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A Study on Reduction of Energy Consumption in the Student Hostel of College of Science and Technology

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***Abstract:** This paper presents a suitable lamp and an automated display system to reduce energy consumption in student hostels at College of Science and Technology. The study was carried out as a part of student project, and discusses on the ways to reduce energy consumption. From the data collected, hostel area consumes more power than other places in the campus; reasons could be usage of lamps with higher power rating and students' carelessness. Based on these reasons, two solutions were proposed viz. selection of suitable lamp to overcome first reason, and development of an automated system to further reduce energy consumption due to students' carelessness. The paper proposes in brief a suitable lamp based on theoretical calculations, and more on the automated system. The system was designed and tested for a student room. The system worked satisfactory for the purpose, but there are improvements or studies needed to carry out to reduce overall cost, and also to make it work for all the rooms in a hostel.*

Keywords: ZigBee. Arduino Microcontroller, Sensor, Display

1. Introduction

While the living has steadily improved over the years due to development, the demand for energy usage and energy consumption has also increased [1][2]. Therefore, the effective usage of energy is becoming an important and a challenging task. One of the ways of using energy effectively and conserving is to conduct energy audit to study the current energy pattern and recommend possible viable solutions for the conservation of energy. This can be achieved through deliberate practice such as energy management, which includes the effective methods to reduce the cost incurred for the same amount of energy consumption.

For the establishment of such practices in hands, an attempt was being made to ascertain energy utilization more effective in the college campus. With the increasing number of students in the campus, the demand for energy in terms of electricity is increasing every year. Table 1 shows energy consumption for July and August, 2015.

Table 1: Energy Consumption in the Campus

<table>
<tr><th rowspan="2">Places in the Campus</th><th colspan="3">Energy Consumption (KWh)</th></tr>
<tr><th>July</th><th>August</th><th>Average</th></tr>
<tr><td>Supporting Staff 1</td><td>1067</td><td>860</td><td>963.5</td></tr>
<tr><td>Supporting Staff 2</td><td>897</td><td>731</td><td>814</td></tr>
<tr><td>Supporting staff 3</td><td>574</td><td>451</td><td>512.5</td></tr>
<tr><td>Bachelor Building</td><td>1346</td><td>1021</td><td>1183.5</td></tr>
<tr><td>Lecture Block A</td><td>1982</td><td>1912</td><td>1947</td></tr>
<tr><td>Lecture Block B</td><td>1634</td><td>1821</td><td>1727</td></tr>
<tr><td>Provost Quarter</td><td>1530</td><td>1509</td><td>1519</td></tr>
<tr><td>Cook Residents</td><td>2733</td><td>2022</td><td>2377.5</td></tr>
<tr><td>Library Building</td><td>1800</td><td>1220</td><td>1510</td></tr>
<tr><td>Student Dining Hall</td><td>72</td><td>260</td><td>166</td></tr>
<tr><td>Hostel Block A</td><td>920</td><td>2480</td><td rowspan="7">**6390**</td></tr>
<tr><td>Hostel Block B</td><td>1360</td><td>2120</td></tr>
<tr><td>Hostel Block C</td><td>920</td><td>2760</td></tr>
<tr><td>Hostel Block D</td><td>1360</td><td>2360</td></tr>
<tr><td>Hostel Block E</td><td>880</td><td>1920</td></tr>
<tr><td>RK Hostel left Wing</td><td>1120</td><td>2200</td></tr>
<tr><td>RK Hostel Right Wing</td><td>2080</td><td>3080</td></tr>
</table>

Student hostel consumes more energy than other places. It could be due to the following reasons,

i. Number of occupants
ii. More rooms, hence more lamps
iii. Lamps of higher power rating
iv. It was observed; some students leave their room with lights ON while they leave for classes.

It was difficult to reduce student intake in the college because of the increasing number programme/courses. Same is with the number of rooms. Therefore, the study was focused to find solutions for last two reasons; i.e. to do with lamp and students' carelessness. A study on selection of suitable lamp was carried out which reduces the energy consumption but it does not help solve student carelessness problem. So an automated display system was developed to take care of it. The system makes uses of sensors, microcontroller, display board and ZigBee module as the main components. The display unit is installed at the entrance of the hostel to display the room number which has the light ON and no occupants.

2. Selection of suitable lamp

Different types of lighting lamps are commonly used in the residential building for room lighting. The most commonly used lighting lamps are incandescent lamp(IL), fluorescent lamp, compact fluorescent lamp (CFL) and light emitting diode (LED) [1][3][4]. At CST, the hostel rooms have fluorescent lamps (FL).

For the theoretical calculation to select suitable lamp, following steps were carried out:

i. A room was selected and the area was calculated for the same. The room area was 14.62m^2.
ii. With reference to electrical engineering data book[5], illumination level for the room was considered for a classroom since students need to study in their room.
iii. Number of light points was calculated based on the illumination level and the area. Maintenance factor and utilization factor were also considered. The lumen output was taken as 1600 lumen for a 100W incandescent lamp.
iv. With this, the total number of light required was 10.

Number of Light points = (area *lumen required) / (lumen output*MF*UF)

The power rating of different lamps which has output lumen equivalent to 100W incandescent lamp are 15W for LED, 40W for FL, and 25W for CFL. Table 2. shows energy consumed by 10 light points fixed with different lamps. It was assumed that the lamps were ON for 7 hours in a day. LED consumes minimum energy, and incandescent lamp consumes maximum energy which is 6.5 times the energy consumed by LED. However, the initial cost in purchasing LED lamps was higher. The cost for 10 LED amounted to Nu. 4500.00 and Nu. 150.00 for incandescent lamp; but in long run, it was observed that the overall cost including tariff charged for the energy consumed is minimum for LED when compared with incandescent lamp. This was calculated based on the lifespan of lamps. The average lifespan of LED is 50,000 hours which would last for 239 months if used 7 hours in a day. In 239 months, CFL requires 6 times replacement, five times for FL and 41 times for incandescent lamp based on their lifespan. The calculation neglects the external factors that would blow off the lamp like lighting, surge voltage etc. It can be seen in Table 3. that the total cost incurred in buying lamps, and tariff for energy consumed is minimum for LED and maximum for incandescent lamp.

The tariff was calculated based on the Bhutan Power Cooperation (BPC) billing system. BPC charge customer based on the unit consumed in a month. If the unit consumed was between 0-100, BPC charge Nu.1.28 per unit, Nu 2.52 for unit between 100-300 and Nu. 3.79 for unit above 300[6].

Table 2: Total energy consumed by different lamp

Sl. No	Area of the room (m2)	Light Intensity (lux)	Types of Lamp	No. of lamp	Power Rating (watt)	Energy Consumption (kwh)
1	14.62	500	IL(100w)	10	1000	7
2	14.62	500	FL 40W	10	400	2.8
3	14.62	500	CFL 25W	10	250	1.75
4	14.62	500	LED 15W	10	150	1.05

Thus it can be concluded that the use of LED would be ideal to help reduce the energy consumptions in the campus. To further reduce energy consumption and to avoid leaving empty students' rooms with the light turned ON, an automated an automated display system was designed, whereby a display board is installed at the entrance/exit where everyone can see. When a student leaves the room with the light turned ON, he or his friends can see his room number on display board. The student is informed, and he goes to turned OFF the light. The design and operation of system is discussed in following topics.

Table 3: Total cost for purchasing lamps and energy tariff incurred for different lamp in 239 months

Sl. No	Lamp	Life span (Hrs)	life span (Months)	lamp replacement for 50,000 Hrs	Price per lamp	Total cost for the lamps (A)	Energy consumed (Kwh)	Tariff for Energy Consumed (B)	TOTAL AMOUNT (A+B) *10
1	LED	50,000	239	1	450 (15W)	450	750	2842.5	32925
2	CFL	8000	38	6	280 (25W)	1680	1200	4737.5	64175
3	FL	10000	47.5	5	45 (40W)	225	2000	7580.0	78050
4	IL	1200	5.8	41	15 (100W)	615	4920	18950.0	196550

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3. Overview of the system

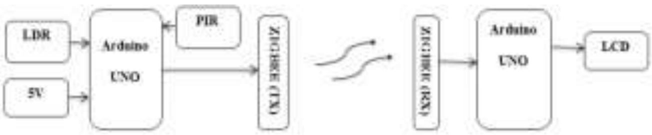

Figure 1: Block diagram representation of the system

Figure 1. is the block diagram representation of the system. The system consists of a transmitter and a receiver. Transmitter is fixed in the room, and receiver is fixed at the entrance/exit of the student hostel. The transmitter uses Passive Infrared Sensor, Light Dependent Resistor, microcontroller and ZigBee module in transmission mode. Figure 2. is the circuit diagram of transmitter showing interfaces between different components. The receiver contains ZigBee module in receiving mode, microcontroller and Liquid Crystal Display (LCD). At the transmitter, PIR sensor detects the presence and absence of the people in the room[7] and LDR sensor [8] is used to detect the light in the room. Figure 3. is the circuit diagram of the receiver.

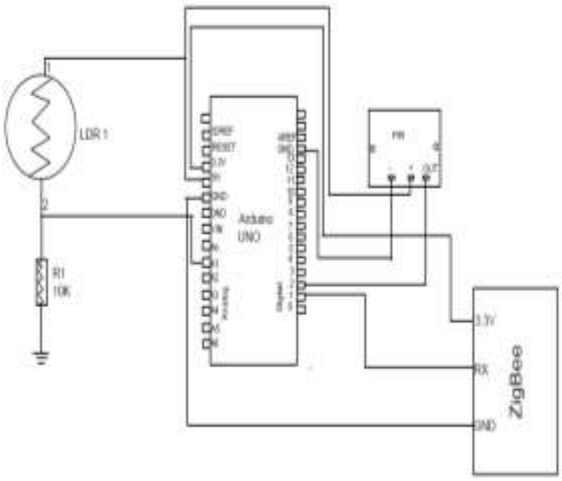

Figure 2: Transmitter Circuit Diagram

In case the output of the PIR sensor is low, and output of the LDR sensor is high indicating there is no people in the room but the lights are ON; microcontroller then sends signal to receiver via ZigBee transmitter. The information transmitted is received by the ZigBee receiver[9][10][11]. Microcontroller on receiver side is programed to display room number on the LCD upon receiving signal from ZigBee module. The display size of LCD used in the study is small. It was used only for testing purpose and can be replaced with bigger one.

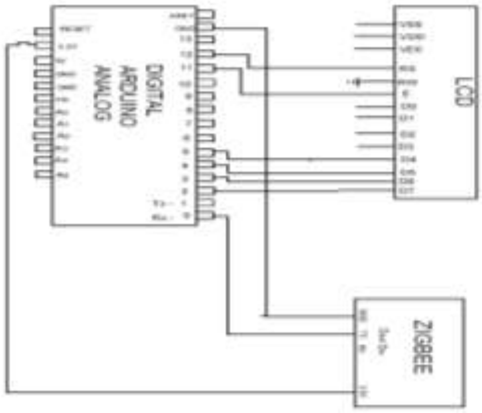

Figure 3: Circuit Diagram of the receiver

4. Simulation of the system

The simulation of the system was carried out in Proteus and is shown in the Figure 4. under different cases considered.

Case 1: When both LDR and PIR sensor were activated; indicates there is occupant in the room, and the light is ON. The LCD will display "NORMAL" as shown in Figure 4.

Case 2: When both LDR and PIR sensor were not activated; indicates no occupant, and the light is OFF. The LCD will display "NORMAL" as shown in Figure 5.

Case 3: When PIR sensor is low and LDR sensor is high; indicates no occupant, and the light is ON. The LCD displays "LIGHT ON ROOM NO 1" as shown in Figure 6.

In the first two cases, no signal from transmitter is sent to the receiver. In the third case, a signal is transmitted to receiver and receiver display the room number on LCD.

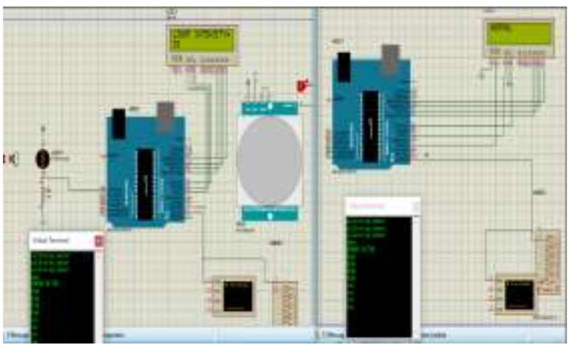

Figure 4 : When both LDR and PIR are activated

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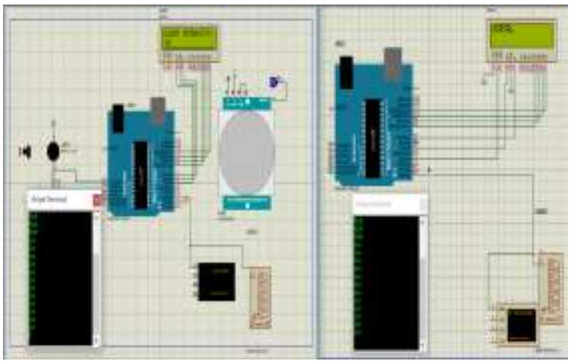


Figure 5: When both LDR and PIR are not activated

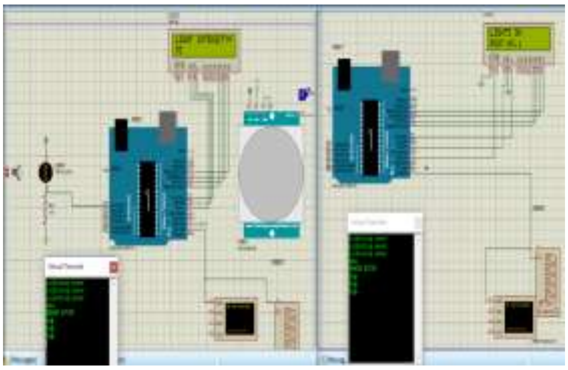


Figure 6: When PIR is not activated and LDR is activated

The microcontroller requires a code to operate and execute the process associated with the proposed system. Arduino software has been used as the interface between the software and the hardware of this system. The Arduino version 1.0.6 makes it easy to write and upload the code in embedded C to the board. Embedded C language is highly suitable for the Arduino microcontroller to use. The complete flow chart is shown in the Figure 7. representing the work flow in transmitter and receiver.

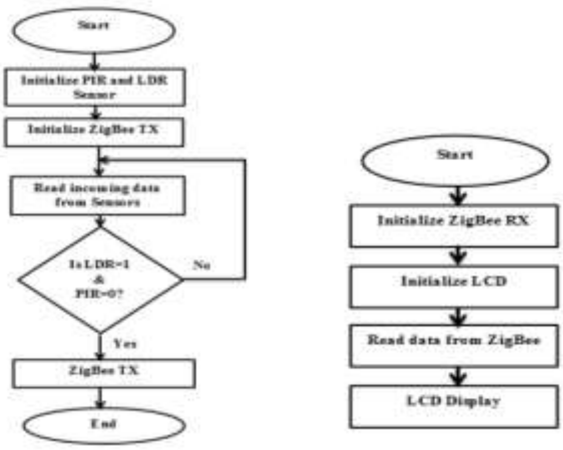


Figure 7: Flow chart

5. System Positioning and Testing

The student hostel has common entry and exit. Receiver of the system was fixed on the wall just next to the entrance/exit where everyone can see the display as shown in Figure 8.

The transmitter was fixed on the wall of a student room as shown in Figure 9.

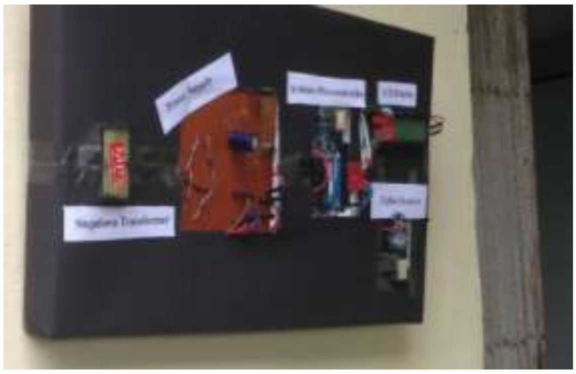


Figure 8: Receiver at the entrance

Figure 9: Transmitter in the student room

The testing was carried out with three cases discussed earlier. The room light was turned ON with a student inside. The receiver should display 'NORMAL' in this case as shown in Figure 10. Similar for the 2nd case, the light is turned OFF and without a student in the room. The receiver should display 'NORMAL' since the light is OFF. Figure 11. shows the output for the 2nd case. For the third case, the light is turned ON, and there is no one in the room. Therefore, receiver should display 'Light ON' with room number as shown in Figure 12. The PIR sensor glows when it gets activated. It gets activated only when there is object with body surface temperature above absolute zero in its detection range. This can be seen in Figure 10. The round red colour in the right corner of the transmitter is the PIR sensor. When it is not activated, it can be seen as white colour as in Figure 11 and Figure 12.

Transmitter

Receiver output

Figure 10: Prototype output with light turned ON, and student in the room

Transmitter

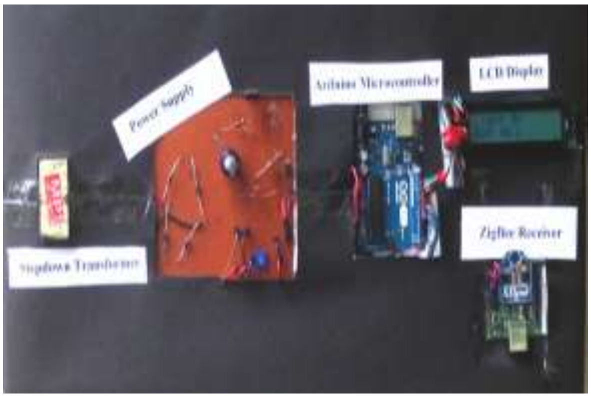
Receiver output

Figure 11: Prototype output with light turned OFF and without student in the room

6. Result, Conclusion and Critical Analysis

Two methods were proposed for the reduction of energy consumption in the college campus. The replacement of lamps with LED reduces energy consumptions, but initial investment is higher than using other lamps. However, in long run, LED is a cost effective option. For further reduction in energy consumption, an automated display system was proposed. The system can help students to turn OFF the light when they forget. The system was tested only for a room and it worked well to serve the purpose. However, the system was not tested for more than one room. This requires further modification in the design of the system; probably both coding for the microcontroller and hardware. With the present system one set was costing approximately Nu. 3500. There is need to study if this amount can be recovered from the energy savings from the room where this system was installed. In long run, the cost may be recovered, but the college is located in the southern region of Bhutan where the humidity is very high in summer, and most of electronic components of system are susceptible to humidity and might need repair or replacement. This cost should also be recovered from the energy savings of the room where is system is set up.

Transmitter



Receiver output

Figure 12: Prototype output with light turned ON and without student in the room

7. Future Work

Some works or studies have been identified as future work so that the system can be used in the student hostel. These works suggest ideas to make the system more efficient, feasible and cost effective for use.

i. While each student room requires a transmitter unit, the receiver at the entrance/exit point can be a common one. For this, there is the need to develop an algorithm at receiver to know from which rooms the signals transmitted.

ii. Cost analysis to see if the expenditure spent on installing the system can be recovered from the energy saving using this system.

iii. Make the design feasible for classrooms as environment.

iv. Apply same idea to electrical points like fan, air conditioner etc. in the campus.

8. Acknowledgment

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References

[1] Anon. (2009, April). ELC Federation: Environmental aspects of lamps. *Second Edition* , p. 3
[2] Li, Y. 2014. Energy audit of high school hostel. p3-7.
[3] Ressler, A., & Rechal, S. 2012. Water and Energy conservation plan. 1-4.
[4] Padmini, v. 2014. Conservation of electrical energy on SET-JU campus through auditing and optimal alternative techniques. Renewable Energy and Environmental Engineering .
[5] Sharma, P., & Sarma, A. 2003. Electrical Engineering Data Book, Department of Electrical Engineering.
[6] Revised Electricity Tariff, 2017. Retrieved from http://www.bpc.bt/electricity-tariff/
[7] Anon. (2016, 2 25). *PIR motion sensor*. Retrieved from http://www.passive-infrared-proximity-motion-sensor/overview
[8] Anon. 2011-2017. “Light Dependent Resistor” Retrived from https://www.electrical4u.com/light-dependent-resistor-ldr-working-principle-of-ldr/
[9] Alfred, A. 2012. How to Interface XBEE with Arduino. Retrieved from http://www.engineersgarage.com/embedded/arduino/how-to-interface-xbee-with-arduino-tutorial
[10] Bilal, M. 2011. *Zigbee interfacing with Arduino*. Retrieved from http://microcontrollerslab.com/zigbee-interfacing-arduino
[11] Patri, A., & Nimaje, D. S. 2015. “Radio frequency propagation model and fading of wireless signal at 2.4 GHz in an underground coal mine”. Journal of the southern African institute of mining and metallurgy

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