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Energy Audit of an educational building: College of Engineering

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ABSTRACT

Educational buildings are the most suitable type of building for the application of energy audit. Such measures can promote sustainability and ensure a comfortable and healthy environment for educational purposes. This study aimed to assess energy efficiency and conservation of the College of Engineering specifically the lighting system of the building. A walkthrough audit was made to acquire preliminary assessment on the building. A luxmeter was used to measure illumination (lux). The study showed that the illumination levels did not meet proper standards. Through data logger and theoretical calculations, it was determined that lighting system consisted 44% of total power consumption. These led to the development of a new lighting system (room E209 selected as a sample) composed of F28T5 lamps which improved lighting levels and saved more energy than the old F40T12 lamps. Through calculations, the new lighting systems showed an annual savings of Php5708 for room E209 alone with payback period of 2 years and 3 months.

Keywords: Energy, Energy Audit, Energy Efficiency

I. INTRODUCTION

1.1 Background of the study

Energy is as important as any other commodity in today's civilization. In developing countries like the Philippines where energy crisis is common, the need for efficient usage of energy is highly regarded. Consuming energy efficiently is of prime importance in any sector of the economy. Energy cost is a significant factor that affects every economic activity on par with factors of production like capital, land and labor (Noah et al., 2011). Reducing energy consumption and cost is becoming central to planning, construction, and use of buildings from an environmental and economic point of view (Sapri et al., 2010).

In order to assess the efficient consumption of energy, a process called energy audit is applied. An energy audit (EA) is a process aimed at the detection of problems in operations, improvement of the comfort of occupants, and optimization of energy usage of existing buildings. Furthermore, it identifies the opportunities for energy conservation. The process has a periodic nature. It assesses the possible changes in building use, the condition of existing equipment, and the applicability of new energy-efficient technologies (Alajmi, 2011).

In this study, the energy efficiency of the College of Engineering building is assessed through an energy audit. It is necessary to be able to know the status at which the building has been operated energy-wise. A walk through assessment is conducted in order to survey important points that could be seen directly upon inspection. An energy analyzer is also used to record and perform analysis of the energy consumption of the building.

1.2 Objective

1.2.1 General objective

This study aimed to have an assessment of the energy efficiency of the College of Engineering building, Central Mindanao University through an energy audit.

1.2.2 Specific objectives

- To acquire the profile of the College of Engineering through a walk-through assessment;
- To analyze how efficient the energy consumption of the building and determine the possible energy saving measures for further efficiency;
- To know the financial viability of applying energy-efficient techniques on the operation and maintenance of the College of Engineering building

II. MATERIALS AND METHODOLOGY

The building improvement of energy efficacy was improved based on load profile assessment and the energy consumption behavior was analyzed. The analysis was the basis in the development of a new lighting system.

2.1 Load profiling

2.1.1 Walk-through assessment

The building under study for efficacy of energy consumption is the College of Engineering building through a walk -through audit. The important points in

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the usage of the lighting system was assessed and data was revealed in Table 3 and 4.

2.1.2 Lighting systems
A luxmeter was used to measure the light intensity of the rooms. The number of lights and their corresponding types was also investigated.

2.2 Energy Analysis

2.2.1 Data gathering

The data on the building's energy consumption and its behavior was gathered through an Energy Analyzer. The illumination of the rooms was also gathered through the use of luxmeter. The rooms were divided into equal spaces (2m by 2m).

2.2.2 Data analysis

The energy consumption data that has been gathered was analyzed. The study consolidated all data from the walk-through assessment to the Energy Analyzer.

The following data have been acquired:

a. Building energy consumption obtained from utility;
b. Building performance obtained from site measurements;
c. Equipment/system characteristics obtained from site surveys;
d. Equipment/system performance data obtained from site measurements; and
e. Equipment/system operating conditions based on design and/or general engineering practices.

2.3 New Lighting System

A new lighting design was created in order to improve the illumination levels and minimize the energy consumption. F28T5 lamps were selected as replacement for the current F40T12 and Compact Fluorescent Lamps (CFL).

2.3.1 Energy Consumption

The energy consumption of the new and old lighting system was calculated. In this calculation, the ballast loss considered was equal to 20 percent of the energy consumption of a lighting fixture. Also, Demand factors and load factors was used to determine the energy consumption.

2.3.2 Financial Viability

After identifying the possible fixtures that can be installed and used to measure the energy consumption, financial viability followed and analyzed the old and new lighting system. The analysis was based using the simple payback period.

2.3.2.1 Simple payback method

Through this method, the quantity or duration of time for an investment to be paid back is illustrated. The payback period can therefore be determined through the cost of investment per annual saving.

III. RESULTS AND DISCUSSION

3.1 Walkthrough assessment

The building audited was the College of Engineering building (Central Mindanao University). The two-storey building has five laboratories (2 of which are computer laboratories), one drafting room, one conference room, and 11 classrooms. The building had been operated 12 hours per day, five days per week but classes were occasionally held during weekends.

3.2 Lighting system

All the luminaires installed at the building were single-lamp fixtures of fluorescent lamps, CFL and some pin-type/recessed CFL (at E112). The number of lamps and their corresponding lamp types are shown in Table 1.

3.3 Load History

The figure below shows the graphical representation of the energy consumption of the College of Engineering building from January of 2010 to July of 2013 from FIBECO data. It can be noticed from the graph that the behavior of the energy consumption of the College of Engineering building was erratic. It was due to the fact that many factors such as school activities and the number of days without classes in a specific month could have made a major effect on the energy consumption of the building.

3.4 Load Characteristics

As seen in figure 2, the curve started to rise at around 7:00 AM but sagged at around 11:00 AM to 1:00 PM which was indicative of the effect on the energy usage

Table 1
Types of Luminaires Installed

Type of Lamps	Number of Luminaires	Number of Functional Luminaires	Number of Busted Luminaires	Rating (W)
F40T12	114	83	31	40
CFL	170	121	49	24
Pin-type fixtures	36	36	0	25

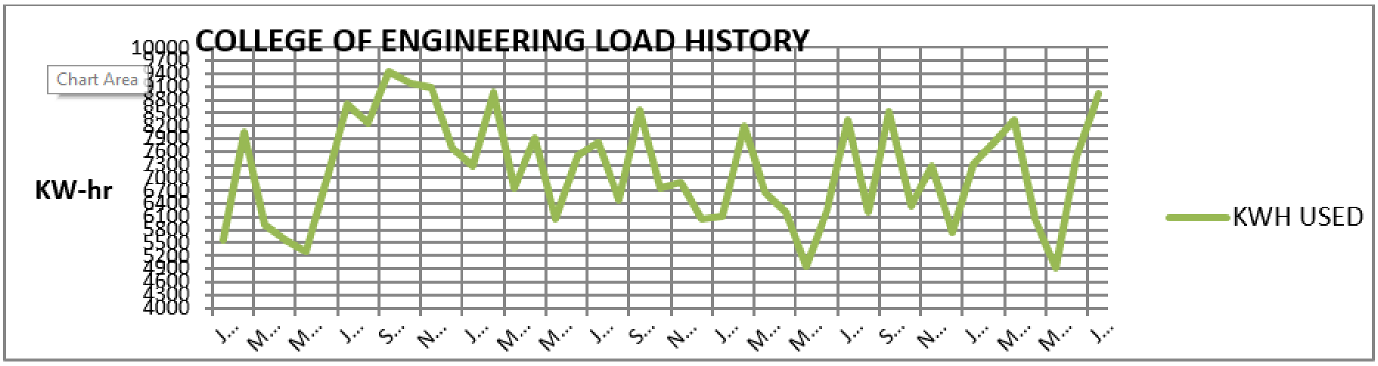

Figure 1. Past Energy Consumption of the College of Engineering building

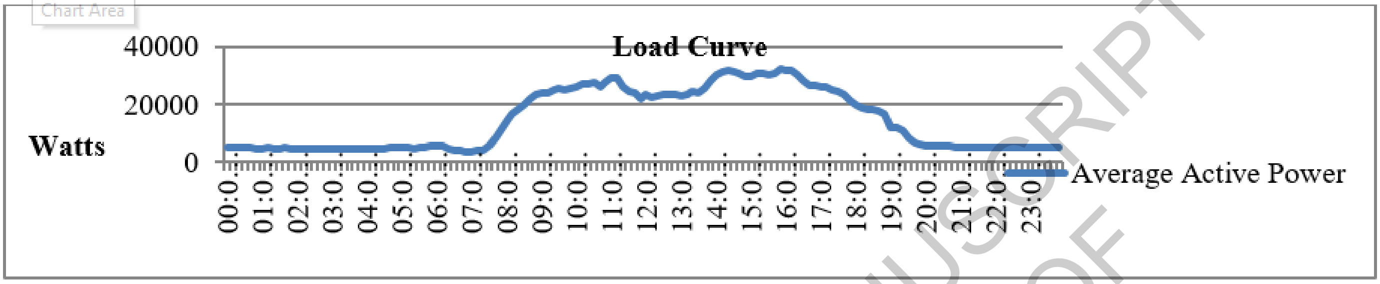

Figure 2. Daily load curve of the college of engineering building on a ten-minute interval

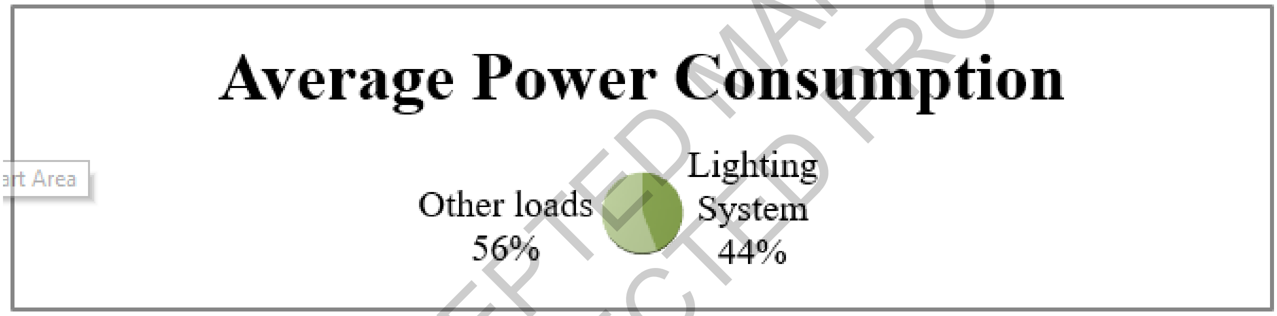

Figure 3. Percent power consumption of the lighting system to the other loads

of lunch break. From 2:00 to 4:00 PM would then be the peak hours of the building. The energy consumption then started to lower down at around 6:00 to 7:00 PM since classes started to dismiss around this time. The average power consumption during these hours (7:00 AM to 7:00 PM) was calculated to be 23,572 watts.

From the figure below, the theoretical lighting system power consumption (10416 W) is 44 percent of the total loads. The other loads were comprised of the HVAC systems and other appliances such as computers.

3.5 Room Illumination Levels

3.5.1 Daytime Illumination

Despite the availability of daylight, 72% of the classrooms still did not reach the standard illumination level for classrooms as per Indian Standard IS - 3646 I: 1992 and IESNA standards which require an illumination level of 200-500 lux.

3.6 Old and New Lighting System

The lamps in the room were suggested to be replaced by F28T5 lamps in a louver-type luminaire.

3.6.1 Energy Consumption

Table 3 shows the current and new total connected lighting loads in watts for Room E209. The watt saved by improving the lighting system is 168 watts.

Energy consumption (per month) was then calculated by multiplying the load factor to the product of the maximum demand and the number of hours of operation (per month) as shown in table 4. The result was 28 kW-hours for the old lighting system and 19 kW-hours for the new lighting system.

3.6.3 New Illumination Levels

As shown in Table 5, the daytime illuminance for Room E209 increased from 185 lux to 324 lux while the nighttime illuminance increased from 161 lux to 212 lux. Both of these new values are within the standard range as per IESNA and Indian standards.

3.6.4 Financial Viability

3.6.4.1 Simple Payback

Investment cost comprises is Php12899.7. The kilowatt saved (168 watts) was divided by 1000. The

Table 2
Walk-Thru Audit form for Room E209

Types of Fixtures	Fluorescent lamps	Compact fluorescent lamps
Number of Fixtures	9 fixtures	3 fixtures
Number of lamps per fixture	1 lamp per fixture	1 CFL per fixture
Watts per fixture	40 watts	24 watts
Fixtures height from work plane	2.0 m	1.955 m.
Lamp brand	GE, Phillips	Omni, Phillips
Number of functioning lamps	8	3
Number of defective lamp	1	none

Table 3
Current and New Total Connected Loads for the lighting system in E209

Type	Quantity	Rated Watts	Ballast Factor (W)	Load (W)
Compact Fluorescent Lamp (CFL)	3	24		72
Fluorescent Lamp	9	40	8	432
			TOTAL	504
New lighting (T5)	12	28		336
			TOTAL	336

Table 4
Energy consumption of the lighting systems applying demand and load factor

Lighting System	Total Load	Demand Factor	Load Factor	Maximum Demand	Hours of Operation per month	Energy Consumption (kWh) per month
Old	504	0.5	0.26	302	360	28
New	336	0.6	0.26	202	360	19
				Energy Savings		9

Table 5
New illumination levels for Room E209

Particulars	Intensity of Light			
	Existing Average Illumination (Lux)	Recommended Standard (Lux)	Percentage of Inadequacy and Adequacy of Light(%)	Remarks
Daytime	324	200	62%	Adequate
Nighttime	212	200	6%	Adequate

cost per kilowatt-hour as per FIBECO is Php7.865 and the number of hours of operation is 4320 hours a year if the lighting system is operated twelve hours a day. From that, the annual savings can be calculated (Php 5708). The calculated payback period for the new lighting system was 2 years and 3 months.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

It is necessary to manage and minimize energy costs while considering the comfort of the occupants (faculty, students, staff, etc.) which is related to their productivity. The lighting system was found out to be 44% of the total demand of the building. Also in this study, only the classrooms were considered which showed that most of the classrooms were below standard illumination levels even during daytime. The overall average illumination levels were 175 lux and 87 lux for daytime and nighttime respectively. The values obtained were below the IESNA standards for illumination (200-500). As seen, 200 lux was selected as the standard illumination level.

A new lighting system design was done in Room E209 (EE laboratory). The lamps were replaced with more efficient F28T5 lamps in a louver-type luminaire. The new lighting system increased the illumination level (324 and 212 lux for daytime and nighttime respectively) and reduced the energy consumption of the room. From this, a savings of 9 kW-hrs monthly was achieved. This led to an annual savings of Php5708 in room E209 alone with a payback period of 2 years 3 months. This is an affirmation of the improvement of the energy efficiency after the installation of the new lighting system.

4.2 Recommendations

For the better assessment regarding this study, it is recommended that energy-saving design for general and task lighting be created. It is necessary to create a rather task-oriented approach in offices, laboratories and drafting rooms in order to efficiently utilize the illumination provided by artificial light sources. This is done by focusing the illumination in the work plane and avoiding excess lighting on areas where light is less needed (e.g. lobbies).

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