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Energy Conservation Opportunities: A Case Study of Kalayaan Residence Hall

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***Abstract*— This study presents the actual energy audit of Kalayaan Residence Hall as a preliminary to establishing a framework for determining energy intensity of all residence halls in the University of the Philippines Diliman. The purpose of the study is to determine the factors that influence the current level of electricity usage and techniques to reduce energy consumption. From the as built plan of the residence hall, electricity consumption record from Meralco, and the survey answered by the student residents, electricity usage was determined to be largely due to the lighting and ventilation requirements of the residents, which accounts to 41% and 22% of the total electricity consumption respectively. An estimated savings of 57% can be realized simply by replacing existing light bulbs with LED bulbs. Energy policy and initiatives for Kalayaan Residence Hall are then formulated to ensure proper energy management in the next 5 years. It is recommended that improved profiling of energy use be done by using real-time electricity consumption.**

Keywords*— *Energy Audit; Dormitory Energy Use; Energyconservation

I. INTRODUCTION

It is a state university's civic responsibility to be a role model in being stewards in energy sustainability, not only to the community but also to the whole country. Proper energy management should therefore be given emphasis and should be the concern of University stakeholders. A study by Manegdeg [1] predicts that by 2018 the University of the Philippines Diliman will consume 18 million KWh amounting to PhP 245 million. There are 133 buildings in the University of which 11 are residence halls. The University provides housing to a percentage of its students through these residence halls on campus managed by the Office of the Student Housing. Of the eleven residence halls, six are co-educational, four are exclusively for female students and one for male students. As the residence halls are subsidized by the University, any measure to reduce electricity consumption is deemed a significant step towards achieving a decrease in overall energy usage of the University.

Kalayaan residence hall is a co-educational dormitory housing freshmen students. It was first opened on June 1975, three years later an annex was constructed to accommodate more freshmen coming from distant provinces. There are two students per room, each provided with a student's basic necessity such as a cabinet, bed and mattress, study table and study lamp, and a study chair. As of the second semester of 2014-2015, there are 272 male and 268 female student residents in Kalayaan, 8 resident assistants who are upper class students, 6 maintenance staff, a dorm manager, and a house parent. Kalayaan residence hall is the first dorm that was audited as a preliminary to establishing a framework for determining energy intensity of all residence halls in the University of the Philippines Diliman. The purpose of the study is to determine the factors that influence the current level of electricity usage and propose specific techniques and policy to reduce energy consumption. The findings can be used to influence significant changes in existing and future dorm rooms. It is important to highlight that the study is in line with the university's Green UP initiative which aims to make UP campuses environment-friendly. And inculcating sustainability awareness to freshmen students such as in this study is a good head start to promoting energy conservation. Ease of Use

II. METHODOLOGY

The goal of the energy audit is to identify processes and activities in the residence halls that are energy intensive and to quantify energy consumption for these processes. This is done by actual measurements of power consumption of all the equipment and estimation of energy use. Using the data collected from survey, estimate of average electricity consumption per room was derived. To compute for the estimated monthly consumption of individual appliance in kilowatt-hour, Equation 1 was used.

$$\text{Appliance kWhr consumption} = \text{Appliance wattage} \times \text{Usage factor} \times n \text{ hours per day} \times 30 \text{ days per month} \div 1000 \quad (1)$$

The computed monthly consumption is verified by comparing with the actual electricity consumption over the last 5 years. Processes that contribute to the electricity level are then identified. Pareto analysis is used in the decision making process by identifying processes that need to be prioritized.

III. DATA ANALYSIS

Data processing includes analysis of the consumption history to get an insight on the pattern of energy usage. This will then serve as a baseline for the projection of energy savings once energy conservation measures are implemented.

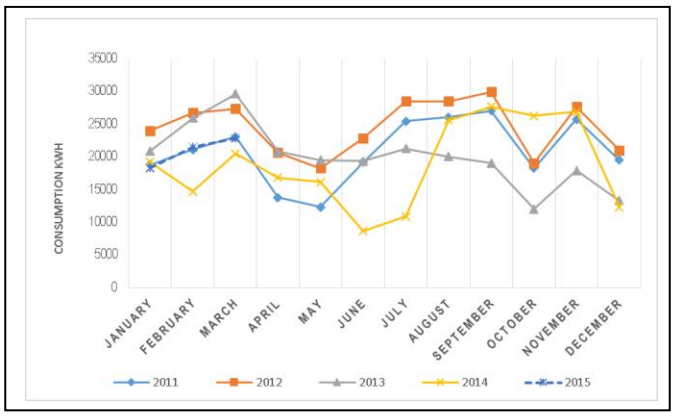

Fig. 1. Electricity consumption from Meralco bill 2011 to 1st quarter of 2015

Figure 1 presents the electricity consumption of Kalayaan Residence Hall within the last 5 years. While there are variations in monthly consumption over the given period studied, a pattern can be distinguished that can be correlated to the number of residents in a given month. From 2011 to 2013, electricity consumption is lowest during the months of April and May due to summer vacation, October because of the semestral break, and December because of Christmas vacation. With the implementation of the new academic calendar in 2014, months of low electricity consumption is now shifted to the months of June and July as students are still on summer vacation.

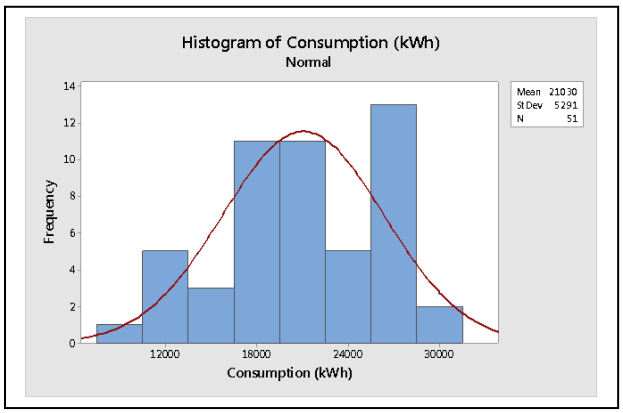

Fig. 2. Distribution of electricity consumption from 2011 to 1st quarter of 2015

Figure 2 shows the distribution of electricity consumption of the residence hall in the last 5 years with an average of 21030 kWh. This average consumption is equivalent to 38.94 kWh per student per month, or roughly Php 4,200 per student per year. The computed electricity consumption based on the actual energy audit is 18077 kWh, which is well within the range of mean plus minus two standard deviations.

Pareto analysis is used to identify which processes contribute to 80 percent of the electricity consumption level. This method allows for prioritizing solutions that will have a great impact in the overall situation. It is identified that lighting is the most energy intensive of all the processes with its 47% share in the electricity consumption level followed by ventilation, and water dispensing. A total of 1,182 lights, installed in various areas in the dorm, account to this 47%, and majority of this consumption is due to hallway lighting that is used for 11 to 13 hours every day.

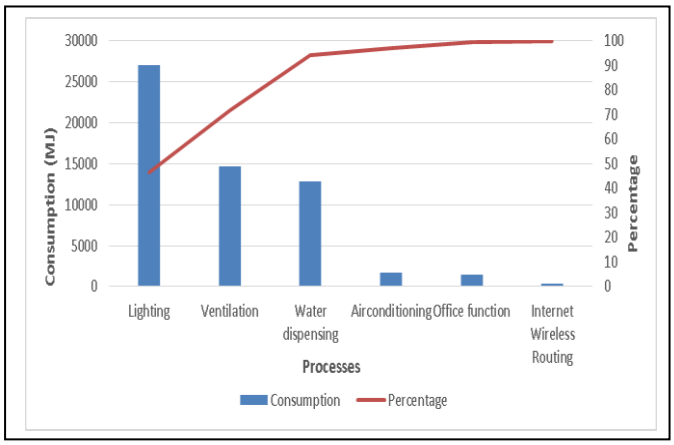

Fig. 3. Pareto chart of the different processes that contribute to the consumption level of the residence hall

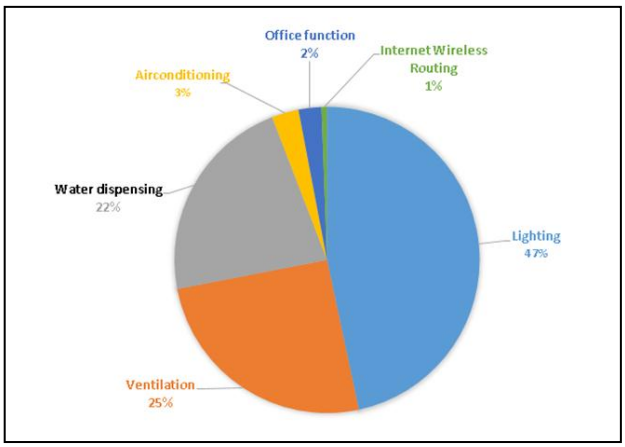

Fig. 4. energy usage allocation

Factors affecting current level of electricity consumption are the following:

- Use of inefficient lighting in all areas of the dormitory
- Natural lighting is not utilized well
- Dark flooring in hallways renders the need for more lighting than is required for the given floor area
- Natural ventilation is not utilized well
- Water dispensing unit is switched on 24 hours a day

IV. ENERGY SAVINGS

The most straight forward solution to lowering energy consumption is through energy efficient practices. This involves using efficient alternatives to replace existing appliances/processes without sacrificing performance. Having identified that lighting requirements of the dorm has the greatest impact in the energy consumption level through Pareto analysis, the focus now is on replacing existing fluorescent lights and CFLs with LED tubes and bulbs. Table 1 presents a comparison of the existing light fixtures and the proposed replacement showing the corresponding wattages and market prices. The proposed replacement LED tubes are chosen as they do not require rewiring nor replacement of existing receptacle. It was also made sure that the lumens requirement for a given floor area or work space is satisfied by all the replacement LED tubes.

Table 1

Energy Savings for Lighting					
Existing	Replacement	Lumen	Power W	Qty	Market Price PhP
Fluorescent (40W)	LED tube	2000	18	633	1000
Fluorescent (20 W)	LED tube	950	10	432	699
CFL (18 W)	LED bulb	600	7	117	399

Table 2

Monthly Consumption (Lighting)	
Existing	Replacement
7498.2 kWh	3234.3 kWh
26993.52 MJ	11643.48 MJ

Table 3

MONTHLY SAVINGS PhP/kWh/month @ Php 9/kWh per month based on Meralco Bill dated March 2015	Savings in a year	Payback Period (months)
38,375.10	460,501.20	26.42

Savings of as much as 57% can be realized with the use of LED tubes and bulbs with a payback period of 26.42 months. Installation of occupancy sensor switches in rest rooms and laundry areas may also help reduce lighting electricity consumption by ensuring that lights are switched on only when needed. Additionally, daylight sensor switches may be installed in the lobby where natural lighting is available and may be used together with the replacement LED tubes.

Due to the layout of the residence hall, some hallways require artificial lighting even during daytime. To further reduce the need for artificial lighting, one solution is by replacing emergency exit doors with steel security gates that allow natural light to pass through. This and the use of LED lights are some of the small scale changes that can readily be implemented. Another solution that should be looked into is the replacement of dark floor tiles in the hallways with light colored tiles that diffuse artificial light and make the hallways look bright. This may be considered as a large scale change which could influence the choice of flooring for future residence halls.

Another technique to reduce energy consumption in Kalayaan residence hall is energy conservation. This involves the conscious effort of all the residents in being mindful of their use of electricity. Positive attitude towards energy conservation may be cultivated early on by facilitating in-house workshops and educational environmental campaigns which will teach freshmen residents some simple ways to reduce electricity consumption. Basic knowledge such as being able to identify appliance wattage rating and computation of kilowatt-hour consumption of appliances will be beneficial for the residents in achieving energy reduction.

Institution of an energy management committee headed by the dorm manager with student representatives as members of the committee is also another effort to promoting energy conservation in the residence hall. The energy management committee will lay down energy conservation policies, and will champion the proposed workshops for the students. Given the layout of the dorm, ease in management may be facilitated by assigning or having a volunteer student leader for each dorm wing whose role is to ensure that energy conservation policies are adhered to. This puts responsibility to the students and promotes mindfulness and sustainable habits.

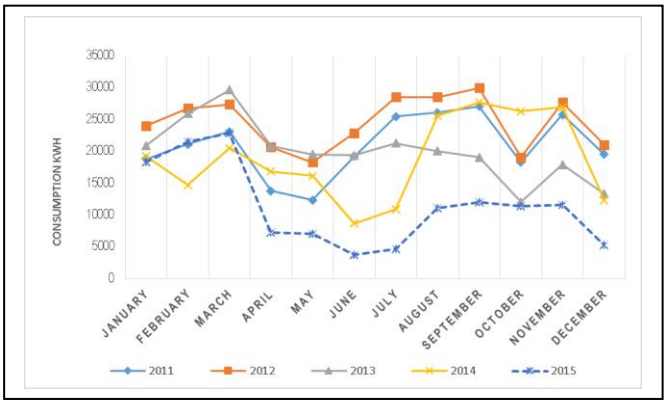

Fig. 5. Projected electricity consumption

To put things in perspective, real-time monitoring systems may be installed that will reflect actual consumption and will show reduction in consumption as a positive feedback to the residents' efforts. Figure 5 shows the projected reduction in monthly consumption by the replacement of existing fluorescent tubes and CFL with LED lights alone. Actual monthly consumption is used for the months of January to

March 2015 while projected consumption are used for April to December 2015. Further decrease is expected upon installation of other infrastructural changes and the residents' proactive involvement in energy conservation.

V. CONCLUSION

The study has identified factors that contribute to the current electricity consumption level of Kalayaan residence hall by performing actual energy audit. The proposed replacement of existing T12 fluorescent lights and CFLs with appropriate LED lights will result to an estimated savings of 57%. Further decrease in electricity consumption is expected with the use of occupancy sensor switches for restrooms and laundry area and daylight sensor switches for the lobby and reception area. Institution of an energy management committee to oversee strict adherence to energy conservation policies, and facilitating in-house workshops and seminars for energy and environmental consciousness are also identified as initiatives towards reducing electricity consumption. Presently, the cost of electricity per student per year is Php 4,205. Upon implementation of the proposed energy saving measures, the estimated cost of electricity per student is reduced to Php 2,762.73. It is recommended that improved profiling of energy use be done by using real-time electricity consumption.

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REFERENCES

[1] Manegdeg, Ferdinand G. (2015). "Academic Building Energy Conservation Opportunities." Philippine Engineering Journal:Vol. 36, No. 1.

[2] Moss, Keith J. (2006). Energy Management in Buildings 2nd Edition, Taylor & Francis, London & New York.

[3] Golloti, Brandon (2009). "Energy Use in Penn's Student Housing and Techniques to Achieve Energy." University of Pennsylvania, Urban Studies Program.

[4] N. A. Muhamad, Mohd Fadil Abu, Syed Norizazul Syed Nasir, Zuraidy Kadir (2014). "Potential Energy saving for Student Dormitories: A Case Study at Institut Latihan Perindustrian Pasir Gudang, Jabatan Tenaga Manusia, Malaysia." 2014 IEEE International Conference Power & Energy

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