ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 6, Issue, 03, pp. 6993-6998, March, 2016

International Journal of
DEVELOPMENT RESEARCH

Full Length Research Article

ELECTRICAL ENERGY AUDIT EVALUATION IN JIMMA UNIVERSITY

***Hiwot Digafe Berihun**

Department of Physics, College of Natural Sciences, Jimma University, Jimma, Ethiopia

ARTICLE INFO

Article History:

Received 14th December, 2015
Received in revised form
05th January, 2016
Accepted 10th February, 2016
Published online 31st March, 2016

Key Words:

Energy, University,
Specific Energy Consumption,
Power Density,
Energy Audit.

ABSTRACT

The research aimed at obtaining a detail idea about the various end uses of energy consumption activities and identifying, and evaluating the possible energy saving opportunities. Longitudinal design method was employed starting from October of 2013 to June of 2015. The findings of the research indicated the presence of various types of energy wasting electrical equipment and poor awareness of energy saving mechanism among staff and students of the university. Among the interviewed students 132(66%) of them are not turn off the light when they go to bed. Among interviewed staff 173(72%) are not switch off the computers at their lunch time and also 79(33%) are not turn off their office light when they go to their house. Specific energy consumption is 140 Kwh/person /annum. Financial analysis performed for the Fluorescent Tube Lamp (FTL), Air Conditioner (AC) and Computers (cathode Ray Computers) with present system cost and as a result if the university implement the result, possible to reduce current energy bill by 435754 Birr ($21787) which is 10% of the current bill. Moreover the study suggests that there should be a mechanisms to enhance awareness and behavioral change among students and staff with respect to energy saving.

INTRODUCTION

Jimma University, set up by an Act of Parliament, was established in 1992, at Jimma town, south west of the capital city of Ethiopia. Today, the University is recognized as one of the centers for academic excellence in the country. Over the years, there has been significant progress at Jimma University in all academic and research activities, and a parallel improvement in facilities and infrastructure, was made to keep it on part with the best institutions in the world. Institutes in positions of excellence grow with time. As on today, it has 56 Departments, 10 Centers, 3 Schools and 4 Interdisciplinary programs. The student's strength of the University is about 42917, with academic staff 1538 and supporting staff of about 4926 over an area of about 250,000 hectare of land (Jimma University, 1991). The energy consumption in Jimma University is mainly in the form of electricity, apart from the use of LPG as cooking fuel in the lounge. The campus had a connected electrical load of 2MW as on April 2011 but actually consuming load is about 1.6MW. The monthly recorded peak demand for the year 2010 is 348140 Birr. Energy bill for the year 2010 was 4,200,000 Birr.

****Corresponding author: Digafe H. Berihun,***
Department of Physics, College of Natural Sciences, Jimma University, Jimma, Ethiopia.

The electricity bill is increasing time to time because of the number of students coming to the campus is becoming high and the university is constructing new building for different purposes. This energy audit assumes significance due to the fact that the Jimma University electricity bill had been too much for the last few years and it will be aimed at obtaining a detailed idea about the various end use energy consumption activities and identifying and evaluating the possible energy savings opportunities. The target is to achieve savings in the electrical energy consumption. The audit is also aimed at giving the possible energy conservation means and making the teaching and learning process better in terms of energy usage. Policies are essential in guiding the university in all forms of energy initiatives. They help determine university goals and ensure compliance (Simpson, 2000). The policy development process allows for thorough consultation between all stakeholders to ensure support from all members of the community throughout the projects' progress. Lastly, strong policies allow administration and staff to resist pressures to deviate from their goals (Simpson, 2000).University community is populated with thousands of people on a daily basis. Their regular use of energy contributes to high electrical bills and cost penalty. Faculty members require electricity to power classroom lights and media players (e.g., projectors, laptops, etc.) in order to lecture. Students require the same technologies to learn.

The university is dependent on staff, such as employees working closely in the facilities and services department, to monitor energy distribution throughout the campus (Clark *et al*., 1998). Campus growth is inevitable, in line with the growth of the country Ethiopia and with this growth comes increases in energy use. The question then becomes: how can this population use energy resources more efficiently and conservatively? With this question in mind, universities must discover different methods of achieving energy reductions within their community.

It is therefore important that students, faculty and administration collaborate and support one another in achieving energy conservation on a campus-wide level (Clark *et al*., 1998). Currently the word is facing climate change due to greenhouse gas emissions because of unwisely consumption of non-renewable energy sources all over the globe. This type of research has an impact on reduction of energy consumption in different part of the world where universities are found. Especially their budget can be used for other education related expenses instead of wasting on energy bills. The area to be focused would be indicated.

MATERIALS AND METHODS

Study Design and Site

A longitudinal design was employed in this study. There were two phases. In phase one pre-Audit phase was employed in which historical and descriptive data were gathered and in the second phase detail investigation was carried out using observation check list and interview questions.

Source of information

Source of the information of this study are in first place all electrical equipments in all buildings of the university, 230 staff and 200 students were randomly selected for interview. The instruments for data collections are observation check lists and interview questions.

Data Collection and administration

The method used in this research work was through survey using different observation check list that contains the type of equipment, duration of usage and electrical efficiency capability. Using these check list the researcher collected different data from each and every building of the university. And also there were interview for randomly selected of 30 staffs and 50 students. As a first step in this regard, 8 teams formed a total of 16 data collectors were formed and each group was assigned a particular area or application of energy in the campus. The data collectors are laboratory technicians and the researcher gave training how to collect energy data from different parts of the university.

Data analysis

The collected data through observation list and interview are analyzed carefully based on the principle in descriptive statistics in addition to energy wasted by different equipment are quantified and forwarded possible saving mechanisms.

Ethical consideration

Letter from the research and publication office of college was written for the researcher to get appropriate data from different office of the university and for observation of electrical appliances in different buildings. In particular ethical letter was important for data collection through interview. The letters were distributed to college deans and proctor of student's dormitories.

RESULTS

Energy consumption pattern in Jimma University

The loads were segregated based on the end use as lighting and fans, air conditioning, Computer, printers, Dormitory, Hospital loads, Common area lighting, and lounge and student cafe. Quantification, types and necessary measurements were carried out. The details are given here. It is quite clear from the Fig.1.1 that maximum power is wasted in lighting (22%) such as lighting in dormitory mainly and lighting in different building. In most areas (99%) fluorescent tube lamp(36watt) is used and few places(1%) incandescent is used both of them are inefficient compared to that of compacted fluorescent lamp. Computers with 14% of the total power consumption is an application where energy efficiency can be achieved very easily by replacing CRT which has 66wattage by LCD computers whose power consumption is around 40watt. According to the data there are about 33% of the computers are in standoff mode of operation even though the staffs are not around the office. Office appliances including printers, copier, scanner contribute are not using not simple amount of energy. Air circulation appliances such as AC and fan having share of (19%) are also among the major energy consuming electrical equipments. Among the areas mention in the pie chart workshop and Garage are consuming great amount of electrical energy around 18%.

Energy use by computers

As computers energy consumption load is about second to lighting consumption load the campus contract demand, any savings achieved in this field would be significantly important for the reduction of energy bill of the university. As we can learn from Table 1.1 that computers are the essential electrical equipments in the University for teaching and learning purpose and for other office duties. According to the collected data 80% of computers are LCD and the rest 20% are CRT type. From the total computers 90% of them are used at least in average 6 hrs per day and working almost above 300 days per year. CRT type computers are the most energy wasting computers compared to LCD type computers. This tells us that if the university replaces those CRT computers by LCD result 12000Kwh amount of energy are saved within a year.

Lighting and Fans

Jimma University main campus has about 22500 Fluorescent tube lights in dormitories, different building, different offices and labs. Out of which about 6,000 tube lights are fitted with electromagnetic ballast and the rest are with electronic ballast.

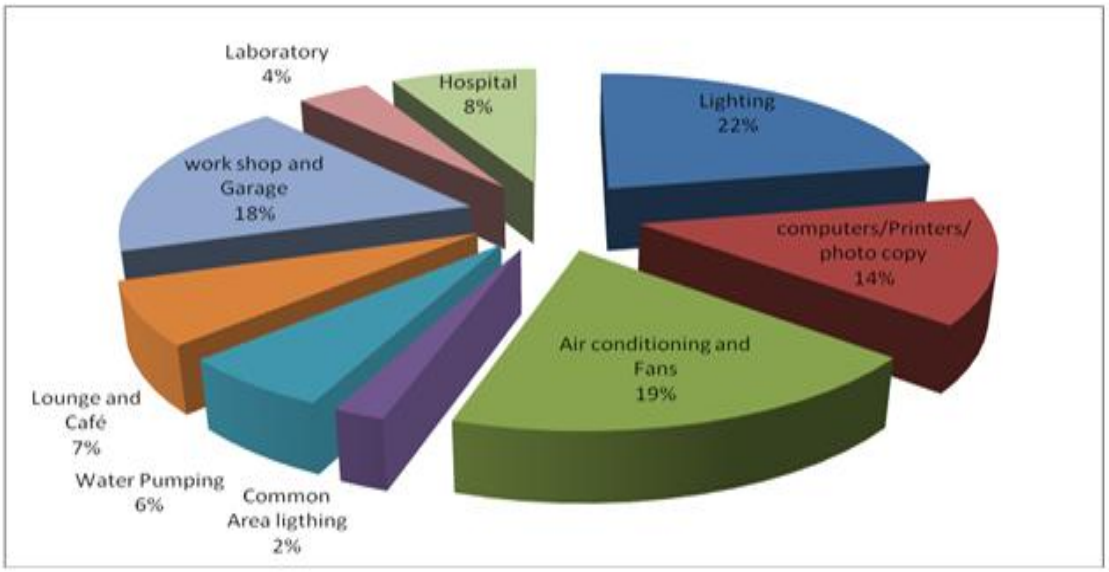

Figure 1.1. Distribution of connected load by end use in Jimma University

Table 1.1. Energy consumption by computers in different colleges

S. No	Colleges	Computers	Period of usage	Energy Consumption(KWh)
1	Natural Sciences	850(82 w each)	6hrs	107100
2	Social Sciences	450(82 w each)	6hrs	56700
3	Law and Governance	280(82 w each)	6hrs	35280
4	Education and Behavioral Science	150(82 w each)	6hrs	18900
5	Health Sciences	1400(82 w each)	6hrs	176400
	Total			394380

Table 1.2. AC loads in various Buildings, Computer Centers, and Departments

S. No	Places	No of AC	Period of usage(hrs)	Energy Consumption (Kwh)
1	Different Buildings	36	5	64800
2	Computer Centers	28	7	70560
3	Library	24	12	103680
4	Laboratory	18	4	25920
5	President Offices	8	4	11520
	Total			276480

If the university replaces all Fluorescent lamps by Compacted Fluorescent lamp it is possible to achieve 900,000kwh amount of energy can be saved within a single year. In the university there are 270 fans in different Libraries, conference rooms and laboratories. Out of which about 30% fans are fitted with resistance type regulator and rest are with electronic regulator.

Air Conditioners

On using the rated capacity details supplied by the manufacturers (Greenreportcard, 2009), the total room AC load was calculated and which is much greater than that of table fan and exhaust fans. The total AC energy consumption is about 276480kwh. The distribution of ACs in different buildings, laboratories, computer rooms and computer centers is shown in **Table 1.2.** Most of the buildings are not using AC like dormitory but it is common to see air conditioning systems in different Libraries, laboratory and computer centers/rooms and conference rooms. But the whole demand is not usually at one time due to diversity in time of usage of air conditioning systems.

As air conditioning load is about 14% of the campus contract demand, any savings achieved in this field would be significantly important. The tonnage of AC per unit of total area for different departments is calculated and it is below the standard of air conditioning systems. This is because of the fact that ACs is not available in all rooms of the department. But the numbers of laboratory and computer centers in the different department which are air conditioned have a clear influence on this.

Specific Energy Consumption (SEC) for different Colleges

Specific Energy Consumption (SEC) is defined as the energy consumption per unit of product output (Thumann, 2007). The specific energy consumption by considering students, colleges and staff members were calculated which forms the institute SEC and was taken as reference for comparison. The SEC was calculated to be 270 kwh / person/annum in the academic year of 2005 which is 132 Birr per person per annum based on EEPCo tariff (Tariff, 1992).

Table 1.3. Energy Consumption per Person per Year

S .No	Colleges	SEC (Kwh/person/year)
1	Natural Science	180
2	Social Science	100
3	Law and Governance	218
4	Education and Behavioral Sciences	122
5	Public Sciences	93

Table 1.5. Energy consumption per student (SEC)

S. No	Colleges	Average normalized
1	Natural Science	1
2	Social Science	0.8
3	Health Sciences	2.2
4	Law and Governance	1.2
5	Education and Behavioral Science	0.7

Table 1.6. Energy consumption per student and staff

S. No	Colleges	Energy Consumption per Capita(kwh/person)
1	Natural Science	2.8
2	Social Science	0.8
3	Health Sciences	3.4
4	Law and Governance	1.2
5	Education and Behavioral Sciences	1

Table 1.7. Measured values of lighting power density as selected locations in Jimma University

S. No	Space/application	Lighting power density (w/sq.m)	Lighting power density (w/sq.m) in Literature
1	Enclosed offices	11.1	11.8
2	Offices-open plan	13.1	11.8
3	Conference/meeting rooms/multipurpose	13.5	14.0
4	Class rooms/ lecture theatres	13.6	15.1
5	Lounge	13.1	12.9
6	Dining area	10.1	9.7
7	Food preparation	10.7	12.9
8	Library stacks	12.2	18.3
9	Library reading area	10.2	12.9
10	Workshops	11.1	15.1
11	Café/lounge	14.1	15.1

This figure is by far greater than the average values of colleges which are 140kwh/person/year because of the fact that the total energy consumption of the university includes workshop, Garage and Hospital. The specific energy consumption considering students and staffs of the colleges is calculated to be minimum, 93 kwh/ person/ annum (for 2005) or 43 Birr per person per annum and the maximum is lies over the college of Law and Governance which is 218Kwh per person per annum. This is very small compared to what other scholars put in different literature which reaches 750Kwh per person per year (ECA, 1996).

Dormitory

There are 32 buildings reserved for student dormitory in Jimma University main campus, having fluorescent tube lamp 13,500 and corridor lights. The loads are used for lighting purpose and sometimes for electrical devices like laptops and mobile charging. Here in the dormitory, according to the observation data out of the total students dormitories around 10% of total dormitory students are using personal laptops and in the total dormitories in the university students in 6% of dormitories are using different types of electrical stoves and out of the total dormitories in the campus 15% of students are using heaters for making tea and coffee.

Per Unit Area Energy Consumption

The energy consumption per sq. m for each College is determined and it is normalized with respect to the average value of per sq. m energy consumption of the university which was set as the basis. For normalization the university average 205kwh/sq.m/year is taken as the denominator.

Per Capital Energy Consumption for Colleges

As per capital (students + staff) consumption for each College is determined and it is normalized with respect to the average value of the per capital consumption for the university.

Lighting Power Density

It can be seen that the lighting power density values in the university are not higher than the values in the literature (Okoro, 2008). But when we see the lamps, most of the areas (95%) are Fluorescent tube lamp. Enclosed office especially their power density is close to what is there in standard values.

Very huge gap between literature value and the data synthesized lies at work shop and Library stacks. It can be seen that the lighting power density values in the university are not higher than the values in the literature (Okoro, 2008). But when we see the lamps, it is Fluorescent tube lamps which consumes 36 watt that makes energy wastage higher in campus. Areas to be focused in the University are as follows:

Energy Consumption by Lighting

Energy Consumption by FTL=225000FTL X 36w/FTL X 6hrs/day X 365days/year = 1773900kwh/yr
Energy Consumption by CFL= 22500CFL X 13w/CFL X 6hrs/day X 365days/year = 640575kwh/yr
The difference in energy consumption=1133325kwh/yr
The amount of energy can be saved per year=1133325kwh/yr
The amount of money can be saved per year=396664Birr/yr.
Capital investment =337500Birr, Simple payback period =1 year

Energy Consumption by Computers (CRT type)

Energy Consumption by CRT=400CRT X 66w/CRT X 8hrs/day X 365days/year=63360kwh/yr

Energy Consumption by LCD= 400LCD X 40w/LCD X 8hrs/day X 365days/year =38400kwh/yr
The difference in energy consumption=24960kwh/yr
The amount of energy can be saved per year=24960kwh
The amount of money can be saved per year=8736Birr/yr
Capital investment =400000Birr, Simple payback period =4year

Energy Consumption by AC

Energy Consumption by AC=82AC X 1500w/AC X 4hrs/day X 365days/year =147600kwh/yr.
Energy Consumption by AC= 82 X 1500w/AC X 3hrs/day X 365days/year =110700kwh/yr.
The difference in energy consumption=36900kwh/yr
The amount of energy can be saved per year=36900kwh/yr
The amount of money can be saved per year=12915Birr/yr
Capital investment = zero (only awareness), Simple payback period =zero

Profile of interviewed staff and students and their perception

Among the 230 randomly selected staff participated in the study 184(80%) were male and 46(20%) of them were females and 214(93%) were within the age range 28-50 years. more than 221(96%) of the staff have second degree. The participants have a minimum of five years' experience in the university and 168(73%) of the respondents having experience of 8-16 years. None of the staff involved in the study possess less than five years' experience. Among the 200 randomly selected students participated in the study 88(44%) were third year students and 48(24%) were third year students and 24(12%) were first year students and 40(20%) were fourth year students. None of interviewed students are above fourth year students.

DISCUSSION

The purpose of this research was to explore the detail of energy consumption pattern in Jimma University and what measures could be taken to reduce energy bill of the university. The research carried out to determine energy wastage by lighting in different buildings, dormitory of students and also computer energy wastage besides these the research tried to address the energy wastage by old AC in different libraries, conference room and different buildings. Based on these findings in depth calculations were carried out to determine the amount of energy wasted by fluorescent tube lamp in dormitories and CRT computers. Analysis made from the collected observation data and interview information. In measuring the energy consumption of FTL in dormitory and different buildings, it was found out that putting CFL significantly reduced energy consumption by lighting when the CRT is used for lighting. When FTL consumes an amount of 1773900kwh per year that is 920,000 birr per year according to EEPCo tariff, if all FTL is replaced by CFL the energy consumption reduced to 640575kwh/yr which means 320000birr per year. This suggests that the university can save an amount of 1133325 kwh/yr. It can be saved around 396664 birr per year. Additionally it was found that the capital investment to replace FTL by CFL is 337500 Birr hence it is possible to calculate payback period of this investment can be one year based on the current price of CFL assessed in the market.

This study also found that Among the interviewed students 132(66%) of them are not turn off the light when they go to bed and even they do not know they are wasting energy in the campus. there were behavioral barrier to reduce energy consumption in the dormitory. That is it was assumed that students would not be willing to turn off the light while they are sleeping or going to bed in the night. This shows behavior relating to energy use offer significant potential for improving energy conservation this research reveals that energy conservation could also be improved by changing certain behavior and manner of energy usage in dormitory. Based on the fact computer power management, the research found out that all CRT computers replaced by LCD computers can save an amount of 24960kwh/yr the amount of money can be saved per year becomes 8736 birr. however, this study also found that a barrier to improve energy management concern was that putting computer in to standby mode while the staffs leaves the office this suggests that there may be a need for greater awareness and implementation of these recommendation which is given at the end of this paper.

The study has shown that significantly saving in energy bill can be achieved by realizing AC can be properly utilized in rooms like during their operation hours all doors and windows must be closed for proper functioning of AC, specifically related to AC usage peoples must shutdown the AC before 20 minutes leaving the room, that can save significant amount of energy. The research suggests that there may be a need for improved awareness and education about energy consumption by students and staff. The analysis revealed The present study indicated that 132(33%) of the interviewed staff have no idea about energy saving mechanism and no awareness of they are wasting energy as they are not switch off the computers when

they are leaving for their lunch. Among the interviewed staff 122(53%) of them they are not turn off their office light when they go to their house. That there must be behavioral change turn off computers when they leave their offices and students must turn off their dormitory light when they go to bed. This study the researcher studied an energy audit for Jimma University main campus. The audit includes a survey of the buildings and electrical equipments energy use. The major area where this research achieved is that it is possible to reduce by 10% (435672 Birr) of current energy bill of the university if appropriate measures are taken by higher officials. Specific Energy Consumption (SEC) of the university is (140kwh/person/annum) which is far from the average values of SEC in different literature as shown in Table 1.3. This shows that the university should provide teaching aid for students and staff for quality education in the campus. The average value of power density is calculated in this research as shown in Table 1.4 and that implies that the result is not that much far from figures available in different literature. Finally based on the identified and observed area the research puts some recommendations by which university staff and community can apply for better utilization of energy in the Universities. As recommendation the following points are made by the researcher:

- Adopting a normal energy saving power setting for computers and replacing all CRT by LCD.
- Photo sensors to be installed in staff offices and colliders to utilize optimum day lighting.
- AC may not be working properly if window and doors are open and this adds wastage.
- Proper maintenance for all old AC must be there to save energy.
- As seen during observation period, computers are not switched off when the person leaves the office.
- All the staffs must be aware of energy consumption; the staffs must turn off the light when they leave.
- Attendants must switch off all the computers and LCD after the classes finished.

REFERENCES

Andreas, J.C. 1992. Energy Efficiency motors, Marcel Dekker publ., New York.

Clark, W. 1998. “Retrofitting for energy conservation”. Mc Graw Hill. ISBN; 0-07-011920-1.

Detailed information and case studies on energy audits. Available: www.energymanagertraining.com

EEPCo, ‘Facts in Brief 2007. Energy Audit and Conservation. Available: www.en.wikipedia.org/ wiki/Energy_Audit

Electrical Applianceshttp://www.appa.org/facilitiesmanager/article.cfm?itemnumber=2262&parentid=2248

Energy conservation ACT, 2001. http://powermin.nic.in/ acts_ notification/energy_conservation_act/index.htm

Explanatory Video on various Types lamps. Available: www.commoncraft.com/cfl

General Electric and lighting products. www.gelighting.com/na/home_lighting/Products/energy_smart

Guide book for the nation certificate examination for energy manages and energy auditors. Available: www.energymanager training.com

Information on energy saver for room air conditioners. Available: www.aircosaver.com

Jimma University Background Information, Available: http://www.ju.edu.et

Okoro, O.I., Chikuni, E. Oluseyi, P.O., Introducting an energy efficiency awareness program at the university of Nigeria, Inductrial and Commercial use of energy conf., pp 99-103, 2008.

Simpson, W. (2005). News on Green Design and Energy Conservation from the University at Buffalo. Facilities Manager Magazine, 21(1). Retrieved 23.01.09

Sustainable Endowments Institute (2008). The College Sustainability Report Card 2009.

Available: http://www.greenreportcard.org/report-card-2009

Thumann, A. “Handbook of Energy Audits”. Edit. The press, ISBN: 0-88173-294-X

Turner, W.C. Energy management Handbook, Wiley, Newyork, 1982.

Typical lumen outputs and energy costs for outdoor lighting. Available: www.nofs.navy.mil/about_NOFs/staff/cbl/lumentab.html

US Government’s Energy Star page for fluorescent bulbs. Available: http://www.energystar.gov/index.cfm

Washington state university extension Energy Program, Available: hhtp://www.EnergyIdears.org

Witte, L.C. Schmidt, P.S. Brown, D.R. Industrial Energy Management and Utilization, Hemisphere Publ., Washington, 1988.

****