ENERGY AUDIT OF A HIGHER EDUCATION INSTITUTE – THE FIRST STEP TOWARDS GREENING A COLLEGE CAMPUS

Abstract

A systematic investigation to develop an energy efficiency program in any establishment is known as an energy audit. It consists of tasks that look for potential for energy conservation as a preliminary step to the creation of an energy-saving program. Energy use at colleges and universities has a significant effect on both financial and environmental interests. This article is simply the first step in the direction of our goal of an energy-efficient, environmentally friendly campus.The methodology used for this analysis comprises a thorough inspection of the facilities and the gathering of information on the lighting, fan, computer, printer, pump, and air conditioning loads, among other data. The examination of the data gathered and the identification of areas with a high potential for energy conservation are the next steps in the energy audit process.This study also seeks to pinpoint energy-saving techniques for reducing energy waste on the campus of Bir Bikram Memorial College. Educating the college community about the importance of energy conservation and how they may help to reduce greenhouse gas emissions are the main objectives of this study.

Keywords: Institutional energy audit, Energy conservation, Energy management

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I. INTRODUCTION

All of the energy demands of an institution or establishment may be satisfactorily addressed via energy conservation. Utilizing less of an energy service is referred to as energy conservation. An effective service called an energy audit looks into ways to save energy without compromising performance in a building or system. Energy audits are described as "the verification, monitoring, and analysis of use of energy, including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption" in the Energy Conservation Act of 2001. The adoption of the suggested actions can assist consumers in significantly reducing their energy consumption levels. Energy conservation is the first step in a good energy management program; it will result in proper equipment rating, the use of high efficiency equipment, and a change in practices that result in significant energy waste. Energy management and conservation both depend on energy audits.

Bir Bikram Memorial College was chosen for the energy audit because many people are involved in educational facilities and the potential for energy conservation is also very high in such establishments. The objective of this study is to examine how much energy is used on the college campus and find ways to use less energy while maintaining the same level of productivity. Due to the unplanned and erratic use of light, fans in classrooms, practical rooms, auditoriums, as well as rooms with computer facilities and UPS, institutional buildings are taken into consideration in this article.

II. OBJECTIVE OF ENERGY AUDIT EXERCISE

The goal of the energy audit is to encourage energy conservation in the Bir Bikram Memorial College campus and turn it into a campus that cares about the environment. The energy audit's objective is to find, quantify, describe, and rank, cost-saving measures related to energy use in various College buildings and blocks.
The purpose of the energy audit study was to:

- Determining where energy is being wasted and estimating where it could be saved in the college campus
- Outlining practical, affordable ways to increase energy consumption efficiency.
- Estimating the costs and payback times associated with implementation of each suggested action.
- Documenting the outcomes and important data produced by these efforts.

III. ENERGY AUDIT METHODOLOGY

Energy Audit: Energy audit is an efficient process which looks into ways to save energy without compromising the performance in a building or system. Following are energy auditing activities in general order:

- Identification of all energy systems
- Evaluation of conditions of the systems
- Analysis of impact of improvement to those systems.

- Preparation of energy audit report

The three-step methodology used for this investigation included the following steps:

- **Data gathering**: During the initial data collection phase, thorough data collection was carried out utilizing several approaches, including observation, key person interviews, and measurements.
- **Data Analysis:** Using Microsoft Excel 2007, a thorough analysis of the gathered data was performed. The graphical representations were created using the database that Microsoft Excel created.
- **Recommendation**: Based on the findings of the data analysis and observations, various measures for lowering power usage without compromising comfort and satisfaction, as well as an analysis of their costs, were suggested.

1. **Data Collection:** To know the power consumption pattern in detail, the exhaustive data collection exercise was performed at all the departments.

   - Information about the general electrical appliances was collected by observation and interviewing.
   - The details of usage of the appliances were collected by interviewing key persons
   - Light intensity was measured using Lux meter (Lux Meter LX-101A) at all the places
   - Approximations and generalizations were done at places with lack of information

2. **Data Analysis:** In data analysis, the information is analyzed to uncover patterns, find gaps, and determine the areas that need attention. The power consumption patterns and the locations where electrical energy is squandered were determined by analysis of the power consumption measurements.

3. **Recommendation:** Based on the capital cost recovery time, suggestions were given after performing an energy and cost analysis of various appliances. The following steps made up this process:

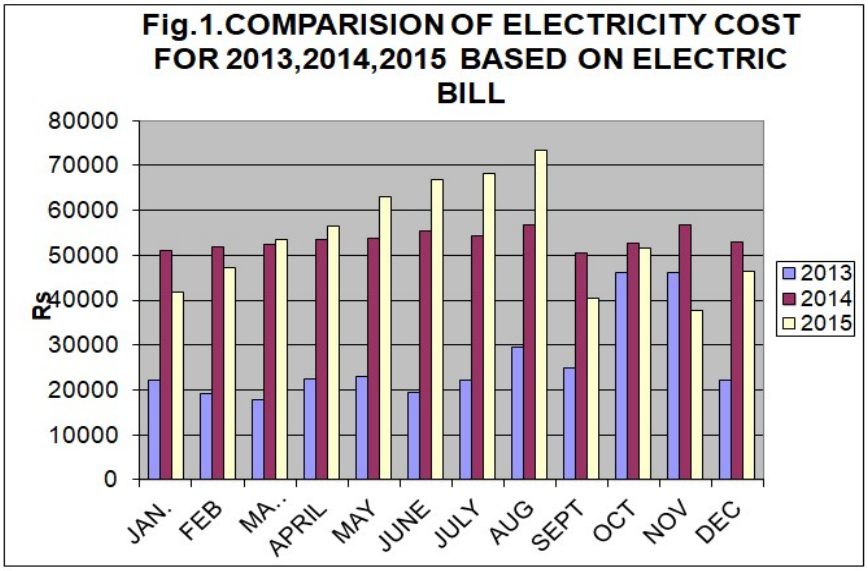
   - A capital cost estimate was made for replacing a process or equipment.
   - The amount of energy saved by the replacement was determined using the annual cost of energy.
   - The capital cost recovery time, which is defined as the entire amount of time it takes for the savings in energy expenses to offset the capital expenditures involved, was calculated by comparing these two prices.

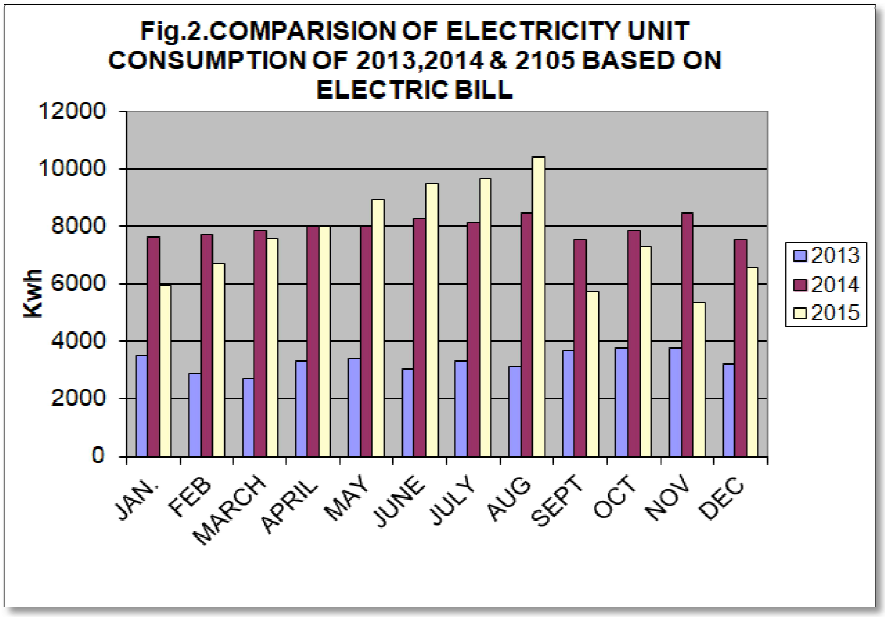
IV. RESULTS AND DISCUSSION

1. **Bir Bikram Memorial College's Present Energy Scenario:** In Tripura, Bir Bikram Memorial College is a renowned public institution of higher learning. The site of Bir Bikram Memorial College is roughly 6 acres in size, and it has a combined student body of 4000 across the arts, commerce and science fields. The College has 33 non-teaching staff employees and 51 faculty members. This college has access to electricity around-the-clock. This college is organized into three sections: the academic section, the science

section, and the administrative section. The academic block is the largest one. The structure has six stories and two basement levels. Admistrative block is a sizable three-story building, while Science block is a lengthy two-story structure.

- **Specific Energy Consumption (SEC):** The amount of energy used for each unit of output from a product is known as the Specific Energy Consumption (SEC). The power bills that made up the College's SEC were used to compute the precise energy consumption by students, faculty, and staff. For the 2014–2015 fiscal year, the SEC was determined as 24.57 kWh/person/year and Rs. 173.22/person/year.





- **Academic Building:** Academic building structural foundation was planned for Basement I+ Basement II+ Ground floor + 3 floors. The total covered area of all the floors is **4545.99** square mt. The layout drawing (Plate.3) shows the dimensions of each individual room. To give it a respectable and official appearance, the structure is painted a cream colour. The academic building's total connected load is 99682 Watt.

  Room analysis on the basis of energy consumption

  - **Basement I** consists of 1) Canteen kitchen 2) Canteen room 3) Toilet (Gents) and corridor. Total covered area for Basement I is: **224.34 square mt.** So basement –I is having total 3 rooms. Total energy consumption per month in the basement I is **620.1 kWh.** (Table 1 in Annexure)

  - **Basement II** consists of 1) Professors' room 2) Examination committee's room 3) Staff toilet (Ladies and Gents) 4) Xerox room and locker room 5) Locker room and Corridor. Total covered area for Basement II is: **411.85square mt .** So in basement –II is having a total of 5 rooms. Total energy consumption per month in the basement II is**1336.01 kWh (**Table 2 in Annexure)

  - **Ground floor** covered an area of **1414.54 square mt** with **10** nos of theory classrooms, one seminar room and 2 toilets (Ladies and gents). Energy consumption per month in the ground floor is **2246.26 kWh** (Table 3 in Annexure)

    Six theory classrooms, two restrooms, and a hallway were located on the first floor, which had a floor space of 659.22 square meters. The first floor's monthly energy consumption is 1110.52 kWh (Table 4 in the Annexure).

  - **Second floor** covered an area of **964.42 square mt** with 5 nos of theory classrooms, one smart class, Library, music room, 2 toilets and corridor. Total energy consumption per month in the second floor is **1945.44 kWh**(Table 5 in Annexure)

  - **Third floor** covered an area of **871.59 square mt** with 5 nos of theory classrooms, 2 toilets, Computer room, conference hall and corridor. Total energy consumption per month in the second floor **1634.25 kWh** (Table 6 in Annexure)

- **Administrative Block :** Administrative block is a large three- storied building having a total of 13 rooms. Principal's office, DDO room and UGC room are situated in this building. Ground floor, 1st floor and 2nd floors of the building covered an area of **601.08 sq mt, 631.47** sq mt and **569.29** sq.mt respectively. Energy consumption units per month of ground floor, 1st and 2nd floors are **899.34** kWh, **2359.5** kWh and **1161.784** kWh respectively. Total connected load of the administrative building is **35827 Watt** (Table7, 8,9 in Annexure).

- **Science Block:** Science block consists of a long two- storied building having a total of 9 rooms. Physics and Chemistry labs, boys and girls' common rooms are situated here. Ground floor of the building covers an area **of 564,54 Square mt and the total**

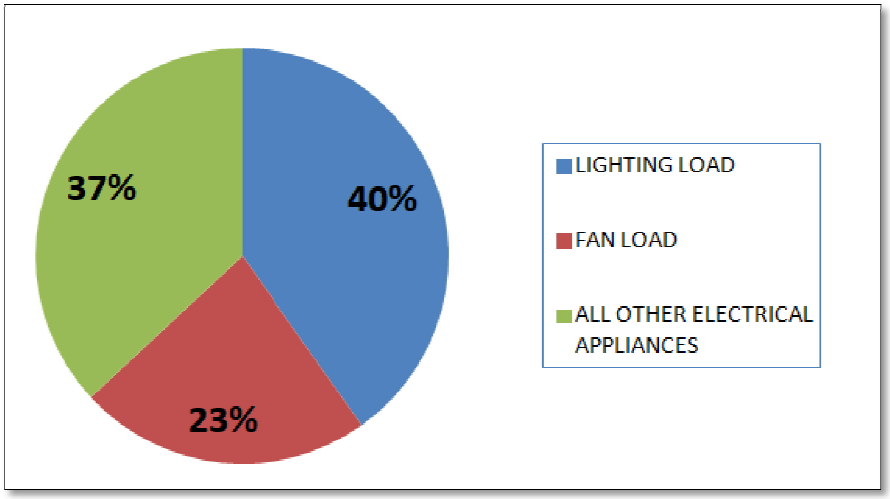
energy consumption 1305.24 kWh. (Table 10 in Annexure). 1st floor covered an area **of 470.63 Square mt. Total** energy consumption of 1st floor is **158.73kWh and** Total connected load of Science block is **19191Watt.** (Table 10& 11 in Annexure)

Table 12. TOTAL CONNECTED LOAD FOR DIFFERENT USAGE(IN WATT)

	Lighting	**Fan load**	**Other electronic appliances**	**Total**
Academic Block	42035	26445	31202	**99682**
Science Block	5900	3025	10266	**19191**
Administrative Block	14228	5920	15679	**35827**
Total	**62163**	**35390**	**57147**	
TOTAL CONNECTED LOAD OF THE COLLEGE 1,54,700 Watt				

(Number of lights, fans and other electrical appliances and their respective wattage details are given in Annexure Table No.1-11)

Figure 3: Load Distribution in the College



2. **Analysis of Lighting System Efficiency in the College:** Calculating the amount of energy used per square meter is the first step in calculating the fluorescent lighting system's efficiency. This is done by dividing the total wattage of the lighting system by the size of the classroom.

Table 13: Energy used per sq meter

Name of Blocks	Area (Sq.mt)	Total wattage of light(Watt)	Energy used per sq meter (Watt/ sq.mt)
Academic block	4545.99	42035	**9.25**
Science block	1035.17	5900	**5.70**
Administrative block	1801.85	14228	**7.90**
	7383.01	62163	**8.42**

Measuring the illumination lux levels is the next stage. A lumen is a unit of measurement for light, and a lux is the lumens per square meter. The recommended illuminance are listed in Table 14 below and are in accordance with the Energy Conservation Building Code (ECBC) - 2006, which was released by the Bureau of Energy Efficiency (BEE), Government of India.

Table 14: ECBC Standard

Type of Interior Or Activity	Minimum Illuminance required(In Lux)
General	200
Reading Room	200
Reading tables	200
Bathrooms	50
Computer Workspace	300
Parking Area	20
Music Rooms	200
Interior Sports halls	200
Corridors, passageways &Stairs	50
Cafeterias ,Dining Rooms and Mess Rooms	150
Canteens , Food Preparation and Cooking	300

Table 15: Lux meter Reading of Academic Block

Floors	Rooms and other Places of the College	Illuminance (Lux)
Basement I	Corridor	30
	Toilet	60
	Canteen	230
Basement II	Corridor	47
	Toilet	44
	Professor's room, exam committee room, locker room	40
Ground floor	Class rooms	470

	Corridor	180
1st floor	Class rooms	580
	Corridor	230
2nd floor	Class rooms	790
	Library	260
	Corridor	260
3rd floor	Class rooms	940
	Corridor	260

Table 16: Lux meter Reading of Science Block

Floors	**Rooms and other Places of the College**	**Illuminance (Lux)**
Ground floor	Physics lab	22
	Corridor	220
	Girls common room	26
	Boys common room	50
	Student's Council room	230
	Chem. Lab	110
1st floor	Class rooms	50
	Corridor	150

Table 17: Lux meter Reading of Administrative Block

Floors	**Rooms and other Places of the College**	**Illuminance (Lux)**
Ground floor	Academic sec.	390
	Corridor	266.69
1st floor	Principal's office	450
	Meeting ROOM	260
	Establishment section	380
	Corridor	260.75
2nd floor	Toilet	30
	E.V.S lab	170
	Conference hall	4270
	Corridor	450

According to the ECBC standards it is found that the current lighting intensities are high in most of the class rooms and office rooms in academic building and Administrative building. Very low light intensities were observed in all the laboratories. Toilets also show lower lux level than the standard. In the Academic block, lux readings of all the rooms in the basement II area are below the ECBC standard.

BENCHMARKING

Benchmarking is the practice of contrasting a given process' performance with that of the best possible process in an effort to raise the standard of the process and raise the quality of the resulting system, product, and services, among other things. It enables businesses to create strategies for implementing best practices, typically with the goal of enhancing certain performance facets. Benchmarking may be a one-time occurrence, but it's frequently seen as an ongoing process in which businesses always look to improve. Energy consumed per person, including faculty, staff, and students, serves as the standard for comparing Bir Bikram Memorial College's energy usage. Here are the benchmarking criteria: Block-wise energy performance is measured in terms of kWh per person and kWh per m^2.

3. Energy saving potential in the Bir Bikram Memorial College

1. **Elimination of Energy Wastages :** It has been observed that in all the toilets, exhaust fans are on for 6 hours a day though it is not required and much of the total load consumed can be saved without any effect on their performance. This wastage of energy can be saved if the usage hours are reduced to 3 hours per day.

- **Energy and Cost Saving Calculation for reducing Exhaust fan's operating hours**

Total 37 Exhaust fans (each 40 Watt) are there in our College.
Total energy consumption 40x 37=1480 Watt
Currently exhaust fans are on for 6 hrs /day
Power consumption /day= 1480x6=8880 Watt-hr
(1 kWh=1 unit) =8.88 kWh
Energy cost/day= 8.88x7.05=Rs.62.60/-
Energy cost per month for 26 days working days=62.60x26=Rs. 1627.60/-
Annual energy Cost=Rs.1627.60x12=19531.20/-

Now we calculate assuming the operating hours -3 hrs /day

Total energy consumption 40x 37=1480 Watt
Power consumption /day= 1480x3=4440 Watt-hr
(1 kWh=1 unit) = 4.44 kWh
Energy cost/day= 4.44 x7.05=Rs.31.30 /-
Energy cost per month for 26 days working days=31.30x26=Rs. 813.8/-
Annual energy Cost=Rs.813.8x12=9765.6 /-

Annual energy cost saving =Rs (19,531.20-9,765.6)/-= Rs. 9765.6/-

- **Conserving energy by using the photocopier only when necessary or avoiding using it in sleep mode, consumes energy as follows:**

  Energy Consumption of Xerox Machine in Sleep Mode = 1x 100Watt
  Power Saving for Approximate Non operating Mode Hours For 1 hours In A Day =100W x 1hr/day = 100Wh/Day
  Energy in kWh = 100/1000 = 0.1kWh/day
  Energy for a Month = 0.1kWh x 26days =2.6 kWh =2.6 Units
  Monthly Energy Cost =2.6 x 7.05 =Rs18.33/-

  Annual Energy Cost Saving = Rs18.33x12 =Rs 219.96/-

  - ❖ **Saving energy cost by using energy efficient appliances**

  - ❖ **Potential of Saving Energy by Replacing all fluorescent lamps (FL) with compact fluorescent lights (CFL)**

  - ➢ **Fluorescent lamps Energy Savings Cost Estimation**

    Total number of Fluorescent lamps or tubes = 1072
    Actual wattage of Fluorescent lamps inclusive of choke =50W
    Energy consumed by Fluorescent lamps for 5 hour per day =1072 x50x5 =268000 watt-hours
    Energy consumed by Fluorescent lamps for 5 hour per month = 268000x26 working days=6968000 watt-hr/month =6968kWh
    Therefore, Monthly Energy consumed cost by Fluorescent lamps = 6968x7.05= Rs.49124.40/-
    So, Annual Energy Consumed cost by Fluorescent lamps =49124.40x12= Rs. 589492.80/-

  - ➢ **Energy savings by switching to CFL that are equivalent to fluorescent lamps**

    A 23 watt CFL can produce 1600 lumens of illumination
    A 50 watt FL lamp can produce 2400 lumens of illumination.
    Consequently, 1.5 numbers of 23 watts CFL are needed to produce 2400 lumens of illumination.
    Hence, the total wattage of Fluorescent lamps = 1072 x 50watts =53600 watts

    So, the number of CFL required to replace all Fluorescent lamps @ 23 watts x1.5, 34.5 watts CFL=50watts FL. =53600 /34.5watts = 1554
    1554 number of CFLs are needed to replace all Fluorescent lamps
    Energy saving by CFL replacement = 1554 x15.5 watts =24087 watts
    Energy consumption from CFL on average 5 hours /day = 24087watts x5 hours = 120435 watt-hr =120.435 kWh
    Daily cost of energy consumption by CFL =120.435x7.05 kWh=Rs.849.06/-
    Saving Cost of energy /day = Rs.849.06/-

Monthly Energy cost saving due to CFL=849.06x26working day=Rs.22,075.73/-

Annual Energy cost saving=22075.73x12=Rs. 2,64,908.82/-

Calculation of Payback Period for switching to CFL :-
Expenditure t on 1 CFL of 23 watts = Rs230/-
Total cost of replacement =1554 x 230 = Rs. 3,57,420 /-
Payback Period = 3,57,420 /2,64,908.82= 1 year 4 months

- **Using motion sensors in restrooms and hallways:** By using automation techniques, there is a lot of opportunity to save energy in hallways and bathrooms. There, motion sensors can be utilized to automatically turn on the light whenever there is movement and turn it off when there is none. This can significantly lower the overall energy load in the hallways and restrooms.

  Approximate number of tube lights in college corridor = 4
  Average power of the tube lights = 50W
  Approximate number of motion sensors need to be installed= 3
  Average daily consumption decrease due to motion sensors = 4h
  Total annual energy saved in corridor = (4x50x4x26x12)/1000 = 249.6 kWh
  Annual Saving in Rs. = 249.6 x7.05 = Rs. 1760/-
  Installation price for each motion sensor = Rs. 250
  Installing motion sensors throughout a corridor will cost in total = 3x250 = Rs. 750/-
  Time for Capital Cost Recovery = (750/1760) = 0.42 yr=5 months

  Therefore, it takes 0.42 years to recoup the capital cost of installing motion sensors in hallways. Similar capital cost recovery times are also applicable for toilets. Therefore, taking this action is strongly advised to significantly lower energy usage in hallways and bathrooms.

Table 18: Summary of energy saving potential in the Bir Bikram Memorial College

Energy-saving techniques	**Cost Of Savings Amount in Rupees (Rs)**	**Investment (Rs)**	**Payback Period**	**Feasibility**
Replacing Fluorescent Tubes by CFL	**2,64,908.82/-**	3,57,420/-	1year 4 months	Technically & Economically feasible
Operating the photocopier machine in active mode	**219.96/-**	Nil	Nil	Technically feasible
Reducing Exhaust fan's operating hours	**9765.60/-**	Nil	Nil	Technically feasible
Use of Motion Sens	**1760/-**	750/-	5 months	Technically

ors in a typical Corridor				feasible

- **Suggestions for Increasing Energy Efficiency**

  - On the basis of the study of the power usage data, some actions have been suggested for enhancing the campus's energy efficiency. Where appropriate, a thorough cost analysis of implementing the suggested remedies has been conducted. A variety of general energy efficiency measures have also been listed.
  - Replacing of all T-12 Fluorescent Tubes by CFL is recommended.
  - Enameled paint, which would reflect light, should be used to paint all interior walls.
  - When not in use, turn off the photocopier at the main outlet; in other words, avoid leaving the machine in standby or sleep mode, which consumes energy.
  - Use of Motion Sensors in Corridors and Toilets.
  - Verify the star ratings of each new electrical installation.
  - Energy efficient design should be encouraged for any new constructions and renovations of buildings
  - Raise awareness with regular awareness campaigns
  - Posters and hoardings should be used as reminders
  - Install tubelights in the proper place and orientation. These tube lights must be equipped with a reflector, electronic ballast, and other necessary components.
  - Rather of repairing fans, replace them.

- **Future Plan**

  - Energy audit is an ongoing continuous process. After implementation of the recommendations, regular monitoring is very important
  - It is necessary to establish a committee at the college level, under the direction of the Principal, to examine the application of energy-saving methods. A biannual compliance report from each department and section head should be submitted for evaluation and action.
  - Performance of energy efficiency should be tracked and an annual review of the adoption of energy-saving measures should be conducted. The Principal of the college should get a report on the situation. The Institute budget should make electrical energy consumption a top priority with separate heads for departments.
  - The college must keep looking for new ways to lead in terms of cost reduction, energy security, and environmental protection.

V. CONCLUSION

The adage "Energy saved is energy generated" is well-known. This demonstrates that energy audit needs to be conducted in order to save electricity at a significantly cheaper cost than adding generation capacity of energy at higher cost. The power utility is under pressure to increase capacity in order to fulfil the demand due to the steadily increasing demand for electricity. With very little adjustments to the current system, all sectors can save energy through energy audits, which will lower our nation's demand for electricity.

Energy use at colleges and universities has a significant effect on both financial and environmental interests. For example, less CO_2 is emitted if less electricity is used. Reductions in CO_2 emissions can be paired with financial benefits as well as it will help in mitigating global warming, climate change and natural resource conservation. Good environmental performance positively influences the reputation of a College. Furthermore, a lower CO_2 emission and energy efficient practices can result in a better image of the College for students, employees vis-a-vis other educational institutions. Bir Bikram Memorial College can create a climate responsible energy efficient green campus through implementation of some simple recommendations as formulated in this energy audit study.The entire college community must be determined and committed to make the campus green and climate-responsible over the long run. However, these efforts can have a big payoff in the form of increased quality of life on campus, environmental and economic sustainability, and reputation as a leader by example, and financial gains.

Bir Bikram Memorial College and other educational institutions can have a significant impact on how the next generation thinks about energy and the environment. With the results of this energy audit, the college is in a strong position to assume a leading position in the fight against energy waste and climate change. The college must also keep looking for new opportunities to lead in terms of cost reductions, energy security, and environmental protection.

VI. ACKNOWLEDGEMENTS

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ANNEXURE

TABLE1. **Basement-I**

Palces	Name of the equipments	Rating of equipment(watt)	Number of equipments	Connected load (Watt)	Total running hrs/day	Energy consumed /month(kwH)
	Tube light	50	20	1000	5	130
Canteen Kitchen	Fan	55	15	825	5	107.25
	Exhaust fan	40	1	40	5	5.2
	Bulb light	15	1	15	5	1.95
	Tube light	50	28	1400	5	182
Canteen	Fan	55	15	825	5	107.25
(Toilet)	Tube light	50	1	50	5	6.5
	Exhaust fan	40	4	160	5	20.8
	Bulb light	15	3	45	5	5.85
Corridor	Tube light	50	5	250	5	32.5
	Alarm bulb	100	1	100	5	13
	Wall light (CFL)	15	4	60	5	7.8
Total energy consumption per month =620.1 kWh						

TABLE. 2.**Basement-II**

Places	Name of the equipments	Rating of equipment(watt)	Number of equipments	Connected load (watt)	Total running hrs/day	Energy consumed /month(kwH)
Professor's room)	Tube light	50	32	1600	5	208
	Fan	55	21	1155	5	150.15
Xerox and Locker Room	Tube light	50	25	1250	5	162.5
	Fan	55	15	825	5	107.25
Locker room	Tube light	50	21	1050	5	136.5
	Fan	55	12	660	5	85.8
	Room ac		1	0	5	0
	Xerox machine	1300	1	1300	5	169
	Table fan	80	1	80	5	10.4
	Inverter	50	1	50	24	31.2
Exam committee room	Tube light	50	8	400	5	52
	Fan	55	6	330	5	42.9
	Computer	120	2	240	5	31.2

	Printer	120	2	240	5	31.2
Ladies toilet	Exhaust fan	40	1	40	5	5.2
	Bulb	100	1	100	5	13
Gents toilet	Tube light	50	2	100	5	13
	Exhaust fan	40	3	120	5	15.6
	Bulb light	100	3	300	5	39
Corridor	Tube light	50	4	200	5	26
	CFL light	15	3	45	5	5.85
	Alarm bell	2	1	2	5	0.26
Total energy consumption per month =1336.01 kWh						

TABLE3.Ground floor						
Places	**Name of the equipments**	**Rating of equipment (watt)**	**Number of equipments**	**Connected load (Watt)**	**Total running hrs/DAY**	**Energy consumed /month(KWH)**
Room No - 101	Tube light	50	22	1100	4.5	**128.7**
	Fan	55	12	660	4.5	**77.22**
Room No - 102	Tube light	50	27	1350	4.5	**157.95**
	Fan	55	15	825	4.5	**96.525**
Room No - 103	Tube light	50	29	1450	4.5	**169.65**
	Fan	55	15	825	4.5	**96.525**
Room No - 104	Tube light	50	8	400	4.5	**46.8**
	Fan	55	6	330	4.5	**38.61**
Room No.105	Tube lights	50	14	700	1	**18.2**
	Ceiling fans	55	16	880	1	**22.88**
	CFL Bulbs	15	7	105	1	**2.73**
	Sound box	150	2	300	1	**7.8**
	Projector	297	1	297	1	**7.722**
Toilet (F)	Tube light	50	1	50	1	**1.3**
	Exhaust fan	40	1	40	1	**1.04**
	Tube light	50	1	50	1	**1.3**

Toilet (M)	Exhaust fan	40	1	40	1	**1.04**
Room No - 107	Tube light	50	16	800	4.5	**93.6**
	Fan	55	12	660	4.5	**77.22**
Room No.108	Tube light	50	10	500	4.5	**58.5**
	Ceiling fans	55	6	330	4.5	**38.61**
Room No - 109	Tube light	50	26	1300	4.5	**152.1**
	Fan	55	15	825	4.5	**96.525**
Room No.110	Tube lights	50	25	1250	4.5	**146.25**
	Ceiling fans	55	15	825	4.5	**96.525**
Room No.113	Tube lights	50	21	1050	4.5	**122.85**
	Ceiling fans	55	12	660	4.5	**77.22**
Corridor	Tube lights	50	8	400	4.5	**46.8**
	CFL bulbs	15	12	180	4.5	**21.06**
	Motor pump	6000	2	12000	1	**312**
Toilet(F)	Tube lights	50	1	50	4.5	**5.85**
	C.F.L	15	1	15	4.5	**1.755**
	Exhaust fan	40	5	200	4.5	**23.4**
Total energy consumption per month =2246.26 kWh						

TABLE4. 1st floor

Places	Name of the equipments	Rating of equipment(watt)	Number of equipments	Connected load(Watt)	Total running hrs/day	Energy consumed /month(kwH)
Room No.201	Tube Lights	50	22	1100	4.5	**128.7**
	Ceiling Fans	55	12	660	4.5	**77.22**
Room No.202	Tube lights	50	26	1300	4.5	**152.1**
	Ceiling Fans	55	15	825	4.5	**96.525**
Room No.203	Tube lights	50	29	1450	4.5	**169.65**

	Ceiling Fans	55	15	825	4.5	**96.525**
Room No.204	Tube lights	50	12	600	4.5	**70.2**
	Ceiling Fans	55	6	330	4.5	**38.61**
Defence studies room	Tube lights	50	16	800	1.5	**31.2**
	Ceiling Fans	55	16	880	1.5	**34.32**
	CFL bulbs	15	7	105	1.5	**4.095**
	over head projector	750	1	750	1	**19.5**
Toilet	Tube lights	50	1	50	1.5	**1.95**
	exhaust fan	40	1	40	1.5	**1.56**
Room No.207	Tube lights	50	12	600	4.5	**70.2**
	Ceiling Fans	55	6	330	4.5	**38.61**
corridor	Tube lights	50	8	400	4.5	**46.8**
	CFL bulbs	15	12	180	4.5	**21.06**
	diode bulb	100	1	100	4.5	**11.7**
Total energy consumption per month =1110.525 kWh						

TABLE.5.2nd floor						
Places	**Name of the equipments**	**Rating of equipment (watt)**	**Number of equipments**	**Connected load (Watt)**	**Total running hrs/day**	**Energy consumed/month(kwh)**
Room No - 301	Tube lights	50	22	1100	4.5	**128.7**
	ceiling fan	55	12	660	4.5	**77.22**
Room No 302	Tube lights	50	30	1500	4.5	**175.5**
	ceiling fan	55	15	825	4.5	**96.525**
Room No - 303	Tube lights	50	30	1500	4.5	**175.5**
	ceiling fans	55	15	825	4.5	**96.525**
Library	Tube lights	50	80	4000	4.5	**468**

	ceiling fans	55	38	2090	4.5	**244.53**
	CFL light	15	15	225	4.5	**26.325**
	Vacuum cleaner	400	1	400	1	**10.4**
	Table fans	80	1	80	4.5	**9.36**
	Computer	120	2	240	4.5	**28.08**
	Printer	120	1	120	4.5	**14.04**
Smart class	Tube lights	50	14	700	2.25	**40.95**
	ceiling fan	55	16	880	2.25	**51.48**
	CFL light	15	8	120	2.25	**7.02**
	Sound box	150	4	600	2.25	**35.1**
	LCD projector	297	1	297	2.25	**17.3745**
	Computer	120	1	120	2.25	**7.02**
	Amplifier	160	1	160	2.25	**9.36**
Toilet (M)	Tube lights	50	1	50	2.25	**2.925**
	Exhaust fans	40	1	40	2.25	**2.34**
	CFL Bulb	15	1	15	2.25	**0.877**
Toilet (F)	Tube lights	50	1	50	2.25	**2.925**
	Exhaust fans	40	1	40	2.25	**2.34**
	Bulb	15	1	15	2.25	**0.877**
Music dept.	Tube lights	50	30	1500	1.5	**58.5**
	ceiling fan	55	15	825	1.5	**32.175**
	sound box	150	1	150	1.5	**5.85**
	Amplifier	160	1	160	1.5	**6.24**
	wall speaker	150	6	900	1.5	**35.1**
Corridor	Tube lights	50	8	400	4.5	**46.8**
	CFL light	15	10	150	4.5	**17.55**
	Alarm light	100	1	100	4.5	**11.7**
	bell	2	1	2	4.5	**0.234**
Total energy consumption per month =1945.443kWh						

TABLE.6.3rd floor						
Places	**Name of the equipments**	**Rating of equipment (watt)**	**Number of equipments**	**Connected load (Watt)**	**Total running hrs/day**	**Energy consumed /month(kwh)**
Room No - 401	Tube	50	22	1100	4.5	128.7
	Fan	55	12	660	4.5	77.22
Room No - 402	Tube	50	30	1500	4.5	175.5
	Fan	55	15	825	4.5	96.525
Conference hall	Tube	50	52	2600	1	67.6
	Fan	55	38	2090	1	54.34
	LCD projector	297	1	297	1	7.722
	Sound box	300	4	1200	1	31.2
	Amplifier	160	1	160	1	4.16
	CFL light	15	13	195	1	5.07
	Mixer	1000	1	1000	1	26
IT department	Tube	50	10	500	1.5	19.5
	Fan	55	16	880	1.5	34.32
	Computer	120	20	2400	1.5	93.6
	CFL light	15	8	120	1.5	4.68
	Printer	120	1	120	1.5	4.68
	Internet server	6000	1	6000	4.5	702
Corridor	Tube	50	12	600	4.5	70.2
	CFL light	15	11	165	4.5	19.305
	Alarm light	100	1	100	4.5	11.7
	Bell	2	1	2	4.5	0.234
Total energy consumption per month =1634.256 kWh						

Administrative block

TABLE.7.Ground floor						
Places	**Name of the equipments**	**Rating of equipment (watt)**	**Number of equipments**	**Connected load (Watt)**	**Total running hrs/day**	**Energy consumed/month(kwH)**
Store room	Stand fan	100	1	100	6	15.6
	Tube Lights	50	2	100	6	15.6

	Ceiling Fans	55	1	55	6	8.58
Academic sec.	Tube Lights	50	15	750	6	117
	Ceiling Fans	55	8	440	6	68.64
	computer	120	1	120	6	18.72
	printer	120	1	120	6	18.72
Stipend section	Stand fan	80	1	80	6	12.48
	Ceiling Fans	55	6	330	6	51.48
	Tube Lights	50	12	600	6	93.6
Corridor	Tube light	50	5	250	6	39
	Fan	55	6	330	6	51.48
	CFL bulb	15	12	180	6	28.08
	CFL bulb	15	9	135	6	21.06
	Aqua guard	20	1	20	6	3.12
Gents toilet	Bulb	15	1	15	6	2.34
	Exhaust fan	40	4	160	6	24.96
	Tube light	50	4	200	6	31.2
Ladies toilet	Tube light	50	2	100	6	15.6
	Exhaust fan	40	3	120	6	18.72
	Bulb light	15	1	15	6	2.34
Store room	CFL light	15	4	60	6	9.36
	Tube light	50	10	500	6	78
	Fan	55	5	275	6	42.9
	Exhaust fan	40	1	40	6	6.24
	CFL bulb	15	1	15	6	2.34
Reception room	Tube light	50	1	50	6	7.8
	Fan	55	1	55	6	8.58

	CFL bulb	15	1	15	6	2.34
Store room	Tube light	50	1	50	6	7.8
	Fan	55	1	55	6	8.58
	CFL bulb	15	2	30	6	4.68
	Motor pump	2400	1	2400	1	62.4
Total energy consumption per month =899.34 kWh						

TABLE.8.1st floor						
Palces	**Name of the equipments**	**Rating of equipment (watt)**	**Number of equipments**	**Connected load (Watt)**	**Total running hrs/day**	**Energy consumed/month (kWh)**
Establishment	Tube Lights	50	12	600	6	93.6
	Ceiling Fans	55	6	330	6	51.48
	Bulbs	15	6	90	6	14.04
	Printer	150	1	150	6	23.4
	Computer	120	1	120	6	18.72
	Heater	2000	1	2000	6	312
Cash Room	Tube Lights	50	10	500	6	78
	Ceiling Fans	55	4	220	6	34.32
	Bulbs	15	2	30	6	4.68
	Computer	120	1	120	6	18.72
	Printer	150	1	150	6	23.4
D.D.O Room	Tube Lights	50	6	300	6	46.8
	Ceiling Fans	55	3	165	6	25.74
	Computer	120	1	120	6	18.72
	Printer	150	1	150	6	23.4
	Heater	2000	1	2000	6	312
	Calling bell	2	1	2	6	0.312
	Stand Fan	80	1	80	6	12.48
Room For meeting	Tube light	50	14	700	6	109.2
	Fan	55	4	220	6	34.32
	CFL light	15	6	90	6	14.04
Xerox room	Tube light	50	1	50	6	7.8
	Fan	55	1	55	6	8.58

	CFL light	15	1	15	6	2.34
	Xerox machine	1300	3	3900	6	608.4
Room of PS to the principal	Tube light	50	2	100	6	15.6
	Fan	55	2	110	6	17.16
	CFLlight	15	1	15	6	2.34
	Alarm	2	1	2	6	0.312
	Computer	120	1	120	6	18.72
	Table fan	50	1	50	6	7.8
Principal's room	Tube light(with reflector)	50	12	480	6	74.88
	CFL light	15	4	60	6	9.36
	Fan	55	5	275	6	42.9
	Computer	120	2	240	6	37.44
	Table fan	50	1	50	6	7.8
	Printer	120	1	120	6	18.72
	Inverter	50	1	50	24	31.2
	Scanner	36	1	36	6	5.616
	Fax	30	1	30	6	4.68
Toilet	Tube light	50	1	50	6	7.8
	Exhaust fan	40	2	80	6	12.48
	CFL light	15	1	15	6	2.34
Toilet(f)	CFL bulb	15	2	30	6	4.68
	Exhaust fan	40	3	120	6	18.72
	Tube light	50	1	50	6	7.8
Gents toilet	Tube light	50	4	200	6	31.2
	Exhaust fan	40	4	160	6	24.96
	CFL bulb	15	1	15	6	2.34
Corridor	Tube light	50	1	50	6	7.8
	CFL Bulb	15	4	60	6	9.36
	Tube	50	5	250	6	39
Total energy consumption per month =2359.5 kWh						

TABLE.9.2nd floor						
Places	**Name of the equipments**	**Rating of equipment (watt)**	**Number of equipments**	**Connected load (Watt)**	**Total running hrs/day**	**Energy consumed/month (kwH)**
Corridor	Tube lights	50	5	250	6	39
	Bulbs	15	4	60	6	9.36
	Calling bell	2	1	2	6	0.312
	C.F.L tube	15	1	15	6	2.34
Gents toilet	Tube lights	50	1	50	6	7.8
	Exhaust fan	55	4	220	6	34.32
	Bulbs CFL	15	4	60	6	9.36
Conference hall	Tube Lights	50	36	1800	6	280.8
	Bulbs CFL	15	9	135	6	21.06
	Ceiling Fans	55	22	1210	6	188.76
U.G.C room	Tube light	50	12	600	2	31.2
	CFL bulb	15	6	90	2	4.68
	Computer	120	2	240	2	12.48
	Xerox machine	1300	1	1300	2	67.6
	Fan	50	6	300	6	46.8
	Scanner	36	1	36	6	5.616
	Printer1	120	2	240	6	37.44
	Printer2	120	1	120	6	18.72
E.V.S lab	Refrigerator	299	1	299	24	186.576
	Hot plate	1000	1	1000	1	26
	Autoclave	1000	1	1000	1	26
	Hot air oven	2000	1	2000	1	52
	Incubator	1000	1	1000	1	26
	Weighing machine	20	1	20	1	0.52
	pH. meter	20	1	20	1	0.52
	Spectro-photometer	200	1	200	1	5.2
	Tube light	50	4	200	1	5.2
	CFL bulb	15	4	60	1	1.56
	Fan	55	4	220	1	5.72
Record room	Tube light	50	4	200	1	5.2
	CFL bulb	15	2	30	1	0.78
	Fan	55	2	110	1	2.86
Total energy consumption per month =1161.784 kWh						

Science Block

TABLE.10.Ground floor

Places	Name of the equipments	Rating of equipment (watt)	Number of equipments	Connected load (Watt)	Total running hrs/day	Energy consumed /month (KwH)
	Diode bulb	100	1	100	5	13
	Tube light	50	3	150	5	19.5
	Aqua guard	20	2	40	5	5.2
Corridor	Motor pump	1800	1	1800	1	1.8
	water cooler	200	2	400	5	52
Physics lab	Tube light	50	25	1250	2.5	81.25
	Diode bulb(large)	200	8	1600	2.5	104
	Ceiling fan	55	15	825	2.5	53.625
	Refrigerator	150	1	150	1	3.9
	D.C Power supply	2	3	6	2.5	0.39
	Computer	120	1	120	2.5	7.8
	Printer	150	1	150	2.5	9.75
common room(girls)						
	Diode bulb	100	6	600	5	78
	fan	55	10	550	5	71.5
common room(boys)						
	Tube Light	50	14	700	5	91
Student's council	Tube light	50	4	200	6	31.2
	Fans	55	4	220	6	34.32
Chemistry lab	Tube light	50	20	1000	3	78
	Fans	55	9	495	3	38.61
	Bulbs	100	3	300	3	23.4
	Hot plate	1200	2	2400	3	187.2
	Melting point apparatus	200	2	400	3	31.2
	Regulator water bath	1000	1	1000	3	78
	Refrigerator	200	1	200	3	15.6

	Distillation pump	2500	1	2500	3	195
Total energy consumption per month =1305.245kWh						

TABLE.11.1st floor						
Places	**Name of the equipments**	**Rating of equipment (watt)**	**Number of equipments**	**Connected load (Watt)**	**Total running hrs/day**	**Energy consumed /month (kWh)**
Room No.11	Tube Lights	50	2	100	3	7.8
	Diode Bulbs	100	1	100	3	7.8
	Ceiling Fans	55	4	220	3	17.16
Room No.10	Tube Lights	50	2	100	3	7.8
	Diode Bulbs	100	3	300	3	23.4
	Ceiling Fans	55	5	275	3	21.45
Room No.9	Tube Lights	50	3	150	3	11.7
	Diode Bulbs	100	2	200	3	15.6
	Ceiling Fans	55	4	220	3	17.16
Room No.8	Tube Lights	50	3	150	3	11.7
	Ceiling Fans	55	4	220	3	17.16
Total energy consumption per month =158.73kWh						

Plate 1: Academic building of Bir Bikram Memorial College

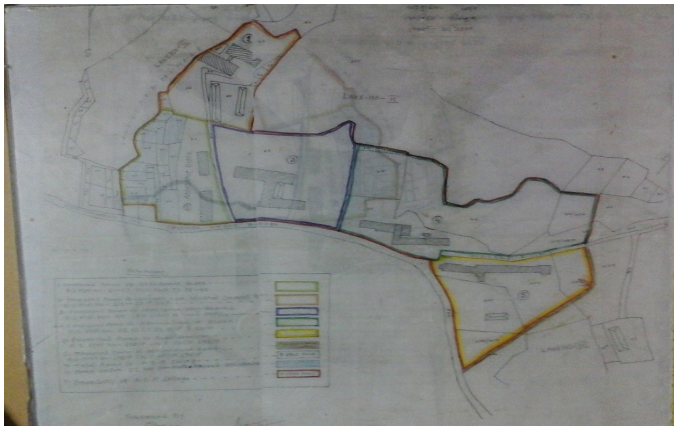

Plate 2: Map of Bir Bikram Memorial College campus

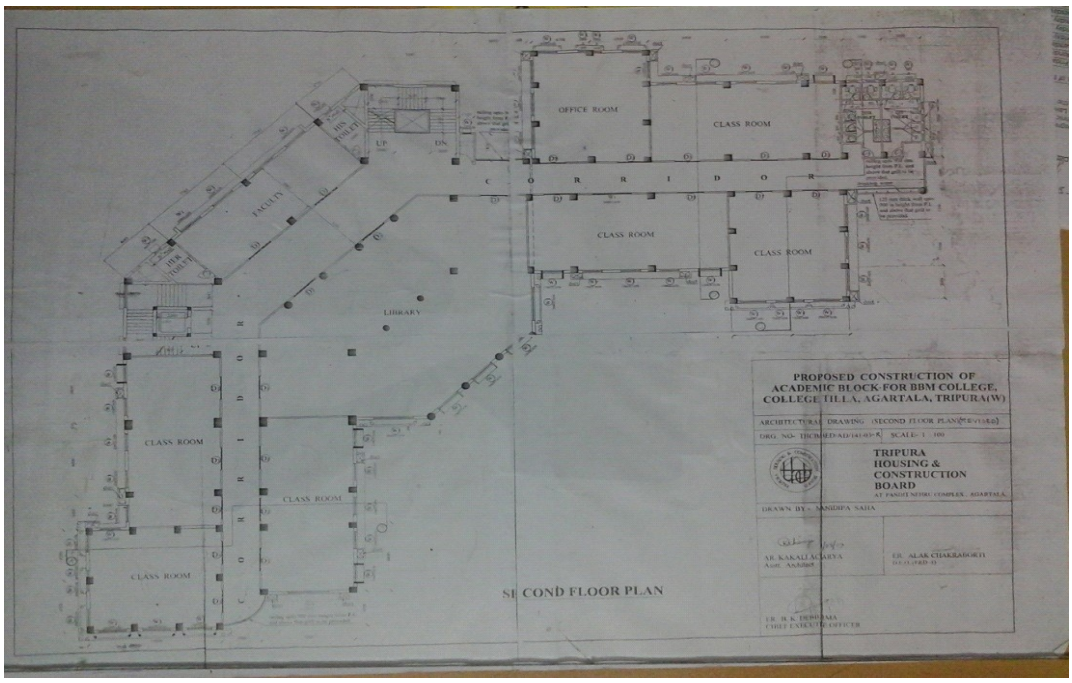

Plate 3: Blue print of Academic building of Bir Bikram Memorial College with area

Plate 4 : Lux meter (Lux Meter LX-101A)used for light intensity study of Bir Bikram Memorial College buildings

