ENERGY AUDIT AND GREEN BUILDING AUDIT REPORT

of Hindol College, Khajuriakata, Dhenkanal, Odisha

Submitted to:

Hindol College, Odisha

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PRINCIPAL
HINDOL COLLEGE
KHAJURIAKATA

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ACKNOWLEDGEMENT

Power Tech Consultants (PTC) places on record its sincere thanks to Principal of Hindol college for entrusting task of conducting the energy audit and Green Building Audit of Hindol College, Khajuriakata.

PTC acknowledges with gratitude the wholehearted support and encouragement given by all Hindol Collage officials while carrying out the study at Hindol College, Khajuriakata.

PTC acknowledges with gratitude and sincerely thanks all the officials, staff members and students of Hindol College who have rendered their all possible co-operation and assistance to the study team during the entire period of the audit.

Our special thanks to Dr. Asit Kumar Jenamani (Principal), Sri. Jayanta Narayan Pati (I.Q.A.C Coordinator), Sri. Ashok Kumar Sahoo (HOD, Physics), Sri. Sashi Bhusan Behera (Accountant) for their whole hearted co-operation and guidance in carrying out the Energy Audit of Hindol College.

M/s. Power Tech Consultants
13.03.2020
Authorised Signatory

Mr. Bibhu Charan Swain
Sr. Consultant
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AUDIT TEAM DETAILS

1. Mr. Bibhu Charan Swain
   Sr. Consultant & Accredited Energy Auditor, Regd. No. –AEA-0121
2. Mr. Nilamani Behera, Sr. Consultant, Certified Energy Auditor, Regd. No. - EA-9407
3. Mr. Barada Prasana Subudhi, Asst. Manager (Project)
4. Ms. Itishree Rout, Asst. Manager (Project)
5. Mr. Nirjhar Biswal,(Project Associate)

CERTIFICATE

We certify the following

- The data collection has been carried out diligently and truthfully.
- All data measuring devices used by the auditor are in good working condition, have been calibrated and have valid certificate from the authorized approved agencies and tampering of such devices has not occurred.
- All reasonable professional skill, care and diligence had been taken in preparing the energy audit report and the contents thereof are a true representation of the facts.
- The investment grade energy audit has been carried out in accordance with the BEE prescribed norms.

Signature
Name: Bibhu Charan Swain
Designation: Sr. Consultant
Accredited Energy Auditor
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EXECUTIVE SUMMARY

The Hindol College is situated at Khajuriakata, Dhenkanal in Odisha state which was centrally located in the Hindol Sub-Division for setting up of a College of higher education and christened. Effulgent worth the elegance of natural flora and fauna, enriched with green resources encompassed by hills and adorned by forest streams Hindol Sub-Division was one of the princely states till 1950 and the total area is around 11.93 acres.

In order to identify the energy conservation opportunities and reduce the present energy consumption Principal, Hindol College has entrusted the work of conducting Energy Audit and Green Building Audit to Power Tech Consultants. The Energy Audit of Hindol College was carried out on 18th February 2020.

Hindol College has a contract demand of 40 KW and it avails Power Supply from CESU, the local DISCOM at 415V voltage level. Power supply has been carried out from Chainpal 33/11 kV primary substation which is situated 32 KM distance from college. Then it has stepped down to 11 kV to 415 V by 63 kVA distribution transformer. It has a connected load of around 48.218 KW (As per Inventory Load Survey).

Summary of Energy Conservation Option

Energy Conservation Option and Financial Benefit for Hindol College				
Particulars	**Energy Saving in KWH**	**Financial Saving in Rs.**	**Investment in Rs.**	**Pay Back Period in Months**
Replacement of 27 W CFL with 9 W LED	1966	11007	2730	2.98
Replacement of 200 W Inc. Lamp with 20 W LED	1176	6586	660	1.20
Replacement 75W Conventional Fan with 49W Energy Efficient Fan	8154	45660	124320	4.41
Total	**11295**	**63253**	**127710**	**2**

CO2 Emission

From the CEA CO2 baseline database the combined margin is 0.82 tCO2/ MWh

The annual CO2 Emission Reduction shall be= 0.82 x (11295/1000) = 9.26 Ton

1.0 INTRODUCTION

The Government of India has enacted the Energy Conservation Act, 2001, with the objective of providing sustainable and more efficient management of our energy resources. The aim of EC Act 2001 is to provide the much-needed legal framework and other institutional arrangements so that various energy efficiency improvement drives can be easily launched at the state and national level. In order to implement the various provisions under the EC Act 2001, the Government of India established the Bureau of Energy Efficiency (BEE), to enact and enforce energy efficiency through various regulatory and promotional measures.

Energy Conservation has become a top most priority in today's scenario in order to have a sustainable growth, productivity, enhancement and Environmental Protection. Considering the vast potential of energy savings and benefits of energy efficiency as per the report prepared by National Development Council (NDC) Committee on power, Govt. of India enacted the Energy Conservation Act 2001. Accordingly, the Govt. of India set up the Bureau of Energy Efficiency (BEE) under the provision of the Energy Conservation Act 2001 for development of policies and strategies with a thrust on self regulation and market principles, with the primary objective of reducing energy intensity of the Indian Economy.

College consume significant portion of Energy for lighting, Air Conditioning, Ventilation purpose and hence Energy Conservation is a major focus and requirement in Colleges, Commercial and Government Buildings. Besides Building owners are focusing Energy Conservation and Energy Efficiency in a larger extent for a higher productivity. Efficient Energy management, Usage of Energy Efficient Technologies and adopting best-practices that would help a Building Owner to reduce their energy cost considerably. Hence in order to identify the energy conservation opportunities and reduce the present energy consumption Principal, Hindol College in consultation with Hindol College officials has entrusted the work of conducting Energy Audit and Green Building Audit to Power Tech Consultants. The Energy Audit of Hindol College was carried out on 18th February 2020. The scope of work includes collection of existing layout of Building., Collection of various data including lighting inventory, AC list, Pump, Motor and other electrical load list, Collection of Month wise Energy Bill for FY 2016-17 to 2018-19 and available period for FY 2019-20, Power measurement of all running Transformer, Panels, AC, Pump and Motor.

1.1. ABOUT THE SITE

The Hindol College is situated at Khajuriakata, Dhenkanal in Odisha state of India which was centrally located in the Hindol Sub-Division for setting up of a College of higher education and christened. Effulgent worth the elegance of natural flora and fauna, enriched with green resources encompassed by hills and adorned by forest streams Hindol Sub-Division was one of the princely states till 1950 and the total area is around 11.93 acres.

The college is getting power from the nearby 33/11 kV substation of Chainpal which is about 32 km from the college in 11 kV supply line. Hindol College, is one of reputed college of Dhenkanal, Odisha consumes on an average 8165 kWh (units) of electricity which turns out to be 97981 kW-hr per year only to maintain its volumetric activities throughout the year.

The college includes Main Building, Mini Conference Hall, Library, physics, chemistry, mathematics botany and economics departments, laboratory, IT department, Guest Room, Administrative block and Girls Hostel etc.

Their capacities become privileged adequate science education the college opened Intermediate in science in 1985 with 64 seats which was increased to 128 in 1990-91. The number of seats in arts was increased to 256 in 1992. Degree classes in arts were opened in 1988 with 128 seats and the degree science stream with 96 seats was started in 1992. Further academic expansion was obtained by opening of honours subject in history and political science in 1994. Honours subject in physics, chemistry, mathematics botany and economics were opened in 2003.

The college also provides facilities for vocational education with courses like diploma in Medical laboratory Technician and Diploma in computer science. The National social service (NSS) wing started functioning in the institution since 1990. Students of both +2 and +3 wings are part of the NSS. Different social service schemes are conducted by the NSS.

The Youth Red Cross started functioning in the college since 1995. The wing is involved various awareness programs and activities like AIDS awareness, blood donation camp etc.

The college has been privileged to open Bharat Scouts and Guides and steps are also being taken to open NCC in the College.

Now the college was joined in a new activity i.e: Green Energy Club by making wings involving students for making awareness and to grow the college towards '*Green Energy*'.

1.2. SCOPE OF WORKS

a) **Review of present electricity consumption and fuel oil. Estimation of energy consumption in various loads like lighting, AC, DG Set etc in premises of the Building.**

b) **Electrical Distribution system:**
- Study of reactive power management and option for power factor improvement, functioning of capacitor banks.
- Study of power quality, like harmonics, current unbalance, voltage unbalance etc.
- Exploring the energy conservation options (ENCON) in the electrical distribution system.

c) **Lighting System**
- Review of present lighting system, lighting inventories etc.
- Estimation of lighting load at various locations like different floors, outside (campus) light, pump house and other important locations.

- Detailed illuminations survey with measurement of LUX level at various locations and comparison with acceptable standards.
- Study of present lighting control system, lighting maintenance systems, present procedure for management of lighting spares and consumables and recommendation for improvement
- Analysis of lighting performance indices like LUX/m^2 LUX/Watt, LUX/Watt/m^2 and comparison of the same with benchmark.
- Exploring the possibility of retrofitting options with energy efficient lighting system like LED lamp, Control Gears, Sensors and Automators, voltage regulators.
- Developing a suitable lighting energy accounting and monitoring system.
- Exploring the energy conservation options (ENCON) in lighting system.

d) Air conditioning system (HVAC system)

- Review of present HVAC system like Spilt AC, Window AC, water coolers and air heater etc.
- Performance assessment of window AC, and Split AC
- Exploring the energy conservation options (ENCON) in HVAC system

e) Diesel Generators (DG) sets

- Review of DG set operation
- Performance Assessment of DG sets in terms of specific fuel consumption (SFC i.e. KWH/Ltr.), Exploring the energy conservation options (ENCON) in lighting system.
- Exploring the energy conservation options (ENCON) in DG sets.

f) Water pumping system

- Review of water pumping, storage and distribution systems.
- Study the flow control mechanism.
- Study of rational utilization of water pumping system, energy efficient retrofitting etc.
- Exploring the energy conservation option (ENCON) in water pumping system.

i) Energy Monitoring & Accounting System:

- Detail Review of present energy monitoring & accounting system in terms of metering, record keeping, data logging, periodic performance analysis etc.
- Suggest for procedures for improvement in energy monitoring and accounting system.

k) Others:

- Review of present maintenance practice, replacement policies and building safety practices as applicable to high rising buildings and recommend for improvement.
- Cost benefit Analysis of each ENCON indicating simple payback period, return of investment (ROI) internal rate of return (IRR)

1.3. METHODOLOGY

The following step by step methodology and approach were adopted to carry out the Green energy audit of Hindol College. Prior to energy audit, PTC team made a walk through survey of

the Building and associated subsystems to assess the followings:-

- The existing layout of Building.
- Collection of various data including lighting inventory, AC list, Pump and electrical load list.
- Collection of Month wise Energy Bill for FY 2016-17 to 2019-20.

The methodology was explained / discussed with Hindol College officials. The broad methodology adopted for the Energy Audit at Hindol College is furnished below.

1. The program of visit of energy audit team to site for carrying out the Energy Audit work was informed to Hindol college official.
2. Data collection and Energy Bill Collection was carried out through discussions with the officials and from past records, log books.
3. Technical specification of equipments and their operating parameters were collected, while visiting the area. The data so collected were analyzed and the deviations were noted.
4. Performance of the major energy consuming equipments was analyzed.
5. Measurement of electrical energy parameters, wherever possible, using portable instruments were carried out.
6. Power Measurement of all running Transformer was carried out using portable power analyzer brought by PTC for this purpose.
7. Review of present lighting system, lighting inventories collection were carried out. Estimate all lighting load at various locations like different parts of Building, outside area i.e. street lighting and area lighting and other important locations. Also detailed illuminations survey was determined with measurement of LUX level at various locations.
8. Ambient parameters (Temperature, Humidity) were measured using portable test instrument brought by PTC.
9. Energy Conservation option were identified and tabulated on the basis of priority.
10. Draft soft copy of energy audit report comprising of observations and recommendations with adequate financial justification, vendor support data, etc. was prepared and submitted to Hindol College for acceptance.
11. Final energy audit report shall be submitted after acceptance of the draft energy audit report.

1.4. INSTRUMENTS USED

PTC have a wide array of latest, sophisticated, portable, diagnostic and measuring instruments to conduct energy audit investigations and analysis. The following special portable instruments are used to carry out various field measurements and analysis during the energy audit period.

- Three Phase Power Analyzer(ALM-30)
- Clamp on electrical power analyzers
- Anemometer
- Hygrometer
- Lux meter

2.0. ENERGY SCENARIO

Hindol College receives the electrical power supply from CESU at 11 kV. Then it has stepped down to 11 kV to 415 V by 63 kVA distribution transformer. The available contract demand of the Building with CESU is 40 KW. The energy fact file of the building is furnished below:

Table 2.1: Energy Fact File of Hindol College

Location	**Hindol College**
Areas of Utilization of Energy	Hindol College Building, Administrative Building, Laboratory, Class Room, Garden Area
Source of Supply	33/11 KV Chainpal Substation of CESU
Total Contract Demand	40 KW
Major Loads	Lighting & Power, Air Conditioning, Computers , Printers, Fans, Pump, Geyser, DG Set and Household Appliances
Usage Hours	Mainly 09.00 am to 5.00 pm on all working days
Monthly Energy Consumption	Avg. 215.5 KWH per Month assuming FY 2018-19
Monthly Energy Bill	Avg. Rs. 1498.71 per month assuming FY 2018-19

2.1. ANALYSIS OF ENERGY BILL

The energy bills details and tariff categorization of Hindol College for FY 2016-17 to FY 2019-20 (till November 2016) having consumer no- DGP-172 are furnished below:

Consumer Name & Address	Principal Hindol College Khajuriakata
Category	Govt.
Consumer No.	DGP-172
Account No.	401I 81300495

Contract Demand	40 KW
Tariff Code	PINHT(18)
Supply Voltage	415V

SUMMARY OF ENERGY BILL OF HINDOL COLLEGE FOR FINANCIAL YEAR 2016-2017				
Month	**Total Energy Consumed in KWH**	**Rebate**	**Total amount in Rs.**	**Unit cost in Rs. per KWH**
Total / Av.	235.142	13.69	1562.875	5.6

SUMMARY OF ENERGY BILL OF HINDOL COLLEGE FOR FINANCIAL YEAR 2017-2018				
Month	**Total Energy Consumed in KWH**	**Rebate**	**Total amount in Rs.**	**Unit cost in Rs. per KWH**
Total / Av.	316.57	16.44	1777.68	5.6

SUMMARY OF ENERGY BILL OF HINDOL COLLEGE FOR FINANCIAL YEAR 2018-2019				
Month	**Total Energy Consumed in KWH**	**Rebate**	**Total amount in Rs.**	**Unit cost in Rs. per KWH**
Total / Av.	215.5	31.74	1498.71	5.6

From the Energy Bill of FY 2018-19 it is observed that Average Energy consumption in this year is 215.5 kWh with Unit cost 5.6 Rs./kWh.

2.2. BASE LINE ENERGY CONSUMPTION AND SPECIFIC ENERGY CONSUMPTION

During our observation it is seen that the load drawl pattern of college building is typical of a unit functioning in day time only. Beyond office hours, at night time minimum illumination inside the building and full outside lighting with street-lights is maintained. The working hours in Hindol Collegeis from 10 AM to 5PM normally for 350 days in a year. During the working period normal loads are room lighting, fans, ACs and other lab appliances. During the entire working hours the load remains steady with small variations. Rest of the period in night hours the drawl comparatively reduces.

The following table provides the details base line energy consumption and specific energy consumption data which is termed as performance indicator (PI) to describe the energy performance of the building. The toal built up area of the premises is calculated to be around 3200 Sqmtr.

Table 2.6: Base Line & Specific Energy Consumption

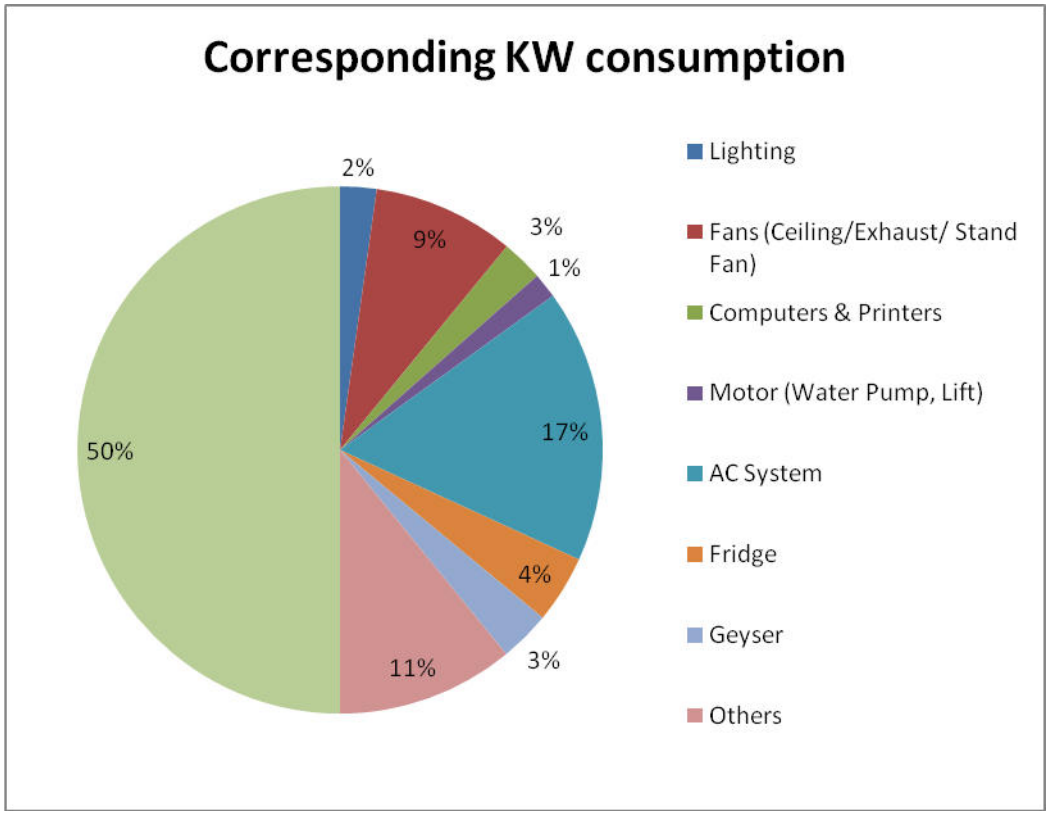
Base line SEC Calculation	
Base line energy consumption (KWh/Annum)	215.5
Specific energy consumption (KWh/M²/Annum)	0.067
Installed TR/ m²	0.005
Lighting Load Watts/ Sq. mtr.	0.671
Total connected Load Watts/ Sq. mtr.	44.4

Connected load details & corresponding KW consumption

From the inventory survey, it is estimated that there is a connected load of about **48.218** KW in Hindol College. It may be seen that the lighting load constitutes about 4.4% of the total load, and air conditioning loads share about 33% of the total connected load. The following table indicates the estimated connected load details (KW).

Load Centre	KW
Lighting	2.148
Fans (Ceiling/Exhaust/ Stand Fan)	8.4
Computers & Printers	2.46
Motor (Water Pump, Lift)	1.49
AC System	16.2
Fridge	4.02
Geyser	3
Others	10.5
TOTAL	**48.218**

Chart 2.4 Connected load details & corresponding KW consumption



Detail Inventory of Fans of Hindol College				
Sr. No.	**Room Details**	**Type & Make**	**Wattage**	**Number**
1	**Botany Department**	Ceiling Fan	75	4
2	**Zoology Department**	Ceiling Fan	75	4
3	**Physics Department**	Ceiling Fan	75	6
4	**Chemistry Department**	Ceiling Fan	75	5
5	**Math Department**	Ceiling Fan	75	2
6	**Room No. 20, 21, 22 & 23**	Ceiling Fan	75	40
7	**Girls Common room**	Ceiling Fan	75	5
8	**Laibrary+SAMS+IT Room**	Ceiling Fan	75	10
9	**Girls Hostel**	Ceiling Fan	75	20
10	**Staff Common Room & Examination Hall**	Ceiling Fan	75	6
11	**Office & Principal Chamber**	Ceiling Fan	75	6
12	**Common Room**	Ceiling Fan	75	4
			Total	**112**

Detail Inventory of ACs of Hindol College					
Sr. No.	**Room Details**	**Type & Make**	**Number**	**Rated Tonnage**	**Remarks**
1	Library+SAMS+IT Room	SPLIT	1	1.5	OK
2	Girls Hostel	SPLIT	4	1.5	OK
3	Staff Common Room & Examination Hall	SPLIT	2	1.5	OK
4	Office & Principal Chamber	SPLIT	1	1.5	OK
5	Common Room	SPLIT	1	1.5	OK

Detail Connected Electrical Load Inventory of Hindol College				
Area	**Types of Load**	**Wattage of each load**	**Nos installed**	**Total connected Wattage**
Botany Department	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
Zoology Department	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
Physics Department	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
Chemistry Department	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
Math Department	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
Room No. 20, 21, 22 & 23	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500

	Computer	250	1	250
Girls Common room	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
Laibrary+SAMS+IT Room	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
Girls Hostel	TV	350	5	1750
	Pump	750	2	1500
	Fridge	335	1	335
	Aquagard	100	7	700
	Xerox Machine	1000	3	3000
	Printer	400	1	400
	Geyser	1500	1	1500
	Laptop	250	5	1250
	Computer	250	20	5000
Staff Common Room & Examination Hall	TV	350	1	350
	Fridge	335	1	335
	Xerox Machin	1000	1	1000
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
Office & Principal Chamber	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Laptop	250	5	1250
	Computer	250	20	5000
Common Room	TV	350	1	350
	Fridge	335	1	335
	Printer	400	1	400
	Geyser	1500	1	1500
	Computer	250	1	250
	Computer	90	4	360
	Printer	150	2	300
			Total	54280

3.0. ELECTRICAL DISTRIBUTION SYSTEM AND TRANSFORMER DETAILS

The Power Supply system of Hindol College was studied. The power measurement of transformer is carried out by 3 phase power analyzer. Based on Average Power measurement data the transformer loadings and efficiency are calculated and furnished below.

Technical data sheet of Hindol College Transformers	
Particulars	**TRF-1**
Make	Kapilash Transformer
Transformer rated kVA	63.00
Rated voltage ratio in kV	0.42
Rated current ratio in Amp	240.00
No. of phase	3.00
Measured voltage at LT side in kV	0.23
Measured current in Amp	4.60
Quantity	1.00
Measured load kVA	1.82
% Loading on the transformer	3%

3.1. STUDY OF VOLATAGE, CURRRENT, POWER FACTOR PROFILE

Trend of Output voltage profile, Current profile, Output Power profile, Power Factor profile, Voltage Unbalance and Current unbalance of Transformer furnished below.

Date and Time	Phase	Voltage	Current	KW	PF	% Unbalance	I-THD in %	V- THD in %
18-02-2020, 1.25 PM	R-N	229.1	2.80	933.28	0.84	0.09%	1.40%	0.20%
	Y-N	225.8	4.60	1439.20	0.8	0.18%	1.30%	0.40%
	B-N			0.00				
	Total/ Average	227.45	3.7	790.82	0.82	0.26%	0.0135	0.003

4.0. LIGHTING SYSTEM

LIGHTING INVENTORY

Adequate and proper lighting contributes both directly and indirectly towards productivity and safety, and towards providing an improved work atmosphere. In fact, all these are inter-related and complimentary to each other. There are several factors, which contribute towards proper lighting. It would be very difficult to deal with all of them when providing general illumination to a large area. However, all efforts were made to study and include these factors during audit of Hindol College for lighting loads.

To study, analyze and identify energy conservation options in lighting, a study of the building lighting load was conducted. The purpose of the study was to determine the lighting load and its distribution in various sections of the Building, 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, type of luminaries, physical condition of lamps and luminaries, use of day lighting, etc. was also noted down.

During the study, measurement of lighting loads, voltage conditions, phase balancing in the facility areas were carried out. The illumination level was also measured primarily at various office rooms and common areas of the building. Care was taken to reduce the effect of day lighting while taking the measurements. The recorded inventory are enclosed in tabular form.

To determine the quantity of lighting load a physical count of the light fittings in Hindol College was carried out. Further, the inputs from the officials and maintenance log books were taken into consideration for calculating the inventory of total light fittings of the Hindol College. The total connected load of lighting in Hindol College is about 33.47 KW. The summarized lighting installations are furnished below.

Table 4.1: Total individual lighting calculation of Hindol College

ROOM INDEX AND ILER CALCULATION					
SL. NO.	**Area Name**	**Types of Load**	**Wattage of each load in Watt**	**Nos. installed**	**Total connected Wattage in Watt**
1	**Botany Department**	1x9W Lights(LED)	9	2	18
		1x27W C.F.L	27	1	27
		1x200W Inc. Lamp	200	1	200
2	**Zoology Department**	1x9W Lights(LED)	9	2	18
		1x27W C.F.L	27	1	27
		1x200W Inc. Lamp	200	1	200
3	**Physics Department**	1x9W Lights(LED)	9	1	9
		1x27W C.F.L	27	4	108
		1x200W Inc. Lamp	200	1	200
4	**Chemistry Department**	1x9W Lights(LED)	9	1	9
		1x27W C.F.L	27	4	108
5	**Math Department**	1x9W Lights(LED)	9	1	9
		1x27W C.F.L	27	4	108
6	**Room No. 20, 21, 22 & 23**	1x9W Lights(LED)	9	1	9
		1x27W C.F.L	27	1	27
7	**Girls Common room**	1x9W Lights(LED)	9	1	9
		1x27W C.F.L	27	2	54

8	**Laibrary+SAMS+IT Room**	1x9W Lights(LED)	9	3	27
		1x27W C.F.L	27	10	270
9	**Girls Hostel**	1x9W Lights(LED)	9	40	360
		1x27W C.F.L	27	1	27
10	**Staff Common Room & Examination Hall**	1x9W Lights(LED)	9	1	9
		1x27W C.F.L	27	6	162
11	**Office & Principal Chamber**	1x9W Lights(LED)	9	1	9
		1x27W C.F.L	27	1	27
12	**Common Room**	1x9W Lights(LED)	9	1	9
		1x27W C.F.L	27	4	108
Total				**97**	**2148**

4.1. O & M PRACTICE, ENERGY ACCOUNTING AND MONITORING FOR LIGHTING SYSTEM

It is observed that there is no proper document available for keeping the records of lighting maintenance, Lux survey, lighting inventory list, area wise lighting consumption etc. A set of well designed format for lighting system record keeping may be developed and maintained at the earliest.
Proper lighting inventory list to be maintained, further during any replacement of lighting system, same may be simultaneously updated in the inventory.

The Monitoring and Targeting programs have been so effective that they show typical reductions in annual energy costs between 5% and 20%.

The essential elements of M&T system are

- Recording: Measuring and recording energy consumption.
- Analyzing: Correlating energy consumption to actual energy consumption
- Comparing:-Comparing energy consumption to an appropriate standard or benchmark.
- Setting Targets: Setting targets to reduce or control energy consumption.
- Monitoring: Comparing energy consumption to the set target on a regular basis.
- Reporting: Reporting the results including any variances from the targets which have been set.
- Controlling:-Implementing management measures to correct any variances, which may have occurred.

4.2. ILLUMINATION SURVEY AND LUX LEVEL MEASUREMENT

The Illumination survey and Electrical Equipment Inventory List of the Hindol College Building including Corridor was carried out by measuring the Lux of the different area, class rooms, conference room and lab using Lux meter, by physical counting of inventory and the results are tabulated below.

Calculation of Room Index and installed Load efficacy (ILER) of Hindol College

ROOM INDEX AND ILER CALCULATION																	
SL. NO.	**Area Name**	**Types of Load**	**Wattage of each load in Watt**	**Nos. installed**	**Total connected Wattage in Watt**	**Average Lux Level**	**Room Length in Meter**	**Room Width in Meter**	**Room Height in Meter**	**Room area in M^2**	**Recommended Illumination**	**Room Index**	**Total Circuit Watts**	**Watt /M^2**	**Lux/ Watt /M^2**	**Standard Target Lux/ Watt /M^2**	**Installed Load efficiency Ratio (ILER)**	**Remarks**
1	**Botany Department**	1x9W Lights(LED)	9	2	18	110	15.2	6.1	3.6	92.72	150-200-250	1.612	245	2.6424	41.62939	43	0.968	Satisfactory
		1x27W C.F.L	27	1	27													
		1x200W Inc. Lamp	200	1	200													
2	**Zoology Department**	1x9W Lights(LED)	9	2	18	110	9.2	6.1	3.2	56.12	150-200-250	1.595	245	4.3656	25.19673	43	0.586	Review Suggested
		1x27W C.F.L	27	1	27													
		1x200W Inc. Lamp	200	1	200													
3	**Physics Department**	1x9W Lights(LED)	9	1	9	48	18.3	9.2	3.2	168.36	150-200-250	2.662	317	1.8829	25.55201	48	0.532	Review Suggested
		1x27W C.F.L	27	4	108													
		1x200W Inc. Lamp	200	1	200													
4	**Chemistry Departme**	1x9W Lights(L	9	1	9	67	18.3	9.2	3.2	168.36	150-200-	2.662	117	0.6949	96.57117	48	2.012	Satisfactor

	nt	ED)									250						y
		1x27W C.F.L	27	4	108												
5	**Math Departme nt**	1x9W Lights(L ED)	9	1	9	92	18.3	9.2	3.2	168.36	150-200-250	2.662	117	0.6949	132.5455	48	2.761	Satisf actor y
		1x27W C.F.L	27	4	108												
6	**Room No. 20, 21, 22 & 23**	1x9W Lights(L ED)	9	1	9	18	15.29	9.2	3.2	140.668	150-200-250	2.497	36	0.2559	68.59736	48	1.429	Satisf actor y
		1x27W C.F.L	27	1	27												
7	**Girls Common room**	1x9W Lights(L ED)	9	1	9	138	15.29	9.2	3.2	140.668	150-200-250	2.497	63	0.4479	308.6261	48	6.430	Satisf actor y
		1x27W C.F.L	27	2	54												
8	**Laibrary+SAMS+IT Room**	1x9W Lights(L ED)	9	3	27	23	24.384	9.2	3.2	224.3328	150-200-250	2.904	297	1.3239	17.1208	50	0.342	Urge nt actio n Requi red
		1x27W C.F.L	27	10	270												
9	**Girls Hostel**	1x9W Lights(L ED)	9	40	360	NA	NA	NA	NA	NA	150-200-250	NA	387	NA	NA	NA	NA	NA
		1x27W C.F.L	27	1	27												
10	**Staff Common Room & Examinati**	1x9W Lights(L ED)	9	1	9	74	15.29	9.2	3.2	140.668	150-200-250	2.497	171	1.2156	61.14808	48	1.274	Satisf actor y
		1x27W	27	6	162												

	on Hall	C.F.L															
11	**Office & Principal Chamber**	1x9W Lights(LED)	9	1	9	112	12.2	9.2	3.2	112.24	150-200-250	2.280	36	0.3207	349.5375	50	6.991	Satisfactory
		1x27W C.F.L	27	1	27												
12	**Common Room**	1x9W Lights(LED)	9	1	9	63	9.2	6.1	3.2	56.12	150-200-250	1.595	117	2.0848	30.16517	52	0.580	Review Suggested
		1x27W C.F.L	27	4	108												

Sample Calculation of ILER

$$\text{Installed Load Efficacy Ratio (ILER)} = \frac{\text{Actual, lux/W/M}^2}{\text{Target, lux/W/ M}^2}$$

Step-1	Measure the floor area of the interior:	Area in m^2
Step-2	Calculate the Room Index	RI
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 approximation can be obtained by totaling up the lamp wattages including the ballasts:	Total circuit watts
Step-4	Calculate Watts per square meter, Value of step 3 ÷ value of step 1	W/m^2
Step-5	Ascertain the average maintained luminance by using lux meter, Eav. Maintained	Eav.maint.
Step-6	Divide 5 by 4 to calculate lux per watt per square Meter	$Lux/W/m^2$
Step-7	Obtain target $Lux/W/m^2$ lux for type of the type of interior/application and RI (2):	Target $Lux/W/m^2$
Step-8	Calculate Installed Load Efficacy Ratio (6 ÷ 7).	ILER

Let's consider Zoology Department

Step-1: Calculation of Room Area

Room Length in Meter=9.2m
Room Width in Meter=6.1m
Room Height in Meter=3.2m
Room Area in Sq. Meter= 9.2x6.1= 56.12 M^2

Step-2: Calculation of Room Index (RI)

$$\text{Room Index (RI)} = \frac{\text{L x W}}{\text{Hm x (L+W)}}$$

Hm= Mounting Height which is the height of the lighting fittings above the horizontal working plane, L= Length of Room, W= Width of Room

Hm=3.2-0.9= 2.3 Meter

Room Index= 56.12/ (3.2-0.9) x15.3= 1.595

Step-3: Total Wattage of Light Fittings

Total wattage of light fittings = 18+27+200= 245 Watt

Step-4: Calculate Watts/ M^2

W/ M^2 = 245/56.12= 4.3656

Step-5: Average Lux level of Room

At the time audit Period the lux was measured at Lux meter = 110

Step-6: Calculate Lux/Watts/ M^2

Lux/Watts/ M^2 = 110/4.3656= 25.1967

Step-7: Obtain Targeted Lux/Watts/ M^2

Target lux/W/m² (W/m²/100lux) values for maintained illuminance on horizontal plane for all room indices and applications			
Room Index	***Commercial Lighting) Offices, Retail stores, etc.) & very clean industrial applications, Standard or good color rendering. Ra:40-85***	***Industrial lighting (Manufacturing areas, workshops, warehousing etc.) Standard or good color rendering. Ra:40-85***	***Industrial lighting installations where standard or good color rendering is not essential but some color discrimination is required. Ra: 20-40***
5	53 (1.89)	49 (2.04)	67 (1.49)
4	52 (1.92)	48 (2.08)	66 (1.52)
3	50 (2.00)	46 (2.17)	65 (1.54)
2.5	48 (2.08)	44 (2.27)	64 (1.56)
2	46 (2.17)	42 (2.38)	61 (1.64)
1.5	43 (2.33)	39 (2.56)	58 (1.72)
1.25	40 (2.50)	36 (2.78)	55 (1.82)
1	36 (2.78)	33 (3.03)	52 (1.92)

Ra: Color rendering index

From the above BEE guideline table targeted Lux/Watts/ M^2 = 43

Ref: Guide Book for National Certification Examination for Energy Managers and Energy Auditors-Book 4

Step-8: Calculation of Installed Load Efficacy Ratio (ILER)

$$ILER = \frac{Lux/Watts/M^2}{Target\ Lux/Watt/M^2} = 25.1967/43 = 0.586$$

As per BEE Guidelines if ILER is less than 0.5 urgent actions are required.

INDICATORS OF PERFORMANCE	
ILER	***Assessment***
0.75 or Over	Satisfactory or Good
0.51 - 0.74	Review Suggested
0.5 or Less	Urgent action Required

Here ILER = 0.586, so here Review Suggested.

Annual energy Wastage (kWh/annum)= (1-ILER) x (watts/1000) x operating hours per annum

= (1-0.586) x (245/1000) x (12 x 350)
= 426.006 kWh/annum

4.3. ENERGY CONSERVATION OPTION

We could not find any timer for switching on / off of the street light, it is being carried out manually. The timer installation and setting and operation in the street light and area lights need to be ensured all the times in different seasons so as conserve energy in lighting circuit and increase productivity of the electrician.

It is suggested to conduct periodic Lux level survey (preferably once in 3 months) and maintain record properly. Necessary corrective actions should be taken periodically.

Awareness among staff and control room operators is to be created for improvement in all aspects of energy conservation especially relating to lighting in their respective wings.

4.4. ENCON OPTION IN LIGHTING SYSTEM

Advantage of LED

LEDs are ideal for use in applications that are subjects to frequent on-off cycling, unlike fluorescent lamps that burn out more quickly when cycled frequently, or HID lamps that require a long time before restarting. LEDs can very easily be dimmed or strobe. These light up very quickly. A typical red indicator LED achieves full brightness in microseconds**.** These do not contain mercury, unlike compact fluorescent lamps.

Replacement of 27W CFL Lamp with 20 W LED Fitting
Background

All buildings of Hindol College, 27 W CFL fittings are used. There are total 39 numbers of such fittings. Replacement of 27 W CFL with 9 W LED shall cause reduction in energy consumption. By this replacement annual energy saving shall be 1966 kWh, annual financial saving shall be Rupees 11007, investment required shall be Rs. 2730 and simple payback period shall be 2.98 Months.

Cost Benefit Analysis

Cost Benefit analysis for Replacement of 27 W CFL with 9 W LED		
Present 27W CFL fitting	No.	39
Present Load before Replacement	kW	1.1
Load after Replacement with 9 W LED	kW	0.35
Power Saving	kW	0.70
Run hour /Day	HR	8
Annual Energy Saving Assuming 350Days	kWh	1966
Total Investment	Rs	2730
Annual Cost of Savings @ Rs 5.6/unit	Rs	11007
Simple Payback Period	Months	2.98

Replacement of 200W Lamp with 20 W LED Fitting
Background

All buildings of Hindol College, 200 W Lamp fittings are used. There are total 39 numbers of such fittings. Replacement of 200 W Lamp with 9 W LED shall cause reduction in energy consumption. By this replacement annual energy saving shall be 1176 kWh, annual financial saving shall be Rupees 6586, investment required shall be Rs. 660 and simple payback period shall be 1.20 Months.

Cost Benefit analysis for Replacement of 200 W Inc. Lamp with 20 W LED		
Present 27W CFL fitting	No.	3
Present Load before Replacement	kW	0.6
Load after Replacement with 120W LED	kW	0.18
Power Saving	kW	0.42
Run hour /Day	HR	8
Annual Energy Saving Assuming 350Days	kWh	1176
Total Investment	Rs	660

Annual Cost of Savings @ Rs 5.6/unit	Rs	6586
Simple Payback Period	Months	1.20

Replacement of 75 W Conventional Fan with 49 W Super Fans

Background

At many places of Hindol College, 75 W Conventional Fan is used. There are total 112 numbers of such fittings. Replacement of 75 W Conventional Fan with 49 W Energy Efficient Fan shall cause reduction in energy consumption. By this replacement annual energy saving shall be 8154 kWh, annual financial saving shall be Rupees 45660, investment required shall be Rs. 124320 and simple payback period is 4.4 Month.

Cost Benefit Analysis

Cost Benefit analysis for Replacing 75W Conventional Fan with 49W Energy Efficient Fan		
Present 75W Conventional Fan	No.	112
Present Load before Replacement	kW	8.4
Load After Replacement	kW	5.5
Saving in Load	kW	2.9
Run hour /Day	HR	8
Annual Energy Saving Assuming 365Days	kWh	8154
Annual Cost of Savings @ Rs 5.6/unit	Rs	45660
Total Investment Required	Rs	124320
Simple Payback Period	Month	4.4

5.0. HVAC SYSTEM

At present, the air conditioning system in the Hindol College is met through 9 numbers of Split AC.

It is estimated that there is about 16.8 KW of AC load in Hindol College contributing to about 33% of the total connected load.

Installed Air conditioning System of Hindol College are furnished below.

Detail Inventory of ACs of Hindol College					
Sr. No.	Room Details	Type & Make	Number	Rated Tonnage	Remarks
1	Library+ SAMS+IT Room	SPLIT	1	1.5	OK
2	Girls Hostel	SPLIT	4	1.5	OK
3	Staff Common Room & Examination Hall	SPLIT	2	1.5	OK
4	Office & Principal Chamber	SPLIT	1	1.5	OK
5	Common Room	SPLIT	1	1.5	OK

Advantages of Inverter Air Conditioner

The latest and the most efficient technology that is available in market today is the Inverter Technology for air conditioners. Inverter technology is designed in such a way that it can save 30-50% of electricity (units consumed) over a regular air conditioner.
Inverter air conditioners are more powerful, offer great savings and are better at maintaining temperature compared to non-inverter air conditioners. When compressor needs more power, it gives it more power. When it needs less power, it gives less power. With this technology, the compressor is always on, but draws less power or more power depending on the temperature of the incoming air and the level set in the thermostat. The speed and power of the compressor is adjusted appropriately.
Let's take an example of 1.5 Ton inverter air conditioner versus non-inverter air conditioner. A 1.5 Ton inverter air conditioner works initially at 1.7 Ton and as the desired temperature is achieved it reduces its capacity to 1.5, 1 or 0.3 Ton based on room conditions.

A 1.5 Ton non-inverter air conditioner on the other hand works at 1.5 Ton all the times.

Every air conditioner is designed for a maximum peak load. A 1.5 Ton AC is designed for a certain size of room and 1 ton for a different size. But not all rooms are of same size. A regular air conditioner of 1.5ton capacity will always run at peak power requirement when the compressor is running. An air conditioner with inverter technology will run continuously but will draw only that much power that is required to keep the temperature stable at the level desired. So it automatically adjusts its capacity based on the requirement of the room it is cooling. Thus drawing much less power and consuming lesser units of electricity.

5.1. MAINTENANCE TIPS FOR SPLIT / WINDOW AC

- Make sure your AC doesn't get overloaded; check the fuse or circuit breaker if it doesn't operate.
- Remember to replace or clean the filter and have your mechanic clean the evaporator and condenser coils regularly, for the air conditioner to cool your home efficiently.
- Install a programmable thermostat, it will lead to 10-15% energy saving.
- Set your thermostat as high as possible comfortable.
- Set the fan speed on high except on very humid days, when humidity is high set the fan speed on low for more comfort.
- Install units in shade, it will lead to 10% saving in energy consumption.

- Use sun films on windows. That will cut heat entry by 70% of the building.
- If the AC makes noise it needs to be checked by the mechanic
- Giving your air conditioning system a good electrostatic air filter is the best thing you can do for your air conditioner. A good air filter will extend the life of your air conditioner because the important parts, like the cooling coil, and other inner parts will stay cleaner, operate more efficiently and last longer.
- Avoid frequent opening of doors/windows. A door kept open can result in doubling the power consumption of your AC.
- Ensure direct sunlight (and heat) do not enter the air-conditioned space, particularly in the afternoons.
- Most people believe that a thermostat set to a lower temperature than desired, will force your air-conditioner to cool faster, not really, all it does, is make your air-conditioner operate for longer. Moreover, you will have an unnecessarily chilly room and wasted power. Every degree lower on the temperature setting results in an extra 3-4% of power consumed. Hence, once you've found yourself a comfortable temperature and set the thermostat at that level, avoid touching the thermostat thereafter.
- Once an air-conditioning system has been designed and installed avoid any major change in the heat-load on the AC. This will add to wasted power.
- Always ensure that whenever you install new unit, make sure its EER (12/ (kW/TR)) should be between 9.5 to10.5.
- No gap should be left during installing units for cool air escape.

STAR RATING PLAN IN ROOM AIR CONDITIONERS

New BEE Energy Efficiency Ratings (EER) for Room Air Conditioners					
STAR RATING LEVELS - Jan 1, 2014 - Dec 31, 2015					
EER (W/W)					
WINDOW AC			SPLIT AC		
Star Rating	Minimum	Maximum	Star Rating	Minimum	Maximum
1 Star ★	2.50	2.69	1 Star ★	2.70	2.89
2 Star ★★	2.70	2.89	2 Star ★★	2.90	3.09
3 Star ★★★	2.90	3.09	3 Star ★★★	3.10	3.29
4 Star ★★★★	3.10	3.29	4 Star ★★★★	3.30	3.49
5 Star ★★★★★	3.30	-	5 Star ★★★★★	3.50	-

STAR RATING PLAN IN DISTRIBUTION TRANSFORMERS

Rating	1 Star		2 Star		3 Star		4 Star		5 Star	
kVA	Max Losses at 50% (Watts)	Max Losses at 100% (Watts)	Max Losses at 50% (Watts)	Max Losses at 100% (Watts)	Max Losses at 50% (Watts)	Max Losses at 100% (Watts)	Max Losses at 50% (Watts)	Max Losses at 100% (Watts)	Max Losses at 50% (Watts)	Max Losses at 100% (Watts)
16	200	555	165	520	150	480	135	440	120	400
25	290	785	235	740	210	695	190	635	175	595
63	490	1415	430	1335	380	1250	340	1140	300	1050
100	700	2020	610	1910	520	1800	475	1650	435	1500
160	1000	2800	880	2550	770	2200	670	1950	570	1700
200	1130	3300	1010	3000	890	2700	780	2300	670	2100

STAR RATING PLAN IN PUMP SETS

Star Rating	Overall Efficiency of the Pump Set*
1 Star	>=1.00 & <1.05
2 Star	>=1.05 & <1.10
3 Star	>=1.10 & <1.15
4 Star	>=1.15 & <1.20
5 Star	>=1.20

LIST OF ABBEREVIATIONS

AC	:	Air Conditioning
BEE	:	Bureau of Energy Efficiency
CFL	:	Compact Fluorescents Lamp
LED	:	Light Emitting Diode
FTL	:	Fluorescents Tube Light
CTR	:	CT Ratio
DB	:	Distribution Board
DG	:	Diesel Generator
ENCON	:	Energy Conservation
HRS	:	Hours
HT	:	High Tension
I	:	Current
KL	:	Kilo Litre
KV	:	Killo Volt
KVA	:	Killo Volt Ampere
KVAH	:	Kilo Volt Ampere Hour
KVAR	:	Killo Volt Ampere Reactive
KW	:	Killo Watt
KWH	:	Killo Watt Hour
THD		Total harmonic distortion
LT	:	Low Tension
PF	:	Power Factor
PTR	:	PT Ratio
SEC	:	Specific Energy Consumption
TF	:	Transformer
UF	:	Utilization Factor
V	:	Voltage