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Assessment Study of Simulated Per-Building Electrical Energy Consumption Profile of Pamantasan ng Lungsod ng Maynila

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Abstract: The Pamantasan ng Lungsod ng Maynila (PLM or also known as University of the City of Manila) is a premier local university that is subsidized by the City of Manila catering to marginalized but deserving students of the said city. Cost of electricity has been very expensive in the country recently that it has become one with the highest power rate in Southeast Asia. To aid the institution in assessing its expenditures in electricity, this paper presents a computer-simulated audit and calculation of energy consumption, in terms of kilowatt-hours, in each of the rooms and offices of PLM. A Pareto analysis is used to identify the types of equipment and the areas of the university that expends electrical energy. An analysis of cause-effect is also be utilized to recognize the factors that contribute to excessive power consumption. The result of the study has generated a simulated energy consumption footprint of the university and can be used as basis for recommending energy conservation measures to reduce the energy consumption cost.

Key Words: energy audit; university; Pamantasan ng Lungsod ng Maynila; Pareto analysis.

1. INTRODUCTION

Commercial and industrial companies have long been battling with the issue of excessive energy consumption. This issue significantly affects a lot of parameters in the production of goods and services of such establishments, particularly the cost of the power consumption necessary to operate which induces an impact on the profit.

Several studies have been made to identify the factors and parameters that significantly effect excessive energy consumption in a certain company. The procedure is generally called an *energy audit*. An energy audit identifies the areas where electrical energy is consumed and the corresponding magnitudes of the consumption (Energy Savings Toolbox). The resulting energy audit presents a detailed examination of the facility's electrical power uses and corresponding costs to come up with recommendations to significantly reduce the use and cost of each equipment without compromising the optimal operation of the said facility.

Commercial establishments include restaurants, bars, hotels, shopping malls, clothing shops, equipment hubs, repair shops, training centers and academic institutions. These companies are mostly service-oriented such that they expend

electrical energy in the operation of the equipment for ventilation, water and use of service equipment more than the production of the goods that they are selling. Industrial establishments, on the other hand, are more product-oriented than the commercial ones. Examples of industrial establishments are factories of food, manufacturers of construction materials, clothes and garments fabricators, etc. The type of establishment roughly defines its energy consumption but it generally helps the assessor to identify the significant factors or parameters that contribute to the power dissipation in the facility. Academic institutions, such as a universities or colleges, seldom assess their electrical power consumption. State and local universities do not see the need to monitor how much electrical power they spend because the expenses would be shouldered by the state or local government that subsidizes them (Reyes2006). Private institutions, however, need to greatly lower their consumption in order to keep a very competitive pricing in the tuition and miscellaneous fees that they charge on their students. Some universities in the United States built their own cogenerating plant facilities in order to augment the electrical power that they would get from the grid. These plants also present an opportunity for their students to improve the existing system further and to aim for a self-sustaining power generation for their respective institutions (Energy Audit Report)(Eikmeier).

The Pamantasan ng Lungsod ng Maynila, or PLM, is located within the walled city of Intramuros in Manila City, Philippines. The university boasts of its exemplary graduates in the field of medicine and medical programs since it was established in 1965 [PLM website]. The establishment of this institution was created by a law, Republic Act No. 4196, which also served as the university charter. As a local university, the city hall of Manila provides for the subsidy of this university. PLM has been an exceptional government-funded university offering tuition-free education to the financially marginalized but intellectually deserving students of the city. The energy audit to be executed in the university would help determine the factors and parameters that contribute to its power consumption and help maximize the subsidy it receives from the said local government office of the city.

Currently, the campus of the university has the following buildings with distinct offices in each of them:

1. Gusaling Villegas (GV or Villegas Building)
   a. College of Engineering and Technology
   b. Internal Control Office
   c. Human Resources Department
   d. Office of the Vice President for Academic Affairs
   e. Civic Welfare Training Services
   f. Student Information Serices
   g. Office of Student Development Services
   h. Guidance Center
   i. Accounting Office
   j. Office of the Treasury
   k. Office of the Vice President for Finance and Planning
   l. University Health Services
   m. Engineering Laboratories
   n. Computer Laboratories
   o. Department of Military Science and Tactics
   p. Classrooms
2. Gusaling Corazon Aquino (GCA or Corazon Aquino Building)
   a. Information Technology Center
   b. College of Physical Therapy
   c. Therapy Clinics
   d. College of Nursing
   e. College of Architecture and Urban Planning
   f. Office of the Board Secretary and University Secretary
   g. Drawing or drafting rooms
   h. Classrooms
3. Gusaling Atienza (GA or Atienza Building)
   a. Graduate School of Arts, Science and Education
   b. Graduate School of Management
   c. Graduate School of Engineering
   d. Classrooms
4. Gusaling Bagatsing (GB or Bagatsing Building)
   a. University Research Center
   b. College of Medicine
   c. Medical Laboratories
   d. Classrooms
5. Gusaling Kanluran (GK or Kanluran Building)
   a. Office of the University Registrar
   b. University Library

c. Physical Development and Special Projects Office
d. College of Law
e. Graduate School of Law
f. Moot Court
g. Classrooms

6. Gusaling Lacson (GL or Lacon Building)
   a. College of Science
   b. Science Laboratories
   c. College of Human Development
   d. College of Liberal Arts
   e. College of Management and Entrepreneurship
   f. College of Accountancy and Economics
   g. College of Mass Communications
   h. Radio and TV Laboratory
   i. College of Tourism, Hotel and Travel Industry Management
   j. Classrooms
7. Ramon Magsaysay Entrepreneurial Center
   a. Office of the President
   b. Office of the Executive Vice President
   c. Office of the Legal Counsel
8. Property Office Building
   a. Property Office
   b. Warehouse
9. Rajah Sulayman Gymnasium
   a. College of Physical Education, Recreation and Sports
   b. Gymnasium Maintenance Office
   c. President's Commission on the Arts and Culture

In connection to this study, the researchers have employed an energy audit procedure in the Pamantasan ng Lungsod ng Maynila (University of the City of Manila) to generate a power consumption profile of the entire university for the year 2014.

2. METHODOLOGY

A computer software can be used to generate the spreadsheet computer-simulated solution from a specified mathematical model. Current and voltage testers may also be used to check the power that the equipment needs in order to work. The data-gathering procedure would require a database of equipment specifications to be entered into the calculator.

The specifications, especially the power rating and the time of usage per day, would be plugged into the energy consumption calculator with the formula:

$$E = Pt \qquad E = VIt \qquad \text{(Eq. 1)}$$

where:

E = energy in (watt-hours) expended by the device
P = power (in watts) dissipated by the device
V = voltage drop (in volts) across the device
I = current (in amperes) dissipated by the device
t = amount of time (in hours) the device is used

The devices, equipment or appliances have been categorized into the following groups:

1. Ventilation – air-conditioning units, electric fans, ceiling fans, exhaust fans, etc.

2. Lighting – any article of lighting or system of illumination.

3. Computers and Peripherals – computers, printers, scanners, office equipment and multimedia peripherals.

4. Appliance – household appliances such as refrigerators, microwave ovens, radio, etc.

5. Laboratory Equipment – any equipment or machinery used for experimentation and laboratory activities, especially for research.

6. Others – emergency lights, chargers, electronic insect repellants, etc.

The results are presented and summarized according to building and device category to determine the most significant consumption or highest consuming cost center of electricity in the university. The identification of such is done using the Pareto analysis and these factors would be noted as the targets for energy conservation measures to maximize optimality impact. Also, an annual energy consumption profile can be created using the available data of specifications of each equipment used and their frequency of usage throughout the calendar year 2014.

3. RESULTS AND DISCUSSION

3.1 Simulated Energy Audit Results

The total energy expended by the university for an entire year has been simulated for the year 2014. The number of working days and school days have been considered to provide for the multiplier that would indicate the number of days that the simulated energy consumption behavior is exhibited.

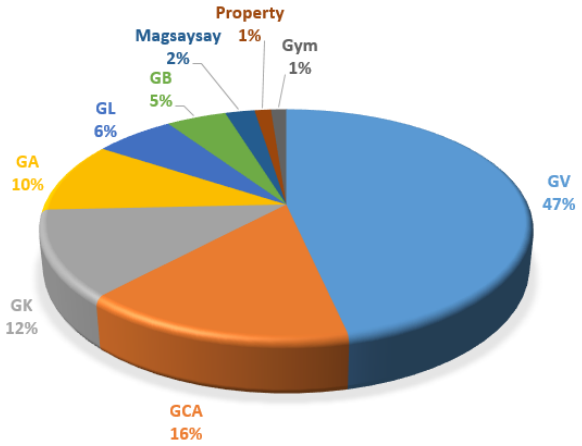

Fig. 1. Electrical Consumption Breakdown per Building of PLM for the Year 2014

Table 1. Electrical Consumption Breakdown per Building of PLM for the Year 2014

Building	*Energy (MWh)*	*Percentage*
GV	1,399.61	46.53
GCA	465.65	15.48
GK	368.96	12.27
GA	298.59	9.93
GL	189.99	6.32
GB	141.47	4.70
Magsaysay	69.61	2.31
Property	38.33	1.27
Gym	35.94	1.19
Total	3,008.17	100.00

Figure 1 shows the percentage breakdown of electrical consumption in the university for the whole year while Table 1 presents the amount of consumption in megawatt-hours (MWh). It is evident that the GV building that houses the most number of offices consumes the greatest amount of energy, 47% of the simulated 3-gigawatt-hour (GWh) consumption of the entire university.

Figure 2 shows the percentage breakdown of the electrical consumption on the equipment or device perspective while Table 2 lists the total energy expended in megawatt-hours. Apparently, ventilation equipment draws 60% of the 3-GWh aggregate energy consumption for the year 2014.

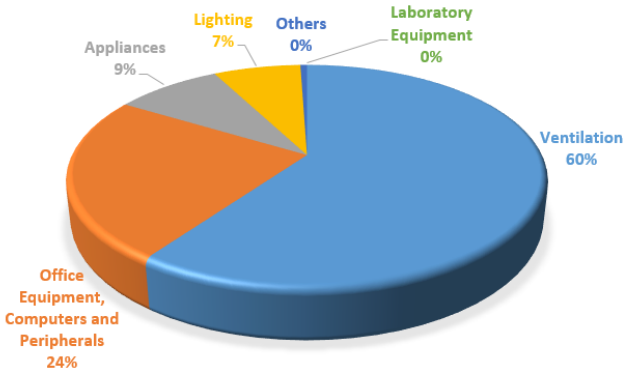

Fig. 1. Electrical Consumption Breakdown per Equipment Category of PLM for the Year 2014

Equipment Category	*Energy (MWh)*	*Percentage*
Ventilation	1,800.37	59.85
Office Equipment, Computers and Peripherals	716.76	23.83
Appliances	261.15	8.68
Lighting	213.78	7.11
Others	15.97	0.53
Laboratory Equipment	0.13	0.00
Total	3,008.17	100.00

3.2 Annual Energy Profile

The electrical energy usage per month has also been observed to determine a trend of energy consumption of the university for the entire year. Figure 3 shows the monthly trend in consumption of each building. The highest consumption are in July and September when the university offices and classes are in full swing. The lowest consumption can be seen in the month of December. This is due to the fact that Christmas break and holidays reduce the working days of the university. Figure 4 presents the

monthly trend of energy consumption at the perspective of the equipment or device categories. Ventilation equipment apparently spends majority of the total consumption of the university throughout the year but it dips to its lowest number during December due to the reduction of the working days.

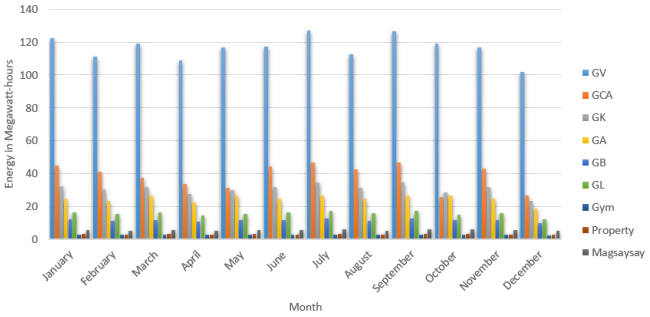

Fig. 3. Monthly Electrical Consumption Profile per Building of PLM for the Year 2014

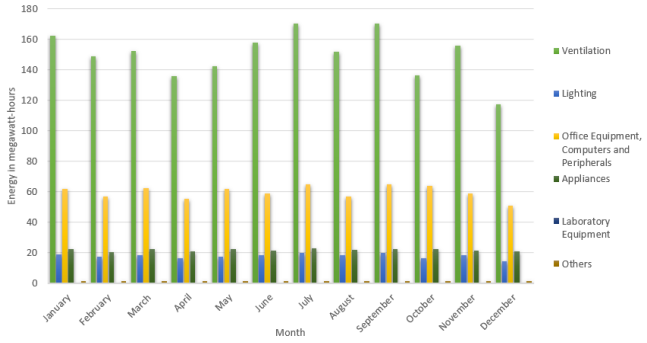

Fig. 4. Monthly Electrical Consumption Profile per Equipment Category of PLM for the Year 2014

3.3 Pareto Analysis

In order to maximize conservation, one must identify the cost center of consumption at which the recommendations and conservation measures must be aimed at. The Pareto principle (sometimes called the Pareto efficiency, the 80-20 rule, the law of the vital few, or the principle of factor sparsity) states that approximately 80% of the effects come from 20% of the total causes (Bunkley 2008). Joseph Juran, a business management consultant, is the first to suggest the principle and named it after Vilfredo Pareto, an Italian economist. Pareto first observed that 80% of the land in Italy was owned by 20% of the population back in 1906.

Using the Pareto principle to identify the particular buildings to which the conservation measures must be aimed at, Figure 5 indicates that the two buildings, Gusaling Villegas (GV) and Gusaling Corazon Aquino (GCA) consumes the most electricity at more than 60% of the total for the university. This indicates that if the reduction can be done to reduce the consumption in these two buildings, the savings would be maximized.

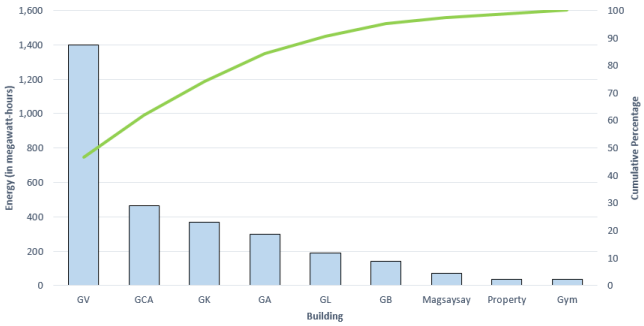

Fig. 5. Pareto Analysis on the Energy Consumption of PLM Buildings

Figure 6 presents the Pareto analysis done in the equipment category perspective, and the ventilation equipment and machineries have evidently displayed a massive 60% consumption of the total for the university.

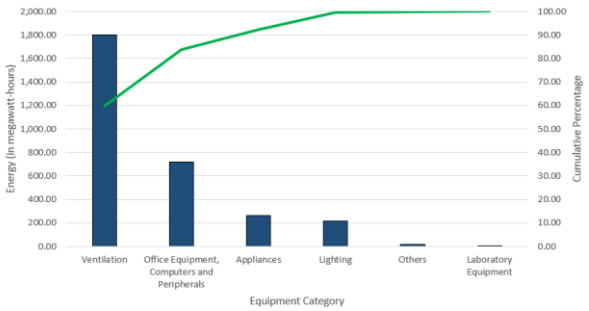

Fig. 6. Pareto Analysis on the Energy Consumption of Equipment Categories of PLM

Although the percentages of consumption do not reach 80%, the choice of the 20% factors such as the two buildings GV and GCA, and the ventilation equipment have shown significance in the consumption profiles that were produced via simulation and would still induce a great impact if reduction can be done.

4. CONCLUSIONS

From the nine buildings that were considered in this study, the electrical consumption of the Pamantasan ng Lungsod ng Maynila was simulated for the year 2014 and it was found out to have expended 3 GWh worth of electricity. The annual profile was created and the highest consumption was seen during the fully-operational months of July and September while the lowest had been observed in the holiday-filled month of December. The buildings Gusaling Villegas and Gusaling Corazon Aquino have been identified as the major cost centers of electricity at a combined total of at least 60%. Ventilation equipment and machinery has been recognized as the highest energy consuming devices used in the entirety of the university. The Pareto analysis done in both perspectives indicated that the recommendations and measures of conservation must be targeted at these factors to maximize consumption reduction.

5. ACKNOWLEDGMENTS

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