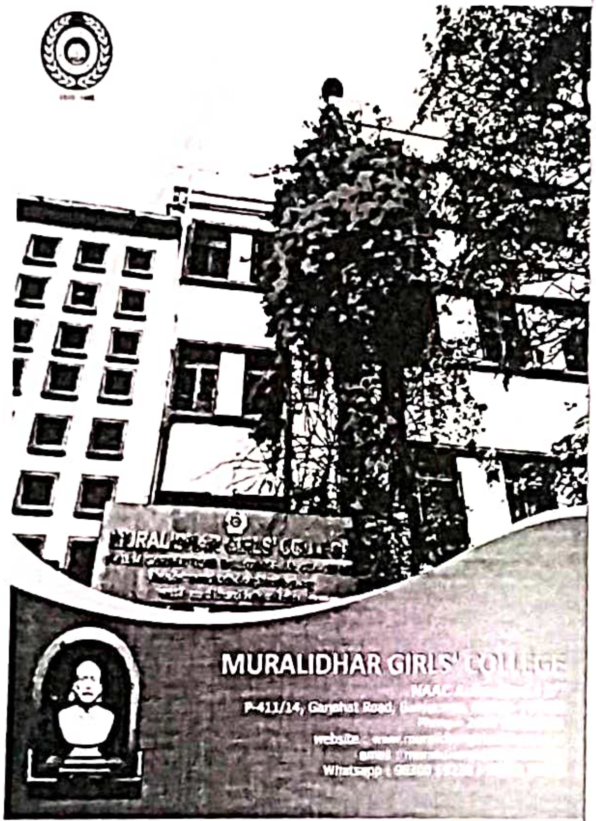

Energy Audit Report of Muralidhar Girls' College

P-411/14, Gariahat Road, Ballygunge,
Kolkata-700 029, West Bengal

Prepared By

Nu Energy India

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Nu Energy India expresses sincere thanks to the management of Muralidhar Girls' College for awarding Nu Energy India to conduct 'Energy Audit, FY 2021-22 at College Campus Building' Premises vide WO Ref. No.- 53, dated 10.03.2023. The field study of this audit was carried out on 25.03.2023.

The following officials of Muralidhar Girls' College, Kolkata have coordinated and helped the audit team during the site visits:

Dr. Kinjalkini Biswas (Principal)

& Co-ordinating Team

We extend our sincere gratitude to Dr. Kinjalkini Biswas and all other Teachers, officers, technicians and staffs for their keen interest shown in the study and the courtesy extended.

We are thankful to the management for giving us the opportunity to involve in this very interesting and challenging project of energy audit at their college premises.

We would be happy to provide any further clarifications, if required, to facilitate implementation of the recommendations.

Anjan Majumdar.

ANJAN MAJUMDAR
Certified & Accredited Energy Auditor
Bureau of Energy Efficiency
Ministry of Power, Govt. of India
Reg. No.: [illegible]

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ENERGY IS LIFE
BEE
CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

Examination Registration No. : EA-0167

Accreditation Registration No.: AEA-0193

Certificate of Accreditation

This is to certify that Mr./Ms. Anjan Majumdar having its trade/registered office at Kolkata has been given accreditation as accredited energy auditor. The certificate shall be effective from 9th day of October 2014

The certificate is subject to the provisions of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010.

This certificate shall be valid until it is cancelled under regulation 9 of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010

On cancellation, the certificate of accreditation shall be surrendered to the Bureau within fifteen days from the date of receipt of order of cancellation.

Your name has been entered at AEA No. 193 in the register of list of accredited energy auditors. Your name shall be liable to be struck out on the grounds specified in regulation 8 of the Bureau of Energy Efficiency (Qualifications for Accredited Energy Auditors and Maintenance of their List) Regulations, 2010.

Given under the seal of the Bureau of Energy Efficiency, Ministry of Power, this 16th day of January 2015

Secretary,
Bureau of Energy Efficiency
New Delhi

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Muralidhar Girls' College, located at south Kolkata, West Bengal is very energy conscious institution & belief of continuous improvement in their establishment. The working staffs & officers are co-operative and extend their hands to conduct the field trial & testing during field audit. Management of this college has taken many energy saving measures from 2017. Still, some of lacunas were identified by energy audit team during study.

This section presents a brief summary of the results of the Energy Audit carried out last week of March 2023, when ambient condition was favorable for human comfort & working comfort. The study covers mainly the weaknesses of electrical energy aspects at college premises with a focus mainly on proposals and recommendations on energy & cost savings.

A team of two specialist consultants of Certified & Accredited Energy Auditor, BEE, Ministry of Power, Govt. of India were involved in this energy audit. The energy audit was mainly targeted at identifying practical, sustainable and economically viable ENCON measures in all sections of this Warehouse, resulting from a detailed study and analysis of technical parameters. The energy audit involved using a wide range of sophisticated, portable, diagnostic and measuring instruments to generate the data and facilitated in analysis to understand the condition of energy aspects in the Warehouse premises. Following are the observations on field energy audit.

1.0 Electricity is the main source of energy in Muralidhar Girls' College. The electrical energy Consumption of this College from CESC for the FY 2021-22 works out to 262 Lakh kWh (@ Rs.8.53/ kWh).

2.0 Muralidhar Girls' College has already adopted & harnessed roof top 25 kWp, 415 volt rated renewable clean & green Solar Photo voltaic power since 2017, which facilitates college to consume electricity fully in daytime without incurring any cost and also injects & export power to CESC grid partly through bi-directional digital communicable energy meter and saves considerable amount of energy & money per month.

3.0 Muralidhar Girls' College has replaced all old non-star air-conditioners with energy efficient 3-STAR rated Split Air-conditioners for 17 nos. of office rooms & saves considerable amount of money per month.

4.0 Muralidhar Girls' College is started to adopt most energy efficient & long-lasting LED based lighting system in selected indoor application & saves considerable amount of electrical energy.

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5.0 At present this girl's college uses large number of 36 Watt conventional & inefficient fluorescent tube lights (FTL) with copper ballast, whose efficacy is found to be very poor & consume excess amount of electrical energy compared to new generation long last 20-Watt LED tube light (TL). Audit addresses that if college is replaced all such 36-Watt fluorescent tube lights (FTL) & their copper ballast with new 20-watt LED tube tights, considerable amount (> 50%) of electrical energy in lighting system can be saved.

6.0 Presently this girl's college uses large number of 70 Watt rated conventional & inefficient ceiling fans of 1200 mm sweep, which are consumed excess amount of electrical energy compared to new generation most energy efficient 28-Watt smart BLDC ceiling fan. Audit addresses that if college is replaced all such 70-Watt conventional ceiling fans with new 28-watt rated smart BLDC fan of 1200 mmm sweep, considerable amount (> 60%) of electrical energy in room ventilation system can be saved.

7.0 At present college is not monitored the energy generation in existing Solar PV systems, wherein the digital true r.m.s energy meters are existed & connected to three existing Inverter Panels. Audit addresses to monitor monthly energy generation mandatorily & maintain the records in a log book, which will facilitate to find out the monthly energy consumption of college building from Solar PV alone by subtracting the energy injected from energy generation.

8.0 Measured average & maximum current unbalance in full load condition at CESC LT incomer is found to be significantly high (22.63% & 55.40% respectively), leading to increase line loss further.

9.0 Measured average & maximum Total current harmonic distortion (%THDi) at CESC LT incomer is found to be very high (20.8% & 44.9% respectively) at full load, wherein 3rd order of harmonic dominates greatly & leads to increase line loss further due to effect of skin & proximate effect of wiring cables. Audit addresses to install one small "Advance Static Var Generator" (ASVG) to mitigate evil & odd harmonics.

10.0 The energy saving & cost saving potential are identified as **61.94% & 62.03%** respectively over the existing conditions after considering uncertainty margins for Siliguri Warehouse. Proposals thereof appear to be quite attractive since some cases payback period is less than 2 years & Return on Investment is very high.

11.0 For analysis purpose present electricity cost is considered as 14.22 ₹/kWh.

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1.0 Summary of Recommendation

Proposal No.	Proposal	Annual Energy Saving		Annual Energy Cost Saving	Investment Required	Payback Period
		kWh	TOE	₹ Lakh	₹ Lakh	Month
1.	On Current Unbalancing: *Balancing the Load current in between phases at main CESC fed incomer main panel by Shifting Single Phase Loads (Lights, ceiling fans & split air-conditioners) from higher to lower mutually at different class room, laboratories, teacher room, office room, accounts office room etc & also checking of tightness for feeder cable terminals at MCCB, Bus-bar, MCB, etc. and reduction of Line Losses*	1153	0.10	0.16	0.14	9.9
2.	On Energy Efficient Lighting System *Replacement of all 36W Conventional Fluorescent Tube Lights (FTL) in indoor application step by step with new generation energy efficient & Long Lasting 1 x 20W LED Tube Lights and saving of substantial amount of electrical energy and reduction of maintenance cost*	23120	1.99	3.29	3.93	14.3
3.	On Energy Efficient Smart BLDC Ceiling Fan: *Replacement of 217 nos. of 70-Watt 48" Conventional Ceiling Fans with new 18 nos. of 28 Watt 48" (Φ 1200 mm Sweep) most Energy Efficient BEE 5-Star Rated Smart Ceiling Fans and save substantial amount of electrical energy.*	10937	0.94	1.56	6.18	47.7
	GRAND TOTAL (ELECTRICAL)	35210	3.03	5.01	10.25	24.52

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Energy Audit is an effective means of establishment present efficiency levels and identifying potential areas of improvement in energy consumption. Energy audit of utility systems largely helps in reducing the energy consumption with resultant reduction in electricity bills. Audit involves data collection, data verification and detailed analysis of the data. The analysis leads to focus recommendations, which are short term (with minimum investment), medium term (with moderate investment) and long term (with capital expenditure). The cost benefit analysis of various energy conservation proposals enables managements to take decisions regarding implementation schedules.

Energy conservation is a worldwide objective to save the human being from possible disaster. Under the mandate of The Energy Conservation Act 2001, the Bureau of Energy Efficiency (BEE) and Government of India are implementing various programmers to provide momentum of the energy conservation movement in the country. Energy Auditing is most vital part of the conservation of energy. In order to improve the efficiency of the Energy consuming system, energy auditing is the first necessary action to be taken by the concerned firm. Through the energy auditing actual parameters can be detected at each step, which can be compared with the standard achievable parameters. For proper Energy auditing and energy accounting, parameters need to be monitored on regular basis and for any deviation immediate action is needed to rectify and retain the efficiency at the optimum level.

Electrical energy audit reviews the entire distribution of loads with different electrical parameters from sending end to consumption end, which includes grid supply LT incomer, Solar PV Power Generation outgoing feeders, Air Conditioners, Lighting, UPS, Pump, Ceiling Fan & Electricity Bill Analysis etc.

Review of Energy Monitoring & Accounting System; Detail review of present energy monitoring & accounting system in terms of metering, record keeping, data logging, period performance analysis etc.- Recommendations for improvement.

Recording the parameters in the monthly Electricity bills and analyzing the load demand & sanctioned Load, benefits of solar power injection to CESC grid etc.

Energy Audit includes the review of documentation with regard to the scope covered in audit, an on-site visit, and data collection, their review and analysis. This may also require the cross check and verification of data and data which can include industry norms and peer data. Following is that the methodology in detail:

a. A Pre-Audit Meeting (opening meeting) discussing the main guidelines with the college management team and other concerned departments.

b. Data collection for monthly electricity bills, unit injected to CESC grid, total built-up area, lighting system, ceiling fan, air conditioners, AC

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& non-AC Rooms or areas, water pump capacity, capacity of Solar PV System etc.

c. Review of existing energy accounting system (Energy Meter) in main grid incomer Panel, Solar PV outgoing feeders etc. & identification any gaps in energy accounting.

d. Measurement of all electrical parameters at main grid incomer Panel & Solar PV outgoing feeders & exploring energy saving opportunities if any.

e. Study of Split Air-conditioners & exploring further energy saving opportunities if any.

f. Check & Measurement of illumination at different office areas & estimation of energy consumption pattern in lighting system.

g. Monthly electricity Bill analysis & exploring further monetary saving.

h. Discussion with members of the house.

i. Review of Documentation/Records (All the relevant maintenance documentation, test records, electrical records etc.

During study several interactions were made to the college personnel and staffs to share the actual operational features of equipments, college maintenance schedule and equipment break down, down time of machineries, safety measures etc. At the same time required drawings, documents, data sheets were collected from the college level and the same was reviewed with the operational actual data.

The study focused on improving energy efficiency and identifying energy saving opportunities at various equipments & systems. The analysis included simple payback period & ROI calculations where investments are required to be made to implement recommendations, to establish their economic viability.

7.0 Instrument used in Energy Audit

The audit study made use of various portable instruments along with plant online instrumentations, for carrying out various measurements and analyses. The specialized instruments that were used during the energy audit include:

- Micro-processor-based Load Manager, KRIKARD ALM 31 with software facility for different electrical parameter measurements
- Digital Smart Hygrometer for dry bulb temperature (DBT), wet bulb temperature (WBT) & relative humidity (RH)
- Digital LUX / Foot Candle Meter

8.0 Energy Audit Team:

1. A. Majumdar (Accredited Energy Auditor, BEE, Govt. of India)
2. S. Hazra (Accredited Energy Auditor, BEE, Govt. of India)
3. A. Dutta (Energy Engineer)

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College Profile

Muralidhar Girls' College, established in 1940, is an undergraduate women's college in Kolkata, West Bengal, India. It is affiliated with the University of Calcutta. The mission of the college is to extend educational facilities to all deserving students, including first generation learners.

The college aims towards a greener campus through use of rain water harvesting system and adopts & harnesses grid connected solar photo voltaic (Solar PV) power generation system (both government funded and college purchase) for generation of clean electricity. The college regularly opts for green audits.

Energy Conservation Measures Taken by Muralidhar Girls' College

a. Installation of 25 kWp, 415 volt rated Solar Photo voltaic Power Generation System & harnessing clean & green power for college use in daytime & excess power is exported to grid through bi-directional energy meter.

b. Measured power factor (efficiency of electrical system) is found to be high (avg.-0.975) without using any capacitor banks and saving of some amount line losses & kVA demand.

c. All old non-star air-conditioners are replaced with energy efficient 3-STAR rated Split Air-conditioners for 17 nos. of office rooms & saves considerable amount of money per month.

d. College is started to adopt most energy efficient & long-lasting LED based lighting system in selected indoor application & saves some amount of electrical energy.

e. Some of old wiring cables in ground floor conference room & office room are replaced with new cable with pipe wiring, resulting in lesser conductor resistance & lesser line losses.

f. Partly natural day light harnesses in the all-class room floors through clear wall glass, resulting in less use of existing lighting system in day time & reduction lighting power consumption further.

g. Solar PV Inverter Panels are equipped with high accuracy of 0.5 class digital Energy Meter.

Barriers Towards Energy Conservation

The study identified following barriers towards energy conservation & Energy Savings in the Muralidhar Girls College:

a. Use of large population of 36 Watt conventional & low efficacy fluorescent tube lights (FTL) with copper ballast in all office rooms & class rooms, which consume excess amount of electrical energy compared to new generation long last 20-Watt LED tube light (TL).

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b. Use of large population of 70 Watt rated conventional & inefficient ceiling fans of 1200 mm sweep, which are consumed excess amount of electrical energy compared to new generation most energy efficient 28-Watt smart BLDC ceiling fan.

c. At present college is not monitored the energy generation in existing Solar PV systems, wherein the digital true r.m.s energy meters are existed & connected to three existing Inverter Panels.

d. Measured average & maximum current unbalance in full load condition at CESC LT incomer is found to be significantly high, leading to increase line loss further.

e. Measured average & maximum Total current harmonic distortion (%THDi) at CESC LT incomer is found to be very high at full load, wherein 3rd order of harmonic dominates greatly & leads to increase line loss further due to effect of skin & proximate effect of wiring cables.

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Main Source of energy in Muralidhar Girls' College is electricity from Grid (CESC) & Solar PV Generation. A summary and comparison of the annual energy consumption & Energy Performance Index (specific energy consumption) is given in tables below:

Table 1 Summary of Energy Consumption Profile

SUMMARY OF ENERGY CONSUMPTION PROFILE

Sl. No.	Particulars	Unit	2020-21 (CESC)	2021-22 (CESC)
1.0	**Electrical Energy Purchased & Cost Figure:**			
1a.	Annual Grid Energy Purchased & Consumed	kWh	9986	15796
1b.	Annual Energy Generation from Solar PV	kWh	9752	8777
1C.	Annual Energy Injected to CESC Grid	kWh	7058	6352
1d.	Annual Solar Energy Consumed by College	kWh	2694	2424
1e.	Ton of Oil Equivalent (TOE)	TOE	0.86	1.36
1f.	Cost of Electricity Purchased & Consumed	₹ Lakh	0.30	0.50
1g.	Unit Rate of Electricity Purchased & Consumed	₹/kWh	2.99	3.15

<u>NOTE:</u> "TOE" stands for Metric Tonne of oil Equivalent Energy
Where, 1 TOE = 10^7 kCal

****Due to COVID situation during above financial years, college was closed most of time and hence energy consumption & cost of electricity are found to be very less.*

A COMPARISON OF ELECTRICITY CONSUMPTION & COST OF ELECTRICITY

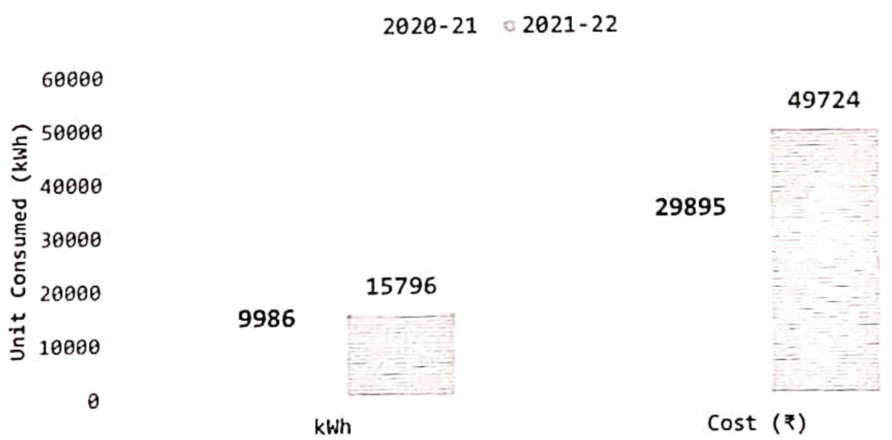

Figure 1 A Comparison of Annual Electricity Consumption & Cost of Electricity

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COMMENTS:

Energy consumption from grid for the FY 2020-21 & FY 2021-22 is found to be very less due to COVID 19 pandemic, wherein energy consumption for the FY 2020-21 is found to be less by 36.78% compared to the FY 2021-22.

Estimation of Energy Performance Index (EPI):

As per ECBC 2017, the Energy Performance Index (EPI) of a building is its annual energy consumption in kilowatt-hours per square meter of the building. At present built up area of air-condition areas & non-air conditioning areas college building is found to be 393.54 m² & 2740.96 m² respectively i.e. 12.56% is air-conditioned area & 87.44% is non-airconditioned area. EPI can be determined by:

$$EPI = \frac{\text{Annual energy consumption in kWh}}{\text{Total built-up area (excluding unconditioned basements)}}$$

Energy Performance Index of Muralidhar Girls College for FY 2020-21

- Total Built-up areas Muralidhar Girls' College : 3134.5 m²
- Annual energy consumption of Muralidhar Girls' College : 9986 kWh
- Specific Energy Consumption by Muralidhar Girls' College : **3.18 kWh/m²/year**

Energy Performance Index of Muralidhar Girls College for FY 2021-22

- Total Built-up areas Muralidhar Girls' College : 3134.5 m²
- Annual energy consumption of Muralidhar Girls' College : 15796 kWh
- Specific Energy Consumption by Muralidhar Girls' College : **5.04 kWh/m²/year**

NOTE: **Considering *3134.5 m² total built-up areas for EPI Calculation & there is no basement in this College.***

As per ECBC published by BEE, in warm & humid climate "Specific Energy Consumption" as "Energy Performance Index" (EPI) for 5-star rated building having less than 50% Air-conditioned area is below 45 kWh/m²/year with 5-Star Level-***.**

Table 2 Building Energy Star Rating less than 50% Air-conditioned built-up Area at Warm & Humid Climate

Building Energy Star Rating in Less than 50 % air-conditioned built-up area at Climatic Zone - Warm and Humid

EPI (kWh/sqm/year)	Star Label
85-75	1 Star
75-65	2 Star
65-55	3 Star
55-45	4 Star
Below 45	5 Star

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12.2.1 Comments on EPI:

During the FY 2020-21 & FY 2021-22, Energy Performance Index is found to be **3.18** kWh/m²/Year & **5.04** kWh/m²/Year respectively, which are very less & highly satisfactory and belong to 5 Star Category as per ECBC 2017 wherein COVID 19 situation was prevailed. Still, there is further scope for reduction of line losses further in electrical distribution system by the balancing line current, harmonic mitigation at main LT PCC Panel at CESC supply point & replacement of conventional high wattage fluorescent tube lights & ceiling fans and accordingly fix the target for action plan.

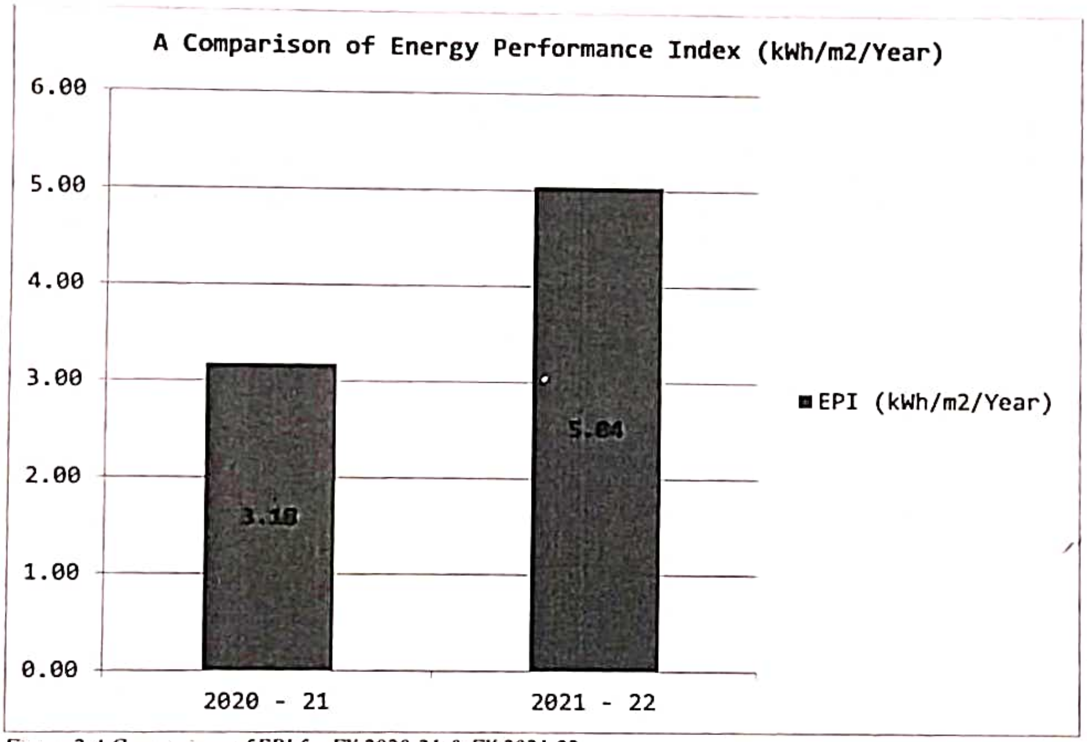

Figure 2 A Comparison of EPI for FY 2020-21 & FY 2021-22

COMMENTS:

Energy Performance Index pattern for FY 2021-22 & FY 2020-21 is found to be similar in nature & no such big gap is found after analysis.

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13.0 Details of Major Energy Consuming Machinery

At present there are many major energy consuming machineries like star rated Split Air conditioners, Water Pump, LED based lighting system, Conventional Fluorescent Tube Lighting system, Ceiling fans, Computers, UPS etc. in Muralidhar Girls' College.

Table 3 Details of Energy Consuming Equipments of Muralidhar Girls' College

Type of Equipments	Unit	Number
1.5 TR Split Air-conditioner	Nos.	17
1.5 kW Bore-well Water Pump	Nos.	1
15-Watt LED Light Fixture	Nos.	47
1200 mm Sweep 70-watt Ceiling Fan	Nos.	217
36-watt Fluorescent Tube Light	Nos.	655
20 kWp Solar PV Generator	Nos.	1
5 kWp Solar PV Generator	Nos.	1

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14.0 Electrical Load Measurements on CESC Incomer

During different electrical parameters were measured & noted at Main Incomer of LT PCC Panel, located at CESC supply Point. During study several electrical parameters, like Voltage, Load Current, Neutral Current, Voltage Unbalance, Current Unbalance, Power factor, Powers, Harmonic Distortions etc. were logged for 20 second time interval and compared with load carrying capability of existing cables of respective feeders.

14.1 Measured Electrical Parameters at LT PCC Panel

Table 4 Measured Electrical Parameters for LT PCC Panel

Line Voltage Measurements at LT PCC of CESC Incomer

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
U12 rms	24-03-2023	411.0	407.3	415.1	V	01:00:40	(h:min:s)
U23 rms	24-03-2023	413.0	409.1	417.3	V	01:00:40	(h:min:s)
U31 rms	24-03-2023	408.4	403.8	412.8	V	01:00:40	(h:min:s)

Line Current Measurements at LT PCC of CESC Incomer

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
A1 rms	24-03-2023	43.53	18.33	76.87	A	01:00:40	(h:min:s)
A2 rms	24-03-2023	56.51	6.9	94.53	A	01:00:40	(h:min:s)
A3 rms	24-03-2023	54.04	11.2	97.6	A	01:00:40	(h:min:s)
AN rms	24-03-2023	28.29	13.5	36.88	A	01:00:40	(h:min:s)

Power Factor Measurements at LT PCC of CESC Incomer

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
PF1	24-03-2023	0.975	0.955	0.988	p.u.	01:00:40	(h:min:s)
PF2	24-03-2023	0.972	0.84	0.992	p.u.	01:00:40	(h:min:s)
PF3	24-03-2023	0.974	0.883	0.993	p.u.	01:00:40	(h:min:s)
PFT	24-03-2023	0.975	0.912	0.99	p.u.	01:00:40	(h:min:s)

Unbalance Measurements at LT PCC of CESC Incomer

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
Aunb (IEEE 112)	24-03-2023	22.6	4.6	55.4	%	01:00:40	(h:min:s)
Aunb (u2)	24-03-2023	11.9	2.3	40.0	%	01:00:40	(h:min:s)
Uunb (IEEE 112)	24-03-2023	0.6	0.5	0.7	%	01:00:40	(h:min:s)
Vunb (IEEE 112)	24-03-2023	0.4	0.2	0.6	%	01:00:40	(h:min:s)
Vunb (u2)	24-03-2023	0.6	0.5	0.8	%	01:00:40	(h:min:s)

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Measured Power at LT PCC of CESC Incomer

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
D1 (var)	24-03-2023	2.02	1.24	2.49	kvar	01:00:40	(h:min:s)
D2 (var)	24-03-2023	2.29	0.85	2.93	kvar	01:00:40	(h:min:s)
D3 (var)	24-03-2023	1.89	1.10	2.64	kvar	01:00:40	(h:min:s)
DT (var)	24-03-2023	6.38	3.66	8.18	kvar	01:00:40	(h:min:s)
P1 (W)	24-03-2023	9.7	4.6	15.4	kW	01:00	(h:min:s)
P2 (W)	24-03-2023	12.4	1.5	18.8	kW	01:00	(h:min:s)
P3 (W)	24-03-2023	11.8	2.6	17.6	kW	01:00	(h:min:s)
PT (W)	24-03-2023	34.0	8.9	51.6	kW	01:00	(h:min:s)
Q1 (var)	24-03-2023	456.8	-186.4	976.0	var	01:00	(h:min:s)
Q2 (var)	24-03-2023	0.7	-0.4	1.3	kvar	01:00	(h:min:s)
Q3 (var)	24-03-2023	-59.1	-904.9	759.2	var	01:00	(h:min:s)
QT (var)	24-03-2023	1.1	-0.84	2.7	kvar	01:00	(h:min:s)
S1 (VA)	24-03-2023	10.0	4.81	15.6	kVA	01:00	(h:min:s)
S2 (VA)	24-03-2023	12.7	1.80	19.0	kVA	01:00	(h:min:s)
S3 (VA)	24-03-2023	12.0	2.89	17.7	kVA	01:00	(h:min:s)
ST (VA)	24-03-2023	34.6	9.68	52.1	kVA	01:00	(h:min:s)

Harmonic Distortion Measurements at LT PCC of CESC Incomer

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
A1 THDf	24-03-2023	21.6	15.1	30.8	% f	01:00:40	(h:min:s)
A2 THDf	24-03-2023	21.6	12.5	60.9	% f	01:00:40	(h:min:s)
A3 THDf	24-03-2023	19.1	11.2	43.1	% f	01:00:40	(h:min:s)
U12 THDf	24-03-2023	1.3	1.1	1.5	% f	01:00:40	(h:min:s)
U23 THDf	24-03-2023	1.4	1.2	1.6	% f	01:00	(h:min:s)
U31 THDf	24-03-2023	1.6	1.4	1.8	% f	01:00	(h:min:s)
V1 THDf	24-03-2023	1.8	1.5	2.0	% f	01:00	(h:min:s)
V2 THDf	24-03-2023	1.3	1.1	1.5	% f	01:00	(h:min:s)
V3 THDf	24-03-2023	1.8	1.5	2.0	% f	01:00	(h:min:s)

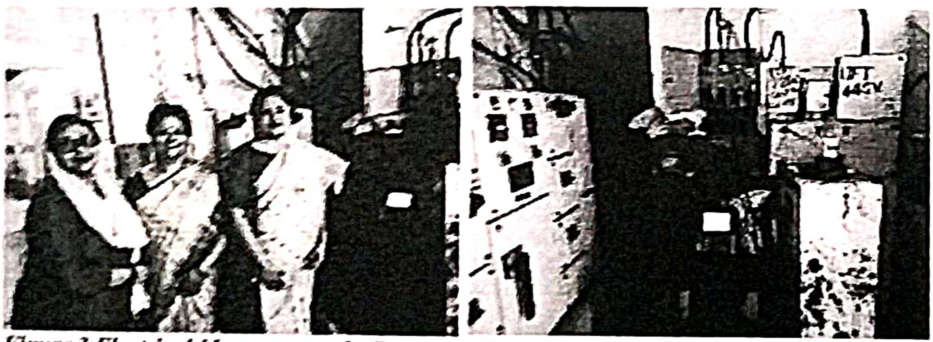

Figure 3 Electrical Measurement by Power Analyzer at LT PCC Main Panel

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14.2 Curves for Measured Power & Harmonics at LT PCC of Main Panel

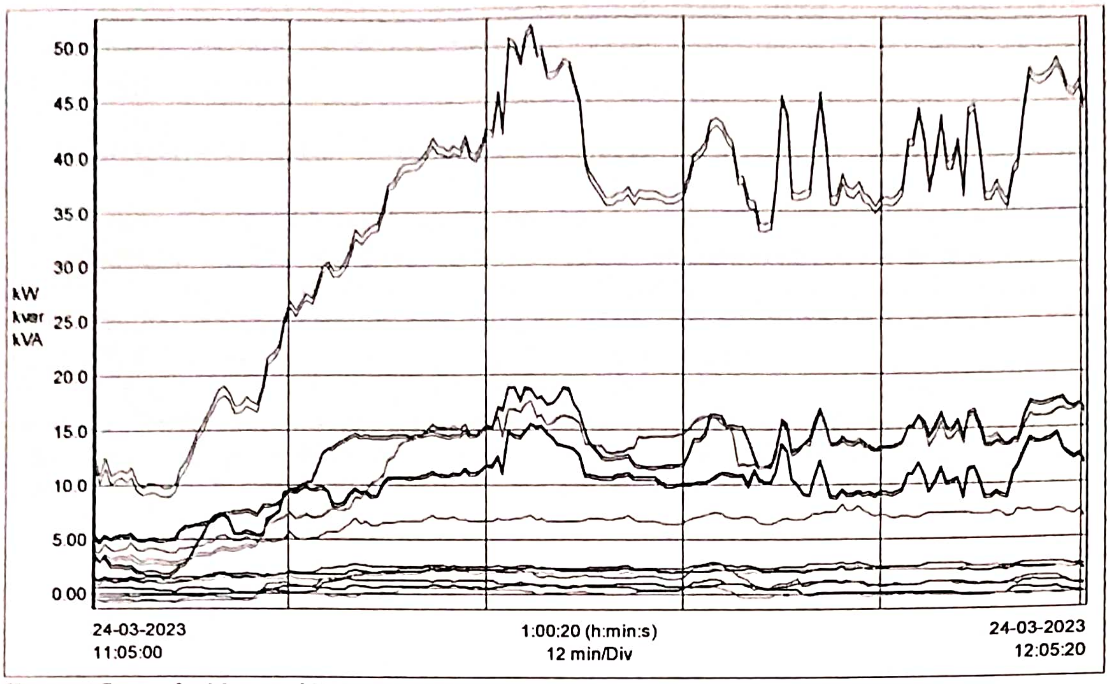

Figure 4 Curves for Measured Powers

COMMENTS:

Maximum measured active power (kW), apparent power & reactive power drawn is found to be 51.6 kW, 52.1 kVA & 2.7 kVAr respectively. Although at low load or partial load condition over Var compensation took place due to leading power factor.

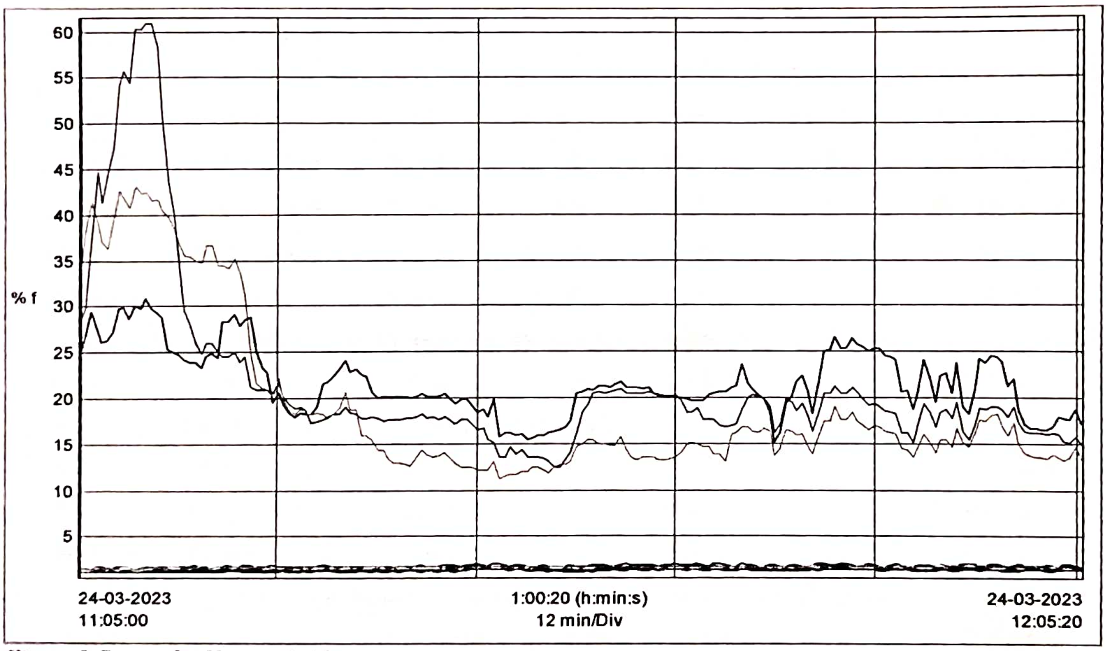

Figure 5 Curves for Harmonic Measurements

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COMMENTS:

Measured maximum Total Current Harmonic Distortion (%THDi) is found to be 44.9%, which is high and mainly 3rd harmonic & other triple-n order of harmonics are dominating, resulting in increase of line loss. It will reduce after installation of harmonic filter.

15.0 Measured Solar Power Generation at 4th Floor Solar PV Inverter Panel

At present there 100 nos. of 250Wp rated solar modules. Located at 4th floor roof top. During audit, different electrical parameters were measured at AC Outgoing feeder of 10 kVA Inverter LT Panel, located at west side & north side 4th floor stair case and same outgoing feeder of 5 kVA Inverter LT Panel, located at south wall 2nd floor stair case. During study several electrical parameters, like Voltage, Load Current, Neutral Current, Voltage Unbalance, Current Unbalance, Power factor, Powers, Harmonic Distortions etc. were logged for 20 second time interval. Only same was not possible to measure in 2nd floor outgoing 5 kVA Solar PV Inverter Panel due to inaccessibility in inverter panel.

15.1 Measured Electrical Parameters at 10 KVA Solar PV Panel-1 (West Side)

Table 5 Measured Electrical Parameters for 10 kVA Solar PV Panel-1 (West Side)

Line Voltage Measurements at Outgoing Side of 10 kVA Inverter LT Panel-1

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
U12 rms	24-03-2023	415.3	411.2	419.0	V	05:20:00	(min:s)
U23 rms	24-03-2023	419.0	414.5	422.9	V	05:20:00	(min:s)
U31 rms	24-03-2023	420.3	415.7	424.4	V	05:20:00	(min:s)

Line Current Measurements at Outgoing Side of 10 kVA Inverter LT Panel-1

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
A1 rms	24-03-2023	4.95	1.77	6.77	A	05:20:00	(min:s)
A2 rms	24-03-2023	5.04	1.80	6.91	A	05:20:00	(min:s)
A3 rms	24-03-2023	5.03	1.80	6.86	A	05:20:00	(min:s)
AN rms	24-03-2023	0.00	0.00	0.00	A	05:20:00	(min:s)

Power Factor Measurements at Outgoing Side of 10 kVA Inverter LT Panel-1

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
PF1	24-03-2023	0.993	0.986	0.997	p.u.	05:20:00	(min:s)
PF2	24-03-2023	0.991	0.983	0.997	p.u.	05:20:00	(min:s)
PF3	24-03-2023	0.993	0.985	0.998	p.u.	05:20:00	(min:s)
PFT	24-03-2023	0.992	0.985	0.997	p.u.	05:20:00	(min:s)

Measured Power at Outgoing Side of 10 kVA Inverter LT Panel-1

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
D1 (var)	24-03-2023	109.70	89.15	143.40	var	05:20:00	(min:s)

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D2 (var)	24-03-2023	117.90	99.58	151.00	var	05:20:00	(min:s)
D3 (var)	24-03-2023	101.40	88.46	132.60	var	05:20:00	(min:s)
DT (var)	24-03-2023	331.60	281.90	430.40	var	05:20:00	(min:s)
P1 (W)	24-03-2023	1.1	0.6	1.6	kW	05:20	(min:s)
P2 (W)	24-03-2023	1.1	0.6	1.6	kW	05:20	(min:s)
P3 (W)	24-03-2023	1.1	0.6	1.6	kW	05:20	(min:s)
PT (W)	24-03-2023	3.4	1.7	4.8	kW	05:20	(min:s)
Q1 (var)	24-03-2023	7.5	-2.7	14.7	var	05:20	(min:s)
Q2 (var)	24-03-2023	17.2	11.4	19.3	var	05:20	(min:s)
Q3 (var)	24-03-2023	35.4	32.1	39.8	var	05:20	(min:s)
QT (var)	24-03-2023	60.1	41.54	66.8	var	05:20	(min:s)
S1 (VA)	24-03-2023	1.1	0.56	1.6	kVA	05:20	(min:s)
S2 (VA)	24-03-2023	1.1	0.57	1.6	kVA	05:20	(min:s)
S3 (VA)	24-03-2023	1.2	0.58	1.6	kVA	05:20	(min:s)
ST (VA)	24-03-2023	3.4	1.71	4.8	kVA	05:20	(min:s)

Unbalance Measurements at Outgoing Side of 10 kVA Inverter LT Panel-1

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
Aunb (IEEE 112)	24-03-2023	1.3	1.0	1.7	%	05:20:00	(min:s)
Aunb (u2)	24-03-2023	1.3	1.1	1.7	%	05:20:00	(min:s)
Uunb (IEEE 112)	24-03-2023	0.7	0.6	0.7	%	05:20:00	(min:s)
Vunb (IEEE 112)	24-03-2023	0.6	0.5	0.7	%	05:20:00	(min:s)
Vunb (u2)	24-03-2023	0.7	0.6	0.8	%	05:20:00	(min:s)

Harmonic Distortion Measurements at Outgoing Side of 10 kVA Inverter LT Panel-1

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
A1 THDf	24-03-2023	7.4	4.5	11.5	% f	05:20:00	(min:s)
A2 THDf	24-03-2023	8.3	4.8	13.4	% f	05:20:00	(min:s)
A3 THDf	24-03-2023	7.0	4.3	11.4	% f	05:20:00	(min:s)
U12 THDf	24-03-2023	1.6	1.6	1.7	% f	05:20:00	(min:s)
U23 THDf	24-03-2023	1.3	1.3	1.4	% f	05:20	(min:s)
U31 THDf	24-03-2023	1.4	1.4	1.5	% f	05:20	(min:s)
V1 THDf	24-03-2023	1.8	1.7	1.9	% f	05:20	(min:s)
V2 THDf	24-03-2023	1.9	1.8	1.9	% f	05:20	(min:s)
V3 THDf	24-03-2023	1.4	1.3	1.4	% f	05:20	(min:s)

COMMENTS:

1) Above measured parameters parameter indicates that hourly average & maximum generation are found to be 3.4 kWh (Unit) & 4.8 kWh (unit) with near to unity power factor & also with pure sine curve, which are highly satisfactory.

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2) Total voltage harmonic distortion (%A THD) & total current harmonic distortion (%V THD) is found to be satisfactory & complies the harmonic regulation of IEEE 519 2014.

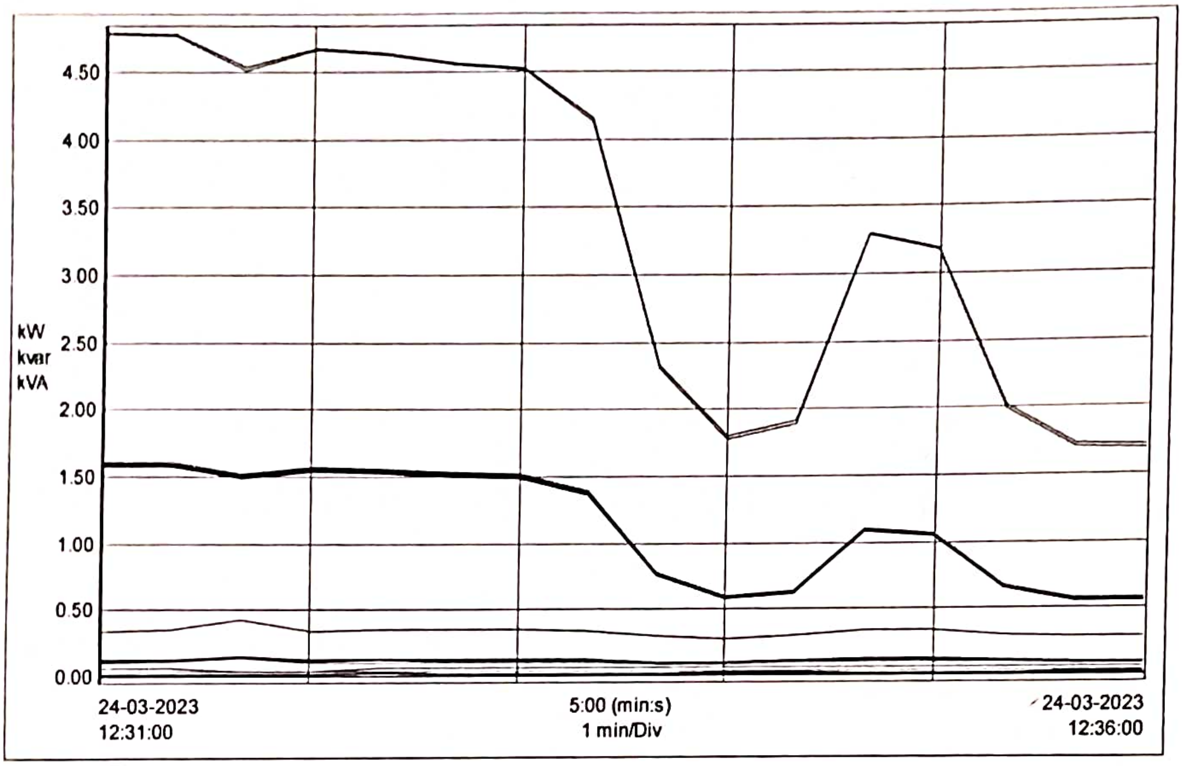

Figure 6 Curve for Measured Power Generation by 10 kVA Solar PV under Inverter LT Panel-1

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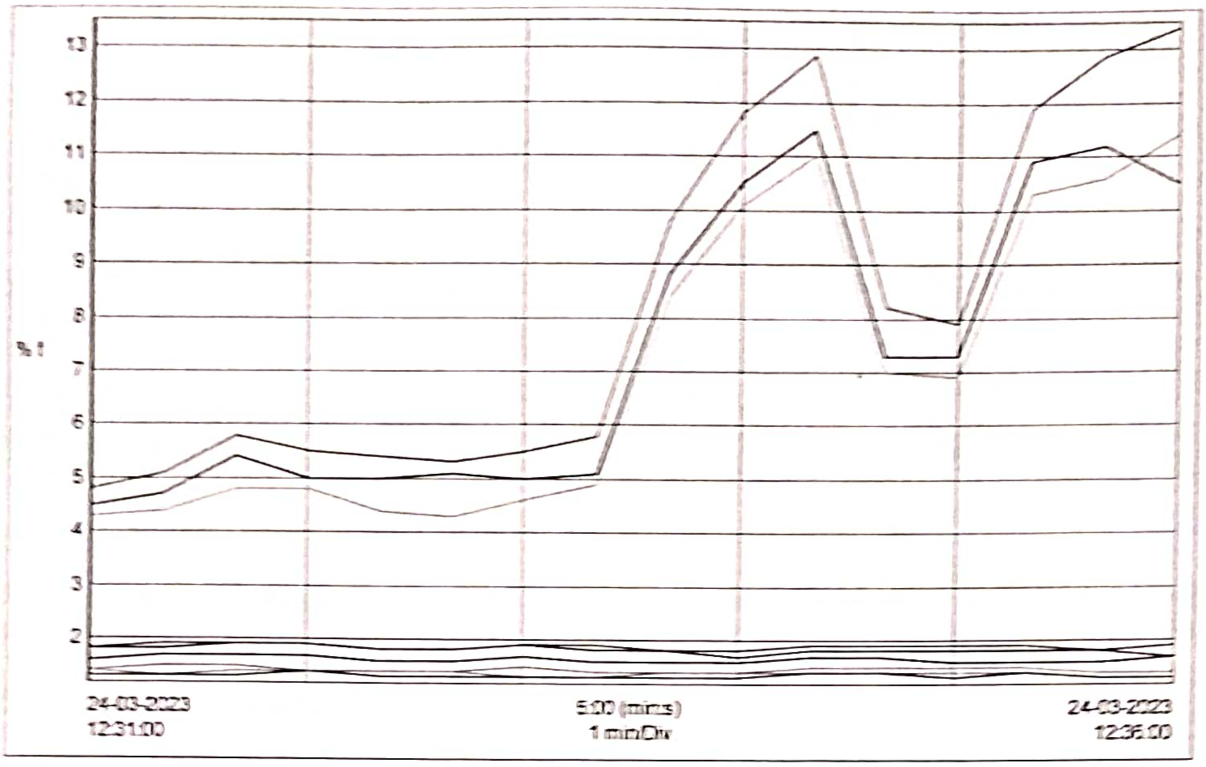
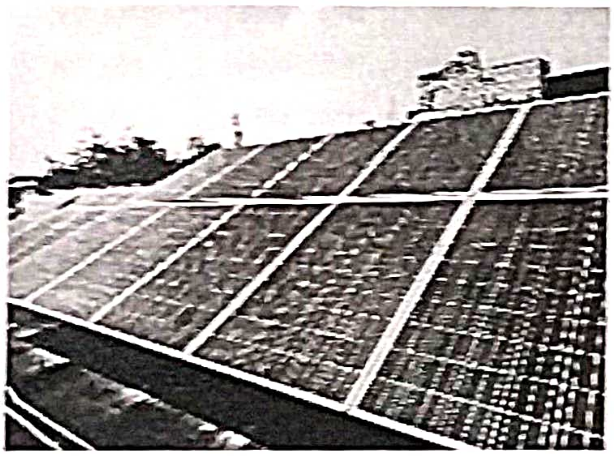


Figure 7 Curve for Measured Harmonic Distortion by 10 kVA Solar PV under Inverter LT Panel-1



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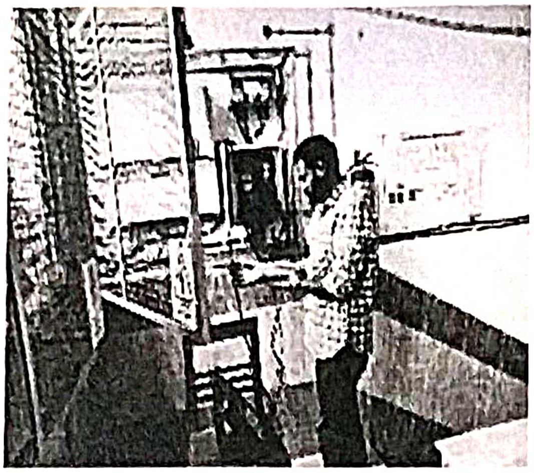

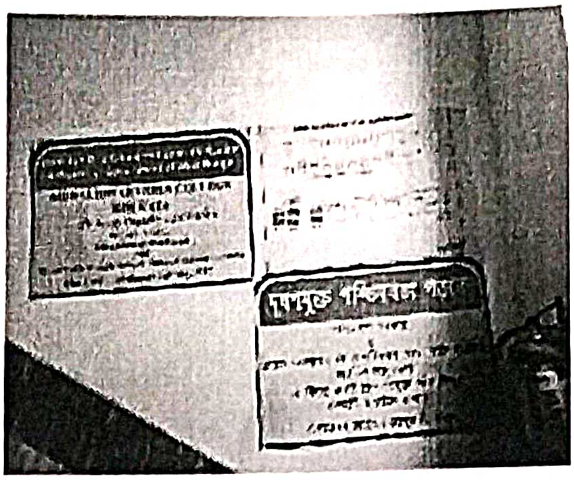

Figure 8 Measurement of Solar PV Generation at 10 kVA Inverter LT Panel-1 (West Side)

15.2 Measured Electrical Parameters at 10 KVA Solar PV Panel-2 (North Side)

Table 6 Measured Electrical Parameters for 10 kVA Solar PV Panel-2 (North Side)

Line Voltage Measurements at Outgoing Side of 10 kVA Inverter LT Panel-2

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
U12 rms	24-03-2023	420.0	415.6	423.6	V	04:40:00	(min:s)
U23 rms	24-03-2023	423.7	419.6	428	V	04:40:00	(min:s)
U31 rms	24-03-2023	424.9	420.0	429.3	V	04:40:00	(min:s)

Line Current Measurements at Outgoing Side of 10 kVA Inverter LT Panel-2

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
A1 rms	24-03-2023	6.63	1.62	7.77	A	04:40:00	(min:s)
A2 rms	24-03-2023	6.72	1.69	7.93	A	04:40:00	(min:s)
A3 rms	24-03-2023	6.73	1.67	7.9	A	04:40:00	(min:s)
AN rms	24-03-2023	0.00	0.00	0.00	A	04:40:00	(min:s)

Power Factor Measurements at Outgoing Side of 10 kVA Inverter LT Panel-2

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
PF1	24-03-2023	0.996	0.990	0.998	p.u.	04:40:00	(min:s)
PF2	24-03-2023	0.996	0.990	0.997	p.u.	04:40:00	(min:s)
PF3	24-03-2023	0.997	0.991	0.998	p.u.	04:40:00	(min:s)
PFT	24-03-2023	0.996	0.991	0.998	p.u.	04:40:00	(min:s)

Measured Power at Outgoing Side of 10 kVA Inverter LT Panel-2

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
D1 (var)	24-03-2023	123.20	107.20	140.70	var	04:40:00	(min:s)
D2 (var)	24-03-2023	127.90	108.80	142.50	var	04:40:00	(min:s)
D3 (var)	24-03-2023	110.70	98.78	126.50	var	04:40:00	(min:s)

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DT (var)	24-03-2023	364.60	316.10	412.40	var	04:40:00	(min:s)
P1 (W)	24-03-2023	1.6	0.8	1.8	kW	04:40	(min:s)
P2 (W)	24-03-2023	1.6	0.8	1.8	kW	04:40	(min:s)
P3 (W)	24-03-2023	1.6	0.8	1.9	kW	04:40	(min:s)
PT (W)	24-03-2023	4.8	2.5	5.6	kW	04:40	(min:s)
Q1 (var)	24-03-2023	1.1	-7.4	11.2	var	04:40	(min:s)
Q2 (var)	24-03-2023	16.0	8.7	18.5	var	04:40	(min:s)
Q3 (var)	24-03-2023	31.9	25.5	35.2	var	04:40	(min:s)
QT (var)	24-03-2023	48.8	26.82	60.3	var	04:40	(min:s)
S1 (VA)	24-03-2023	1.6	0.81	1.8	kVA	04:40	(min:s)
S2 (VA)	24-03-2023	1.6	0.83	1.9	kVA	04:40	(min:s)
S3 (VA)	24-03-2023	1.6	0.83	1.9	kVA	04:40	(min:s)
ST (VA)	24-03-2023	4.8	2.47	5.6	kVA	04:40	(min:s)

Unbalance Measurements at Outgoing Side of 10 kVA Inverter LT Panel-2

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
Aunb (IEEE 112)	24-03-2023	1.0	0.9	1.4	%	04:40:00	(min:s)
Aunb (u2)	24-03-2023	1.0	0.9	1.4	%	04:40:00	(min:s)
Uunb (IEEE 112)	24-03-2023	0.7	0.6	0.7	%	04:40:00	(min:s)
Vunb (IEEE 112)	24-03-2023	0.5	0.5	0.6	%	04:40:00	(min:s)
Vunb (u2)	24-03-2023	0.7	0.6	0.8	%	04:40:00	(min:s)

Harmonic Distortion Measurements at Outgoing Side of 10 kVA Inverter LT Panel-2

Name	Date	AVG.	MIN.	MAX.	Units	Duration	Units
A1 THDf	24-03-2023	5.1	3.7	9.3	% f	04:40:00	(min:s)
A2 THDf	24-03-2023	5.4	4.3	9.5	% f	04:40:00	(min:s)
A3 THDf	24-03-2023	4.7	3.7	8.7	% f	04:40:00	(min:s)
U12 THDf	24-03-2023	1.8	1.7	1.8	% f	04:40:00	(min:s)
U23 THDf	24-03-2023	1.4	1.3	1.5	% f	04:40	(min:s)
U31 THDf	24-03-2023	1.6	1.4	1.7	% f	04:40	(min:s)
V1 THDf	24-03-2023	2.0	1.8	2.1	% f	04:40	(min:s)
V2 THDf	24-03-2023	1.9	1.8	2.0	% f	04:40	(min:s)
V3 THDf	24-03-2023	1.4	1.3	1.5	% f	04:40	(min:s)

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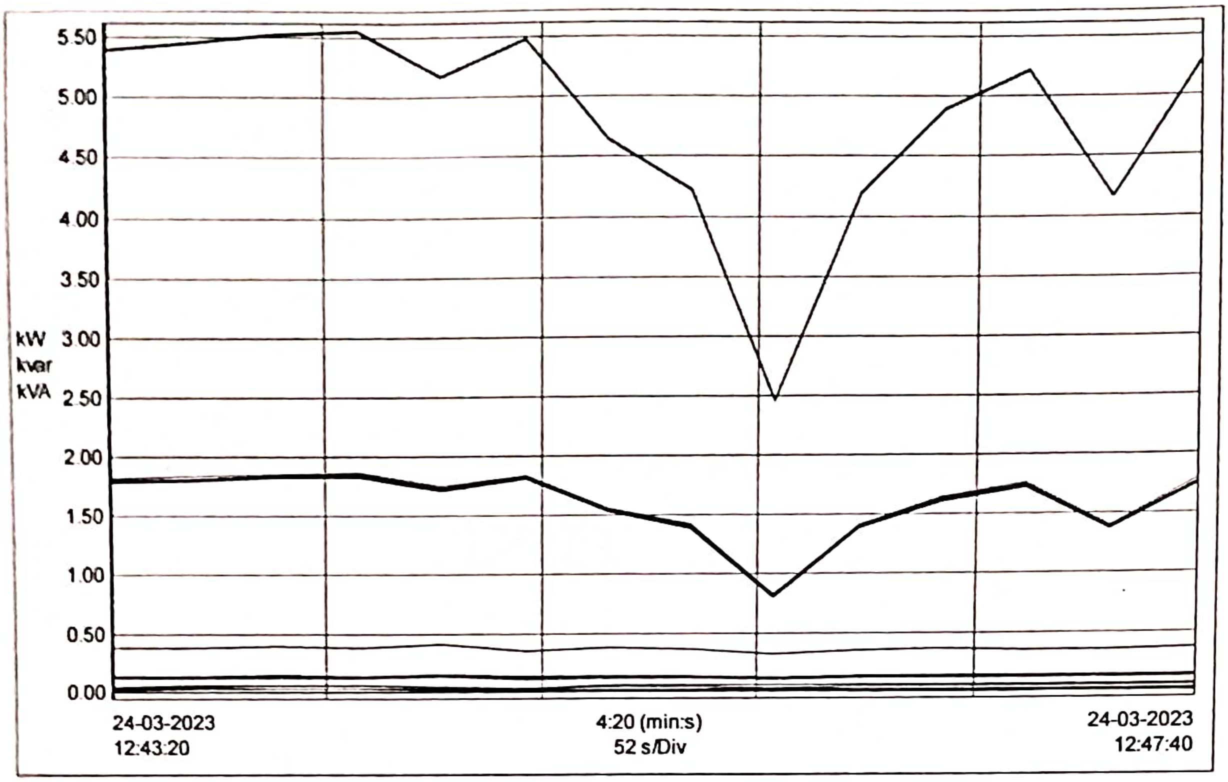

Figure 9 Curve for Measured Power Generation by 10 kVA Solar PV under Inverter LT Panel-2

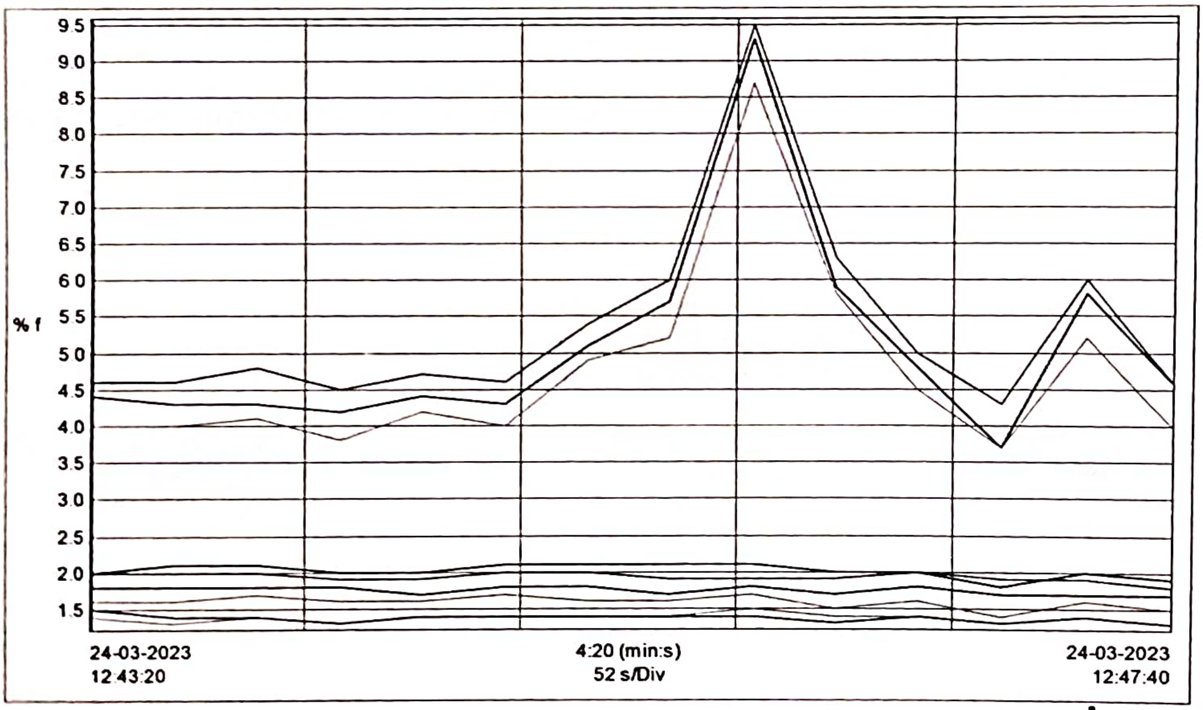

Figure 10 Curve for Measured Harmonic Distortion by 10 kVA Solar PV under Inverter LT Panel-2

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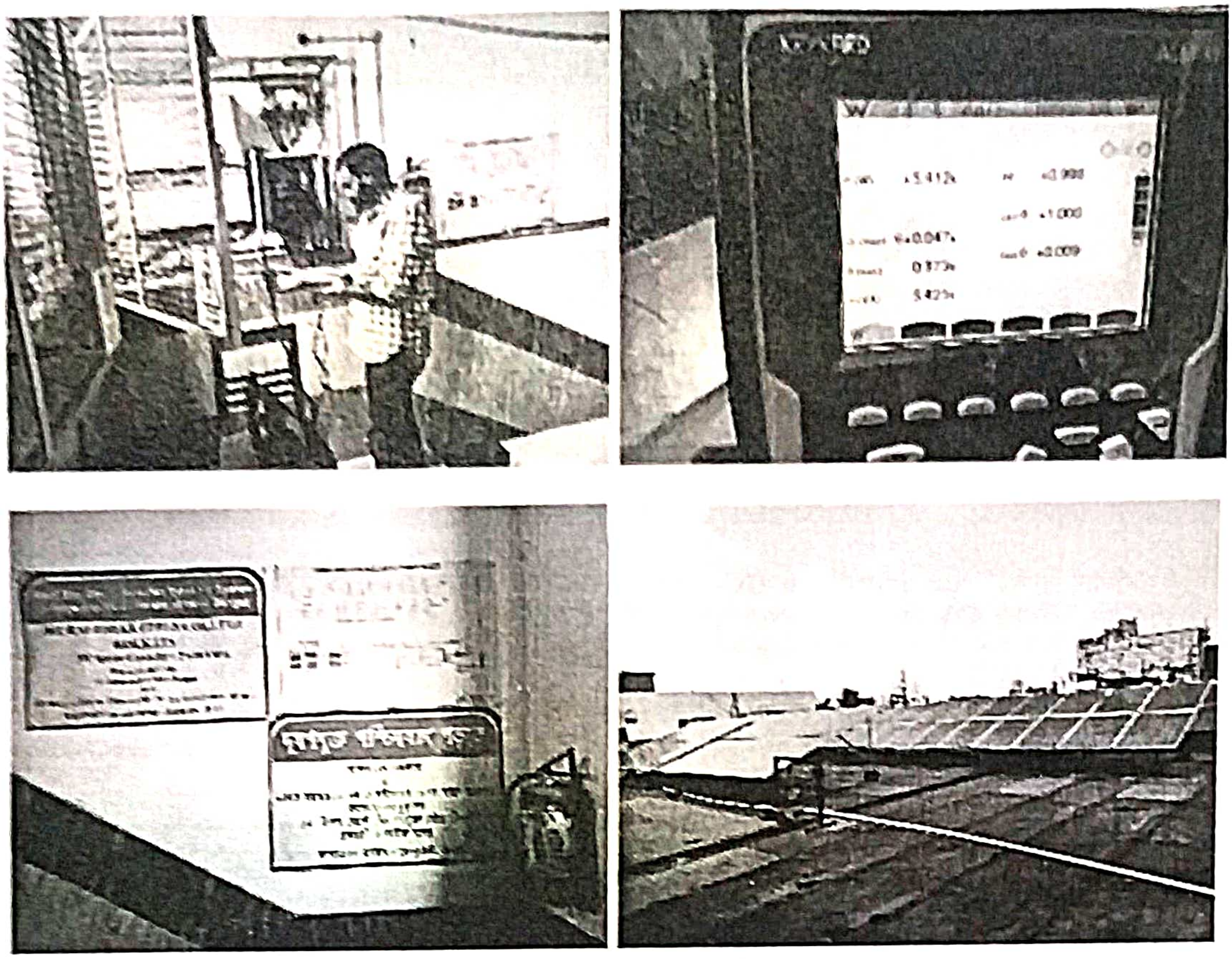

Figure 11 Measurement of Solar PV Generation at 10 kVA Inverter LT Panel-2 (North Side)

COMMENTS:

1) Above measured parameters parameter indicates that hourly average & maximum generation are found to be 4.8 kWh (Unit) & 5.6 kWh (unit) with near to unity power factor & also with pure sine curve, which are highly satisfactory.

2) Total voltage harmonic distortion (%A THD) & total current harmonic distortion (%V THD) is found to be satisfactory & complies the harmonic regulation of IEEE 519 2014.

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16.0 Illumination & Lighting System

16.1 Introduction:

Lighting energy contributes to around **43.65%** of power in Muralidhar Girls' College, which is found to be very high, wherein only few areas use small number of energy efficient & long-lasting LED Lighting Fixtures 15-Watt LED Fixture areas compared to conventional fluorescent tube light (FTL). Hence, there is a further scope for cutting down the lighting power consumption by the adoption of energy efficient LED based lighting system.

Part 8 of National Building Code of India enlisting standards for Building services (Illumination) are the set of standards required to be implemented across all warehousing structures. (IS 3646 Part 1) of BIS.

The field study was included the LUX measurements randomly in class room, office rooms, laboratory and teachers room etc. & estimation of lighting power consumption and comparison with IS standard, condition of lamp/luminaries' survey.

Details of LUX measurements in all floors of college building room and electrical measurements on lighting feeder are given in tables below.

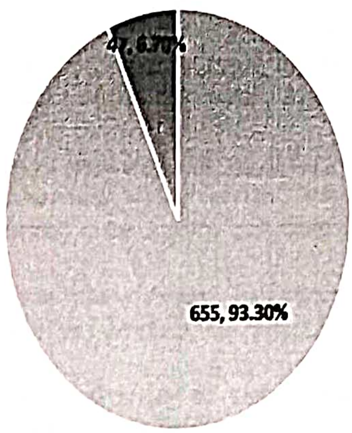

Figure 12 Population of Different Kinds of Lighting System

COMMENTS:

College management should focus mainly to use energy efficient & high efficacy LED Fixture than conventional & high wattage fluorescent tube lights, which will bring down the overall energy consumption of college substantially.

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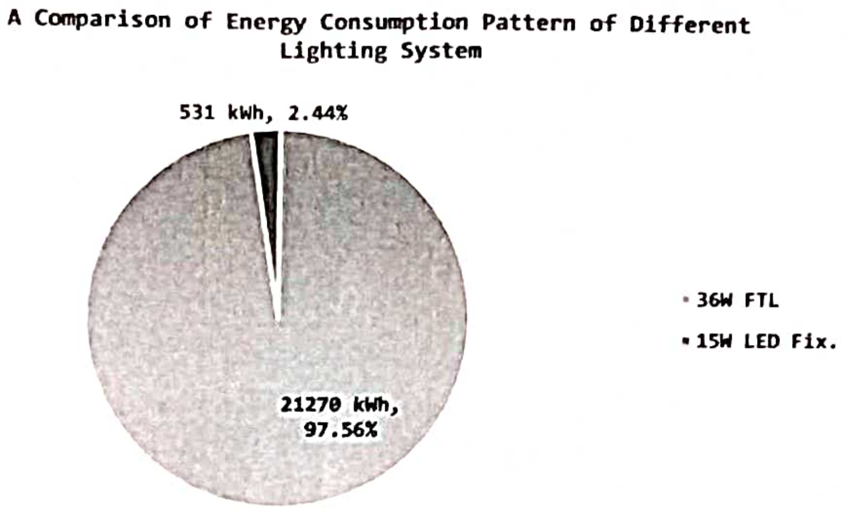

Figure 13 Energy Consumption (kWh) Pattern of Different Lighting System

COMMENTS:

College management should focus mainly to use energy efficient & high efficacy LED Fixture than conventional & high wattage fluorescent tube lights, which will bring down the overall energy consumption of college substantially.

16.2 Salient Observations:

⇒ Most cases college is using extensively high wattage conventional fluorescent tube light, which increases lighting power consumption substantially.

⇒ Most cases measured LUX in office space areas was found to be poor as compared to recommended value of IS 3646 (Part-1)-1992 as most cases low efficacy fluorescent tube lights are used.

⇒ Most cases class rooms, laboratories are harnessed Natural Day light through glass window, leading to reduction of necessity of additional lighting loads.

⇒ At present switching of indoor lighting system is done manually and no sensor based automatic switching is available after completion of classes. Hence, there is a uncertainty in switching of circuit in correct time, which may lead to loss of power unnecessarily.

⇒ At present there is no cloud (IoT) based lighting control system, wherein today switching of lighting system can be easily controlled efficiently by Smart Mobile or Laptop or Desktop through Internet based Router Connection from any single location.

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16.3 Recommended Illumination [Source: IS 3646 (Part 1): 1992]

L - R - H (L- Lower Value of illuminance, H- Higher Value of illuminance, R- Recommended illuminance).

	L	R	H
Office Room	200	300	500
Class Room	200	300	500
Laboratory	300	500	750
Library	200	300	500
Conference Hall	100	200	300

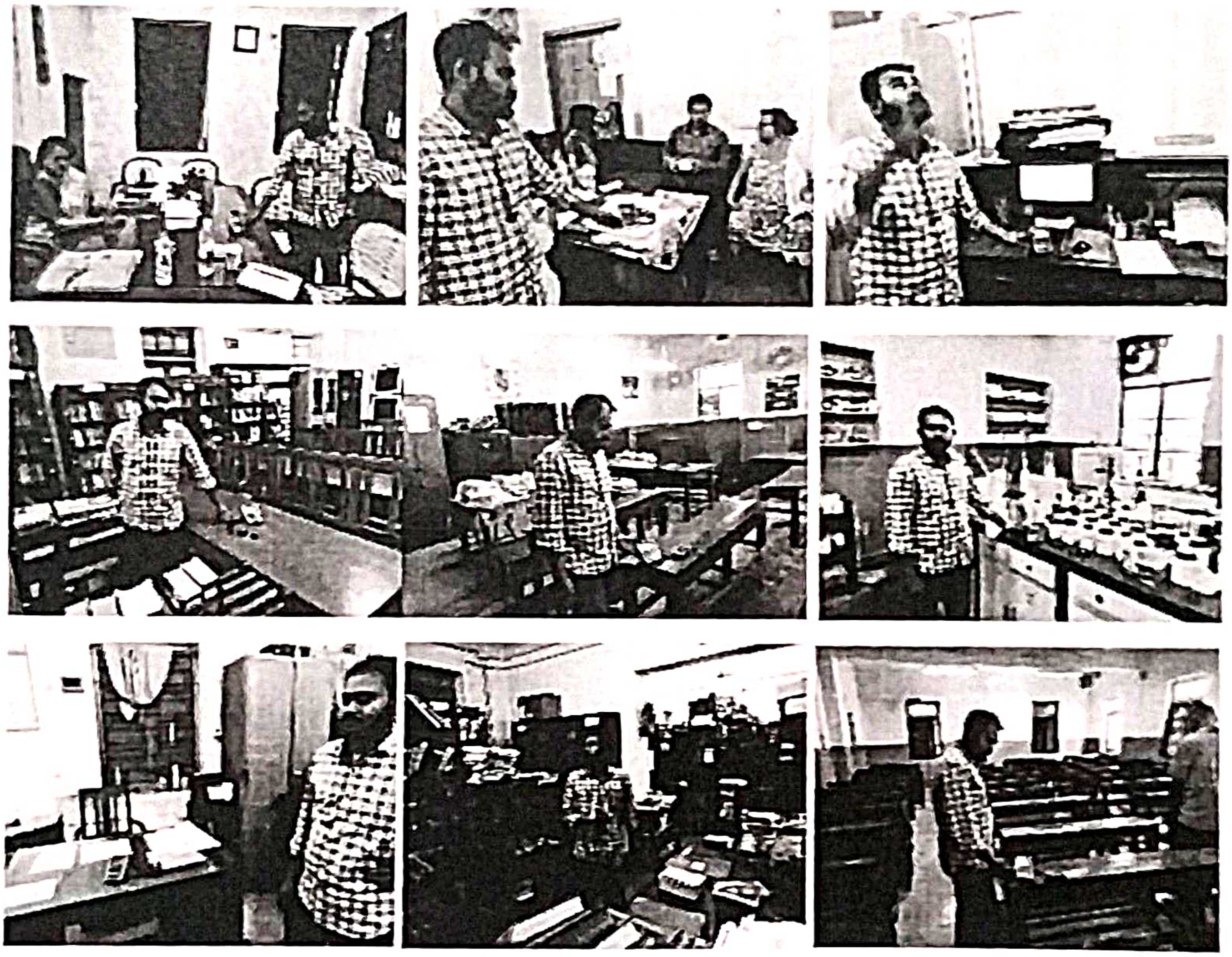

Figure 14 LUX Measurement at different Room

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Table 7 Measured Illumination & Power Consumption Profile in Lighting System

Measured illumination & Energy Consumption for Muralidhar Girls College

Sl. No.	Location/Room	Type of Lamp & Fittings	No. of Glowing Lamp	Watt / Lamp	Watt / ballast	Total Power (kW)	Annual Running Hours	Annual Energy Consumed (kWh)	Avg. LUX Level	LUX As per IS 3646 (Part-1)-1992 (L-R-H)
1.	Gr. Fl. Accounts Room	2 x 36W FTL	8	36	10	0.368	882	325	89.3	200-300-500
2.	Gr. Fl. Office Room	2 x 36W FTL	20	36	10	0.920	882	812	120.3	200-300-500
3.	Gr. Fl. Principal Room	15W LED Fix. (R)	8	15	1	0.128	882	113	206.3	200-300-500
4.	Gr. Fl. Library	2 x 36W FTL	40	36	10	1.840	882	1624	127.1	200-300-500
5.	3rd. Fl. Room-29	2 x 36W FTL	14	36	10	0.644	882	568	129.3	200-300-500
6.	3rd. Fl. Psychology Laboratory	2 x 36W FTL	20	36	10	0.920	882	812	136.7	200-300-500
7.	2nd Fl. Class Room-27 (Projection Room)	2 x 36W FTL	20	36	10	0.920	882	812	196.0	200-300-500
8.	2nd Fl. Chemistry LAB	2 x 36W FTL	16	36	10	0.736	882	649	204.9	200-300-500
9.	1st Fl. Auditorium	1 x 36W FTL	14	36	10	0.644	300	193	233.0	200-300-500
10.	9/Bengali Seminar	2 x 36W FTL	6	36	10	0.276	200	55	99.0	200-300-500
11.	Gr. Fl. Teachers Room	2 x 36W FTL	16	36	10	0.736	919	677	130.9	200-300-500
Total			**182**	**-**	**-**	**8.13**	**-**	**6639**	**152**	

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17.0 Energy Conservation Proposal

Proposal-17.1 (On Current Unbalancing)

Balancing the load current in between phases at main CESC fed incomer main panel by Shifting Single Phase Loads (lights, ceiling fans & split air-conditioners) from higher to lower mutually at different class room, laboratories, teacher room, office room, accounts office room etc & also checking of tightness for feeder cable terminals at MCCB, Bus-bar, MCB, etc. and reduction of line losses

17.1.1 Background:

Three-phase unbalance is a familiar issue for power system engineering. This can introduce additional power losses in distribution network in steady states due to both negative and zero sequence components.

From the measurements at CESC fed ground floor incomer main panel, it is seen that large amount of current unbalancing exists in between three phases & considerable amount of unbalance current flows through neutral, which leads to increase line losses (I^2R). It is also noticed that considerable amount of unbalance current flow through neutral conductor, which also heats up neutral conductor & increase losses.

Any large single-phase load or a number of small loads connected to only one phase cause more current to flow from that particular phase causing voltage drop on line. Switching of three phase heavy loads results in current and voltage surges which cause unbalance in the system.

17.1.2 Causes of Unbalance:

Practical imperfections which can result in unbalances are: -

1. Any large single-phase load like fan load, lighting load, computers, Printers, Xerox Machines, UPS, single phase split air-conditioners etc. or a number of small loads connected to only one phase cause more current to flow from that particular phase causing voltage drop on line.
2. Switching of three phase heavy loads results in current and voltage surges which cause unbalance in the system.
3. Flow of triple-n order of harmonics through neutral conductor.
4. Besides, an unbalance can also be quantified by comparing the intensity of negative sequence currents in comparison to the positive sequence currents. The permissible limit in terms of percentage of negative phase sequence current over positive sequence current is 1.3% ideally but acceptable up to 1%.

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17.1.3 Summary of Techno-economic Analysis:

SUMMARY OF TECHNO ECONOMICS FOR CURRENT BALANCING IN ELECTRICAL SYSTEM	
➢ Annual Energy Saving Potential	: 1153 kWh
➢ Annual Cost Saving Potential	: ₹0.164 Lakh
➢ Investment Required	: ₹0.135 Lakh
➢ Payback Period	: 9.9 Months

Details of techno-economic analysis are given in annexure-1.

Proposal-17.2 (On Energy Efficient Lighting System)

Replacement of all 36W Conventional Fluorescent Tube Lights (FTL) in indoor application step by step with new generation energy efficient & Long Lasting 1 x 20W LED Tube Lights and saving of substantial amount of electrical energy and reduction of maintenance cost

17.2.1 Background:

Presently Muralidhar Girls College uses 655 nos. of conventional 36W Conventional Fluorescent Tube Light with copper ballast, located mainly at all class rooms, laboratory, office room, accounts room, conference hall, auditorium etc, which consume excess power than new generation energy efficient & long-lasting LED lighting fixture. It is well proven that LED Light Fixture is very efficient, which consumes less power corresponding to lumen output.

Power LED Round Fixture for indoor application is designed with high-illumination Power LEDs having a life of 30,000 hours to 50,000 hours. This light has light output similar to fluorescent, and involves a much lower initial investment. The light output is more homogenized then in the existing model, and it provides flicker-free operation from 110V-260VAC.

17.2.2 Features of PowerLED Tube Light Indoor Fixture:

- Light emission divided over a greater number of LEDs (for same wattage and total light output), hence more homogenous light and less 'spotty'
- Light output similar to that of standard FTL
- Simplified passive control circuitry provides high reliability of driver; no active SMPS circuitry involved
- Contributes to Power Factor improvement
- Large-chip power LED construction for efficient thermal management of the LED chip, thus providing high reliability and long life

17.2.3 Technical Specifications for 20-watt LED Tube Light (indoor):

- Equivalent to about 36-watt FTL
- Working Voltage- 110 - 260 V AC
- LED lamp Efficacy- Minimum 100 lumens/watt
- Rated system Wattage- 18W ± 3%

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- Frequency- 50 ± 1 Hz
- Colour Rendering Index (CRI)- > 80
- Total harmonic distortion (THD)- Should not be more than 20%
- Corrected Colour Temperature (CCT)- 5700 ± 300 K
- Average Lighting Angle- 160°
- System lumen efficacy- Should be min. 100 lumens / watt
- Power factor- > 0.95
- LED / Type- High Power LEDs should be used
- Life Expectancy (Design life)- Min. 30,000 burning hours
- Ingress Protection- IP20 (Indoor)
- Driver efficiency- More than 85 %

17.2.4 Summary of Techno-economic Analysis:

SUMMARY OF TECHNO ECONOMICS FOR REPLACEMENT OF FLUORESCENT TUBE LIGHT

➤ Annual Energy Saving Potential	: 23120 kWh
➤ Annual Cost Saving Potential	: ₹3.29 Lakh
➤ Investment Required	: ₹3.93 Lakh
➤ Payback Period	: 14.3 Months

Details of techno-economic analysis are given in annexure-2.

Proposal-17.3 (On Energy Efficient Smart BLDC Ceiling Fan)

Replacement of 217 nos. of 70-Watt 48" Conventional Ceiling Fans with new 18 nos. of 28 Watt 48" (Φ 1200 mm Sweep) most Energy Efficient BEE 5-Star Rated Smart Ceiling Fans and save substantial amount of electrical energy.

17.3.1 Background:

At present Muralidhar Girls' College uses 217 nos. of 70 watt Conventional 48" Ceiling Fans at all class rooms, office rooms, laboratory rooms, conference hall, auditorium etc. During study it was observed that such conventional ceiling fan consumes excess power than new generation low wattage (28 Watt) smart (sensor based) ceiling fan, which saves considerable amount of electrical energy. Hence, it is suggested to replace all conventional ceiling fans with new generation smart energy efficient fans and save considerable amount of electrical energy.

17.3.2 Features of Smart Ceiling Fan:

a.> Super energy efficient (Brushless Direct Current Motor, BLDC)
b.> High service value (air delivery/watt)
c.> Runs 3 times longer on inverter resulting
d.> No humming noise
e.> No heating of fan even after long hours of runtime resulting in extra-long life
f.> Easy speed control using smart remote
g.> Consistent performance even at low voltage and power fluctuation

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h.> Timer features to auto switch off the fan
i.> Sleep mode that reduces the speed after set hours and saves energy

17.3.3 Technical Specifications:

1.> Blade Span (mm/inch)	:	1200/48
2.> RPM	:	380
3.> Service Value	:	> 8
4.> Input Voltage (V)	:	140 - 285
5.> Power Consumption (W)	:	28
6.> Frequency (Hz)	:	48 - 52
7.> Air Delivery (CMM)	:	230
8.> Power Factor	:	> 0.98
9.> No. of Blades	:	3
10.> Voltage THD	:	< 10%
11.> Current THD	:	< 2%
12.> Bearing (Double)	:	Deep Groove Double Sided Steel Shielding
13.> Remote Control (12 Keys)	:	Speed Control, Timer and Sleep Mode

17.3.4 Summary of Techno-economic Analysis:

SUMMARY OF TECHNO ECONOMICS FOR ENERGY EFFICIENT SMART BLDC CEILING FAN

- Annual Energy Saving Potential : 10937 kWh
- Annual Cost Saving Potential : ₹1.56Lakh
- Investment Required : ₹6.18 Lakh
- Payback Period : 47.7 Months

Details of techno commercial analysis are shown in Annexure-3.

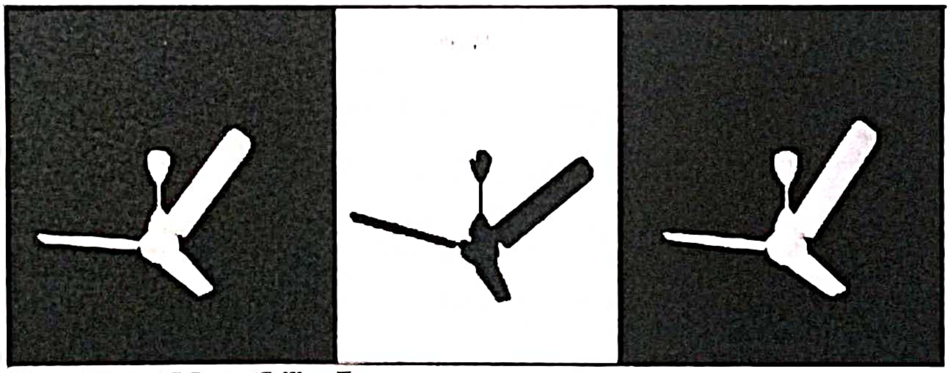

Figure 15 BLDC Smart Ceiling Fan

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18.0 Annexure

Annexure 1 Saving Potential by Load Current Balancing at load centres

Analysis for Energy Saving Potential due to Balancing of Load Currents at Load Centres & Reduction of Neutral Current			
Sl. No.	**Particulars**	**Unit**	**Analysis & Result**
1.	Avg. Measured "R" phase Load Current, I_R	Amp.	76.9
2.	Avg. Measured "Y" phase Load Current, I_Y	Amp.	94.5
3.	Avg. Measured "B" phase Load Current, I_B	Amp.	97.6
4.	Mean Load Current, $I_M = (I_R + I_Y + I_B)/3$	Amp.	89.7
5.	Avg. Neutral Current, I_N	Amp.	36.9
6.	Percentage Unbalancing, $((MAX(I_R : I_B)-I_M)*100/I_M)$	%	8.85
8.	Copper Losses in "R" phase, I_R^2	$Amp.^2$	5909
9.	Copper Losses in "Y" phase, I_Y^2	$Amp.^2$	8936
10.	Copper Losses in "B" phase, I_B^2	$Amp.^2$	9526
11.	Copper Losses in "Neutral", I_N^2	$Amp.^2$	1360
12a.	Overall Cable Resistance of upstream to downstream for phases	Ohm	0.25
12b.	Overall Cable Resistance of upstream to downstream for Neutral	Ohm	0.50
13.	Total Copper Losses due to unbalance currents, $I_{tot}^2 = I_R^2 * R_R + I_Y^2 * R_Y + I_B^2 * R_B + I_N^2 * R_N$	Watt	6773
14.	For balanced load condition, Current per phase (I)	Amp.	89.7
15.	Total Copper Losses in balance current condition, $3*I_M^2*R_{Ph} + I_N^2*R_N$	Watt	6030
16.	Net CU loss due to unbalanced load	Watt	743
		kW	0.743
17.	Allowable targeted current unbalancing (Max.)	%	10.0
18.	Power Saving Potential due to balancing of load currents	kW	0.67
19.	Annual Load running time of plant	Hour	3600
20.	Load Factor, LF	p.u.	0.659
21.	Loss Load Factor, LLF = 0.2 LF + 0.8 LF^2	p.u.	0.479
22.	Annual energy saving due to balancing of load currents	kWh	**1153**
23.	Cost of Electricity	₹/kWh	14.22
24.	Annual cost of energy saving potential	₹Lakh	0.164
25.	Tentative Investment required for deployment of additional man power for shifting & balancing of single-phase unbalance light & fan loads, AC Load & any other single-phase loads, checking of tightness for all MCCB & MCB cable terminals etc.	₹ Lakh	0.135
26.	Payback Period	Month	9.9

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Annexure 2 Techno-Economic Analysis for Replacement of Existing 36W Conventional Fluorescent Tube Light (FTL) with Energy Efficient 20W LED Tube Light

Techno-Economic Analysis for Replacement of Existing 36W Conventional Fluorescent Tube Light (FTL) with 20W LED Tube Light			
Particulars	Unit	Existing	Proposed
Fixture		36W FTL	20W LED TL
Power consumed per Lamp	W	36	20
Power consumed by Ballast	W	10	1
Total power consumed by fixture	**W**	**46**	**21**
Operating Hours/day	Hr	3.7	3.7
Annual days of operation	Day	240	240
Energy Used per year/fixture	**kWh**	**65**	**30**
Energy Rate	₹/kWh	14.22	14.22
Lamp life	hrs	5000	30000
Project Life of Lighting system	Yrs	34.0	34.0
Average Project Life	Yrs	34.0	
Replacement frequency during project lifetime	No.	5.00	0
Replacement frequency/year	No.	0.15	0
Initial Cost/unit	₹	250	550
Annual R & M cost	₹	6936	0
No. of Fixture	Unit	655	
Annual Saving Calculation			
Energy Saving	kWh	23120	
Energy Cost Saving	₹	328760	
Saving in R & M Cost	₹	6936	
Total Annual Saving	**₹**	**335695**	
Cost Benefit Calculation			
Capital cost of LED	**₹**	**360250**	
Labour & Other Cost	₹/Fixture	50	
Implementation Cost	**₹**	**32750**	
TOTAL INVESTMENT	**₹**	**393000**	
Annual M & V cost	**₹**	**6550**	
Net Annual Monetary Saving	**₹**	**329145**	
Simple payback	**Month**	**14.3**	

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Annexure 3 Analysis of Energy Saving for the Replacement of Conventional Ceiling Fan with Most Energy Efficient Smart Ceiling Fan

Analysis of Energy Saving for the Replacement of Conventional Ceiling Fan with Most Energy Efficient Smart Ceiling Fan			
Sl. No.	Particulars	Unit	Analysis & Result
1.	Avg. Power Consumed by 48" Conventional each Ceiling Fan	Watt	70
2.	Number Ceiling Fan exist	Nos.	217
3.	Avg. Running hour per day	hour	6
4.	Running hours per annum	hour	1200
5.	Annual energy consumed by 48" Conventional all Ceiling Fans	kWh	18228
6.	Avg. Power Consumed by each 48" Energy Efficient Smart Ceiling Fan	Watt	28
7.	Power Consumed by all 48" Energy Efficient Smart Ceiling Fans	Watt	6076
8.	Annual energy consumed by 48" Energy Efficient Smart Ceiling Fans	kWh	7291
9.	Annual energy saving potential	kWh	10937
10.	Cost of Electricity	₹/kWh	14.22
11.	Net annual energy cost savings	₹ Lakh	1.56
12.	Net Cost of 48" Energy Efficient Smart Fans	₹ Lakh	6.18
13.	Payback period	Month	47.7

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19.0 Details of Vendors & Service Providers

Sl. No.	NAME OF THE PROPOSED SYSTEM	NAME OF THE PROBABLE SUPPLIERS & IMPLEMENTORS
1.	Supplier of 5-Star Rated BLDC Smart Ceiling Fan	S.K. Enterprise 95, Dum Dum Parl, Tank No.-1, Kolkata- 700 055 Tel: 033 2590 5011, Mob: +91 9432674011, 9830472960, Email: skroy09@gmail.com
2.	Supplier of 20-Watt Rate LED Tube Light	S.K. Enterprise 95, Dum Dum Parl, Tank No.-1, Kolkata- 700 055 Tel: 033 2590 5011, Mob: +91 9432674011, 9830472960, Email: skroy09@gmail.com

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