Energy Audit Report

DELHI METROPOLITAN EDUCATION

Address – B-12, Sector-62, Noida, Uttar Pradesh, 201309

Audit Date – 25th Jan, 2022

Audit Conducted by:

M/S Samarth Management Private Limited
192, 3rd FLOOR, BHERA ENCLAVE, PASCHIM VIHAR, DELHI – 110087

Acknowledgement

Samarth Management Private Limited is thankful to **Delhi Metropolitan Education** for providing us an opportunity to conduct an Energy Audit of their esteemed Institute. We are grateful to the Management, officers, and staff of Delhi Metropolitan Education for showing keen interest in the study and for the help and co-operation extended to Samarth Management Private Limited team during the study.

We do hope that you will find the recommendations given in this report useful in helping you save energy. While we have made every attempt to adhere to high quality standards, in both data collection and analysis, as well as in presentation through the report, we would welcome any suggestions from your side as to how we can improve further.

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List of Abbreviations

SEC	-	Specific Energy Consumption

List of Units

^{o}C	-	Degree Celsius
CFM	-	Cubic Feet per Minute
CMH	-	Cubic Meter per Hour
LPM	-	Liters Per Minute
Kg/cm^2	-	Kilogram per centimeter square
kW	-	Kilo watt
kWh	-	Kilowatt hour
KOE	-	Kg of Oil equivalent
m^3/hr	-	Meter cube per hour
Nm^3/hr	-	Normal Meter cube per hour
MW	-	Mega Watt
MWh	-	Mega Watthour

1. Introduction

The working details of assignment are as follows:

Project	**Energy Audit**
Client	**Delhi Metropolitan Education**
Industry	**Educational Institute**
Contact	**Dr. Ravikant Swami** **Ph:91 9991102036** **info@dme.ac.in**
Site	**B-12, Block B, Industrial Area, Sector 62, Noida, Uttar Pradesh 201309**
Consultant	**Samarth Management Private Limited**
Duration	January 2022
Project Scope	Examination of detail energy audit in the utility and process to assess the loss in the system.
Report	This document gives recommendations, details of findings and the way forward
Consultants involved	Mr. Samarth Suri (Audit Manager) Mrs. Seema Suri (EA-0048) (Certified Energy Auditor) Mr. Sagar Mahour (Engineer) Mr. Sanjeev Sharma (Engineer)
Notes	- The critical points are marked in red - The assumptions are marked in blue - The suggestions / alternatives in the audit report are based on the present operating conditions of equipment/systems and to the best of our knowledge. - Investment figures are estimated values and recommended to obtain cost from vendor

1.1 Summary of Energy Conservation Measures

Table 1. **Summary of Energy Conservation Measures**

S. No	Energy Conservation Measure	Annual Savings Electricity		Investment	Payback
		kWh	Rs. Lakhs	Rs. Lakhs	Month
	Payback 12-24 months				
1	**AC Replacement** It is recommended to replace the 2/3 star with 5-star AC	31588.2	2.3	3.2	16.7
2	Improvement in Power Factor by installation of Capacitor Bank	10279	1.6	2.5	18.75
	Payback 48> months				
3	**Solar Installation** Solar Energy goes peak during daytime. Institute has flat roofs to produce clean energy and bringing positive impacts to environment. Solar Installation can bring in a greater score to the Institute by installing solar, as it is a step towards, sustainability, a step towards, being environmentally responsible.	179520	12.8	55.0	51.4
	Total	**221142.2**	**16.7**	**60.7**	**43.62**

2. Institute description and energy sources

2.1 About Institute

Delhi Metropolitan Education (DME) was established on 1st August, 2012, under the aegis of Sunshine Educational & Development Society which has been working dedicatedly in the field of education for over 16 years. DME is affiliated to the prestigious Guru Gobind Singh Indraprastha University (GGSIPU), New Delhi and is approved by the Bar Council of India.

DME envisions creating future leaders and nation builders by its endeavours in educating young minds. The institute is committed towards forming and sustaining conditions enabling students to embark on an unparalleled educational journey that is intellectually, socially, and personally transformative and enriching. DME offers sought after courses in the field of Management, Journalism and Law as given below:

- **BA(JMC) – Bachelor of Arts (Journalism and Mass Communication)**
- **BBA – Bachelor of Business Administration**
- **B.B.A. L.L.B (Integrated) – Bachelor of Business Administration Bachelor of Law (Integrated)**
- **B.A. L.L.B (Integrated) – Bachelor of Arts Bachelor of Law (Integrated)**

In a short span of time, DME has made a name for itself as one of the top colleges in NCR and a leading educational institute under GGSIPU. The institute is located 1.5km from Noida Sector 62 Metro Station and is well connected via Delhi-Meerut Expressway and Delhi-Noida-Direct Flyway (DND) for commuters.

2.2 Energy Sources and Cost

Electricity & fuel (Diesel) are major energy sources of the Institute. Electricity is supplied from Pashchimanchal Vidyut Vitran Nigam Limited
The Diesel as a thermal energy source is used mainly in DG. The energy cost from various sources of energy is given below:

Table 2. **Energy cost component of energy sources**

Source of energy	Unit	Cost
Electricity (Grid)	INR /kWh	15.55
Diesel	INR/Liter.	82

2.2.1 Electricity

The energy demand of the Institute is fulfilled by the electricity from Pashchimanchal Vidyut Vitran Nigam Limited. The annual energy consumption from electricity is as follows:

3. Observation and analysis

3.1 Electricity supply and Network

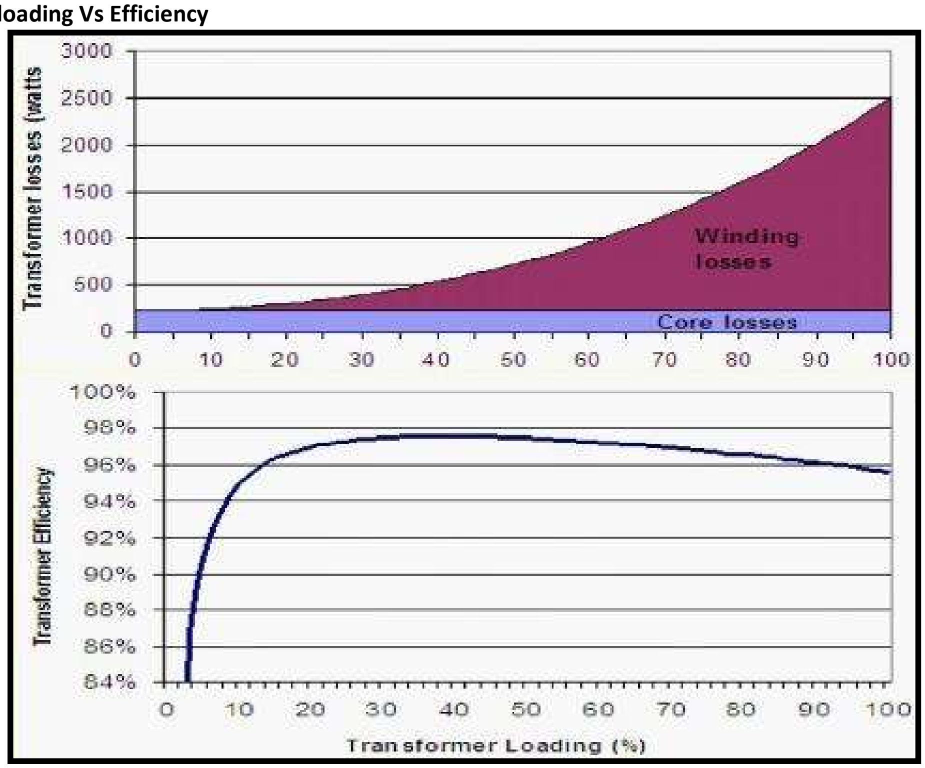
Electricity & fuel (Diesel) are major energy sources of the Institute. Electricity is supplied from Pashchimanchal Vidyut Vitran Nigam Limited

The Diesel is used for mainly in Diesel Generator.

3.2 Transformer loading

The efficiency of the transformers not only depends on the design but also, on the effective operating load. The variable losses depend on the effective operating load on the transformer. The maximum efficiency of the transformer occurs at a condition when the constant loss is equal to variable loss. For distribution transformers, the core loss is 15 to 20% of full load copper loss. Hence, the maximum efficiency of the distribution transformers occurs at a loading between 40 – 60%. For power transformers, the core loss is 25 to 30% of full load copper loss. Hence, the maximum efficiency of the power transformers occurs at a loading between 40 – 60%.

Transformer loading Vs Efficiency



All the electrical parameters required evaluating percentage loading & losses of Transformers were recorded for old building transformer.

No load and full load losses of the transformerare obtained from standards to calculate the transformer losses same is as follows.

Note: Total loss = No load loss+ Full load loss*(% Loading ^{2})

The efficiency of the transformers not only depends on the design but also, on the effective operating load. The variable losses depend on the effective operating load on the transformer.

Table 3. **Transformer loading**

Description	Transformer Capacity	Power factor	Maximum Apparent power	Average Apparent Power	Max Loading	Average Loading
	kVA	PF	kVA	kVA	%	%
TR1	250	0.892	128	83	51.2	33.2

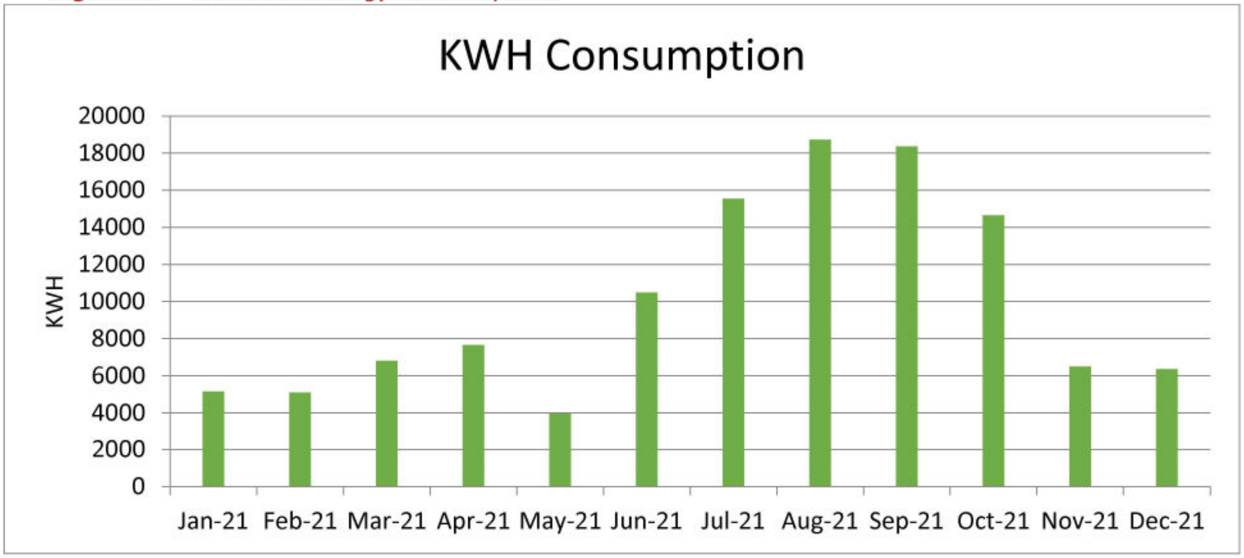
Average Transformer loading is quite less i.e 33.2 % to maximum 51.2%. Institute was closed due to Covid 19. Transformer efficiency is 97% approximately.

Table 4. **Month wise electrical energy consumption (12 Months data)**

Sr.No.	Billing Month	No. of Days	Working Hours	Sanctioned Load, KW	Units Consumed, kWh	Units Consumed, kVAH	Recorded Max. Demand, kVA	Average P.F.	Fixed Charge (Rs)	Energy Charge (Rs.)	Electricity Duty (Rs.)	Total Bill, Rs.	Grid Power Cost, Rs. / KWH	Billing Load Factor, %	Avg Load kVA	Grid Power Cost, Rs. / KVAH
1	Jan-21	31	9	150	5160	5961	27	0.866	48375	59249	8139.4	115763	22.43	79.13	21	19.42
2	Feb-21	28	9	150	5112	5928	22	0.862	48375	50972	7849.7	107197	20.97	107.41	24	18.08
3	Mar-21	31	9	150	6810	7737	50	0.880	48375	65678	8489.6	122543	17.99	55.05	28	15.84
4	Apr-21	30	9	150	7656	8553	61	0.895	48375	73340	9128.6	129632	16.93	51.96	32	15.16
5	May-21	31	9	150	3966	4746	15	0.836	48375	40295	6650.3	94440	23.81	113.86	17	19.90
6	Jun-21	30	9	150	10488	11202	114	0.936	48917	96333	10893.8	148005	14.11	36.47	41	13.21
7	Jul-21	31	9	150	15549	16296	128	0.954	54993	140549	14665.7	208257	13.39	45.67	58	12.78
8	Aug-21	31	9	150	18720	19710	126	0.950	54361	172182	16840.7	243471	13.01	55.98	71	12.35
9	Sep-21	30	9	150	18360	19290	113	0.952	48375	166537	16118.4	243471	13.26	63.51	71	12.62
10	Oct-21	31	9	150	14646	15732	114	0.931	49085	135654	13855.4	196746	13.43	49.40	56	12.51
11	Nov-21	30	9	150	6495	7890	113	0.823	48375	67585	8697.2	123498	19.01	25.98	29	15.65
12	Dec-21	31	9	150	6372	7773	113	0.820	48375	66570	8620.9	122416	19.21	24.76	28	15.75
Sum/Avg.				**150**	**119334**	**130818**	**128**	**0.892**	**594355**	**1134945**	**129950**	**1855439**	**15.55**	**59.10**	**39.73**	**14.18**

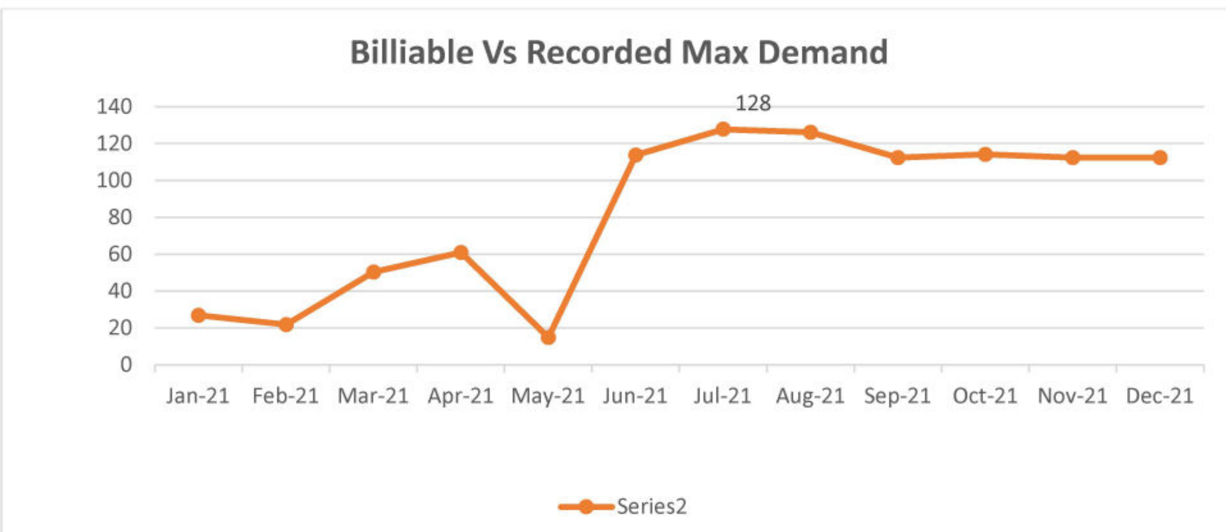
Graphical representation shown of energy Consumption

Figure 1. *Electrical Energy Consumption*



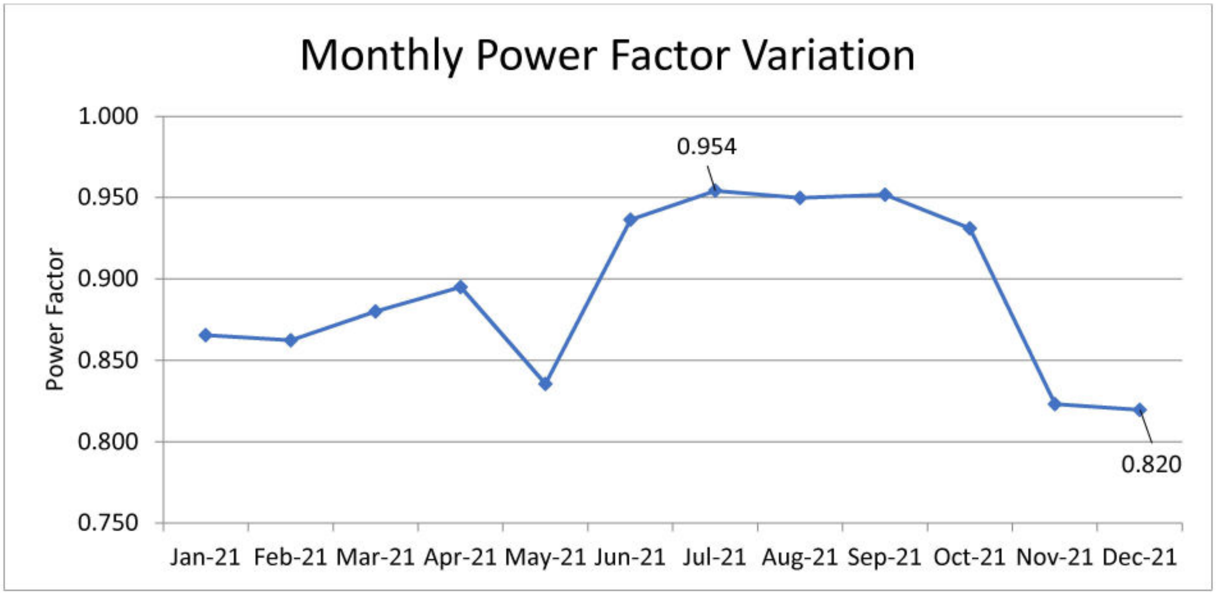
- It can be seen from figure 1, that electricity consumption in the month of August 21' is the highest.

Figure 2. *Billable Vs Recorded Maximum Demand*



- It can be seen from figure 2, that Recorded Highest maximum Demand is 128 KW in July 2021 Which is less than Sanctioned Load. So no action is required.

Figure 3. *Power Factor Variation*



- It can be seen from figure 3, that Recorded Highest Power Factor is 0.954 in July 2021 and Lowest is 0.82 in December 2021. Average Power Factor in Year 2021 is 0.892. Which is quite less. It can be increased to 0.99 by installation of Capacitor Banks and saving can be achieved.

3.3 Water Pumps

DME has installed Four Water pumps of 3 HP each to meet the requirement for usage in Kitchen and Washrooms. All the pumps are running as per the requirement. The detail operating parameters of these pumps were measured to analyze the performance and it is given below.

The following parameters have been measured / recorded to assess the performance of HVAC pumps:

1. Suction pressure
2. Discharge pressure
3. Power consumption
4. Flow rate

3.3.1 Water Pumps

Table 5. **Performance Analysis of water pumps.**

Water Pumps						
Description	**UOM**	**Pump 1**	**Pump 2**	**Pump 3**	**Pump 4**
Design					
Make		Crompton	Crompton	Crompton	Crompton
Model		B99576751P1 19030001	B99576751P11 19030002	B99576751P11 19030010	B99576751P11 19030030
Capacity	m^3/hr	50	50	50	50
Head	M	20	20	20	20
Power	KW	2.5	2.5	2.5	2.5
Operating Parameter					
Suction head	m	10	10	10	10
Discharge head	m	28	28	28	28
Total head	m	18	18	18	18
Flow rate	m^3/hr	46.76	46.76	46.76	46.76
Power consumption	kW	2.36	2.16	2.0	2.25
Combined efficiency	%	51%	61%	55%	65%
Pump Efficiency (ŋ Motor=91%)	%	59%	67%	63%	70%

- **Pump performance found satisfactory.**

3.4 Air conditioners

The Institute has installed 141 Nos. Window, Split and Cassette AC for human comfort.

S. No.	Quantity		
	Split	**Window**	**Cassette**
1.00 Ton AC	5		
1.5 Ton AC	90	1	
2.00 Ton AC	31		
3.00 Ton Cassette AC			6
4.00 Ton Cassette AC			2
Total ACs	**135**		

The analysis was done on few samples to identify the measures that could be undertaken to reduce the energy consumption. The following parameter has studied in each unit.

- Air flow rate
- Air flow cross section area
- Return dry bulb temperature.
- Return wet bulb temperature.
- Power consumption
- Supply dry bulb temperature.
- Supply wet bulb temperature.

Table 6. **Performance Analysis of AC**

Parameters	Units	Window ACs				
Location		Class Rooms	Class Rooms	Class Rooms	Staff Room	Staff Room
Design Capacity	TR	1.5	1.5	1.5	4	4
Total Area	m^2	0.085	0.085	0.085	0.114	0.114
Measured avg. Velocity	m/s	2	1.9	2.2	3.4	3.2
Calculated Flow	m^3/hr	612.0	581.4	673.2	1395.4	1313.3
Supply Air Dry Bulb Temp.	C^0	26	23	28	27	26
Supply Air Wet Bulb Temp.	C^0	18	17	19	18	17
Enthalpy supply air	KCal/Kg	12.1	11.4	12.9	12.1	11.4
Return Air Dry Bulb Temp.	C^0	29	27	30	29	28
Return Air Wet Bulb Temp.	C^0	24	24	25	24	24
Enthalpy return air	KCal/Kg	17.21	17.3	18.18	17.21	17.21
Density of Air	Kg/M^3	1.225	1.225	1.225	1.225	1.225
Calculated Capacity	TR	1.27	1.39	1.45	2.89	3.11
Power Consumption	KW	2.1	2.2	2.25	4.8	4.7
KW/TR		1.658	1.578	1.548	1.659	1.510
EER		7.239	7.605	7.752	7.235	7.946
COP		2.120	2.227	2.270	2.119	2.327

- **Observation:** AC can be replaced with five-star AC. Saving calculation given in ECM sheet.

Table 7. **Performance Analysis of AC**

Parameters	Units	Split ACs					
Location		Class Room	Class Room	Class Room	Class Room	Class Room	Class Room
Design Capacity	TR	2	2	2	2	2	2
Total Area	m^2	0.108	0.108	0.108	0.108	0.108	0.108
Measured avg. Velocity	m/s	4.3	4.2	2.9	2.2	2.9	4.6
Calculated Flow	m^3/hr	1671.8	1633.0	1127.5	855.4	1127.5	1788.5
Supply Air Dry Bulb Temp.	C^0	26	26	25	24	25	23
Supply Air Wet Bulb Temp.	C^0	20	21	17	16	18	19
Enthalpy supply air	KCal/Kg	13.7	14.5	11.4	10.7	12.1	12.9
Return Air Dry Bulb Temp.	C^0	27	29	28	26	28	29
Return Air Wet Bulb Temp.	C^0	23	25	22	23	23	23
Enthalpy return air	KCal/Kg	16.27	17.21	15.36	16.27	16.26	15.36
Density of Air	Kg/M^3	1.225	1.225	1.225	1.225	1.225	1.225
Calculated Capacity	TR	1.76	1.79	1.82	1.94	1.90	1.79
Power Consumption	KW	3.02	3.1	3	3.1	3.1	3.2
KW/TR		1.715	1.729	1.646	1.595	1.635	1.788

Parameters	Units	Split ACs					
EER		6.997	6.939	7.290	7.525	7.337	6.711
COP		2.049	2.032	2.135	2.203	2.149	1.965

- **Observation:** AC can be replaced with five-star AC. Saving calculation given in ECM sheet.

3.5 Lighting system

The Institute has already implemented energy efficient measures in lighting area at different places. All conventional lamps are replaced by LED Lamps. Recommended value of illumination given as per National Building Code of India, 2005 clause 4.1.3, 4.1.3.2, 4.3.2 and 4.3.2.1

Table 8. **Details of measured lux in Institute**

S.NO.	LOCATION NAME	MIN LUX	MAX LUX	Recommendation
1	MCC Room Table	121	126	100-200
2	MCC Room Near TR Incomer Panel	103	115	100-200
3	MCC Room Near DG Panel	28	32	100-200
4	Classrooms	310	450	300
5	Lecture rooms (including Demonstration areas)	310	450	300
6	Reading rooms	250	450	300-500
7	Laboratories	101	165	500-750
8	Corridors	150	170	150
9	Libraries	210	295	300
10	Auditorium i) Hall ii) Foyer iii)	245	450	300-500
11	Stage area	125	325	300
12	Cafeteria	80	120	100
13	Staff Room	155	185	150

Observation:

- It is recommended to installed occupancy sensors ex. restroom, offices, lobby, staircases, panel room etc.
- Institute has opted latest LED technology for lighting.
- Lux found satisfactory in many palaces but in some places, it is differed with standard. It can be maintained as per Institute requirement.

3.6 DG Performance

- DG rating installed Cummins = 125 KVA
- DG was run for only testing purpose for last 1 year as there was NO major power cut was observed
- Total diesel consumed = 1000 Ltrs

OBSERVATIONS

- No maintenance log books or servicing records were available at site. Hence efficiency of DG and Specific fuel consumption can not be calculated.

4. Power Quality Analysis

This report presents the results of power quality & harmonic analysis carried at Institute.
The agreed objectives of the assessment is analysis and the finding based on the analysis of parameters like frequency, voltage, current & waveforms, Total Harmonic Distortion (THD) etc.

The audit comprised of Power Quality & Harmonics Audit at main panel was taken using Calibrated Krykard ALM31 make Digital Power and Harmonic Analyser. This Electrical Power Quality audit report presents the analysis, findings and recommendations for improving the system efficiency.

Summary of measurements & recommendations are below:

Power Quality Analysis is done at Main Panel. Current and Voltage harmonics are within required level. No action is required for Power Quality.

Standards for Evaluation

3E Energy subscribes to the industry wide standards used for the evaluation of the electrical systems for computer installations, which include but are not limited to: Institute of Electrical and Electronic Engineers Standard 1100-2005, "Powering and Grounding Electronic Equipment", (Emerald Book)
The standards conform to the requirements of the National Electrical Code (NFPA 70). References:

- IEEE 1100 – 1999 & 2005 Emerald Book
- IEEE 446 - 1995 Orange Book
- Particulate and Gaseous Contamination Guidelines for Data Centers (ASHRAE TC 9.9)
- IEEE 142 – 1991 Green Book

BACKGROUND

Power Quality Analysis Audit carried out by using Krykard make ALM31 Load Manager at Institute.

This report presents the analysis and the finding based on the analysis of parameters like frequency, voltage, current & waveforms, Total Harmonic Distortion (THD) etc. The details of harmonic analysis are given in Appendix.

PROBLEMS DUE TO HARMONICS

Current harmonics causes increased losses in the power system and the components. The current harmonics also distort the voltage waveform and cause voltage harmonics. Voltage distortion affects not only sensitive electronic loads but also capacitor banks.
Higher frequency harmonic currents generally flow on the outer sides of the conductor due to the "skin effect" thus effectively reducing the cross-sectional area of the Conductor. This effect leads to the heating of the conductors. Overheating of the Neutral wires are also caused by the harmonics produced in any one phase of a balanced three phase system. False tripping of circuit breakers can also happen due to the harmonics which can be many times higher than sinusoidal waveform which can loss data and time.

EFFECTS DUE TO HARMONICS

- Blinking on Incandescent Lights - Transformer saturation
- Capacitor Failure - Harmonic Resonance
- Circuit Breakers Tripping - Inductive Heating and Overload
- 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
- Motor Failures (overheating) - Voltage Drop
- Neutral Conductor and Terminal Failures - Additive Triplen Currents
- Electromagnetic Load Failures - Inductive Heating
- Overheating of Metal Enclosures - Inductive Heating
- Power Interference on Voice Communication – Harmonic Noise
- Transformer Failures - Inductive Heating

POWER FACTOR

It is suggested to maintain an average power factor close to unity as far as practically possible. This can be achieved by adding additional capacitor banks and ensuring proper functioning of capacitor banks and keeping the system harmonics under check and balances.

THREE PHASE CURRENT UNBALANCE

As per the standards, the limits of voltage unbalance and current unbalance are specified as a maximum of 3% and 10% respectively. Under unbalanced conditions, the power system will incur more losses and heating effects, and be less stable because when the phases are balanced, the system is in a better position to respond to emergency load transfers.

SELECTION OF NEW DEVICES/EQUIPMENT

The devices/equipment resulting in generation of harmonics is available with THD rating. Selection of these devices with THD rating less than 5% helps in maintaining good system power quality. It is thus suggested to consider the THD rating of the new equipment/devices like VFDs, UPS, and electronic chokes before installation.

Power Quality Analysis – Guidelines

STANDARDS

As per IEEE 519, the maximum permissible limit for voltage harmonics is 8% (less than 1KV).
As per IEEE, the maximum permissible limit for Current Unbalance is 10% and Voltage Unbalance is 3%.
As per IEEE, the maximum permissible limit for Short Term Flickering is 0.65.
As per IEEE 519-1992, the maximum permissible limit for Harmonics Order 2-10 is 7%, Harmonics Order 11-16 is 3.5%, Harmonics Order 17-22 is 2.5% and Harmonics Order 23-34 is 1%.

Table 9. **Standards THD & Unbalancing**

Sr. No.	Parameters	Value
1	Voltage THD %	8% (Less than 1KV)
2	Voltage Unbalanced %	3%
3	Current Unbalanced %	10%

Table 10. **Current Distortion Limits**

Current distortion limits (120 V to 69kV) – User's responsibility

Isc/IL	h< 11	11<h<17	17<h<23	23<h<35	35<h	TDD
<20*	* 4.0	2	1.5	0.6	0.3	5
20<50	7	3.5	2.5	1	0.5	8
50<100	10	4.5	4	1.5	0.7	12
100<1000	12	5.5	5	2	1	15
>1000	15	7	6	2.5	1.4	20

Note: *All power generation equipment is limited to those values regardless their Isc/IL.
Odd harmonics are represented as % of fundamental at Power Control Centre (PCC).

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

Table 11. **Harmonics Limits**

Isc	Short Circuit current at the point of common coupling (PCC), corresponding to system MVA level
IL	Fundamental full load current in Amps
H	Harmonic number
11<h<1 7	Limits of individual currents at PCC
THD	Total harmonic distortions

Table 12. **HT-Transformer**

Parameters	Avg.	Min.	Max.
Frequency	49.96	49.69	50.38
Ampere- R phase (A)	19.04	13.90	25.78
Ampere- Y phase (A)	20.47	15.18	28.83
Ampere- B phase (A)	20.31	14.73	27.68
Ampere- Neutral (A)	1.171	0.925	1.525
Voltage- R phase (V)	413.5	402	425
Voltage- Y phase (V)	412.5	405	420
Voltage- B phase (V)	413.5	402	423
P.F. Total	0.88	0.925	0.825
POWER- Total (KW)	43.128	30.58	50.36
V THD % R phase	0.913	0.600	1.400
V THD % Y phase	0.999	0.700	1.500
V THD % B phase	0.844	0.500	1.200
I THD % R phase	7.580	4.500	4.30
I THD %Y phase	7.808	5.000	4.40
I THD % B phase	8.277	4.400	4.50
Voltage Unbalance %	0.459	0.300	0.600
Current Unbalance %	1.513	3.000	5.800

Observation:

Results are satisfactory

5. Energy Conservation Measures

5.1 Replace 3-star AC with 5-star AC.

Background

AC is used for human comfort at office area.

Findings

AC used in office areas are in two- and three-star rating.

Recommendations

Replace old AC with five-star rating AC. Consider first phase to replace 9 AC.

Benefits

By replacing old AC, the power consumption of AC will reduce.

Table 13. **Cost benefit Analysis of 3-star AC to 5-star AC**

Parameters	Units	DME		
Location		Class Rooms	Class Rooms	Class Rooms
Design Capacity	TR	1.5	1.5	1.5
Total Area	m^2	0.085	0.085	0.085
Measured avg. Velocity	m/s	2	1.9	2.2
Calculated Flow	m^3/hr	612.0	581.4	673.2
Supply Air Dry Bulb Temp.	C^0	26	23	28
Supply Air Wet Bulb Temp.	C^0	18	17	19
Enthalpy supply air	KCal/Kg	12.1	11.4	12.9
Return Air Dry Bulb Temp.	C^0	29	27	30
Return Air Wet Bulb Temp.	C^0	24	24	25
Enthalpy return air	KCal/Kg	17.21	17.3	18.18
Density of Air	Kg/M^3	1.225	1.225	1.225
Calculated Capacity	TR	1.27	1.39	1.45
Power Consumption	KW	2.1	2.2	2.25
KW/TR		1.658	1.578	1.548
EER		7.239	7.605	7.752
COP		2.120	2.227	2.270
Proposed				
Design Power of AC	kW	1.5	1.5	1.5
Present power consumption of AC	kW	2.1	2.2	2.25
Expected saving	%	28	28	28
Reduction in power consumption	kW	0.588	0.616	0.63

Parameters	Units	DME		
Running hours of AC fan	Hr/day	18	18	18
Running days of AC fan per annum	Days/Year	250	250	250
Cost of electrical energy	INR/KWh	7.15	7.15	7.15
Energy Saving/yr	kWh	2646	2772	2835
Monetary saving per year	INR	18918.9	19819.8	20270.3
Investment	INR	35,000	35,000	35,000
Payback period	month	22.20	21.19	20.72

Table 14. **Cost benefit Analysis of 3-star AC to 5-star AC**

Parameters	Units	DME					
Location		Class Rooms	Class Rooms	Class Rooms	Class Rooms	Class Rooms	Class Rooms
Design Capacity	TR	2	2	2	2	2	2
Total Area	m^2	0.108	0.108	0.108	0.108	0.108	0.108
Measured avg. Velocity	m/s	4.3	4.2	2.9	2.2	2.9	4.6
Calculated Flow	m^3/hr	1671.8	1633.0	1127.5	855.4	1127.5	1788.5
Supply Air Dry Bulb Temp.	C^0	26	26	25	24	25	23
Supply Air Wet Bulb Temp.	C^0	20	21	17	16	18	19
Enthalpy supply air	KCal/Kg	13.7	14.5	11.4	10.7	12.1	12.9
Return Air Dry Bulb Temp.	C^0	27	29	28	26	28	29
Return Air Wet Bulb Temp.	C^0	23	25	22	23	23	23
Enthalpy return air	KCal/Kg	16.27	17.21	15.36	16.27	16.26	15.36
Density of Air	Kg/M^3	1.225	1.225	1.225	1.225	1.225	1.225
Calculated Capacity	TR	1.76	1.79	1.82	1.94	1.90	1.79
Power Consumption	KW	3.02	3.1	3	3.1	3.1	3.2
KW/TR		1.715	1.729	1.646	1.595	1.635	1.788
EER		6.997	6.939	7.290	7.525	7.337	6.711
COP		2.049	2.032	2.135	2.203	2.149	1.965
Proposed							
Design Power of AC	kW	1.937	1.937	1.937	1.937	1.937	1.937
Present power consumption of AC	kW	3.02	3.1	3	3.1	3.1	3.2
Expected saving	%	28	28	28	28	28	28
Reduction in power consumption	kW	0.8456	0.868	0.84	0.868	0.868	0.896
Running hours of AC fan	Hr/day	18	18	18	18	18	18
Running days of AC fan per annum	Days/Year	250	250	250	250	250	250
Cost of electrical energy	INR/KWh	7.15	7.15	7.15	7.15	7.15	7.15
Energy Saving/yr	kWh	3805.2	3906	3780	3906	3906	4032

Parameters	Units	DME					
Monetary saving per year	INR	27207.2	27927.9	27027.0	27927.9	27927.9	28828.8
Investment	INR	35,000	35,000	35,000	35,001	35,002	35,003
Payback period	month	15.44	15.04	15.54	15.04	15.04	14.57

5.2 Installation of APFC Panel

Average Power Factor of last 12 months is 0.892 which is quite less. It could be increased to 0.99 to avail cost benefit.

Auditors recommend to install Automatic Power Factor Panel of suitable size ti increase Power Factor from 0,892 to 0.99

Annual saving in KWH is 10279 approximately 1.6 Lakh Rs.

5.3 Solar Panel

Background

Renewable energy is not utilized by Institute. Roof top space available at Institute.

Findings

Solar Energy goes peak during daytime. Institute has flat roofs to produce clean energy and bringing positive impacts to environment. Solar Installation is a step towards sustainability, a step towards being environmentally responsible.

Recommendations

Install 100 kWh solar PV panel.

Benefits

The cost benefit analysis is as follows.

Table 15. **Cost benefit Analysis of Solar Installation of 100 KW**

Sr No	Parameter	Unit	Value
1	Total clear roof top available	m^2	1000
2	Proposed roof top solar PV installation	kWh	100
3	Hyderabad solar irradiation level	kWh/m2/d	5.44
4	Active sun days in a year	days	330
5	Energy generation by proposed PV solar panels per annum	kWh/yr.	179520
8	Savings in energy bills per annum	Rs.	13
9	Investment (@ rate Rs.55 per watt peak)	Rs.	55
10	Simple Payback period	month	51