De La Salle University

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ABSTRACT

This paper presents the results of the energy audit of five buildings in De La Salle University. It presents the inventory of electric devices in the buildings. Lux level measurements were also conducted and the results of the user acceptability survey of the LED lighting installation in one of the buildings were also presented. The researcher also presented energy recommendations to the university.

ACKNOWLEDGEMENTS

First of all, I would like to thank God, for without Him none of all the things we would ever do would be possible.

I would like to thank Ms. Maria Antonette Roque for her guidance in conducting this practicum project.

I would also like to acknowledge Mr. Antonio Carlos Maralit, Director of the Campus Sustainability Office for his inputs and assistance in the study, Engr. Gerardo Mendoza, Director of Mechanical and Electrical Works Office, for his inputs in the study, Dean Rosemary Seva for suggesting the energy audit as a practicum project and for providing inspiration in finishing this project, and Monika Louize Valdez for helping in editing and formatting the document.

Lastly, I would like to thank Br. Ricky Laguda, without whom this project would not be possible.

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CHAPTER ONE

INTRODUCTION

1.1 Background

The energy audit is a practicum project of the researcher for De La Salle University and would cover a survey of the energy utilization in five of its buildings. These buildings are the St. Joseph Hall, Miguel Hall, William Hall, Mutien-Marie and the Faculty-Student Center. The inspection, inventory of electrical equipment and installations, monitoring of energy utilization and preparation of the report was conducted over a thirteen-week period.

The key deliverables of the study are as follows:

1. Energy audit report
2. List of energy saving recommendations, possible savings and other alternatives
3. Recommended illumination standards for classrooms, laboratories, offices, hallways and open areas in the aforementioned buildings

1.2 Overview of the Current System in Place

The primary activities in the significant areas in St. Joseph Hall and Miguel Hall are lecture classes and laboratory work. There are also offices, meeting areas and seminar rooms in both buildings. Mutien-Marie Hall has several classrooms and a single office. In William hall, the ground floor houses William Shaw Auditorium, while the other 6 floors house the administrative and faculty rooms of the College of Science. In the Faculty and Student Center, the ground floor houses several kiosks, eating areas, performance stage, and the Green Giant radio station. The second floor of the building is devoted to the Shalom Center, a rest and recreation center exclusive for the faculty and staff of the university.

The personnel from the physical facilities office handle the maintenance of all electrical installations in the entire campus. Every day, lighting fixtures are monitored and replaced the following day if they are no longer working. There is no scheduled replacement of lighting fixture in the campus since replacements are done on the as-need basis. Air-conditioners on the other hand follow a regular preventive maintenance schedule. Other appliances and equipment in the offices and laboratories were maintained by the office and laboratory personnel in coordination with pertinent supplier of the equipment. Computer facilities, thin clients and multimedia projectors are maintained by the Information Technology Services office (ITS).

Mutien-Marie Hall:

There are two floors in Mutien-Marie Hall mainly housing classrooms with only a single office in the ground floor.

There are three classrooms in the first floor and a single office. In the second floor there are four classrooms.

Faculty and Student Center:

There are two floors in the Faculty and Student Center.

The ground floor is mainly occupied by food kiosks and eating areas. There is also a performance stage in the ground floor. The two rooms of the Green Giant radio station could also be found in the ground floor. The second floor houses the Shalom Center, which is the rest and recreation center exclusive for the faculty and staff of the university.

William Hall:

There are seven floors in William Hall. The first floor is the main lobby of the building and it is also where William Shaw Little Theater is located. There are also two restrooms in the ground floor. The second floor is where the Dean's office and the administrative offices of the College of Science are located. The Osaka University satellite office is also located in this floor. The third floor is where the Social Development and Research Center is located. The remaining four floors of the building house the faculty of each department in the College of Science. There is also a pantry and consultation in each of the top four floors in the building.

St. Joseph Hall:

There are six floors in St. Joseph Hall. The first floor houses four offices and 12 classrooms. The second and third floors of the building house an additional 23 classrooms. The remaining three upper floors house the 32 laboratory rooms of the College of Science. There are also two classrooms, one each in the fourth and fifth floor, and a lecture hall in the fifth floor. There are five technicians and stock rooms also located in the upper three floors of the building.

Miguel Hall:

There are four floors in Miguel Hall. The first floor is where nine offices and nine laboratories of the College of Engineering are located. The second floor houses eight laboratories from the College of Liberal Arts, seven lecture rooms and three offices. The third floor consists of fifteen (15) classrooms and two offices. The fourth floor, which is the top floor of the building, houses six laboratory rooms, five lecture rooms and one office.

1.3 Scope of Work

The researcher gathered an inventory of the equipment, lighting fixtures and air-conditioning units in the five buildings covered in the study. There is only an official inventory of air-conditioning units installed in the university which the proponent used to validate his own inventory. The Campus Sustainability Office provided also the researcher an inventory of the lighting installed in the university. However, there is no single official university inventory for the rest of the electrical equipment used in the facilities which the researcher can use to validate his own findings.

After the inventory gathering and validation were made, the researcher conducted a random month long walk-through and observation of the buildings covered in the study from 0800h – 2030h. During this phase of the study, he observed and noted usage of electricity and practices of personnel. He has noted particularly sources of energy wastage in the offices, classrooms and laboratories.

The researcher also conducted lux measurements on each of the buildings. He has made readings on classrooms, offices, laboratories and hallways. He has recorded light intensity readings and compared them to international standards to check the university's compliance with these standards.

From the data gathered, the researcher would provide a set of recommendations that would enable De La Salle University to save energy and reduce energy cost.

Chapter Two

RESULTS AND DISCUSSIONS

2.1 Data Gathered and Measurements

The researcher conducted an inventory of the lighting fixtures, air-conditioning system and other electrical equipment in the buildings covered in the study. These inventories are compared to available inventories from the Physical Facilities Office (PFO). He has been able to compare his inventories of the air-conditioning units with that provided by PFO, while the other equipment is compared to the list provided by various offices, if available. For example, laboratory equipment inventory in Miguel building is compared to the official inventory provided by the department maintaining the laboratory.

Using the inventory list, he was able to come up with the energy distribution based on the quantity and power rating of each equipment in the group.

A. Energy Audit

Mutien-Marie Hall:

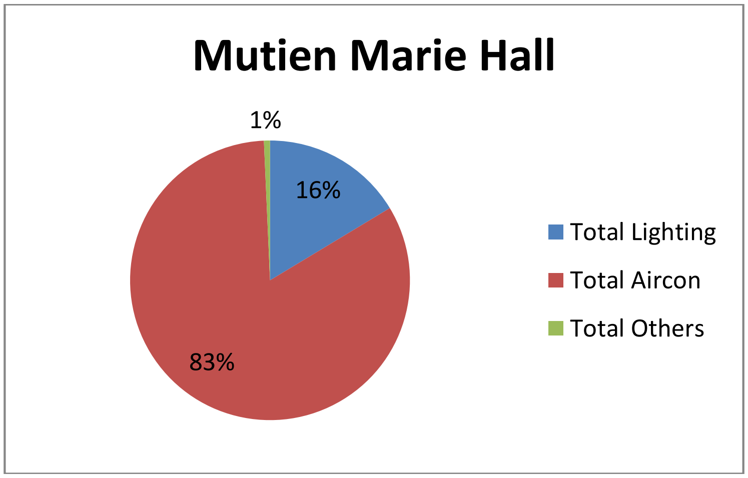


Chart 1
Energy Distribution in Mutien-Marie Hall

Chart 1 provides the distribution of the energy consumption of the various equipment found in Mutien-Marie Hall. Based on the power rating, it can be seen that air-conditioning units account for most of the energy consumption in the building. The equipment listed under others were thin clients, electric fans, and a portable Iwata air-conditioning unit in the hallway of the second floor of the building. Of the total available 25,184 watts 83% were used for air-conditioning and 16% were used for lighting.

During the course of the energy audit, the researcher noted the following observations:

- There are quite a number of rooms with lights and a/c even without students.

The single office is always locked.

Faculty and Student Center:

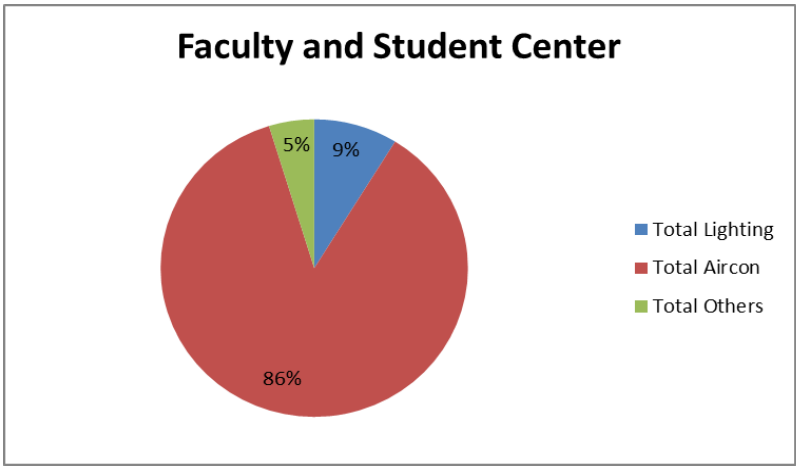


Chart 2
Energy Distribution in Faculty and Student Center

Chart 2 shown above provides the distribution of the energy consumption of the various equipment based on their power rating in the Faculty and Student Center. Based on the power rating, it can be observed again that air-conditioning units account for most of the energy consumption in the building. The air-conditioning units account for 86% of the 45,358 watts of available power in the building. The equipment listed under others were computers, amplifiers, speakers and water dispensers.

During the course of the energy audit, the researcher noted the following observations:

- Some air-conditioning units are always on in the Shalom Center even if there is no one using the center.
- Some of the lighting fixtures in the eating area need to be turned off during the day time since there is significant outside lighting.

- The light intensity in the kiosk is too dim in certain areas, particularly those in the inside where there is no outside lighting.

William Hall:

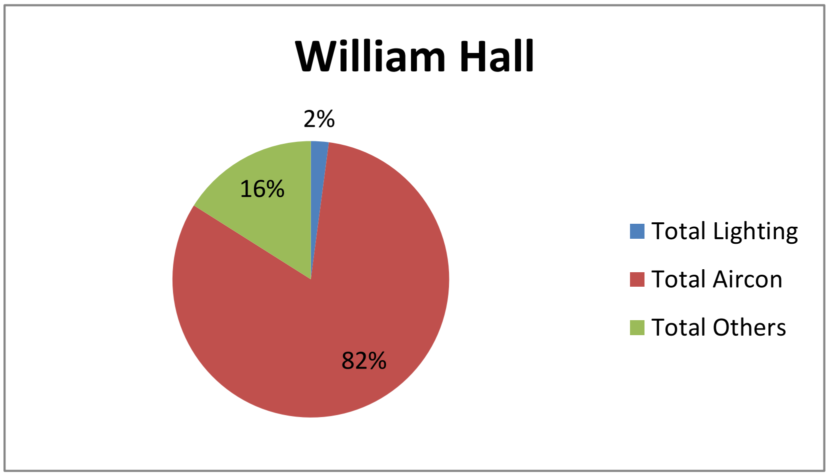


Chart 3
Energy Distribution in the William Hall

Chart 3 shown above provides the distribution of the energy consumption of the various equipment based on their power rating in William Hall. Based on the power rating, it can be noticed again that air-conditioning units account for most of the energy consumption in the building. The air-conditioning units account for 82% of the 630,026 watts of available power in the building. The equipment listed under others were computers, refrigerators, microwave oven, coffee maker and water dispensers. It should be noted that while other equipment accounted for more power than lighting, most of the equipment in this group are not usually turn on.

During the course of the energy audit, the researcher noted the following observations:

- Most of the lamps are turned off in the offices during the day since there is significant outside lighting.
- The outside light in the office though are too bright at certain time of the day since the reflecting film used in the windows is too light.

St. Joseph Hall:

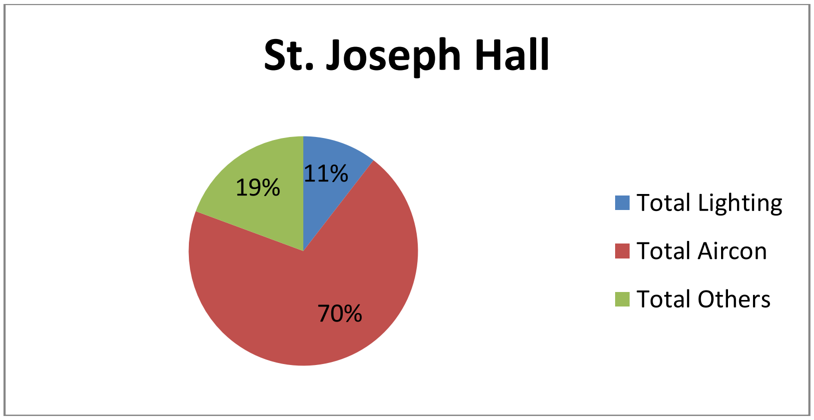


Chart 4
Energy Distribution in the St. Joseph Hall

Chart 4 shown above provides the distribution of the energy consumption of the various equipment based on their power rating in the St. Joseph Hall. Based on the power rating, it can be seen that air-conditioning units account for most of the energy consumption in the building. The air-conditioning units account for 70% of the 447,705 watts of available power in the building. The equipment listed under others were computers, refrigerators, microwave oven, oven, water dispensers, electric fans and laboratory equipment. It should be noted that while other equipment accounted for more power than lighting, most of the equipment in this group are not usually turn on like the fans which are only used when there are no air-conditioning available and the laboratory equipment which are only used when it is required in the experiment.

During the course of the energy audit, the researcher noted the following observations:

- The air-conditioning units are usually left on even when there are no classes.
- The lights and thin client clients are mostly off when there are no classes although there are a few instances during the period of observation that lamps and thin clients are left open.
- The lights in the offices are turned off and the room closed when there are no people inside.

Miguel Hall

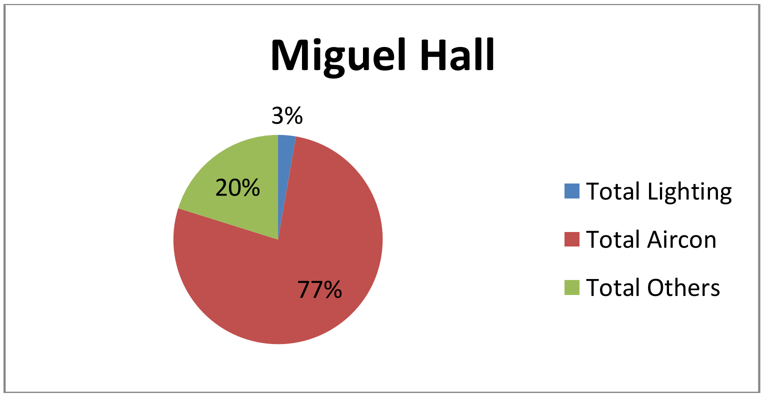


Chart 5
Energy Distribution in Miguel Hall

Chart 5 shown above provides the distribution of the energy consumption of the various equipment based on their power rating in the Miguel Hall. Based on the power rating of various electrical equipment, it can be observed that air-conditioning units account for the majority of the available power in the building. The air-conditioning units account for 77% of the 985,789 watts of available power in the building. The equipment listed under others were the computers, refrigerators, microwave oven, oven, water dispensers, electric fans and laboratory equipment, like furnaces and welding machines. It should be noted that while other equipment accounted for more power than lighting, most of the equipment in this group are not usually turn on like the laboratory equipment which are only used when it is required in the experiment.

During the course of the energy audit, the researcher noted the following observations:

- The air-conditioning units are usually left on even when there are no classes.
- The lights and thin client clients are mostly off when there are no classes although there are a few instances during the period of observation that lamps and thin clients are left open.
- The lights in the offices are turned off and the room closed when there are no people inside.

- **Light Intensity Measurement**

The researcher has performed light intensity measurements in all the buildings. Lux is the measure of the received light intensity in the measured area, while lumen is the measure of the light intensity from the source. These measurements were compared to three international standards to check the compliance.

Mutien-Marie Hall:

	CIBSE – UK	AS/NZS – Australia	IESNA - USA
Classroom	0	0	0
Offices	n/a	n/a	n/a
Hallway	2	2	2
Laboratories	n/a	n/a	n/a
% compliance	20%	20%	20%

Table 1
Compliance on illumination international standards, Mutien-Marie Hall

Based on the lux measurement he has conducted on every classroom and hallway in Mutien-Marie Hall and comparing it to international standards in the US, UK and Australia, it can be seen from Table 1 that the university falls short in their compliance to international standards. No classrooms achieved the lux level of 300, 320 and 400 lux standards listed by CIBSE, AS/NZS and IESNA respectively. The two hallways in the building reached the lux level of 100 lux international standard. However, the walkway at night leading to the building failed in the international standard. The % compliance is based on the 7 classrooms and 3 halls that he has made measurements.

Faculty and Student Center:

	CIBSE – UK	AS/NZS - AUSTRALIA	IESNA - USA
Classroom	n/a	n/a	n/a
Offices	0	0	0
Hallway	0	0	0
Laboratories	0	0	0
% compliance	0%	0%	0%

Table 2
Compliance on illumination international standards, Faculty and Student Center

Based on the lux measurement he has conducted on every office, laboratory and hallway in the Faculty and Student Center and comparing it to international standards in the US, UK and Australia, it can be seen from Table 2 that the university still has not complied to international standards in every area of the building.

William Hall:

	CIBSE – UK(NIGHT)	CIBSE – UK(DAY)	AS/NZS – AUSTRALIA (NIGHT)	AS/NZS – AUSTRALIA (DAY)	IESNA – USA **(NIGHT)**	IESNA – USA (DAY)
Classroom	n/a	n/a	n/a	n/a	n/a	n/a
Offices	1	5	0	5	0	5
Hallway	2	6	2	6	2	6
Laboratories	n/a	n/a	n/a	n/a	n/a	n/a
% compliance	15.18%	57.89	0%	57.89	0%	57.89

Table 3
Compliance on illumination international standards, William Hall

Based on the lux measurements he has conducted on every office and hallway that he was able to gain access in William Hall and comparing it to international standards in the US, UK and Australia, it can be seen from Table 3 that the university still falls short in their compliance to international standards at night. Only one office achieved the lux level of 300 lux standard by CIBSE, and none of the offices and pantry achieved the 320 and 400 lux standards listed by AS/NZS and IESNA respectively. Of the seven hallways inside the building, only two hallway lighting systems reached the 100 lux international standard.

However, at day the building has a significant increase in lux level compliance to international standards. Five offices achieved the lux level of 300, 320 and 400 lux standard by CIBSE, AS/NZS and IESNA respectively. Of the seven hallways inside the building, six hallway lighting systems reached the 100 lux international standard. The % compliance calculation is based on the 4 pantry/consultation areas, 7 offices, 1 auditorium and 7 hallways he has made measurements.

There is a significant increase in the daytime reading because of the ample outside lighting in the building; this is made even more significant by the light insulating film used in the windows.

St. Joseph Hall:

	CIBSE – UK	AS/NZS - Australia	IESNA - USA
Classroom	1	1	1
Offices	0	0	0
Hallway	6	6	6
Laboratories	0	0	0
% compliance	9.21%	9.21%	9.21%

Table 4
Compliance on illumination international standards, St. Joseph Hall

Based on the lux measurement he has conducted on every classroom, laboratory, office and hallway he was able to gain access in St. Joseph Hall and comparing it to international standards in the US, UK and Australia it can be seen from Table 4 that the university still falls short in their compliance to international standards. Only one classroom achieved the lux level of 300, 320 and 400 lux standards listed by CIBSE, AS/NZS and IESNA respectively. The six hallways inside the building reached the lux level of 100 lux international standard during the day. However, at night all the hallways failed in achieving the recommended 100 lux standard. The university has zero compliance on the recommended lux standard of 500 lux by CIBSE and IESNA, and 400 lux by AS/NZS. The % compliance is based on the 37 classrooms, 19 laboratories, 14 office and 6 halls he has made measurements.

Miguel Hall:

	CIBSE – UK	AS/NZS – AUSTRALIA	IESNA - USA
Classroom	2	1	1
Offices	3	3	3
Hallway	4	4	4
Laboratories	2	3	2
% compliance	14.86%	14.86%	13.51%

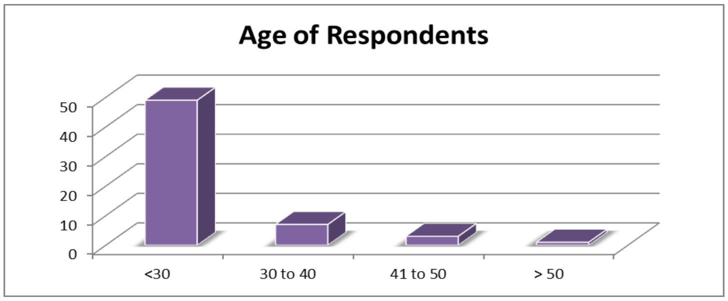
Table 5
Compliance on illumination international standards, St. Joseph Hall

Based on the lux measurement he has conducted on every classroom, laboratory, office and hallway he was able to gain access in Miguel Hall and comparing it to international standards in the US, UK and Australia it can be concluded from Table 5 that they still fall short in their compliance to international standards. Only two classrooms achieved the lux level standard of 300 lux by CIBSE, and only 1 classroom achieved the 320 and 400 lux standards listed by AS/NZS and IESNA respectively. The four hallways inside the building reached the lux level of 100 lux international standard. Two laboratories achieved the recommended lux standard of 500 lux by CIBSE and IESNA, and three laboratories achieved the 400 lux standard by AS/NZS. The % compliance is based on the 28 classrooms, 32 laboratories, 14 offices and 4 halls he has made measurements.

B. User Acceptability of the LED Lighting Survey on Miguel Hall

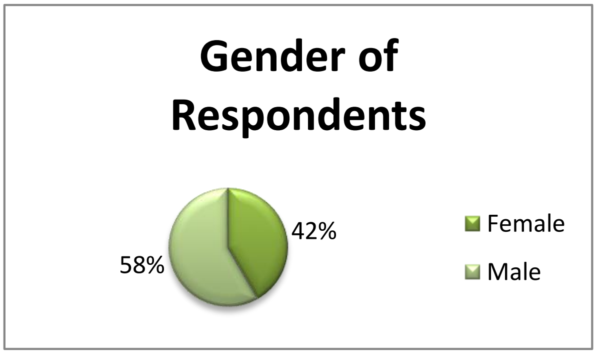
One of the primary recommendations stated in the initial energy audit conducted for De La Salle University on April, 2013, to which the researcher was the project leader, was to replace the fluorescent and CFL lamps with more energy efficient LED lamps. This recommendation was adopted by DLSU through the Campus Sustainability Office. Since one of the buildings covered in this audit was already fitted with LED lamps, which is the Miguel Hall, the researcher decided to conduct a user acceptability survey of the new LED lighting installations. A group of 60 users, mainly composed of students, both in the graduate and undergraduate programs, and some faculty and staff, were selected to answer the survey. The 60 users are pre-selected based on the length of time they are using the building. A minimum of one-year of residence prior to the survey date was used by the researcher. This is because the user can give a better impression on the difference between the old lighting installation used in the building and the newly installed LED lighting system.

Graph 1 shown below indicates the age grouping of the survey participants. It can be seen that most of the respondents are aged 30 or below. This is because most of the respondents are students, and they represent majority of the users of the building. The students group account for 80% of the respondents.



Graph 1
Age of Respondents

Graph 2 shown below indicates the gender of the respondents. Majority of the respondents are male, accounting for 58% of the group.



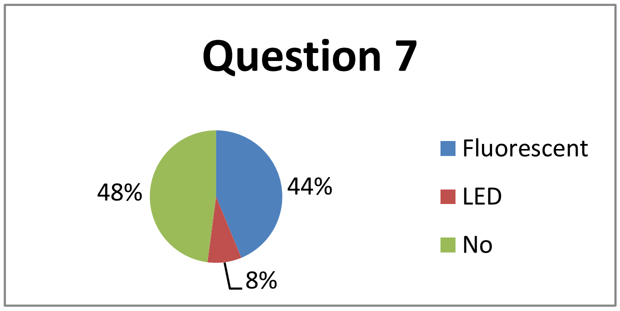
Graph 2

Gender of Respondents

The survey questionnaire proceeded to ask the user about the conduciveness of the lighting in their current area to their various activities. Of the total student respondents, only 1 indicated that the lighting is not conducive for reading. For the faculty and staff group, only 1 indicated the same. All the respondents agreed that the lighting was conducive for reading. All the student respondents agreed that the lighting was suitable for studying, while 1 respondent from the faculty and staff group indicated that the lighting was not suitable for work as it is too bright.

The above result gives a very high acceptability of 97% of users of the LED installation.

Graph 3 shown below shows the user's familiarity with the type of lighting used in the building. The users were asked if they are familiar with the type of lighting used and if they are, they were asked what type of lighting was used. The question was formulated to determine whether the user noticed any difference with the fluorescent lighting with LED lighting.



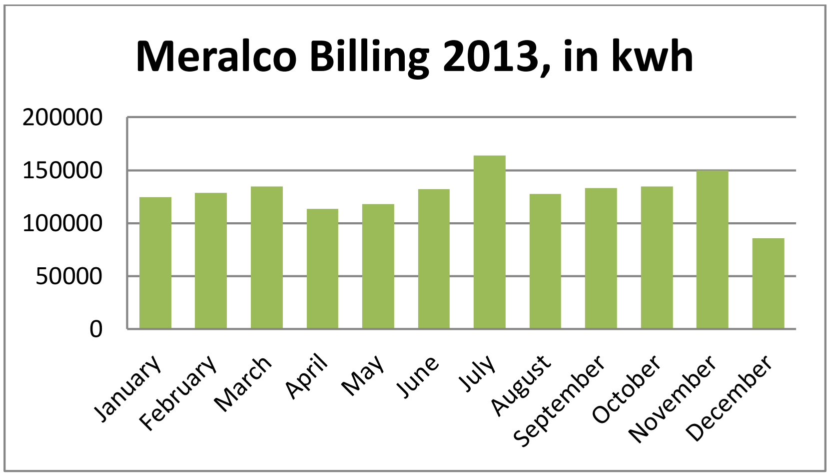
Graph 3

User familiarity with the type of Lighting Installation

As can be seen from the above graph, 52% responded that they are familiar with the lighting installation used, although 44% of the respondents incorrectly indicated that the installed lamps were fluorescent lamps. Of the 8% that responded correctly, all were faculty and staff. Further queried of their knowledge of the type of lighting installed, the 5 faculty and staff indicated that they were informed of the change to LED lamps from fluorescent lamps. This clearly indicates that majority of the respondents are not aware of the transition to the new system.

C. Meralco Billing Statement

Graph 4 shown below indicates the one year per month kwh consumption of the buildings audited in this study.



Graph 4

Meralco Billing

The kwh consumption of the buildings were fairly consistent between the 125,000-135,000 kwh range with an expected significant reduction in the month of December because of the nearly two weeks of Christmas break, and during the months of April and May where the university has its summer break.

The audit of the equipment in the building indicates a total of 2,134 available KW of power. Assuming that the university is using this equipment for 13 hours a day and 5 days a week, they would have 138,710 kwh of monthly consumption. It is significant to note that of all the equipment in these buildings, the air-conditioning consistently accounts for majority of the energy utilization in the buildings, and that it is always on particularly in the classrooms and laboratories.

From the collected data, air-conditioning units account for 1650 kw of available power, or a monthly kwh energy consumption of 107,250, calculated on a 13-hour a day operation on a 5-day weekly schedule. The lighting accounts for 95 kw of available power, or a monthly kwh energy consumption of 6,175, based on the 13-hour a day operation on a 5-day weekly schedule.

D. Color Temperature Measurements

The color temperature of LED lighting system was also measured and compared to the color temperature of the fluorescent lighting installation. The technical specification of the fluorescent lamps used in campus indicates a color temperature of 6,500 Kelvin for both the 36 and 40 watts lamps. While the newly installed 19 watts LED lamps has a technical specification of 6,000 Kelvin color temperature. However, the researcher's measurements on fluorescent lamps show an almost constant color temperature of 6,000 Kelvin near the lamp (source) and on the work and study table (target area of illumination). The LED lamp has an average color temperature of 10,000 Kelvin near the lamp and 7,000 Kelvin near the target area of illumination. This would indicate a slightly bluish hue for the LED lamps as compared to the fluorescent lamps at the target area of illumination. This, however, was not noticed by the users in the user's survey.

Chapter Three

CONCLUSIONS AND RECOMMENDATIONS

The current audit was designed to gather information on the electrical equipment currently available and in use on five buildings in the university. The researcher originally intended to audit only two buildings, however, he was informed that there is only one electric meter used on the five buildings to which the identified two buildings were part of. It was therefore decided to audit the five buildings as they form one group.

It is therefore recommended by the researcher to use sub metering for each of the five buildings to accurately capture the energy utilization in each of these buildings.

The recommendation on the use of LED lighting based on the initial audit done on April 2013, to which the researcher was the project leader, was adopted in some of the buildings in the university and was planned to be adopted in all of its buildings. While the user acceptability survey conducted indicates a very high acceptance ratio from the respondents, it was noticed during the observation phase of the study that there are already non-functional LED lamps only four months from its installation. A further investigation determined that the non-functioning of the lamps were due to loose connection. It is therefore recommended that the supplier be informed of the problem on loose connection to minimize disturbance on the university’s operation, and to minimize manpower cost in dealing with the problem.

The LED supplier should also be informed of the significant difference in the color temperature at the source and the target area of illumination since the ceiling's height of the building affects the color temperature at the work and study area. A low ceiling room would produce a significant bluish hue on the the target area of illumination which might affect the work done in the area.

It was also observed that most of the lights and thin clients were turned off when there are no classes in all of the buildings audited, however, the air-conditioning units are still left open, and there still some instances where lights and thin clients are left open. There is no central control on all of the buildings for its electrical equipment, and the controls are in the individual units making it difficult to turn them off when not in use. This absence of a central control unit is made more significant on the air-conditioning units since air-conditioning accounted for more than 80% of the electrical energy utilization in campus, an alternative to minimize the wastage in electricity of these units should be adopted.

A power monitoring and management system (PMMS) must be adopted by the university. The PMMS would provide a central monitoring and control system for all of its buildings. It could be installed per building or on a grander scale installed centrally in one location while controlling all electrical installations in the university. This would allow the system to turn off all electrical installations per room when not in use, including and most especially the air-conditioning units.

It also recommended to study the implementation of primary metering for the entire university since in the long term the university are expected to save substantial amount in its implementation.

The initial audit indicated several recommendations which are already planned to be implemented including the replacement of air-conditioners 10 years or older, and the utilization of air-conditioners using inverter technology.

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