R.K.S.D. (P.G) COLLEGE, KAITHAL

Ambala Road, Kaithal-136027,

Haryana

DETAILED ENERGY AUDIT REPORT

2022

A-Z ENERGY ENGINEERS PVT. LTD.

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INDEX

List of Tables

LIST OF ABBREVIATIONS AND ACRONYMS

AC	Air Conditioning
APFC	Automatic Power Factor Control
CFL	Compact Fluorescent Lamp
CFM	Cubic Feet per Minute
CoP	Coefficient of Performance
CO_2	Carbon Dioxide
CT	Cooling Tower
CW	Cooling Water
DG	Diesel Generator
EE	Energy Efficient
EER	Energy Efficiency Ratio
ENCON	Energy Conservation Measures
EPI	Energy Performance Index
FRP	Fibre Reinforced Plastic
FTL	Fluorescent Tube Light
HP	Horse Power
HPSV	High Pressure Sodium Vapour
HT	High Tension
HVAC	Heating, Ventilation and Air conditioning
ID	Induced Draft
IEEE	Institute of Electrical and Electronics Engineers
INR	Indian Rupees
IRR	Internal Rate of Return
kVA	Kilovolt Ampere
kVAh	Kilovolt Ampere Hour
kVAR	Kilovolt Ampere Reactive
kWh	Kilowatt Hour
LED	Light Emitting Diode
LT	Low Tension
MH	Metal Halide
Mkcal	Million Kilo Calories
PF	Power Factor
THD	Total Harmonic Distortion
TR	Ton of refrigeration
TRh	Ton of refrigeration in one hour
TOD	Time of Day
VFD	Variable Frequency Drive
WBT	Wet Bulb Temperature

BACKGROUND

Most of present human activities draw its energy from fossil fuel energy sources. The secondary form of energy, the Electricity, which is mainly generated from fossil fuel, is the lifeline of today's modern and highly mechanized lifestyle. Energy is a basic requirement for economic development in almost all major sectors of economy i.e. agriculture. Industry, transport, commercial, and residential (domestic); Consequently, consumption of energy in different forms has been steadily rising all over the country, and more so in Commercial Buildings, which has maintained a steady growth pattern in the past and the trend is likely to continue in future as well. However major concern is that the fossil fuel based sources of Energy are limited and these sources will get exhausted soon. Therefore Every nation whether developed or under-developed is very much concerned about optimal utilization of energy resources. Energy conservations is one of the initiatives which is a proven measure to optimize the uses to retard the depletion of energy resource.

Therefore considering the vast potential of energy saving and benefits of energy efficiency, the Government of India enacted the Energy Conservation Act, 2001 in October 2001. The Energy Conservation Act.2001, become effective from 1st March 2002. The Act provides for institutionalizing and strengthening delivery mechanism for energy efficiency programs in the country and provides a framework for the much needed coordination between various government entities. As per the EC Act, Government of India established "Bureau of Energy Efficiency" (BEE) with the mission to develop policy and strategies with a thrust on self-regulation and market principles, within the overall frame work of the Energy Conservation Act (EC Act) 2001 with the primary objective of reducing the energy intensity of the Indian economy.

ACKNOWLEDGEMENT

We A-Z Energy Engineer Pvt. Ltd. wish to express our gratitude to the Management of **R.K.S.D. (PG) COLLEGE**, Kaithal for assigning this work of Energy Audit. We covey our special thanks to;

Name	Designation
Dr. S.K Goyal	Principal

We also thank to each & every official of Engineering Section for showing keen interest and co-operation during the course of our study.

We hope that the result provided will help to reduce energy bills of the unit.

AUDIT TEAM

Audit team for this assignment consisted of Energy Auditors, Engineers and Experts namely Dr. P.P. Mittal, Accredited Energy Auditor (AEA-011), Sh. Pankaj Chauhan, Sr. Energy Consultant and Sr. Alok Kumar Tiwari, Sr. Engineer.

NOTE: It is intimated that this whole exercise is for Identifying Energy Saving Potential only. It is further recommended that the Management should go for Electrical Safety Audit also.

Place: **DELHI** Date: **March 2022**

1. Scope of the Work

The present audit laid emphasis on the following areas to identify energy saving opportunities**:**

- ✓ Power Distribution System
- ✓ Lighting system
- ✓ ACs & Ventilation
- ✓ Water Pumping and treatment System
- ✓ Transformers
- ✓ DG Sets
- ✓ Air washers and ventilation
- ✓ Compressor

2. Instruments Used for Energy Audit

The following portable instruments were used for data measurement:

- ✓ 3 – phase Power Analyzer
- ✓ Single phase Power Analyzer
- ✓ Anemometer
- ✓ Hygrometer
- ✓ Digital Thermometer
- ✓ Pressure gauge
- ✓ Lux Meter
- ✓ Thermograph Camera
- ✓ Flow Meter
- ✓ Earth Tester

3. Approach and Methodology

3.1 Approach

A team of 3 engineers was involved in carrying out the study, the general scope of which was as follows:

- Identify areas of opportunity for energy saving and recommend an action plan to bring down total energy cost
- Conduct energy performance evaluation and process optimization study
- Conduct efficiency test of equipment's and make recommendations for replacement (if required) by more efficient equipment with projected benefits
- Suggest improved operation & maintenance practices
- Provide details of investment for all the proposals for improvement
- Evaluate benefits that accrue through investment and payback period
- Analyze various energy conservation measures and to prioritize based on the maximum energy saving & investment i.e. short, medium and long term.

PRIORITIZATION	PAYBACK PERIOD
Short Term Project	Less than 1 year
Medium Term Project	Between 1 and 3 years
Long Term Project	More than 3 years

3.2 Methodology

The general methodology followed is captured in the following figure –

The study was conducted in 3 stages:

- Stage 1: Walk through audit to understand process energy drivers, measurability and formulation of audit plan
- Stage 2: Detailed Energy & Safety Audit
- Stage 3: Off-site work for data analysis and report preparation

4. Point of Appreciation

The engineering wing is aware of importance of energy conservation, and eager to learn innovative ways of reducing the electricity consumption: Further

1. Campus is using LED Lights at various locations indoor & outdoor
2. Star-rated & Inverter type Air conditioners are being used.
3. Electrical Panel Maintenance is good and proper numbering
4. Most of the capacitors are in good condition.
5. Temperature of panel & Motor is Normal.
6. Power factor achieved 0.99
7. R.O reject water to used toilet flushing & floor cleaning
8. The DG sets are excellently maintained and proper maintained log book (Fuel consumption & Generation data)
9. Time to time college energy aware conservation program/meeting to all staff member & employees.
10. Energy meter installed all sub panel to monitoring energy consumption department/area wise

5. About the energy audit location

The founder of the College Seth Makhan Lal (1909-1965) was a great philanthropist and a visionary. He was a kind-hearted intellectual and a Karamyogi who believed in Bhagwat Gita's Philosophy of "Nishkam Karma". He was a living symbol of humility and simplicity. He belonged to a renowned aggarwal family of Pundri and later on shifted to Kaithal (Kapisthal of ancient times) where he lived till the end of his Site. He was on enlightened soul and knew very well that service of the fellow beings is the greatest service.

When the idea of setting up a college in Kaithal was mooted before him by some eminent persons of the city, he immediately mode up his mind to contribute large heartedly for this noble act. He volunteered ahead of all others and gave the idea a practical shape by establishing a charitable educational society called Rastriya vidya Samiti in I954. He donated his movable and immovable property for storing the college. With the support of other traders and intellectual of the town, he was able to start the first college of the city i.e. Radha Krishan Sanatan Dharm College in the year 1954. The college was christened after the name of his revered father-in-low Sh. Radha Krishan Ji.

6. Executive Summary

The Electricity and HSD are sources of energy for the unit. The R.K.S.D. (P.G) College is getting electrical power supply from Uttar Haryana Bijli Vitran Nigam Limited (UHBVN) at 415 V (L.T) supply. The Sanctioned Load of college is 49.9 KW, 49.5 KW, 19 KW & 49.5 KW.

The premise is also having three nos. diesel generators of 125 KVA, 62 KVA & 15 KVA used to provide power supply during power failure/emergency. The one year electrical bill analysis indicates that there is no wide variation in MDI. MDI variation depend on season The major energy consuming equipment's in the premises are A/C Unit, Light, water pumping system, Labs equipment's, Computers, fans and other equipment etc.

- The college is being billed on kVAh basis; there for the effect of power factor is inbuilt in the billing structure. Improvement in the power factor would subsequently reduce KVAh consumption, it is thus recommended to replace capacitor Panel where delivery is less than 70%, so that the overall system power factor is maintained at around 0.99 (lag).
- The Management is conscious with regard to its Energy Efficiency Levels and they have initiated several measures to reduce the energy consumption, which include amongst others the use of LED lights of various ratings have been used at most of location in the premises. As the conventional light was already replaced with LED lamps in college. A-Z Energy Engineers Pvt. Ltd. acknowledges and appreciates the commitment of the management towards conservation of Energy.
- Although there is no simpler way to reduce the amount of energy consumed by lighting system than to manually turn OFF whenever not needed, this is not done as often as it could be. In response, automatic lighting control strategies like installation of occupancy sensors can be considered to Control light in response to the presence or absence of people in the space. Quantification of energy savings on this account is not possible.
- During the site visit, measurements were made to record the load profile of the building, which included the variations in the voltage, current, power factor, harmonics etc. The average voltage on LT side of lighting Transformers was around 245 V, which is high. This may be an adequate voltage for motive loads like motors etc., but for the lighting systems normally, the voltage should be around 220 volts (phase to neutral). A reduction of around 15% in the lighting voltage can reduce the power consumption by around 20%.
- The harmonics levels measured in main incomer were at normal level.

Particulars	Ramkrishan Library	P.G Block	Tagore Bhawan	Agrasen Bhawan	Morning College	B.Ed. College
THD Phase1 (V)	1.8	1.5	1.6	1.2	0.9	0.8
THD Phase2 (V)	1.7	1.4	1.6	1.1	1.0	0.7
THD Phase3 (V)	1.6	1.5	1.5	1.1	1.1	0.9
THD Phase1 (A)	4.1	2.8	3.5	2.8	1.9	3.1
THD Phase2 (A)	4.7	3.0	3.3	2.9	2.0	2.9
THD Phase3 (A)	4.5	3.1	2.9	3.1	2.7	3.3

➲ Various capacity & type of window/Split AC are installed in the college. Air conditioning system is not operational due to winter season. College already installed Energy efficient star rated AC Installed in Premises.

The summary of recommendations are as under:

1. Replacement of non-energy efficient light with energy efficient light
2. Occupancy Lights sensor used in Offices & Lab.
3. Ceiling fans replace with with BEE Star Rated Fans.
4. Old Motor replace with energy efficient IE3 &IE4 motor.
5. Power Factor required to be maintained at 0.99.
6. Replace Non Star AC with Energy efficient star rated AC.
7. Use of filters to suppress harmonics levels.
8. Use of smart building management system.
9. Energy Management Certification (ISO 50001 Certification) of the Campus.
10. Leftover conventional lights be replaced with energy efficiency lights.
11. Cleaning of all light points.
12. Switching of lights in day time where ever not required
13. Switching off lights in day time at locations where there is enough light**.**
14. Cleaning solar water panel Panels Regularly.
15. Alignment of shafts and flat belts in motors.

7. Energy Input, Conservation Option & Savings

7.1 Energy inputs

Electricity	For various machines, equipment, illumination system- offices and work place lighting, wards, cooling towers, motors, pumps, Instruments etc.
HSD	DG Sets
Solar	Renewable Energy

7.1.1 Electricity

The Electricity is major Energy input of the college. The historical consumption pattern for last 12 months are as per following details:

Table.1: Details of Energy Consumption

Sr. No.	Billing Month	R.K.S.D PG College		Ram Krishan Library		B.E.d College		Rashtriya Vidya Samiti
		Total Unit consumption	Solar generation Units	Total Unit consumption	Solar generation Units	Total Unit consumption	Solar generation Units	Total Unit consumption
1	Feb.-2021	3780	1040	3620	3620	5289	5289	-
2	Apr.-2021	7160	4280	6380	6300			60.0
3	May.-2021	2880	0	3900	3900	3879	3879	-
4	Jun.-2021	1520	0	3880	3880			0.0
5	Jul.-2021	4880	0	4660	4640	-	-	60.0
6	Aug.-2021	6020	0	3580	3160	-	-	1240.0
7	Sep.-2021	13320	0	9100	6380	-	-	1480.0
8	Oct.-2021	640	0	3240	2260	-	-	800.0
9	Dec.-2021	3580	4320	-	-	-	-	820.0
10	Feb.-2021	3920	2260	960	1300	-	-	
	Total	**47700**	**11900**	**39320**	**35440**	**9168**	**9168**	**4460.00**

7.1.2 HSD

HSD consumption is used in DG set in case of non-supply from grid, in emergency and maintenance etc.

7.1.3 Solar PV

The College has installed (43.5 kWp, 43.5 kWp & 16.5 kWp) solar panel on roof top of building. Solar Photovoltaic Cell for Power Generation and connect to net metering.

7.2 Proposed Summary of saving

Table.2: Sanving of saving

S. No.	Proposed energy conservation measures	Quantity	Energy savings Per annum		Estimated Investments	Simple payback period
		(nos.)	(kWh)	(Rs.)	(Rs.)	(Months)
1	Replacement of T-8 (36W) with 18W LED Tube Lights	60	3226	22582	37800	20
2	Replacing Fans with 5 Star rated BEE label Fans	10	1344.0	9408	29400	38
2	Installation of solar PV	50 kWp	69000	483000	2500000	62
	Total					

Remarks:

1. **The electricity rate has been taken as Rs.7.0/kVAh.**
2. **Calculations are annual average basis. The actual savings will be proportion to uses of uses.**

8. Lighting Details

Various types of lighting fixtures are installed in different areas and locations. Premises has already installed energy efficient LED Lights at most of the places. But still some lighting fixtures needs to be replaced with LEDs. Energy Efficient LED Lights offer reduction in the power consumption besides excellent color rendering properties and high luminous efficacy. The detail of lighting fixtures are given below:

Table 3: Type of lighting

Srl	Fixture	Power Rating (Watt)
1	Led tube light	20
2	LED Ceiling Light	12
3	LED Ceiling Light	18
4	LED Ceiling Light (2'x2')	36
5	LED Bulb	12
6	LED Bulb	9
7	Street Light	50

As units has already installed LEDs lights, still further saving in light could be achieved by taking following steps;

8.1 Timed Based Control or Daylight Linked Control

Timed-turnoff switches are the least expensive type of automatic lighting control. In some cases, their low cost and ease of installation makes it desirable to use them where more efficient controls would be too expensive. Newer types of timed-turnoff switches are completely electronic and silent. The best choice is an electronic unit that allows the engineering staff to set a fixed time interval behind the cover plate. This system is recommended for street Lighting application in the building. Photoelectric cells can be used either simply to switch lighting on and off, or for dimming. They may be mounted either externally or internally. It is however important to incorporate time delays into the control system to avoid repeated rapid switching caused, for example, by fast moving clouds. By using an internally mounted photoelectric dimming control system, it is possible to ensure that the sum of daylight and electric lighting always reaches the design level by sensing the total light in the controlled area and adjusting the output of the electric lighting accordingly.

If daylight alone is able to meet the design requirements, then the electric lighting can be turned off. The energy saving potential of dimming control is greater than a simple photoelectric switching system

8.2 Localized Switching

Localized switching should be used in applications, which contain large spaces. Local switches give individual occupants control over their visual environment and also facilitate energy savings. By using localized switching, it is possible to turn off artificial lighting in specific areas, while still operating it in other areas where it is required, a situation which is impossible if the lighting for an entire space is controlled from a single switch.

8.3 Lighting systems

8.3.1 Replacement of T8 (40W) with LED based LED Light

T8 tube lights with magnetic choke can be replaced with LED based tube lights (18 W) as they provide similar lux levels with further enhanced energy savings. Ballasts are used to provide higher voltage during the starting and also limit the current during normal operation. In electronic ballast the losses are 1 to 2 watts

Recommendation

The replacement of T8 (40 W+ magnetic choke) with LED based tube lights (18 W) will result in close to 64 percent energy savings without compromising on light levels.

Energy and Financial Savings

The following parameters and assumptions have been considered while estimating the energy savings and financial viability of this option.

Table 4: Saving in Replacement of T8 (40W) with LED 18 Watt

Assumptions and Input parameters		
Cost parameters		
Particulars	**Unit**	**Value**
Total T-8 (40W) installed in the campus Building	Number	60
Cost of LED based lights (18W)	INR/ piece	600
Installation Cost	% of capital cost	5
Operating parameters		
Particulars	**Unit**	**Value**
Number of running hours	Per day	6

Number of operating days	Per year	280
Average life of LED based lights (18 W)	Hours	50,000
Average life of LED based lights (18 W)	Years	8
Average electricity tariff	INR/kWh	7
Energy and financial savings		
Parameters	**Unit**	**Value**
Power consumption of T8 tube lights (40 W)	W/piece	50
Power consumption of LED (18W)	W/piece	18
Energy savings	W/piece	32
Annual energy saving	kWh/year	3226
Annual monetary saving	INR/year	22582
Total investment requirement	INR	37800
Simple payback period	Months	20
Internal rate of return	%	53.00%

An energy saving of 64 percent can be achieved by replacing the existing Tube lights T-8 (40 W) with LED based tube lights (18 W). Implementation of this measure needs an investment of INR 37800 and will have a simple payback period of 20 months. Additionally, the IRR comes out to be 53.00 %.

9. Ceiling Fan

There are different type and numbers of ceiling fans installed in campus. Ceiling fan used for air circulation. Ceiling fans used in class room, Office & lab etc.

Study of installed Ceiling Fans and recommendation for improvement

- Ceiling fans 70W installed in premises but more energy efficient fan available in market with very less power consumption.
- These fans can be replaced with BEE 5-star rated ceiling fans or latest super-efficient 35 W Fans equipped with BLDC motor

9.1 Replacing the existing ceiling fans with energy efficient ceiling fans

The average power consumption of each of these fans is around 70W. Energy efficient ceiling fans, which consume 35-30W or less, are available in the market today. The existing ceiling fans can be replaced with energy efficient ones.

Recommendation

The replacement of existing ceiling fans with energy efficient ceiling fans (30 W) will result approx. 57.14 percent energy savings without compromising on air delivery.

Energy and financial savings

The following parameters and assumptions are considered to estimate the energy savings and financial viability of this option

Table 5: Saving in star rated BLDC Fan

Assumptions and Input parameters		
Cost parameters		
Particulars	**Unit**	**Value**
Ceiling fans need to be replaced	Number	10
Cost of energy efficient ceiling fan	INR/ piece	2800
Installation cost	% of capital cost	5
Operating parameters		
Particulars	**Unit**	**Value**
Number of running hours	Per day	12
Number of operating days	Per year	280
Average electricity tariff	INR/kWh	7.0

Energy and financial savings		
Parameters	**Unit**	**Value**
Power consumption of existing ceiling fan	W/piece	70
Power consumption of EE ceiling fan	W/piece	30
Energy savings	W/piece	40
Annual energy saving	kWh/year	1344.00
Annual monetary saving	INR/year	9408
Total investment requirement	INR	29400
Simple payback period	Months	38
Power consumption of existing ceiling fan	W/piece	70

An energy saving of 57.14 percent can be achieved by replacing the existing ceiling fan with Energy Efficient ceiling fan. Implementation of this measure needs an investment of INR 29400.0 and will have a simple payback period of 38 months.

10. Split/Window AC Units Specification

The Premises has installed window & Split ACs at various locations. ACs are star-rated. In the office spilt/window A/C Unit to be used cooling for different area.

Recommendation

As per energy audit study/survey, split type ACs of 1.5 TR capacity which are non-star rated are recommended to be replaced with BEE 5-star rated ACs. These non-star rated ACs are not energy efficient.

Table 6: Types of AC unit

Sr. No	Identification	Star Rating	Tonnage	Make
1	Split	2, 3&5 Star Rated	1.5	Daikin & Hitachi
2	Window	3 Star Rated	1.5	Daikin

Energy and financial savings

The following parameters and assumptions have been considered while estimating the energy savings and financial viability of this option

Indicative TR Load Profile for Air Conditioning

o Small Office Cabins	: 0.1 TR m^2
o Medium Size Office with 10-30 people occupancy with Central A/c	: 0.06 TR/m^2
o Large Multistoried office complex with Central A/c	: 0.04 TR/m^2

Window & Spilts A/Cs are installed in the building complex in different areas. Air conditioning system is not operating during the energy audit. Non star rated AC are installed in a building, which could be replaced by Energy efficient 5 Star rated AC. In absence of any specific norms, which can say that a Window AC can be condemned/ scrapped after it has run for a particular number of hours, the best available criteria for scrapping an AC is its energy efficiency ratio. EER will normally take into account all possible aspect, which could lead to inefficiency like ageing, condition of the cooling coils and above all the technological drawbacks (when compared with modern day similar products).

Recommendation/ Observation of AC System

- Monthly cleaning schedule Air Filters
- Replace Damage filters.

- Yearly service
- Check and clean condenser coils
- Check and clean air filters
- Check pipe Insulation

11. Self-Power Generation

11.1 DG rated specification

The college has installed 03 No's DG Set of 125 KVA, 62 KVA and 15 KVA for in-house power generation. The DG is run during power cut and testing only. Normally all DG set is run during the power cut as per load requirement. The rated specification of DG is as follows

Table 7: Technical details of DG sets

Name Plate Data		DG-1	DG-2	DG-3
Rated	kVA	125	62	15
	KW	100	49.6	12
Voltage	V	415	415	415
Amp.	I	173.9	86	21
Phase		3	3	3
P.F		0.8	0.8	0.8
RPM		1500	1500	1500
Frequency	HZ	50	50	50

11.2 Performance Assessment of DG

During the audit we measured the specific fuel consumption (kWh/Ltr) of DG sets.. Specific energy consumption show in below table as per standard. The standard specific fuel consumption (SFC) of DG sets is in the range of 2.5 to 3.5 kWh/ltr. Present Average SFC of DG is 2.2 to 3.0 kWh/Ltr, which is good as per design value

Sr. No.	D.G	KVA	Fuel Consumption (Ltr/hr.)
1	DG-1	125	20 ltr/hr.
2	DG-2	62	10 ltr/hr.
3	DG-3	15	5 ltr/hr.

Further observations and recommendations are as under:

1. The college has installed 03 No's DG Set of 125 KVA, 62 KVA & 15 KVA for in-house power generation. The DG is run during power cut and testing only. The operating specific energy consumption (SEC) varied from 2.5 kWh/Ltr to 3.5 kWh/Ltr. However, if we look at the overall average specific energy consumption (SEC) is around 3.5 kWh/Ltr, which is good.
2. D.G sets are neat & clean
3. Fuel consumption proper maintained log book
4. DG set area should have Proper Ventilation
5. There is No-Load Testing schedule

General Recommendations for Energy Efficiency Measures in DG Sets

1. Ensure Steady load condition on the DG set and avoid idle running.
2. Improve air filtration.
3. Ensure fuel oil storage, handling and preparation as per manufacturers' guidelines/oil company data.
4. Calibrate and overhaul fuel injectors and injection pumps regularly as recommended by manufacturer.
5. Ensure compliance with maintenance checklist

6. Ensure steady load conditions, avoiding fluctuations, imbalance in phases, harmonic loads.
7. Carryout regular field trials to monitor DG set performance, and maintenance planning as per requirements.
8. Efficiency of DG Set can be increase by loading 70-80% load
9. The starting current of squirrel cage induction motor is as much as six times the rated current for a few seconds with direct-on-line starters. In practice, it has been found that the starting current value should not exceed 200% of the full load capacity of the alternator. The voltage and frequency throughout the motor starting interval recovers and reaches rated values usually much before the motor has picked up full speed
10. It is always recommended to have the load as much balanced as possible, since the unbalanced loads can cause heating of the alternator, which may result in unbalanced output voltage. The maximum unbalanced load between phases should not exceed 10% of the capacity of the generating sets.
11. The electricity rules clearly specify that two independent earths to the body and neutral should be provided to give adequate protection to the equipment in case of an earth fault and to drain away any leakage of potential from the equipment to the earth.

12. Solar Photovoltaic Cell

12.1 Installation of Solar Photovoltaic Cell (SPV)

The College has installed (43.5 kWp, 43.5 kWp & 16.5 kWp) solar panel on roof top of building. Solar Photovoltaic Cell for Power Generation and connect to net metering. Solar photovoltaic technologies convert solar energy into useful energy forms by directly absorbing solar photons—particles of light that act as individual units of energy—and either converting part of the energy to electricity. **A-Z Energy Engineers Pvt. Ltd. acknowledges and appreciates the commitment of the management towards conservation of Energy.**

Sr No.	Description	Solar Capacity (kWp)
1	PG College	43.5
2	Library	43.5
3	B.Ed.	16.5

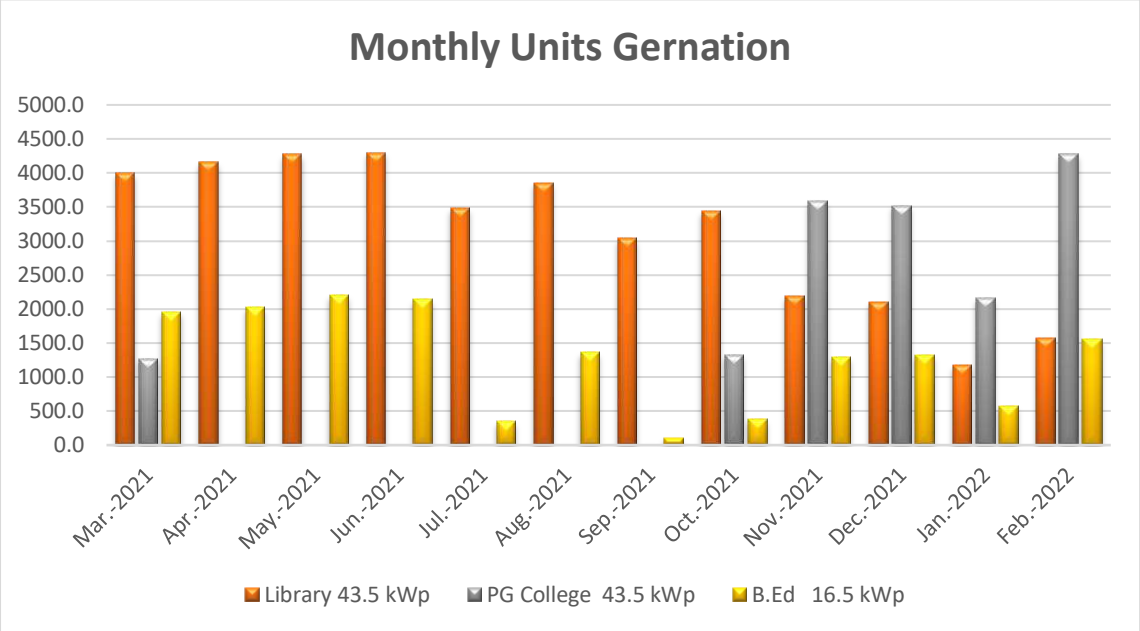
12.2 Unit generation by solar PV

Sr No.	Month	Days	Library	PG College	B.Ed	Total Generation
			43.5 kWp	43.5 kWp	16.5 kWp	
1	Mar.-2021	31.0	3996.0	1270.0	1960.0	7226.0
2	Apr.-2021	30.0	4155.0	Under Maintenance	2020.0	6175.0
3	May.-2021	31.0	4266.0	Under Maintenance	2200.0	6466.0
4	Jun.-2021	30.0	4302.0	Under Maintenance	2140.0	6442.0
5	Jul.-2021	31.0	3479.0	Under Maintenance	343.8	3822.8
6	Aug.-2021	31.0	3853.0	Under Maintenance	1360.0	5213.0
7	Sep.-2021	30.0	3035.0	Under Maintenance	106.7	3141.7
8	Oct.-2021	31.0	3443.0	1320.0	387.3	5150.3
9	Nov.-2021	30.0	2191.0	3580.0	1300.0	7071.0
10	Dec.-2021	31.0	2108.0	3520.0	1320.0	6948.0
11	Jan.-2022	31.0	1173.0	2160.0	575.6	3908.6
12	Feb.-2022	28.0	1580.0	4280.0	1560.0	7420.0
		365	**37581.00**	**16130.00**	**15273.38**	**68984.38**

Table 8: Solar generation details

Capacity Utilization Factor (C.U.F) = (Actual energy from the plant (kWh))
(Plant Capacity (kwp) x 24 x 365)

The performance of Solar PV plant is less than national average of 19%. It is therefore, suggested to regularly clean these panels for better performance



Note:- P.G College Solar is under maintenance in month of Apr.-21 to Sep.-21, so power generation data not available.

The less generation of units is due to poor maintenance of Solar panel, as dust, chimney pollutants found deposited on the surface of solar plates, which act as shield from sun rays thus effecting the Power generation badly. We suggest to regular cleaning of Solar Panels. The units or kWh output of a solar panel will depend on the panel efficiency and availability of sunlight in a location. The factor that defines this output is called CUF (or Capacity Utility Factor). For India, it is typically taken as 19% and the calculation of units goes as:

Units Generated Annually (in kWh) = System Size in Kw * CUF * 365 * 24.

So typically, 1 kW capacity solar system will generate 1600-1700 kWh of electricity per year. This can provide electricity for 25 years.

12.3 Installed additional Solar PV System

The college campus has lot of spare space at roof top area, where additional solar PV panels could be installed. Solar photovoltaic technologies convert solar energy into useful energy forms by directly absorbing solar photons—particles of light that act as individual units of energy—and either converting part of the energy to electricity

The units or kWh output of a solar panel will depend on the panel efficiency and availability of sunlight in a location. The factor that defines this output is called CUF (or Capacity Utility Factor). For India, it is typically taken as 19% and the calculation of units goes as: Around 50 kW of solar PV based power plant can be installed in the areas as recommended above. There are various options for capital Investment.

Inputs	Unit	Value
Capacity of Plant	kWp	50
CUF/PLF	%	19%
1kWp solar Generation (Per day)	kWh	4.6
Inputs	**Unit**	**Value**
Capacity of Plant	kWp	50
Cost (Per Kw)	₹	50000
Electricity Tariff	₹ /Unit or kWh	7.0
Average Yearly generation	kWh (Units)	69000
Total Generation in 25 Years	kWh (Units)	1725000
Tariff rate (Avg over 25 Years)	₹	7.0
Average Monthly Savings	₹	40250
Average Annually Savings	₹	483000
Total Savings over 25 years	₹	12075000
Total Capital Investment	₹	2500000
Simple Payback	**Months**	**62.00**

It is recommended to install a Solar Photovoltaic Cell (50 KW) in the premises. The resultant benefits in terms of energy savings workout to **Rs. 4.83 Lacs per annum** with an estimated investment of Rs. **25 Lacs** and simple payback period of **62 months.**

12.4 Observation & Recommendations

However, the less generation of units is due to poor maintenance of Solar panel, as dust, found deposited on the surface of solar plates, which act as shield from sun rays thus effecting the power generation badly. It is recommended that the solar panel inspect the structure at regular intervals for dirt or some other things that might have piled on top. It is important that the panels should be kept clean.

13. Power Quality

13.1 HARMONICS

Harmonics are the periodic steady-state distortions of the sine wave due to equipment generating a frequency other than the standard 50 cycles per second as now a day's equipment became more sophisticated and with the proliferations of non-linear loads, harmonics have become a pronounced problem on many power systems. Now a-days in many areas non-linear load are approaching significantly.

The Effects of the Harmonics current are:

- Additional copper losses
- Increased core losses
- Increased electromagnetic interference with communication circuits.

The Effects of the Harmonics Voltage are:

- Increased dielectric stress on insulation
- Electro static interference with communication circuits
- Resonance between reactance and capacitance

- **Causes:** There are many sources of harmonics in Power system but all harmonics sources share a common characteristic. This is a non-linear voltage current operating relationship and any device that alters the sinusoidal wave form of voltage or current is harmonics producer. The following are the source of harmonics: **Electronic ballasts; non—linear loads; variable frequency drives, diodes, transistors, thyrusters, rectifier output, frequency conversion, Transformers; circuit breakers; phone systems; capacitor banks; motors, Computers (power supplies) PC, laptop, mainframe, Servers, Monitors, Video display, Copiers, scanners, FAX machines, printers, plotters, lighting controls, UPS systems, battery charges & data centers etc. etc.**
- **Effects:** Overheating of electrical equipment; random breakers tripping, High Neutral current due to 3rd Harmonics, interference with communication, non-proper recording of metering, increase in cooper loss, heating of equipment's such as transformer & generators, breakers & fuse operation occur.

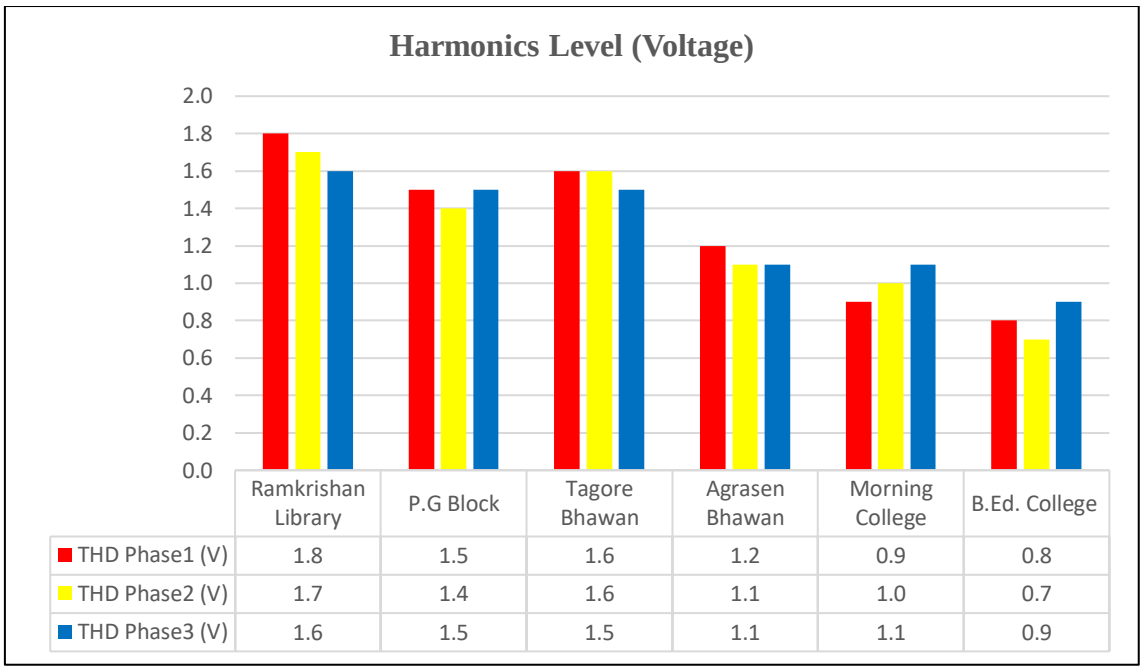
Harmonics contents can place serious Burden on power distribution system. If harmonics distortion may suppose 35%, the distribution of harmonics then will be 5^{th} order 27% 7^{th} order 5%, 11^{th} order – 2 % and 13^{th} order 1%.

- **Solutions:** Harmonics filters employ the use of power electronic technology, which monitors the nonlinear load and dynamically corrects a wide range of harmonics, such as the 3^{rd} to 51^{st} harmonics orders. By the injection of a compensating current into the load, the waveform is restored which dramatically reduce distortion to less than 5% THD, meeting IEEE 519 standards. Further to meet other power quality demand surge protection, metering, relay protection, control, SCADA and communication can be one of the solution. Solution can range from simply tightening connections in a switchboard to help overheating of conductors, to use of a 200% rated neutral in a panel board.

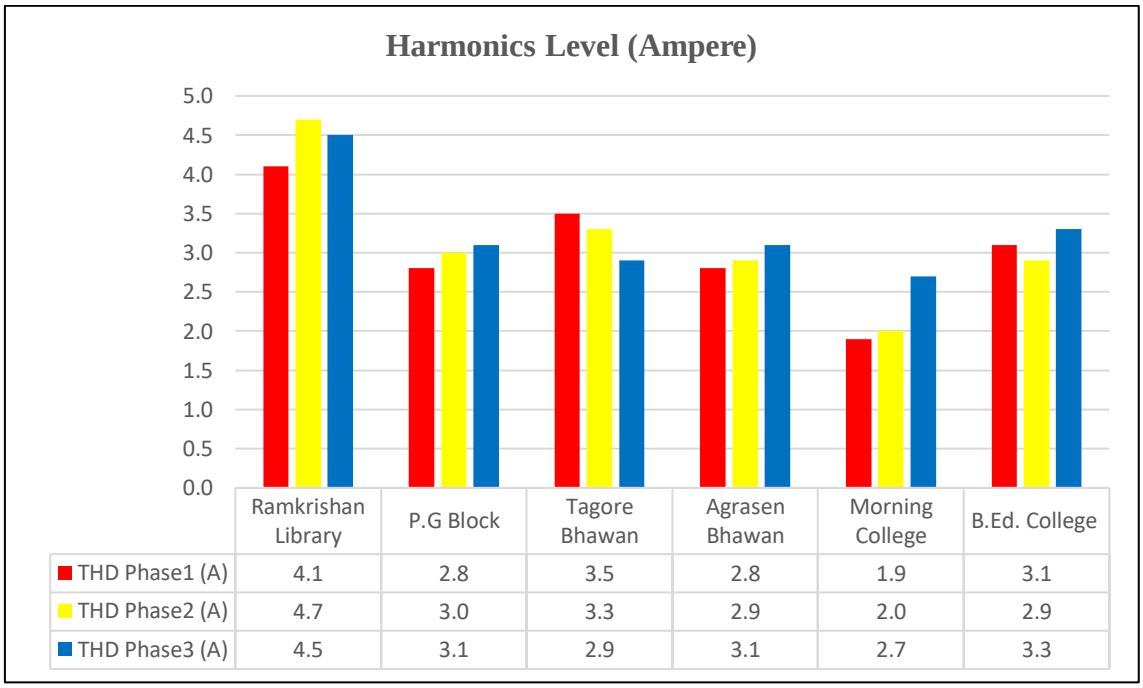
The total harmonic distortion (THD) of current or voltage is equal to the effective value of all the harmonics divided by the effective value of the fundamental.

Particulars	Ramkrishan Library	P.G Block	Tagore Bhawan	Agrasen Bhawan	Morning College	B.Ed. College
Voltage Harmonics (V THD)						
"R" Phase	1.8	1.5	1.6	1.2	0.9	0.8
"Y" Phase	1.7	1.4	1.6	1.1	1.0	0.7
"B" Phase	1.6	1.5	1.5	1.1	1.1	0.9
Current Harmonics (A THD)						
"R" Phase	4.1	2.8	3.5	2.8	1.9	3.1
"Y" Phase	4.7	3.0	3.3	2.9	2.0	2.9
"B" Phase	4.5	3.1	2.9	3.1	2.7	3.3

Table 9: Level of harmonics in main incomer



	Ramkrishan Library	P.G Block	Tagore Bhawan	Agrasen Bhawan	Morning College	B.Ed. College
THD Phase1 (V)	1.8	1.5	1.6	1.2	0.9	0.8
THD Phase2 (V)	1.7	1.4	1.6	1.1	1.0	0.7
THD Phase3 (V)	1.6	1.5	1.5	1.1	1.1	0.9



	Ramkrishan Library	P.G Block	Tagore Bhawan	Agrasen Bhawan	Morning College	B.Ed. College
THD Phase1 (A)	4.1	2.8	3.5	2.8	1.9	3.1
THD Phase2 (A)	4.7	3.0	3.3	2.9	2.0	2.9
THD Phase3 (A)	4.5	3.1	2.9	3.1	2.7	3.3

As per IEEE 519-992& IEEE C-57.110-1986 The current harmonics should be less than 8% as higher value may result in mal-operation of electronics system like control & protection etc. and may result in de-rating of transformer, the most preferred international standard of harmonic for Voltage should not be more than 3% and for current it should not be more than 8%.

HARMONIC CAN BE LIMITED WITH FOLLOWING METHODS:

1. 12 Pulse drives
2. Harmonic filters
3. High-end performance drives
4. Power re-distribution

Further:

1. Every harmonic can create problem, the nature of problem can be different. Due to higher voltage harmonic there can be components failure in electronic circuits, in higher current harmonics there can be high heat generation, which can lead to burning and fire, again due to higher third & ninth harmonic, there will be higher neutral current which can be very dangerous for maintenance team, due to higher negative harmonic there can be mechanical problems which leads to machine failures etc. Therefore, it will be incorrect to say any harmonic is to be given more preference. Mitigation to harmonic should always be specific to the problem and of course be just not more and not less. This is where many people get mislead by marketing team.
2. Every machine has inbuilt capacity to withstand certain amount of harmonics, be it voltage or current. IEEE 519 A& B gives more details on the subject, though there is nothing much mentioned in Indian standard on the subject (To the best of my knowledge). As per thumb rule, voltage harmonic should be less than 3% and current harmonics should be less than 8%. All odd harmonics are dangerous. As I mentioned earlier third & ninth harmonic will increase neutral current and related problems as these are generated mostly by single phase loads and the circuit is completed through the neutral. Other odd harmonics (5th, 7th, 11th, 13th etc.) will be either positive harmonics or negative harmonics. Besides higher current and heat (Other problems will also be there) the negative harmonics will also cause mechanical problems to complicate the problems further. So the danger level is to be analyzed depending upon the situation and problem at hand.

13.2 Power factor

The concept of power factor in the case of sinusoidal voltages and currents, relates to the real power, reactive power, and apparent power associated with a load consisting of resistance and reactance bringing about a direct phase shift between the voltage and current.

Capacitor is a device that generates reactive current and consumes very less power. Installing capacitor will improve the power factor and will also reduce the kVA demand of the system and will increase the capacity of the network i.e. the network cables can be loaded further. Reduction in reactive current will result in reduction of I^2R losses and efficiency of the system will improve.

So it is recommended to keep 50% PF the capacitor at down stream (Load end) of the electrical distribution network and balance 50% at up stream (power house) end with automatic features (APFC). It is the best suited reactive compensating method as it will reduce distance transport of reactive power. It is also recommended to replace all the capacitors which have more than 35% reduction in rated capacity.

Table 10: Measured of Power Factor in Main Incomer

Identification	Location
Power Factor	**Ramkrishan Library**
"R" Phase	0.997
"Y" Phase	0.987
"B" Phase	0.986
Power Factor	**P.G Block**
"R" Phase	0.987
"Y" Phase	0.981
"B" Phase	0.979
Power Factor	**Tagore Bhawan**
"R" Phase	0.989
"Y" Phase	0.987
"B" Phase	0.990
Power Factor	**Agrasen Bhawan**
"R" Phase	0.977
"Y" Phase	0.961
"B" Phase	0.973
Power Factor	**Morning College**
"R" Phase	0.956
"Y" Phase	0.942
"B" Phase	0.930

Identification	Location
Power Factor	**B.Ed. College**
"R" Phase	0.941
"Y" Phase	0.956
"B" Phase	0.936

It is recommended that instead of installing all the capacitors at the beginning 50% should be shifted to load center immediately. As at the main supply system also average power factor recorded is found to be 0.910, it is recommended that at individual locations power factor correction system be installed after conducting detailed study at the time of operation of Air Conditioning system.

The location of power factor correction should by taking following into account:

1. It should be on the main distribution board.
2. It should be either on sub-distribution board
3. It should be at the load end.

The benefits of power factor can be summarized as under:

1. Rebate from State Electricity Board
2. Improvement in Voltage
3. Reduction in maximum demand charges
4. Reduce heat loss

14. Cables

The electric current corresponds to Total Power (kVA) that depends on power factor, flows from utility-supply point to various load points of the unit through power cables (mostly made of aluminum). During the above power transport, considerable power is wasted to oppose the resistance of the cable. The cable resistance increases with length but decreases with cross-section i.e. increase in size. Therefore, the cable capacity has to be selected accordingly to keep the loss within 0.75% and it is only active load which cause the change in PF from no load to full load. By applying capacitor, we will change the PF of supply system hence I^2R of the old cable between supply source and motor.

14.1 Flowing current in feeders

The cable loss is proportional to I^2R (square of current flow and resistance of cable). Normally the current rating given by manufacturer is to withstand thermal stress. Energy conservation point of view, the above needs to be devalued based on length i.e. to curtail excess energy loss caused by off centered powerhouse, longer cables are to carry lesser than the rated current.

14.2 Reducing loss

There are two methods to reduce I^2R cable loss in feeders. They are: (i) reducing the current in cables by adding capacitors near to load or bifurcating the overloaded feeders (ii) reducing the resistance of cable by increasing its size or running additional run of cable of equal size.

14.3 Capacitor shifting/addition

It is possible to reduce current; thereby I^2R losses in cable by providing additional capacitors near to feeder end/ motor end.

15. Energy Demand Management

The energy audit study was under taken at this complex comprising of offices & workshop areas. Electricity is the main energy source for this complex. Electricity is used for meeting requirements of equipment's, machines, Chillers, AHU, lightings, fans, air-conditioning, Water pumps & office equipment etc.

15.1 Electricity Bill Analysis

The R.K.S.D. (P.G) College is getting electrical power supply from Uttar Haryana bijli Vitran Nigam (UHBVN) at 415 V supply. The sanctioned load of college is 49.9 KW, 49.5 KW, 19 KW & 49.5 KW. Billing is done on L.T side.

Table 11: Technical details of Connection

Parameter	Details			
Consumer Name	R.K.S.D PG College	Ram Krishan Library	B.E.d College	Rashtriya Vidya Samiti
Address	Ambala Road, Kaithal	Ambala Road, Kaithal	Ambala Road, Kaithal	Ambala Road, Kaithal
Supply From	UHBVN	UHBVN	UHBVN	UHBVN
Supply Voltage	L.T	L.T	L.T	L.T
A/C No.	0160656637	7656545948	-	1258183025
Sanctioned Load (kW)	49.9	49.5	19	49.5
Tariff Category	LTS	LTS	NDS	LTS

Table 12: Historical Electrical Bill Analysis

A. *R.K.S.D PG College*

Sr. No.	Billing Month	Dated		Days	Total Unit consumption (kVAh)	Total Unit consumption (kWh)	Total Unit consumption	Solae generation Units	Net Billed Units	Energy Charges
1	Feb.-2021	04/01/2021	11/02/2021	38.00	3840.0	2740.0	3780	1040	2740	18480.00
2	Apr.-2021	11/02/2021	08/04/2021	56.00			7160	4280	2880	19668.00
3	May.-2021	08/04/2021	05/05/2021	27.00	2940.0	2880.0	2880	0	2880	19404
4	Jun.-2021	05/05/2021	02/06/2021	28.00	1560.0	1520.0	1520	0	1520	10296.00
5	Jul.-2021	02/06/2021	05/07/2021	33.00	4900.0	4880.0	4880	0	4900	32208.00
6	Aug.-2021	05/07/2021	04/08/2021	30.00	6020.0	5760.0	6020	0	6020	39732.00
7	Sep.-2021	04/08/2021	28/09/2021	55.00	13320.0	13060.0	13320.0	0	13320	85248.00
8	Oct.-2021	28/09/2021	19/10/2021	21.00	640.0	620.0	640	0	640.000	4096.00
9	Dec.-2021	10/11/2021	08/12/2021	28.00			3580	4320	0	0.00
10	Feb.-2021	08/012022	07/02/2022	30.00	1520.0	1460.0	3920	2260	1520	9728.00
	Total			**346**	**34740**	**32920**	**47700**	**11900**	**36420**	**238860**
	Avg.			**34.6**	**4342.5**	**4115.0**	**4770.0**	**1190.0**	**3642.0**	**23886.0**
	Max			**56.0**	**13320.0**	**13060.0**	**13320.0**	**4320.0**	**13320.0**	**85248.0**
	Min			**21.0**	**640.0**	**620.0**	**640.0**	**0.0**	**0.0**	**0.0**

Sr. No.	Billing Month	Fixed Charge	Fuel Surcharge Adjust	Meter service charge	Elect. Duty Charges	Municipal tax	Arrears	Sundry Charges	Sundry Charges Allowances	Total payable amount (INR)
1	Feb.-2021	9994.52	1013.80	190	274.00	589.77	0.28	0.28	0.28	30542
2	Apr.-2021	14728.76	1065.60	280	288.00	709.25	0.28	0.19	0.19	36739
3	May.-2021	7101.37	1065.60	135	288.00	551.42	0.42	0.00	0.00	28546
4	Jun.-2021	7364.38	562.40	140	152.00	364.46	0.19	0.19	0.19	18879
5	Jul.-2021	8679.45	1813.00	165	490.00	854.01	0.05	0.00	0.00	44210
6	Aug.-2021	7890.41	2131.20	150	576.00	995.07	0.49	0.49	2399.89	49075
7	Sep.-2021	11572.60	0.00	0	1306.00	1936.41	0.21	0.21		100063
8	Oct.-2021	4418.63	0.00	0	62.00	170.29	0.20	0.20	426.44	8320
9	Dec.-2021	6545.83	0.00	0	0.00	130.92	34361.30	0.00	0.00	41038
10	Feb.-2021	7013.39	0.00	0	146.00	334.83	11775.06	0.00	0.00	28997
	Total	**85309**	**7652**	**1060**	**3582**	**6636**	**46138**	**2**	**2827**	**386409**
	Avg.	**8530.9**	**765.2**	**106.0**	**358.2**	**663.6**	**4613.8**	**0.2**	**314.1**	**38640.9**
	Max	**14728.8**	**2131.2**	**280.0**	**1306.0**	**1936.4**	**34361.3**	**0.5**	**2399.9**	**100063.0**
	Min	**4418.6**	**0.0**	**0.0**	**0.0**	**130.9**	**0.1**	**0.0**	**0.0**	**8320.0**

B. *Ram Krishan Library*

S. No.	Billing Month	Dated		Days	Total Unit consumption	Solae generation Units	Net Billed Units	Energy Charges
1	Feb.-2021	04/01/2021	18/02/2021	45.00	3620	3620	0.0	0.00
2	Apr.-2021	18/02/2021	08/04/2021	49.00	6380	6300	0.0	0.00
3	May.-2021	08/04/2021	05/05/2021	27.00	3900	3900	0.0	0
4	Jun.-2021	05/05/2021	02/06/2021	28.00	3880	3880	0.0	0.00
5	Jul.-2021	02/06/2021	05/07/2021	33.00	4660	4640	0.0	0.00
6	Aug.-2021	05/07/2021	04/08/2021	30.00	3580	3160	0.0	0.00
7	Sep.-2021	04/08/2021	28/09/2021	55.00	9100.0	6380	0.0	0.00
8	Oct.-2021	28/09/2021	19/10/2021	21.00	3240	2260	0.0	0.00
9	Feb.-2022	08/012022	07/02/2022	30.00	960	1300	0.0	0.00
	Total			**318**	**39320**	**35440**	**0**	**0**
	Avg.			**35.3**	**4368.9**	**3937.8**	**0.0**	**0.0**
	Max			**55.0**	**9100.0**	**6380.0**	**0.0**	**0.0**
	Min			**21.0**	**960.0**	**1300.0**	**0.0**	**0.0**

S. No.	Billing Month	Fixed Charge	Meter service charge	Municipal tax	Arrears	Sundry Charges	Sundry Charges Allowances	Total payable amount (INR)
1	Feb.-2021	11835.61	225	236.71	0.14	0.00	0.00	12297
2	Apr.-2021	12887.67	245	257.75	0.46	0.19	0.19	13391
3	May.-2021	7101.37	135	142.03	0.12	0.12	0.12	7378
4	Jun.-2021	7364.38	140	147.29	0.28	0.00	0.00	7652
5	Jul.-2021	8679.45	165	173.59	0.05	0.05	0.05	9018
6	Aug.-2021	7890.41	150	157.81	0.01	0.01	2399.41	5799
7	Sep.-2021	11572.60	0	231.45	0.19	0.00	0.00	11804
8	Oct.-2021	4418.63	0	88.37	0.00	0.00	0.00	4507
9	Feb.-2022	7013.39	0	140.27	19633.34	0.00	0.00	26787
	Total	**78764**	**1060**	**1575**	**19635**	**0**	**2400**	**98633**
	Avg.	**8751.5**	**117.8**	**175.0**	**2181.6**	**0.0**	**266.6**	**10959.2**
	Max	**12887.7**	**245.0**	**257.8**	**19633.3**	**0.2**	**2399.4**	**26787.0**
	Min	**4418.6**	**0.0**	**88.4**	**0.0**	**0.0**	**0.0**	**4507.0**

C. B.E.d College

S. No.	Billing Month	Dated		Days	Total Unit consumption	Solae generation Units	Net Billed Units	Energy Charges	Fixed Charge	Fuel Surcharge Adjust	Meter service charge
1	May.-2021	11/02/2021	05/05/2021	83.00	5289	5289	0.0	0.00	0.00	0.00	83
2	Jul.-2021	05/05/2021	05/07/2021	61.00	3879	3879	0.0	0.00	0.00	83	61
	Total			**144**	**9168**	**9168**	**0**	**0**	**0**	61	**144**
	Avg.			**72.0**	**4584.0**	**4584.0**	**0.0**	**0.0**	**0.0**	**144**	**72.0**
	Max			**83.0**	**5289.0**	**5289.0**	**0.0**	**0.0**	**0.0**	**72.0**	**83.0**
	Min			**61.0**	**3879.0**	**3879.0**	**0.0**	**0.0**	**0.0**	**83.0**	**61.0**

S. No.	Billing Month	Dated		Elect. Duty Charges	Municipal tax	Arrears	Sundry Charges	Sundry Charges Allowances	LPS Adjustment	Total payable amount (INR)
1	May.-2021	11/02/2021	05/05/2021	0.00	0.00	0.41	164.41	0.41	164.00	83
2	Jul.-2021	05/05/2021	05/07/2021	0.00	0.00	7.41	7.41	7.41	0.00	54
	Total			**0**	**0**	**8**	**172**	**8**	**164**	**137**
	Avg.			**0.0**	**0.0**	**3.9**	**85.9**	**3.9**	**82.0**	**68.5**
	Max			**0.0**	**0.0**	**7.4**	**164.4**	**7.4**	**164.0**	**83.0**
	Min			**0.0**	**0.0**	**0.4**	**7.4**	**0.4**	**0.0**	**54.0**

D. Rashtriya Vidya Samiti

S. No.	Billing Month	Total Unit consumption (kVAh)	Total Unit consumption (kWh)
1	Mar.-2021	96.0	80.0
2	Apr.-2021	60.0	60.0
3	May.-2021		
4	Jun.-2021	0.0	0.0
5	Jul.-2021	60.0	60.0
6	Aug.-2021	1240.0	1240.0
7	Sep.-2021	1460.0	1480.0
8	Oct.-2021	820.0	800.0
9	Nov.-2021	660.0	640.0
10	Dec.-2021	840.0	820.0
	Total	**5236**	**5180**

NOTE

It is suggested the demand of the Industry to reduce Electricity cost. This can be achieved as below**:**

a. Re-schedule the load
b. Staggering of motor load
c. Shedding of non-essential load.
d. Operation of captive power generation
e. To install reactive power compensator
f. Use demand controller
g. Switching off non-essential loads.

16. Illumination & LUX Levels

To study, analyze and identify energy conservation options in lighting, a study of the unit lighting load was conducted. The purpose of the study was to determine the lighting load and its distribution in various sections of the buildings, determine the quality of illumination provided, and recommend measures to improve illumination and reduce electricity consumption.

A high quality and accurate digital LUX meter was used to measure the illumination level at various sections of the building during working hours. Other performance indicators such as type of lamps used, luminaries, mounting height, physical condition of lamps, use of day lighting, etc. were also noted down.

Major reasons for poor illumination levels at selected locations of the building are as follows:

- Poor reflectors/no reflector installed for the tube lights.
- Large height of installed fittings from the working plane.
- Reduction in illumination due to ageing.
- Very old fittings and dust deposition on luminaries

Table 13: Table of assessment of lighting Load

Srl.	Location	Lux Level			
	Ram krishan Library				
1	Library (G. Floor)	450	590	750	1050
2	Library (1st. Floor)	530	640	840	1190
3	Office	390	280	340	380
	P.G Block				
4	Room-413	440	390	350	290
5	Room-412	330	410	370	320
6	Room-406	390	350	450	340
7	Room-407	450	500	400	360
8	Seminar Hall	580	510	490	500
	Tagore Bhawan				
9	Computer Lab	440	450	470	390
10	History Lab	220	330	270	220
11	Geography Lab	340	450	390	475
12	Room-109	240	280	310	330
13	Room-110	250	260	290	300
	Agrashen Bhawan				

Srl.	Location	Lux Level			
14	Management Office	490	510	570	450
15	Room-308	300	350	330	290
16	Room-307	320	340	300	270
17	Room-322	290	370	320	260
18	Room-328	330	350	310	240
	Morning College				
19	Class Room	220	250	290	330
20	Class Room	240	280	300	320
21	Faculty Room	230	275	290	300
	B.Ed. College				
22	Lab	480	350	410	390
23	Lab	390	470	500	400
24	Class Room	280	300	260	270
25	Faculty Room	220	240	180	200

Assessment of Lighting System

Example: Room

Lux Measured = Average Lux = 286

287 284

Length of the Room = 18ft.

Width of the Room = 14ft

Working Place Height = 10ft

STEP 1	Measure the Floor area of the interior :	Area = 18 x 14 = 252 sqft
STEP 2	Calculate the Room Index 18 x 14 / 10 (18 + 14) = .78	RI = .78
STEP 3	Determine the total circuit watts of the installation by a power meter if a separate feeder for lighting is available. If the actual value is not known a reasonable approximate can be obtained by totaling up the lamp wattage including the ballasts	Total Circuit watts 54 W x 16 = 864 32 W x 4 = 128 TOTAL = 992W
STEP 4	Calculate Watts per square meter, Value of Step 3 ÷ Value of Step 1	W/m^2 = 3.9
STEP 5	Ascertain the average maintained luminance by using Lux Meter, Eav. Maintained	Eav.maint = 286
STEP 6	Divide 5 by 4 to calculate Lux per Watt per square Meter	$Lux/W/m^2$ = 72.77
STEP 7	Obtain target $Lux/W/M^2$ lux for type of the type of interior/ application and RI (2)	Target $Lux/W/m^2$ = 36
STEP 8	Calculate Installed Load Efficacy Ratio (6 ÷ 7)	ILER = 2.02

ILER 0.75 or over = Satisfactory to Good

Measuring Units Light Level – illuminance

Illuminance is measured in foot candles (ftcd, fc, fcd) or lux in the metric SI system). A foot candle is actually one lumen of light density per square foot, one lsux is one lumen per square meter.

- 1 lux = 1 lumen / sq meter = 0.0001 phot = 0.0929 foot candle (ftcd, fcd)
- 1 phot = 1 lumen / Sq centimeter = 10000 lumens / sq meter = 10000 lux
- 1 foot candle (ftcd, fcd) = 1 lumen / sqft = 10.752 lux

Common Light Level Outdoor

Common light levels outdoor at day and night can be found in the table below :

Table 14: Lux level of different natural occasions

Condition	Illumination	
	(ftcd)	(lux)
Sunlight	10,000	107,527
Full Daylight	1,000	10,752
Overcast Day	100	1075
Very Dark Day	10	107
Twilight	1	10.8
Deep Twilight	.1	1.08
Full Moon	.01	.108
Quarter Moon	.001	.0108
Starlight	.0001	.0011
Overcast Night	.0001	.0001

Common and Recommended Light Levels Indoor

The outdoor light level is approximately 10,000 lux on a clear day. In the building, in the area closes to windows, the light level may be reduced to approximately 1,000 lux. In the middle area its may be as low as 25- 50 lux. Additional lighting equipment is often necessary to compensate the low levels.

Earlier it was common with light levels in the range 100 -300 lux for normal activities. Today the light level is more common in the range 500 – 1000 lux – depending on activity. For precision and detailed works, the light level may even approach 1500 – 2000 lux.

The table below is a guidance for recommended light level in different work spaces:

Table 15: Required lux level for various activities

Activity	Illumination (lux, lumen/m^2)
Public areas with dark surroundings	20 -50
Simple orientation for short visits	50 -100
Working areas where visual tasks are only occasionally performed	100 -150
Warehouse, Homes, Theaters, Archives	150
Easy Office work, classes	250
Normal Office work, PC work, Study library, Groceries, show room, laboratories	500
Supermarkets, Mechanical workshops, Office landscapes	750
Normal Drawing work, very detailed mechanical works	1000
Detailed drawing work, very detailed mechanical works	1500 -2000
Performance of visual tasks of low contract and very small size for prolonged periods of time	2000 -5000
Performance of visual tasks of low contract and very small size for prolonged period of time	2000 -5000
Performance of very prolonged and exacting visuals tasks	5000 – 10000
Performance of very special visual tasks of extremely low contract and small size	10000 - 20000

17. Energy Balancing

Energy balancing starts from energy accounting and it is one of the principal activities integrated with energy management system aimed to help the energy manager in preparation of an energy balance sheet. Energy balance sheet helps to identify and fix energy guzzlers and take corrective measures**. *It is not possible to prepare an energy balance sheet without metering set-up at important nodes. It is an important activity for the management to initiate and install such metering facilities at least at selected important nodes*** of electrical distribution network starting from transformers outgoing point to motor end. Energy accounting could be done either by manual process or with the aid of data acquisition system supported by menu driven specially software packages to monitor, record and control the process sequences and thereby energy. The diesel storage and distribution system has no measurement, records and monitoring system. The diesel consumed by individual DG set are not measured and recorded, which is not proper practice both for energy efficiency and economic prospective.

18. Main Incomer supply load profile

18.1 Main Incomer

R.K.S.D. (P.G) College, Kaithal draws power from the Uttar Haryana Bijli Vitran Nigam, at 415 V (L.T). The sanctioned load of college is 49.9 KW, 49.5 KW, 19 KW & 49.5 KW. Billing is done on L.T supply.

Details of Load profile, whose load profile has been taken during the audit,

18.2 Load profile for Main Incomer

The load profile of the electrical parameters were recorded by using a portable 3-phase power analyzer. During the recording, the power analyzer recorded all the electrical parameters for further detailed analysis. The analysis of the different parameters recorded 24 hours reading at the LT incoming main supply is given below.

18.2.1 Load profile of Building

The building wise loading was recorded for load Hrs. and load profile of transformer was measured during the audit and readings are given here in

Identification	Ramkrishan Library	P.G Block	Tagore Bhawan	Agrasen Bhawan	Morning College	B.Ed. College
Voltage (Volts)						
"R" Phase	420.0	418.0	419.0	417.0	415.0	415.0
"Y" Phase	419.0	419.0	419.0	416.0	415.0	416.0
"B" Phase	420.0	419.0	420.0	416.0	414.0	415.0
Current (Amps)						
"R" Phase	10.0	7.8	5.6	11.6	15.6	15.6
"Y" Phase	11.0	9.4	4.2	12.2	14.2	14.2
"B" Phase	10.6	6.5	6.6	10.8	17.2	17.2
Power Factor						
"R" Phase	0.997	0.987	0.989	0.977	0.956	0.941
"Y" Phase	0.987	0.981	0.987	0.961	0.942	0.956
"B" Phase	0.986	0.979	0.990	0.973	0.930	0.936
Power Drawn (KW)						
"R" Phase	2.35	1.82	1.31	2.67	3.50	3.45
"Y" Phase	2.55	2.19	0.98	2.78	3.13	3.18
"B" Phase	2.47	1.50	1.55	2.48	3.74	3.77
Total	**7.37**	**5.51**	**3.83**	**7.93**	**10.38**	**10.39**

Identification	Ramkrishan Library	P.G Block	Tagore Bhawan	Agrasen Bhawan	Morning College	B.Ed. College
Power Drawn (KVA)						
"R" Phase	2.36	1.85	1.32	2.74	3.67	3.67
"Y" Phase	2.59	2.23	0.99	2.89	3.32	3.32
"B" Phase	2.50	1.53	1.56	2.55	4.02	4.02
Total	**7.45**	**5.61**	**3.88**	**8.18**	**11.01**	**11.01**
Voltage Harmonics (THD %)						
"R" Phase	1.8	1.5	1.6	1.2	0.9	0.8
"Y" Phase	1.7	1.4	1.6	1.1	1.0	0.7
"Y" Phase	1.6	1.5	1.5	1.1	1.1	0.9
Current Harmonics (THD %)						
"R" Phase	4.1	2.8	3.5	2.8	1.9	3.1
"Y" Phase	4.7	3.0	3.3	2.9	2.0	2.9
"B" Phase	4.5	3.1	2.9	3.1	2.7	3.3
Frequency	50.1	49.9	50.0	50.0	50.0	50.0

Table 16: Building wise load profile

The observations taken from the Table:

- The load (kW) variation ranges from 3.83 kW to 10.39 kW during the Load hours of measurement period.
- The apparent power (kVA) varies from 3.88 kVA to 11.01 kVA during the Load hours of measurement period.
- The power factor varied from 0.930 to 0.997 during the load hours of measurement period.
- There is a considerable current variation in the different phases and hence the phase-to-phase load is not balanced.
- There was a slight variation in phase-to-phase voltage.
- The percentage of average voltage THD is in the range of 0.7 % to 1.8 %. This is well within the recommended limits as per IEEE Standards i.e. 4% variation for voltage & 15% variation for current.
- The percentage of average current THD is in the range of 1.9 % to 4.7 %. The current harmonics in the system are more than the recommended limits as per IEEE Standards. So, it

is recommended to install the harmonics controller in the system to bring the Voltage harmonics with in limit & current THD levels within the limits.

Overall power quality

The analysis of various power quality parameters given above indicates that the overall quality of power received by the facility is good and most of the parameters are within the desired range except the current harmonics in the system.

19. Earthing

The electricity rules clearly specify that two independent earths to the body and neutral should be provided to give adequate protection to the equipment in case if an earth fault, and also to drain away any leakage of potential voltage from the equipment to the earth for safe working.

As there is no standard of earth resistance value, it varies on different type of soil resistivity, ideally it should be Zero but for different kind of soil for electrical equipment it should be better to below .8 Ohm and for electronics equipment it should be below .4 Ohm but best value is .1 Ohm.

Table 17: Details of Earth resistance at various location

Sr. No.	Location	Ohm
1	Main Panel (Ramakrishan Library)	0.8
2	Main Panel (Tagore Bhawan)	0.6
3	Main Panel (Morning college)	1.1
4	DG (125 KVA)	1.4
4	DG (62 KVA)	1.0
5	Solar Panel	0.5
6	Solar Panel	0.4

20. General Tips for Energy Conservation

20.1 Electricity

- Schedule your operations to maintain a high load factor
- Minimize maximum demand by tripping loads through a demand controller
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.99 under rated load conditions.
- Set transformer taps to optimum settings.
- Shut off unnecessary computers, printers, and copiers at night.

20.2 Motors

- Properly size to the load for optimum efficiency.
- (High efficiency motors offer of 4 - 5% higher efficiency than standard motors)
- Check alignment.
- Provide proper ventilation
- (For every 10°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.

20.3 Drives

- Use variable-speed drives for large variable loads.
- Use high-efficiency gear sets.
- Use precision alignment.
- Check belt tension regularly.
- Eliminate variable-pitch pulleys.
- Use flat belts as alternatives to v-belts.
- Use synthetic lubricants for large gearboxes.
- Eliminate eddy current couplings.
- Shut them off when not needed.

20.4 Fans

- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.

- Clean screens, filters, and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimize fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimize bends in ductwork
- Turn fans off when not needed.

20.5 Blowers

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimize blower inlet and outlet obstructions.
- Clean screens and filters regularly.
- Minimize blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable blower loads.
- Use energy-efficient motors for continuous or near-continuous operation.
- Eliminate ductwork leaks.
- Turn blowers off when they are not needed.

20.6 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.
- Stop running both pumps -- add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.
- Increase fluid temperature differentials to reduce pumping rates.
- 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.

20.7 Chillers

- Increase the chilled water temperature set point if possible.
- Use the lowest temperature condenser water available that the chiller can handle.
- (Reducing condensing temperature by 5.5°C, results in a 20 - 25% decrease in compressor power consumption)
- Increase the evaporator temperature
- (5.5°C increase in evaporator temperature reduces compressor power consumption by 20 - 25%)
- Clean heat exchangers when fouled.
- (1 mm scale build-up on condenser tubes can increase energy consumption by 40%)
- Optimize condenser water flow rate and refrigerated water flow rate.
- Use water-cooled rather than air-cooled chiller condensers.
- Use energy-efficient motors for continuous or near-continuous operation.
- Specify appropriate fouling factors for condensers.
- Do not overcharge oil.
- Install a control system to coordinate multiple chillers.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest operating costs to serve base load.
- Avoid oversizing -- match the connected load.
- Isolate off-line chillers and cooling towers.
- Establish a chiller efficiency-maintenance program. Start with an Energy & Safety Audit and follow-up, then make a chiller efficiency-maintenance program a part of your continuous energy management program.

20.8 HVAC (Heating / Ventilation / Air Conditioning)

- Tune up the HVAC control system.
- Consider installing a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Balance the system to minimize flows and reduce blower/fan/pump power requirements.
- Eliminate or reduce reheat whenever possible.
- Use appropriate HVAC thermostat setback.
- Use building thermal lag to minimize HVAC equipment operating time.
- In winter during unoccupied periods, allow temperatures to fall as low as possible without freezing water lines or damaging stored materials.
- In summer during unoccupied periods, allow temperatures to rise as high as possible without damaging stored materials.
- Improve control and utilization of outside air.
- Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.

- Reduce HVAC system operating hours (e.g. -- night, weekend).
- Optimize ventilation.
- Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g. -- computer rooms).
- Provide dedicated outside air supply to kitchens, cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- Use evaporative cooling in dry climates.
- Clean HVAC unit coils periodically and comb mashed fins.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Check HVAC filters on a schedule (at least monthly) and clean/change if appropriate.
- Check pneumatic controls air compressors for proper operation, cycling, and maintenance.
- Isolate air conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Install ceiling fans to minimize thermal stratification in high-bay areas.
- Relocate air diffusers to optimum heights in areas with high ceilings.
- Consider reducing ceiling heights.
- Eliminate obstructions in front of radiators, baseboard heaters, etc.
- Check reflectors on infrared heaters for cleanliness and proper beam direction.
- Use professionally-designed industrial ventilation hoods for dust and vapor control.
- Use local infrared heat for personnel rather than heating the entire area.
- Use spot cooling and heating (e.g. -- use ceiling fans for personnel rather than cooling the entire area).
- Purchase only high-efficiency models for HVAC units.
- Put HVAC window units on timer control.
- Don't oversize cooling units. (Oversized units will "short cycle" which results in poor humidity control.)
- Install multi-fueling capability and run with the cheapest fuel available at the time.
- Consider dedicated make-up air for exhaust hoods. (Why exhaust the air conditioning or heat if you don't need to?)
- Minimize HVAC fan speeds.
- Consider desiccant drying of outside air to reduce cooling requirements in humid climates.
- Seal leaky HVAC ductwork.
- Seal all leaks around coils.
- Repair loose or damaged flexible connections (including those under air handling units).
- Eliminate simultaneous heating and cooling during seasonal transition periods.
- Zone HVAC air and water systems to minimize energy use.
- Inspect, clean, lubricate, and adjust damper blades and linkages.
- Establish an HVAC efficiency-maintenance program. Start with an Energy & Safety Audit and follow-up, then make an HVAC efficiency-maintenance program a part of your continuous energy management program.

20.9 Lighting

- Reduce excessive illumination levels to standard levels using switching, de-lamping, etc. (Know the electrical effects before doing de-lamping.)
- Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
- Install efficient alternatives to incandescent lighting, mercury vapor lighting, etc. Efficiency (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent.
- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete fluorescent systems to Compact fluorescents and electronic ballasts
- Consider lowering the fixtures to enable using less of them.
- Consider day-lighting, skylights, etc.
- Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type, and control. Control it aggressively.
- Change exit signs from incandescent to LED.

20.10 DG Sets

- Optimize loading
- Use waste heat to generate steam/hot water /power an absorption chiller or preheat process or utility feeds.
- Use jacket and head cooling water for process needs
- Clean air filters regularly
- Insulate exhaust pipes to reduce DG set room temperatures
- Use cheaper heavy fuel oil for capacities more than 1MW

20.11 Buildings

- Seal exterior cracks/openings/gaps with caulk, gasketing, weather stripping, etc.
- Consider new thermal doors, thermal windows, roofing insulation, etc.
- Install windbreaks near exterior doors.
- Replace single-pane glass with insulating glass.
- Consider covering some window and skylight areas with insulated wall panels inside the building.
- If visibility is not required but light is required, consider replacing exterior windows with insulated glass block.
- Consider tinted glass, reflective glass, coatings, awnings, overhangs, draperies, blinds, and shades for sunlit exterior windows.

- Use landscaping to advantage.
- Add vestibules or revolving doors to primary exterior personnel doors.
- Consider automatic doors, air curtains, strip doors, etc. at high-traffic passages between conditioned and non-conditioned spaces. Use self-closing doors if possible.
- Use intermediate doors in stairways and vertical passages to minimize building stack effect.
- Use dock seals at shipping and receiving doors.
- Bring cleaning personnel in during the working day or as soon after as possible to minimize lighting and HVAC costs.

20.12 Water & Wastewater

- Recycle water, particularly for uses with less-critical quality requirements.
- Recycle water, especially if sewer costs are based on water consumption.
- Balance closed systems to minimize flows and reduce pump power requirements.
- Eliminate once-through cooling with water.
- Use the least expensive type of water that will satisfy the requirement.
- Fix water leaks.
- Test for underground water leaks. (It's easy to do over a holiday shutdown.)
- Check water overflow pipes for proper operating level.
- Automate blow-down to minimize it.
- Provide proper tools for wash down -- especially self-closing nozzles.
- Install efficient irrigation.
- Reduce flows at water sampling stations.
- Eliminate continuous overflow at water tanks.
- Promptly repair leaking toilets and faucets.
- Use water restrictors on faucets, showers, etc.
- Use self-closing type faucets in restrooms.
- Use the lowest possible hot water temperature.
- Do not use a heating system hot water boiler to provide service hot water during the cooling season -- install a smaller, more-efficient system for the cooling season service hot water.
- If water must be heated electrically, consider accumulation in a large insulated storage tank to minimize heating at on-peak electric rates.
- Use multiple, distributed, small water heaters to minimize thermal losses in large piping systems.
- Use freeze protection valves rather than manual bleeding of lines.
- Consider leased and mobile water treatment systems, especially for de-ionized water.
- Seal sumps to prevent seepage inward from necessitating extra sump pump operation.
- Install pretreatment to reduce TOC and BOD surcharges.
- Verify the water meter readings. (You'd be amazed how long a meter reading can be estimated after the meter breaks or the meter pit fills with water!)
- Verify the sewer flows if the sewer bills are based on them.

20.13 Miscellaneous

- Meter any unmetered utilities. Know what is normal efficient use. Track down causes of deviations.
- Shut down spare, idling, or unneeded equipment.
- Make sure that all of the utilities to redundant areas are turned off -- including utilities like compressed air and cooling water.
- Install automatic control to efficiently coordinate multiple air compressors, chillers, cooling tower cells, boilers, etc.
- Renegotiate utilities contracts to reflect current loads and variations.
- Consider buying utilities from neighbors, particularly to handle peaks.
- Leased space often has low-bid inefficient equipment. Consider upgrades if your lease will continue for several more years.
- Adjust fluid temperatures within acceptable limits to minimize undesirable heat transfer in long pipelines.
- Minimize use of flow bypasses and minimize bypass flow rates.
- Provide restriction orifices in purges (nitrogen, steam, etc.).
- Eliminate unnecessary flow measurement orifices.
- Consider alternatives to high-pressure drops across valves.
- Turn off winter heat tracing that is on in summer.

ANNEXURES

Annexure I –Certification

This part shall indicate certification by Accredited Energy Auditor stating that:

(i) The data collection has been carried out diligently and truthfully;

(ii) All data monitoring devices are in good working condition and have been calibrated or certified by approved agencies authorized and no tempering of such devices has occurred

(iii) All reasonable professional skill, case and diligence had been taken in preparing the energy audit report and the contents thereof are a true representation of the facts;

(iv) Adequate training provided to personnel involved in daily operations after implementation of recommendations; and

(v) The energy audit has been carried out in accordance with the Bureau of Energy Efficiency (Manner and Intervals of Time for the Conduct of Energy Audit) Regulations, 2010.

(Dr. P.P. Mittal)

Accredited Energy Auditor AEA-011

Annexure II –Certificate of Accreditation

ENERGY IS LIFE
BEE
CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

Examination Registration No. : EA-6851

Accreditation Registration No.: AEA-0011

Certificate of Accreditation

This is to certify that Mr./Ms. Prem Prakash Mittal having its trade/registered office at Delhi has been given accreditation as accredited energy auditor. The certificate shall be effective from 26th day of February 2013

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. 0011 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 26th day of May 2014.

Secretary,
Bureau of Energy Efficiency
New Delhi

Annexure III–Recommended Lux Levels for different locations

➢ **Entrance**	
Entrance halls, lobbies, waiting rooms	= 200
Enquiry Desks	= 500
Gate Houses	= 200
➢ **Circulation Areas**	
Lifts	= 100
Corridors, passageways, stairs	= 100
Escalators, revelators	= 150
➢ **Medicine & First Aid Centers**	
Consulting Rooms, Treatment Rooms	= 500
Rest Rooms	= 150
Medical Stores	= 150
➢ **Staff Rooms**	
Offices	= 300
Changing, locker and cleaners room, Cloak rooms, lavatories	= 100
Rest Rooms	= 150
➢ **Staff Restaurants**	
Canteens, Cafeterias, dining rooms, mess rooms	= 200
Survey, vegetable preparation, washing up area	= 300
Food preparation & cooking	= 500
Food stores, cellars	= 150
➢ **Communication**	
Switch board rooms	= 300
Telephone, apparatus rooms	= 150
Telex room, post rooms	= 500
Reprographic room	= 300

Annexure V–Venders List

The details of suppliers/manufacturers of energy efficient technologies are provided below.

Srl.	Product / Equipment	Agency Name / Address
1	DG Synchronization, Automation and capacitors	SGS Industrial Controls & Solutions Pvt. Ltd. Floor-II, MadanpurKhadar, SaritaVihar, New Delhi Tel. 011-29942516, 41402992
2	Eco-Ventilators	Nu Plast Pipes &profilies SCF – 124, Sector – 17 Market, Faridabad - 121002 Tel. 0129-6456217, 4070023
3	Electrical measurement Instrument	Riken Instrument Ltd. 369, Industrial Area, Phase –II, Panchkula Haryana Tel. : 0172-2591651, 2592028 www.rikeninstrumentation.com
4	Energy Management & Control System	Manaco Energy Solutions (P) Ltd. A-6, Shanti Apts. 21 & 22,1st Cross St.TTKRoad, Alwarpet Chennai-18, Tel. 044-42316164 www.mesco.co.in
5	Energy Saving Products	Gautam Enterprises 205, VinayIndl. Est. ChicholiBunder Link Road, Malad(W) Mumbai – 6, India
4	Energy Saving Products	Techmark Engineers & Consultants K-1/28, Ground Floor, Chittaranjan Park, New Delhi – 110019Tel. 011-26238349
5	Flue Gas Analyzer/ Oxygen Analyzer	Nevco Engineers Pvt. Ltd. 90A, (2nd Floor) Amritpuri B, main Road, East of kailash, Opp. Iskcon Temple, New Delhi – 110 065 Tel. 26226328, 26213009 www.nevco.co.in
6	Flue Gas Analyzer/ Oxygen Analyzer	ACE Instruments & Controls 1 Birandari, Above Kashi Dairy MG Road, Ghatkopar (W) Mumbai – 400 086 Tel. 5125153, 5122762
7	FRP Blades & Cooling Tower accessories	Eneertech Engineers SCO 144 – 145, Sector – 34A, Chandigarh Tel. 0172-5018077, 9876022225
8	HVAC related instruments Thermocouples pipe fittings pressure gauges	Waaree, 36 Damjishamji Industrial Complex, Off Mahakali caves Road, Andheri (E) Mumbai tel. 02266963030, 26874778
9	Infrared Temperature Meters (600 ^{o}C to 1800 ^{o}C	Toshniwal Industries Pvt. Ltd. Industrial Area Mahukupura, Ajmer – 305 002 Tel. 91145 2695171, 91145 2695205
10	Infrared Temperature Meters (upto 1500 ^{o}C)	KusamMeco, G-17, Bharat Industrial Area, T.J. Road, Sewree Mumbai – 400015 Tel. 02224156638, 24124540

Srl.	Product / Equipment	Agency Name / Address
11	AC Drives	Rockers Control System SCO 819 2nd Floor, NAC Manimajra, Chandigarh – 160101 Tel. 0172-2730900, 5071627
12	AC Drives	Allen Bradley India Ltd. C – 11, Industrial Area, Site – IV, Sahibabad, Ghaziabad
13	AC Drives	Asea Brown Boveri Ltd. Guru Nanak Foundation Building, 15 – 16, Qutab Institutional Area, SaheedJeet Singh Sansnwal Marg, New Delhi 110 067
14	AC Drives	Crompton Greaves Ltd. Machine 3 Division, A – 6 / 2, MIDC Area, Ahmednagar
15	Automation, Panel Meters	Conzerv System 44P, Electronic City Phase –II, East Hosur Road, Banglore – 560100
16	Automation, Panel Meters	Selec controls Pvt. Ltd. E-121 Ansa Industrial Estate, Saki Vihar Road, Mumbai 400072 Tel.: 022-28471882, 28476443 www.selecindia.com
17	Building Automation, sensors, twilight Switches	Electro Art Plot No. K-11, MIDC Area, Ambad, Nasik – 422010 Tel. 0253-5603954, 2380918, www.electronicswitchesindia.com
18	Burners	Wesman Engineering (P) Ltd. 503-504 Eros Apartments, 56, Nehru Place, New Delhi – 110019 Tel. : 26431723, 26434577
19	Burners, Furnace RecuperatorsHo air Generation, Heating & Pumping unit Laddle pre-heating	ENCON 12/3, Mathura Road, Faridabad – 121003 Tel. : 0129-25275454 www.encon.co.in
20	Capacitors	Asian Electronics Ltd. Plot No. 68, MIDC, Satpur, Nasik – 422 007
21	Capacitors	Shreem Capacitors Pvt. Ltd. /39, VikramVihar, Lajpat Nagar-IV, New Delhi – 110024
22	Capacitors & APFC Panels	Matrix Controls & Engineers Pvt. Ltd. E-725, DSIDC Industrial Complex, Narela, GT Road, Delhi – 011-27786945 / 46 / 47 Rajeev Batra 9811624440, Rajeev@matrixcapacitor.com
23	Capacitors & APFC Panels	Standard Capacitors B-70/43, DSIDC Complex, Lawrence Road, Industrial Area,, Delhi – 110035Tel: 011-27181490, 27151027 www.standardcapacitors.com
24	Capacitors & APFC Panels	Saif Electronics

Srl.	Product / Equipment	Agency Name / Address
		174, Hira Building, 1st Floor, Carnac Road, Opposite Police Commissioner Officer Mumbai Tel. 022-22064626, 22086613 www.saifel.com
25	Insulations	Llyod Insulations (India) Ltd. PB NO. 4321, Kalkaji Industrial Area, Punj Sons Premises, New Delhi Tel. : 26430746-7
26	Insulations	Hirnal Supply (India) Ltd. 168, Rajagarden, New Delhi – 110015 Tel: 011-25438602, 25448602
27	Insulations	Technical & Management Consultancy Center SCO – 324, 2nd Floor, Cabin – 203, Sector – 9, Panchkula Ry_tmcc@yahoo.com
28	LED Lighting	Synergy Solar (P) Ltd. SCO 133, Sector 28D, Chandigarh Tel. : 0172-6451133, www.synergysolars.com
29	Lighting system	Philips India Ltd. Regional Office-North, 9th Floor Ashoka Estate, 24, Barakhamba Road, New Delhi – 110 001 Tel. : 3353280, 3317442
30	Lighting system	Crompton Greaves Ltd. Lighting Business Group, 405, Concorde, RC Dutt Road, Baroda – 390 007
31	Lighting system	Osram India Ltd. Signature Towers, 11th Floor, Tower B, South City-I, Gurgaon -122001Tel.: 0124-6526175, 6526178, 6526285
32	Lighting system	Asian Electronics Surya Place, First Floor, K-185, Sarai Julena New Friends Colony, New Delhi – 110 025
33	Lighting system	Philips India Limited, Technopolis Knowledge Park, Nelco Complex, Mahakali Caves Road, Chakala, Andheri (E) Mumbai – 400 093 Tel : 022 56912000
34	Lighting system	Surya Roshni Ltd. Padma Tower_I, Rajendra Palace, New Delhi – 110 006
35	Lighting system	Wipro Limited SCO – 196-197, Sector – 34-A, Chandigarh – 160 022
36	Lighting Voltage Control Systems	Jindal Electric & machinery Corporation C – 57, Focal Point, Ludhiana – 141010 Tel. : 2670250, 2676890
37	Lighting Voltage Control System	ES Electronics (India) Pvt. Ltd. Plot No. 82, KIADB Industrial Area, Bommasandra – Jigani Link Road, JiganiHobli Banglore – 562 106

Principal
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KAITHAL