & above voltage level.**	
	Demand Charges for Supply at 11 Kv	Rs. 430 / kVA / month
	Energy Charge for Supply at 11 Kv	
	First 2500 kVAh/month	Rs.8.32 / kVAh
	Above 2500 kVAh/month	Rs. 8.68 / kVAh
	Demand Charges for Supply above 11 Kv	Rs. 400 / kVA / month
	Energy Charge for Supply above 11 Kv	
	First 2500 kVAh/month	Rs. 8.12 / kVAh
	Above 2500 kVAh/month	Rs. 8.48 / kVAh

Fig-5.1: Tariff applicable for Institute

5.2 Grid Energy Consumption

Grid Energy Consumption for year 2021 & 2022 have been tabulated in Table- 5.1 and Table-5.2

Sr No	Month (Year 2021)	Electricity Consumption grid (KVAH)	P.F	Actual Demand (KVA)	Demand Charged (KVA)
1	Jan	14390	0.84	130.4	337.5
2	Feb	17643	0.89	144.6	337.5
3	Mar	6532	0.86	187.8	337.5
4	Apr	NA	NA	NA	Lock down
5	May	3036			337.5
6	Jun	11805	0.8	178.44	337.5
7	Jul	29730	0.78	210.84	337.5
8	Aug	33639	NA	NA	NA
9	Sept	33540	0.82	249.72	337.5
10	Oct	21561	0.83	305.52	337.5
11	Nov	22773	0.81	155.4	337.5
12	Dec	32541	0.84	168.6	337.5
Total		**227190**		**1731.32**	**3375**

Table-5.1: Grid Energy Consumption Year 2021

Sr No	Month (Year 2022)	Electricity Consumption grid (KVAH)	PF	Actual Demand (KVA)	Demand Charged (KVA)
1	Jan	34374	0.88	153.12	337.5
2	Feb	1056	0.94	94.08	337.5
3	March	11994	0.98	123.84	337.5
4	Apr	29241	0.9	102.84	337.5
5	May	41745	0.99	212.28	337.5
6	Jun	56283	1	298.64	337.5
Total		**174693**		**984.8**	**2025**

Table-5.2: Grid Energy Consumption Year 2022 (Up to June)

From Table-5.1 & Table-5.2, it is observed that while the sanctioned Load is 450 KVA, the actual maximum demand recorded throughout the year was only 305 KVA in the month of October 2021. The payment for demand was done for 337.5 KVA (75% of sanctioned Load) continuously being the minimum demand charges. It is proposed to reduce sanctioned Load from 450 KVA to 350 KVA. As a result, the minimum chargeable demand will reduce to 262.5 KVA. It will save demand charges for (337.5-262.5) =75 KVA amounting Rs 32250 per year @Rs 430 per KVA.

5.3 Non-Conventional Electrical Energy Source

There is Rooftop Solar Power Plants in the institute of 450 KW capacity. The Solar Plant is connected with Grid through net metering and extra Power generated is accounted in bills of the Institute as per KESCO Tariff rules and regulations. The units generated in year 2022 and 2021 are shown in Table-5.3 and 5.4 respectively.

Sl. No	Month (Year 2022)	Solar Power Generation (KVAH) as per Solar Meter	Export (KVAH) as per KESCO Meter	Net Solar Power consumption (KVAH)
A	B	C	D	E=(C-D)
1	Jan	26681	8184	18497
2	Feb	44935	20346	24589
3	March	34659	10548	24111
4	April	47113	9030	38083
5	May	35421	3108	32313
6	June	52757	5184	47573
	Total	**241566**	**56400**	**185166**

Table-5.3: Solar Power Generation of Year 2022

Sl. No	Month (Year 2021)	Solar Power Generation (KVAH) as per Solar Meter	Export (KVAH) as per KESCO Meter	Net Solar Power consumption (KVAH)
A	B	C	D	E=(C-D)
1	Jan	17395	2922	14473
2	Feb	33836	13476	20360
3	Mar	27311	11694	15617
4	Apr	24902	11592	13310
5	May	19059	10734	8325
6	Jun	31490	7986	23504
7	Jul	25556	2808	22748
8	Aug	33005	6024	26981
9	Sept	32488	7236	25252
10	Oct	48848	16860	31988
11	Nov	18984	3036	15948
12	Dec	21479	3942	17537
Total		**334353**	**98310**	**236043**

Table-5.4: Solar Power Generation of Year 2021

From Table-5.4, it is being observed that in year 2021, 98310 units were exported to grid at negligible cost. Attempt should be made to utilize these units by running nonscheduled load such as pumps during 7 AM to 2 PM.

5.4 Total Electrical Power Consumption

The total Electrical power consumption (Grid + Solar) for year 2021 & 2022 has been shown in Table-5.5.

Sr No	Month (Year 2021)	Electricity Consumption grid (KVAH)	Solar Power Consumption (KVAH)	Total Electricity Consumption (KVAH)
1	Jan	14390	14473	28863
2	Feb	17643	20360	38003
3	Mar	6532	15617	22149
4	Apr	NA	13310	13310
5	May	3036	8325	11361
6	Jun	11805	23504	35309
7	Jul	29730	22748	52478
8	Aug	33639	26981	60620
9	Sept	33540	25252	58792
10	Oct	21561	31988	53549
11	Nov	22773	15948	38721
12	Dec	32541	17537	50078
Total		**227190**	**236043**	**463233**

Sr No	Month (Year 2022)	Electricity Consumption grid (KVAH)	Solar Power Consumption (KVAH)	Total Electricity Consumption (KVAH)
1	Jan	34374	18497	52871
2	Feb	1056	24589	25645
3	March	11994	24111	36105
4	Apr	29241	38083	67324
5	May	41745	32313	74058
6	Jun	56283	47573	103856
	Total	**185166**	**359859**	

Table-5.5: Total Electrical Power Consumption for Year 2021 & 2022

CHAPTER-6

DETAILS OF MAJOR EQUIPMENT CONNECTED WITH THE SYSTEM

6.1 Sanctioned Load:

The sanctioned load of the Institute is 450 KVA.

6.2 Connected Load of Electrical Appliances

Sl. No.	Name of Item	Capacity (Watts)	Total (Nos.)	Connected Load (kW)
1	CFL	36	740	26.64
2	LED Lamps	9	264	2.38
	LED Lamps	20	10	0.2
3	Tube light	36	320	11.52
4	LED Tube Light	20	672	13.44
5	Pole Lights	500	4	2
6	LED Pole Lights	45	50	2.25
		70	32	2.24
		200	10	2
7	Fans	55	150	8.25
8	Ceiling Fan	60	563	33.78
9	**Exhaust Fan**			
	18 inches	250	9	2.25
	15 inches	150	2	0.3
	12 inches	100	20	2
	9 inches	70	29	2.03
10	**Air Conditioners**			
	1.0 T	1100	1	1.1
	1.5 T	1800	4	7.2
	2.0 T	2200	25	55
11	**Packaged Air Conditioners**			
	4.0 T	4800	20	96
	5.5 T	6600	4	26.4
	11 T	13200	1	13.2
	16.5 T	19200	4	76.8
12	Computer system	200	250	50
13	Printers	1000	31	31
14	Photocopier	1000	2	2

Sl. No.	Name of Item	Capacity (Watts)	Total (Nos.)	Connected Load (kW)
15	Refrigerator	200	7	1.4
16	Projectors	300	5	1.5
17	Pumps	2200	7	15.4
18	Motors	2000	12	24
19	Fire Motors	2400	2	4.8
	Grand Total			**517.08**

Table-6.1: Connected Load of Electrical Appliances

The total connected load was found 517.08 KW including Air conditioning load. As such Sanctioned load of 450 KVA is on higher side using Diversity factor as 0.6.

CHAPTER-7

LIGHTING AND ILLUMINATION

7.1 Lighting Load

Following are the Lighting Load details of luminaries installed in the Institute Premises

Sl. No.	Name of Item	Capacity (Watts)	Total (Nos.)	Connected Load (kW)
1	CFL	36	740	26.64
2	LED Lamps	9	264	2.38
	LED Lamps	20	10	0.2
3	Tube light	36	320	11.52
4	LED Tube Light	20	672	13.44
5	Pole Lights	500	4	2
6	LED Pole Lights	45	50	2.25
		70	32	2.24
		200	10	2
Grand Total				**62.67**

Table-7.1: Lighting Load

7.2 Illumination Levels

The Lux levels of various places measured at various places have been shown in Table-7.2

Sr No	Particulars	Lux Level	Sr No	Particulars	Lux Level
1	Director office room no 140	197	16	Boy Hostel room no A 111	136
2	Room no 139	168	17	Room no A 109	64
3	Society Office room no 1	191	18	B Block Gallery	67
4	Admissions room no 133	116	19	Boy Hostel Toilet 1st floor	78
5	Reading room library	180		**Street Light (Night time)**	
6	Computer Lab 2	140	20	Polytechnic Road light 2	53
7	P.C.R.C Block	262	21	Academic Building front side	14
8	Canteen	113	22	Academic Building backside	29
9	Room no 132 Exam Hall		23	Outside Girl's Hostel gate	23
10	Mess		24	Girl's hostel	6
11	Work Shop 1	95	25	Road Near Stadium	42
12	Room no 137 Toilet	66	26	Near Boy Hostel	53
13	LT 101	61	27	Near D G room	40
14	Girls Hostel room no 109	114	28	Inside Main gate	47
15	Room no 107	77	29	Outside Main gate	39

Table-7.2: Lux Levels of various Buildings

7.3 EE Measure

The technologies which have been identified in the Demand Side Management are as follows:

i. Replacement of CFL with LED Lamps
ii. Replacement of T12 FTL with LED FTL

7.3.1 Replacement of CFL with LED Lamps

All CFL 36 W should be replaced by LED FTL of 20 W capacity as shown in Table-7.3. The payback has been calculated on 8 Hrs. per day and 300 days basis per year.

Sl No	Particulars	Quantity	Unit
1	Total nos. of CFLs of 36 W capacity	740	Nos.
2	Proposed replacement of 36 W CFL by 20 W LED Tube Light @ Rs 300 per lamp	222000	Rs
3	Energy saved by replacement @ 18 watts/unit for 8 hours/day and 300 days per year for 740 lamps	28416	KWH
4	Cost of electricity savings per year @ Rs 8.50 per unit	241536	Rs
5	**Payback period (Year)**	0.92	**Years**

Table-7.3: The Pay Back calculations of Replacement of CFL with LED Lamps

7.3.2 Replacement of 40 W traditional Tube lights with energy efficient 20 W LED Tube lights

T12 FTLs of 36 W can be replaced by 20 W LED Tub-Light.

Sl No	Particulars	Quantity	Unit
1	Total nos. of FTLs of 36 W capacity	320	Nos.
2	Cost of installation @ Rs 300 per LED Tube light	160000	Rs
3	Energy saved by replacing 36 W FTLs by 20 W LED Tube Light @ 16 watts for 8 hours/day and 300 days per year	12288	KWH
4	Cost of electricity savings per year @ Rs 8.5 per unit	104448	Rs
5	**Payback period (Year)**	**1.53**	**Years**

Table-7.4: Pay Back Calculations for replacement of Traditional Tube lights to LED Tube Light

CHAPTER-8

DG SETS

8.1 Specifications of DG Sets

DG sets of the specifications as per Table-8.1 are installed in the Premises

Sl. No.	Make	Model	Rating (KVA)	Stand by or Continuous operation	Actual Average Loading	Avg. kWh Units /Lit. of Oil
1	Jackson-Cummins	S38G7	62.5	STAND BY	Rarely used	
2	Jackson-Cummins	6BTA59G2-I	125	STAND BY	57.71	3.84
3	Jackson-Cummins	NTA-14-G3	380	STAND BY	166.39	4.1

Table-8.1: Specifications of DG Sets

Fig-8.1: DG Set 380 KVA

Fig-8.2: DG Set 125 KVA

Fig-8.3: DG Set 62.5 KVA

8.2 Running hours and Diesel consumption for Year 2021-22

Month	Running hrs (All Gensets)	Consumption (KL) (All Gensets)
May-22	18.8	0.62
Apr-22	7.6	0.28
Mar-22	4	0.13
Feb-22	18.4	0.38
Jan-22	14	0.34
Dec-21	19.8	0.61
Nov-21	17	0.51
Oct-21	19.4	0.33
Sep-21	31	0.76
Aug-21	35.8	0.7
Jul-21	33.4	0.7
Jun-21	9.1	0.23
Total one Year	**228.3**	**5.59**

Table-8.2: Running Hours and Diesel Consumption of DG Sets

Average running Hours per day of all DG Sets during past 1 year: 0.761 Hr.

8.3 Performance Test of DG Set

As the running Hours per day of DG sets are very less, performance evaluation is not necessary. Also, the Diesel consumption of individual DG Set was not available. However, DG Set of 380 KVA capacity was chosen for Performance Test and was run for 58 minutes from 02.01 PM to 02.59 PM on dated 26.07.2022 and Diesel consumption was noted. Units produced along with load were recorded, which have been tabulated in Table-8.3.

Time:	Ep1 (Wh)	Ep2 (Wh)	Ep3 (Wh)	EpT (Wh)
2:01:00 PM	0	0	0	0
2:02:00 PM	1200	1132	888.2	3221
2:03:00 PM	2408	2257	1778	6443
2:04:00 PM	3629	3401	2687	9718
2:05:00 PM	4848	4538	3584	12969
2:06:00 PM	6027	5642	4456	16124
2:07:00 PM	7209	6705	5319	19233
2:08:00 PM	8387	7769	6182	22338
2:09:00 PM	9566	8862	7083	25511
2:10:00 PM	10747	9947	8010	28705
2:11:00 PM	11916	11025	8934	31875
2:12:00 PM	13083	12100	9856	35039

Time:	Ep1 (Wh)	Ep2 (Wh)	Ep3 (Wh)	EpT (Wh)
2:13:00 PM	14253	13173	10775	38201
2:14:00 PM	15420	14246	11694	41359
2:15:00 PM	16581	15315	12612	44508
2:16:00 PM	17750	16373	13537	47661
2:17:00 PM	18933	17448	14490	50871
2:18:00 PM	20119	18517	15418	54054
2:19:00 PM	21306	19594	16333	57233
2:20:00 PM	22498	20662	17240	60400
2:21:00 PM	23688	21758	18142	63588
2:22:00 PM	24876	22855	19041	66772
2:23:00 PM	26059	23944	19936	69939
2:24:00 PM	27230	25013	20805	73048
2:25:00 PM	28431	26080	21684	76195
2:26:00 PM	29637	27146	22565	79348
2:27:00 PM	30834	28215	23446	82495
2:28:00 PM	32046	29295	24333	85674
2:29:00 PM	33269	30389	25238	88896
2:30:00 PM	34530	31477	26177	92185
2:31:00 PM	35834	32593	27161	95588
2:32:00 PM	37117	33707	28161	98985
2:33:00 PM	38411	34828	29166	102405
2:34:00 PM	39705	35934	30166	105805
2:35:00 PM	40994	37030	31167	109191
2:36:00 PM	42281	38133	32173	112587
2:37:00 PM	43573	39248	33180	116001
2:38:00 PM	44863	40346	34181	119390
2:39:00 PM	46138	41446	35179	122763
2:40:00 PM	47395	42542	36173	126110
2:41:00 PM	48641	43634	37167	129443
2:42:00 PM	49882	44731	38156	132768
2:43:00 PM	51142	45829	39111	136082
2:44:00 PM	52412	46927	40081	139420
2:45:00 PM	53696	47990	41076	142762
2:46:00 PM	54988	49032	42042	146062
2:47:00 PM	56282	50081	43003	149365
2:48:00 PM	57590	51179	43981	152750
2:49:00 PM	58880	52287	44954	156121
2:50:00 PM	60170	53449	45925	159543
2:51:00 PM	61458	54623	46906	162987
2:52:00 PM	62760	55789	47884	166432
2:53:00 PM	64068	56946	48852	169867

Time:	Ep1 (Wh)	Ep2 (Wh)	Ep3 (Wh)	EpT (Wh)
2:54:00 PM	65366	58123	49835	173325
2:55:00 PM	66671	59330	50824	176826
2:56:00 PM	67979	60544	51795	180318
2:57:00 PM	69279	61733	52759	183771
2:58:00 PM	70558	62894	53697	187149
2:59:00 PM	71772	64055	54630	190457

Table-8.3: Energy Parameters recorded by Power Analyzer

From Table-8.3, Unit produced during 58 minutes time are 190457 WH i.e., 190.457 kWh

The Diesel consumption was 60 Liters.

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
D1 (var)	7/26/2022	2:01:00 PM	7.317	6.827	8.094	kvar	58:00	(min:s
D2 (var)	7/26/2022	2:01:00 PM	6.250	5.976	6.645	kvar	58:00	(min:s
D3 (var)	7/26/2022	2:01:00 PM	5.766	5.590	5.978	kvar	58:00	(min:s
DT (var)	7/26/2022	2:01:00 PM	20.47	19.57	22.12	kvar	58:00	(min:s
P1 (W)	7/26/2022	2:01:00 PM	74.25	69.69	78.53	kW	58:00	(min:s
P2 (W)	7/26/2022	2:01:00 PM	66.26	62.48	72.82	kW	58:00	(min:s
P3 (W)	7/26/2022	2:01:00 PM	56.51	51.78	60.44	kW	58:00	(min:s
PT (W)	7/26/2022	2:01:00 PM	197.0	186.3	210.1	kW	58:00	(min:s

Fig-8.4: Load Parameters recorded by Power Analyzer

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
PF1	7/26/2022	2:01:00 PM	0.939	0.935	0.943		58:00	(min:s)
PF2	7/26/2022	2:01:00 PM	0.933	0.923	0.942		58:00	(min:s)
PF3	7/26/2022	2:01:00 PM	0.912	0.904	0.925		58:00	(min:s)
PFT	7/26/2022	2:01:00 PM	0.929	0.923	0.937		58:00	(min:s)

Fig-8.5: Power Factor recorded during Test

From Fig-8.4, the average load recorded by Power analyzer was 197 KW and from Fig-8.5, Average Power factor was 0.929, which means load of 212 KVA. As such percentage loading of Genset is 212/380*100= 55.8%.

Specific Fuel Consumption= 60/190.457=0.315 Liters/kWh

The Specific Fuel Consumption of DG set is found satisfactory. It is less than to 0.349 for 320*0.65=240 KVA as per Fig-8.6 (Ref. Table 9.5, page 176, Book 3 BEE SI No 14) for equivalent capacity.

TABLE 8.5TYPICAL FORMAT FOR DG SET MONITORING						
DG Set No.	Electricity Generating Capacity (Site), kW	Derated Electricity Generating Capacity, kW	Type of Fuel used	Average Load as % of Derated Capacity	Specific Fuel Cons. Lit/kWh	Specific Lube Oil Cons. Lit/kWh
1.	480	300	LDO	89	0.335	0.007
2.	480	300	LDO	110	0.334	0.024
3.	292	230	LDO	84	0.356	0.006
4.	200	160	HSD	89	0.325	0.003
5.	200	160	HSD	106	0.338	0.003
6.	200	160	HSD			
7.	292	230	LDO	79	0.339	0.006
8.	292	230	LDO	81	0.362	0.005
9.	292	230	LDO	94	0.342	0.003
10.	292	230	LDO	88	0.335	0.006
11.	292	230	LDO	76	0.335	0.005
12.	292	230	LDO	69	0.353	0.006
13	400	320	HSD	75	0.334	0.004
14.	400	320	HSD	65	0.349	0.004
15.	880	750	LDO	85	0.318	0.007
16.	400	320	HSD	70	0.335	0.004
17.	400	320	HSD	80	0.337	0.004
18.	880	750	LDO	78	0.345	0.007
19.	800	640	HSD	74	0.324	0.002
20.	800	640	HSD	91	0.290	0.002
21.	880	750	LDO	96	0.307	0.002
22.	920	800	LDO	77	0.297	0.002

Fig 8.6: Specific Fuel Consumption of DG sets as per BEE for monitoring purpose

CHAPTER-9

HEATING, VENTILATION & AIR-CONDITIONING (HVAC) SYSTEM

9.1 Details of HVAC System

The details of Air conditioning equipment installed in the premises are as per Table-9.1.

Sl. No	Name of Item	Total Nos.	Total Tonnage	Make	Year	Rating
	Air Conditioners					
1	**Window**					
	1.0 T	1	1			
	1.5 T	2	3			Three Star
	2.0 T	1	2	Electrolux	2008	Non-Star
		1	2	Voltas	2021	Two Star
		2	4	LG	NA	Non-Star
2	**Split AC**					
	1.5 T	1	1.5		NA	Non-Star
	2.0 T	1	2		2018	Non-Star
	2.0 T	1	2	Samsung	2008	Two Star
	2.0 T	1	2	Videocon	2009	Three Star
	2.0 T	5	10	Panasonic	2012	Non-Star
	2.0 T	1	2	Voltas	2013	Three Star
	2.0 T	5	10	Dakin	2015	Non-Star
	2.0 T	1	2	Dakin	2016	Non-Star
	2.0 T	2	4	Voltas	2016	Non-Star
	2.0 T	1	2	Voltas	2017	Three Star
	2.0 T	3	6	Voltas	2019	Three Star
	Packaged Air Conditioners					
1	4.0 T	20	80	Blue Star		
2	5.5 T	4	22	Blue Star		
3	11 T	1	11	Blue Star		
4	16.5 T	4	64	Blue Star		
	Grand Total		**232.5**			

Table-9.1 Details of Air Conditioners

9.2 Performance Test

Sr No	Place	Type	Ton	Year	Star Rating	Average Ampere (Amp)	Voltage (V)	Power Drawn (KW)	Power Drawn/Ton (KW/Ton)
1	Ad office Room No 139	W	1.5	2018	3	5.4	217	1.15	0.77
2	Room No 136	S	1.5	NA	No	6.9	219	1.48	0.99
3	Director Office Room No 140	S	2	2017	3	7	218	1.50	0.75
4	Admission Room No 133	S	2	2019	3	7	230	1.58	0.79
5	Room No 124	W	2	NA	No	11.1	209	2.27	1.14
6	Room No 125	W	2	2021	2	8	215	1.69	0.84
7	Room No 125	W	2	NA	2	8.1	215	1.71	0.85
8	Room No 132	S	2	2019	3	7.2	225	1.59	0.79
9	Society Office Room No 1	S	2	2015	No	7.9	226	1.75	0.87
10	N S H Hall	P	4	NA		6.6	397	4.45	1.11
11		P	4	NA		6.5	380	4.19	1.05
12		P	4	NA		7.2	380	4.64	1.16
13	Room No 120	P	5.5	NA		9.5	382	6.16	1.12
14	Stadium	P	16.5	NA		19	385	12.42	0.75

Table-9.2: Performance Test of various Air Conditioners

Power drawn per Ton is not giving any clear picture as most of the rooms were not having staff/ students due to holidays.

9.3 Energy Efficiency Measures

It is proposed to replace non star two Tons window and Split Air Conditioners as detailed below:

Sl. No	Name of Item	Total Nos.	Make	Year	Rating
1	**Window AC**				
	2.0 T	3	Electrolux/LG	2008	Non-Star
2	**Split AC**				
	2.0 T	5	Panasonic	2012	Non-Star

Table-9.3: Proposed Air Conditioners for replacement

EER of none of the Air conditioner was available with the institute. For EE measures, it was taken from various notifications issued by BEE, based on year of purchase as per Figure-9.1 & Figure-9.2.

Table 3.1

Unitary Type Air Conditioners

Table 3.1(a)

(From 12th January, 2009 to 31st December, 2011)

Energy Efficiency Ratio (Watt/Watt)		
Star level	Minimum	Maximum
1 Star	2.3	2.49
2 Star	2.5	2.69
3 Star	2.7	2.89
4 Star	2.9	3.09
5 Star	3.1	

Table 3.1(b)

(From 1st January, 2012 to 31st December, 2013)

Energy Efficiency Ratio (Watt/Watt)		
Star level	Minimum	Maximum
1 Star	2.3	2.49
2 Star	2.5	2.69
3 Star	2.7	2.89
4 Star	2.9	3.09
5 Star	3.1	

Table 3.2

Split Type Air Conditioners

Table 3.2(a)

(From 12th January, 2009 to 31st December, 2011)

Energy Efficiency Ratio (Watt/Watt)		
Star level	Minimum	Maximum
1 Star	2.3	2.49
2 Star	2.5	2.69
3 Star	2.7	2.89
4 Star	2.9	3.09
5 Star	3.1	

Table 3.2(b)

(From 1st January, 2012 to 31st December, 2013)

Energy Efficiency Ratio (Watt/Watt)		
Star level	Minimum	Maximum
1 Star	2.5	2.69
2 Star	2.7	2.89
3 Star	2.9	3.09
4 Star	3.1	3.29
5 Star	3.3	

Fig-9.1: EER as per BEE Notifications for Year 2009-11 & 2012-13

Table 3.1(f)

(From 1st January, 2021 to 31st December, 2023)

Indian Seasonal Energy Efficiency Ratio (kWh/kWh)		
Star level	Minimum	Maximum
1 Star	2.7	2.89
2 Star	2.9	3.09
3 Star	3.1	3.29
4 Star	3.3	3.49
5 Star	3.5	

Table 3.2(f)

(From 1st January, 2021 to 31st December, 2023)

Indian Seasonal Energy Efficiency Ratio (kWh/kWh)		
Star level	Minimum	Maximum
1 Star	3.3	3.49
2 Star	3.5	3.79
3 Star	3.8	4.39
4 Star	4.4	4.99
5 Star	5.0";	

Fig-9.2: EER as per BEE Notifications for Year 2021-2023

9.4 Pay Back Period per Unit of Air Conditioner

Pay Back Period per Unit of Air Conditioner proposed for replacement has been shown in Table-9.4.

Existing Air Conditioner (Each unit)				Proposed Air Conditioner (Each unit))						
S. No.	Details	Rated Watt	EER	Details	EER of new AC	Effective Power drawn (W)	Energy Saving per year (kWh)	Cost of Energy saving @ Rs 8.50	Cost of new Five star AC/ Unit (Rs)	Pay Back Period (Yrs.)
1	2	3	4	5	6	7=3*4/6	8= (3-7) *10 Hr* 150 Days/ 1000	9=8*8.50	10	11=10/ 9
1	Window AC 2 Ton capacity non star year 2008	2100	2.2	Window AC 2 Ton capacity five-star year 2021	3.5	1320.00	1170	9945.00	42000	4.22
4	Split AC 2 Ton non star 2012	1700	2.4	Split AC Five Star 2 Ton as per BEE spec Jan 2021	5	816.0	1326	11271.00	52000	4.61

Table-9.4: Pay Back Period per Unit Air Conditioner

Note: The cost of new Air Conditioner has been taken after deducting scrap value equivalent to Rs 3000/-per unit

9.5 Investment, Energy saving and Pay Back Period for all proposed Air Conditioners

Investment required, Energy saving and Pay Back Period for all the proposed Air Conditioners has been shown in Table-9.5

S. No.	Existing Air Conditioner details	Proposed Air Conditioner details	Qty	Energy Saving per year (kWh)	Total Energy saving per year (kWh)	Total Cost of Energy saving @ Rs 8.50	Cost of new Five-star AC/ Unit (Rs)	Total Cost of new Five-star AC/ Unit (Rs)	Pay Back Period (Yrs.)
1	2	3	4	5	6=4*5	7=6*8.50	8	9=4*8	10=9/7
1	Window AC 2 Ton capacity non star year 2008	Five Star Window AC 2 Ton capacity	3	1170	3510	29835	42000	126000	4.22
2	Split AC 2 Ton capacity non star year 2012	Five Star Split AC 2 Ton capacity	5	1326	6630	56355	52000	260000	4.61
	Grand Total					10140	86190		386000

Table-9.5: Investment, Energy saving and Pay Back Period for all proposed Air Conditioners

CHAPTER-10

ENERGY CONSERVATION OPTIONS & COST BENEFIT ANALYSIS

10.1 Energy Efficiency strategies

The technologies which have been identified in the Demand Side Management are as follows:

I. Replacement of CFL with LED Lamps
II. Replacement of T12 lamps with T5 lamps
III. Replacement of conventional air-conditioners with EE star rated ACs

The Energy consumption options and cost benefit analysis has been shown in Table-10.1.

Sr No	Name of Activity	Quantity	Energy saved (KWH) / Year	Cost of Energy saved/Year @ Rs 8.50 per unit (Rs)	Cost of replacement (Rs)	Payback period (Year)
1	Saving of Demand charges by Reduction of Sanctioned Load from 450 KVA to 350 KVA		Nil	32250	NIL	Immediate
2	Replacement of 36 W FTL with 20 W LED Tube lite	320	12288	104448	160000	1.53
3	Replacement of 36 W CFL by 20 W LED Tube Light	740	28416	241536	222000	0.92
4	Replacement of Window AC 2 Ton capacity non star year 2008 by Window AC 2 Ton capacity Five-Star rating	3	3510	29835	126000	4.22
5	Replacement of Split AC 2 Ton non star 2012 by Split AC Five Star 2 Ton	5	6630	56355	260000	4.61
	Total		**50844**	**464424**	**768000**	

Table-10.1: Energy saving, Investment & Payback Period of various EE Measures

CHAPTER-11

ENERGY CONSERVATION TIPS

11.1 Lighting System

- One of the best energy-saving devices is the light switch. Turn off lights when not required.
- Many automatic devices can help in saving energy used in lighting. Consider employing infrared sensors, motion sensors, automatic timers, dimmers and solar cells wherever applicable, to switch on/off lighting circuits.
- As for as possible use task lighting, which focuses light where it's needed. A reading lamp, for example, lights only reading material rather than the whole room.
- Dirty tube lights and bulbs reflect less light and can absorb 50 percent of the light; dust your tube lights and lamps regularly.

11.2 Room Air Conditioners

- Use ceiling or table fan as first line of defence against summer heat. Ceiling fans, for instance, cost about 30 paisa an hour to operate - much less than air conditioners (Rs.10.00 per hour).
- You can reduce air-conditioning energy use by as much as 40 percent by shading your home's windows and walls. Plant trees and shrubs to keep the day's hottest sun off your house.
- One will use 3 to 5 percent less energy for each degree air conditioner is set above 22°C (71.5°F), so set the thermostat of room air conditioner at 25°C (77°F) to provide the most comfort at the least cost.
- Using room ceiling or room fans allows you to set the thermostat higher because the air movement will cool
- A good air conditioner will cool and dehumidify a room in about 30 minutes, so use a timer and leave the unit off for some time.
- Keep doors to air-conditioned rooms closed as often as possible.
- Clean the air-conditioner filter every month. A dirty air filter reduces airflow and may damage the unit. Clean filters enable the unit to cool down quickly and use less energy.
- If room air conditioner is older and needs repair, it's likely to be very inefficient. It may work out cheaper on life cycle costing to buy a new energy-efficient air conditioner.

11.3 Motors

- Properly size to the load for optimum efficiency. (High efficiency motors offer of 4 - 5% higher efficiency than standard motors)

- Use energy-efficient motors, where found economical.
- Use synchronous motors to improve power factor.
- Check alignment.
- Provide proper ventilation (For every 10 degree C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)
- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply. (An imbalanced voltage can reduce 3 - 5% in motor input power)
- Demand efficiency restoration after motor rewinding. (If rewinding is not done properly, the efficiency can be reduced by 5 - 8%)

11.4 Pumps

- Operate pumping near best efficiency point.
- Modify pumping to minimize throttling.
- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- Repair seals and packing to minimize water waste.
- Balance the system to minimize flows and reduce pump power requirements
- Use siphon effect to advantage: don't waste pumping head with a free-fall (gravity) return

CHAPTER-12

LIST OF INSTRUMENTS

Followings Instruments were used for carrying Energy audit of the Institute:

i. Three Phase Power Analyzer
ii. Ultrasonic Flow meter
iii. Non-contact Temperature meter
iv. Anemometer
v. Digital Lux meter,
vi. Digital Thermo-Hygrometer,
vii. Digital Thermometer,
viii. Digital Capacitance meter,
ix. Digital Clamp on Power, current, voltage meter
x. Measurement Tape