PHILIPPINE ENGINEERING JOURNAL
PEJ 2015; Vol. 36, No. 2: 39-56

Academic Building Energy Conservation Opportunities

Ferdinand G. Manegdeg
Department of Mechanical Engineering
University of the Philippines Diliman, 1101 Quezon City, Philippines

Abstract— **A framework for determining academic building energy consumption was developed, energy audits on selected academic buildings at the University of the Philippines Diliman were conducted, the different influencing factors to electricity consumption were identified, and energy policy options to ensure effective energy management in the next 5 years are suggested. The electricity consumption is primarily due to air-conditioning and lighting loads or data processing. The energy intensity for lecture rooms, conference rooms, libraries, administration offices and auditoriums were established. Policies for future and existing buildings were formulated. It is recommended that a thorough profiling of student usage and technical usage of laboratories be conducted.**

Keywords— Academe Energy Consumption, Building Energy Conservation

1. INTRODUCTION

The energy intensity of the Philippines in 2012 is 577.8 Watt per capita, which is 64 % that of Vietnam, 26 % that of Thailand, 17 % that of Malaysia, 11 % that of Japan, 6 % that of the United States of America, 2.6 % that of Iceland (the highest), and 4.8 x that of Afghanistan (the lowest) [14]. With an aspiration to be at par with the world, the Philippines requires a substantial amount of energy.

The energy consumption of buildings may differ from one country to another but their energy consumption percentage ranges from about 30% to 45% of the total demand. Amongst the buildings, academic buildings are one of the buildings that have very high energy consumption. Different approaches on building energy audit were done [2,3,5,7]. The use of online questionnaire and direct interviews of students and staff were conducted to evaluate their behavior on using electricity inside the premises of academic buildings. The occupancy patterns and its relation to the energy profile demand were evaluated [5]. An energy management system where sensors were installed around the building premises read energy consumption [2]. A study has been started at the University of the Philippines Los Baños to predict the load profiles of power and energy of different buildings [3]. The data collected are used to influence students and staff regarding their future energy consumption activities and to implement energy savings strategies.

In 2005, the electricity consumption of the University of the Philippines Diliman was 15,162,545 KWh and by 2012, the electricity consumption rose to 16,796,528 KWh [12] at an average rate of 233,426 KWh per year. Figure 1 shows the electricity consumption from 2005 to 2018 with actual data

Correspondence to: Ferdinand G. Manegdeg | Department of Mechanical Engineering, University of the Philippines Diliman, 1101 Quezon City, Philippines | *Email: fgmanegdeg@yahoo.com*

from 2005 to 2012 [12] and projected data from 2012 to 2018. The projected data is based on the actual data (from 2005 to 2012) of electricity consumption in KWh (y-axis), which is 235,390 multiplied by time (t) in year (x-axis) minus 456,933,077 with a correlation coefficient of 0.94. The price of electricity in 2005 was PhP 8.81 per KWh and grew to PhP 12.44 per KWh by 2012 [12] at a rate of PhP 0.30 per year. Considering the rates of electricity consumption and price, by 2018, the university will consume approximately 18 million KWh amounting to almost PhP 245 million, assuming current rates.

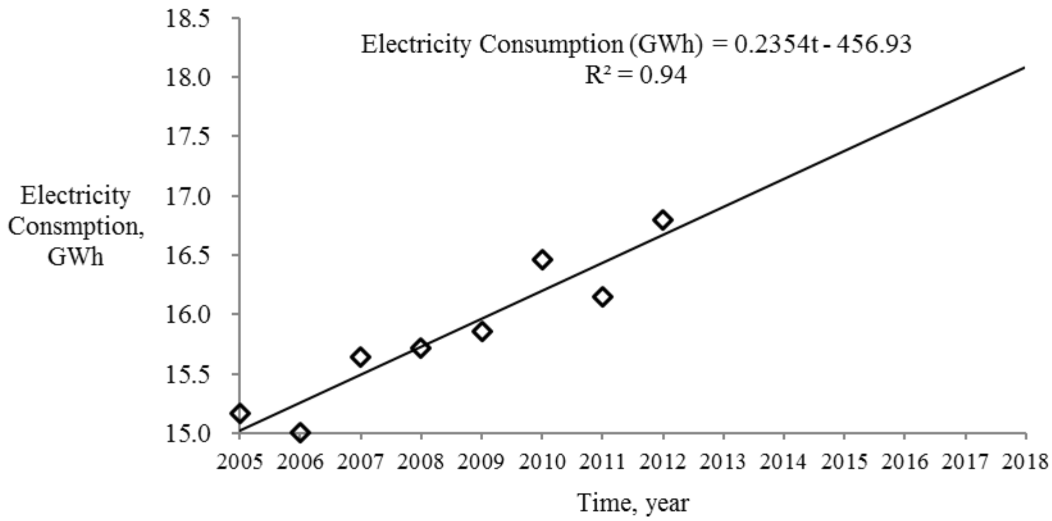

Figure 1. Electricity Consumption.

The electricity consumption in academic buildings of the University of the Philippines Diliman must be managed as the university dreams to increase its desire to provide more output in graduating more undergraduate and graduate students, in doing world class and progressive research, in inventing creative works and significant publications, and in producing timely and quality extension services to the nation. It is therefore imperative that an appropriate energy management policy incorporating energy conservation opportunities is implemented as it progresses to the next five (5) years and beyond.

The general objective of this study is to determine the electricity consumption of selected academic buildings at the University of the Philippines Diliman. The specific objectives are to:

- design a framework for determining the energy consumption of academic buildings;
- audit selected academic buildings;
- identify factors influencing the electricity consumption; and
- provide policy options for effective energy management.

This study focuses on computing and improving the electricity consumption intensity of the various colleges and schools. This is especially useful for colleges and schools to identify which activity or area to support and to balance their electricity consumption to the level of their capability to spend. The electricity consumption intensity computed shall serve as standard and the basis of electricity consumption improvement.

2. METHODOLOGY

The research activities started by reviewing the energy management requirements for a building, developing the energy audit framework, identifying the institutions to be audited, auditing the buildings, computing, evaluating and validating the data, understanding the influencing factors to electricity consumption, and formulating policy for effective energy management. The research activities required 6 man-months to complete.

The framework for energy audit was formulated for academic building with emphasis on electricity consumption. The framework [6,7,8,9] uses process analysis and the ranking of the processes was done using Pareto concept. The framework was validated using the data previously gathered and observed from the Institute for Small-Scale Industries of the University of the Philippines Diliman [9].

The ten (10) colleges and schools were identified. The criteria for inclusion considered are that all the institutions are degree granting and offering graduate and or undergraduate courses within their buildings, located in one contiguous area, at least the buildings are built within the last fifteen (15) years, and with lecture rooms, conference rooms, libraries, administration offices and auditorium. There are 133 buildings of which 50 are academic buildings covering 24 degree-granting institutions. The total samples are 10 degree-granting institutions (representing 42% of the total degree-granting institutions) covering 14 buildings (representing 28% of the total academic buildings).

The actual energy audits were conducted using measuring equipment. The set of equipment was calibrated before the actual measurement. Three (3) sets of data were taken for each of the power measurements, lighting intensities and data processing consumptions. The data were taken for at least three times (3x) to make sure that what were taken are consistent and accurate.

The processes were prioritized by Pareto for those processes with eighty-percent impacts on electricity consumption. The influencing factors to electricity consumption were identified using cause and effect diagrams for the prioritized processes.

The policy for effective energy management was formulated considering the level of energy savings and the ease of implementation. The decision makers for the policies are identified and the timetable is assumed to be 5 years.

3. RESULTS AND ANALYSIS

The framework developed, the energy intensities computed, the influencing factors identified and the policy formulated were discussed. The possible energy savings were assessed.

3.1 The Framework

The building was partitioned by process, the parameters influencing the process were identified and measured, the impacts were modeled, and the model was calibrated and fine-tuned using previous electricity consumptions. A goal was set, the actions were simulated, and then if implemented, possible savings were calculated. The energy audit framework is shown in Figure 2. The framework developed is usable for any energy sources, however, since the academic buildings utilize mainly electricity, the framework was primarily designed for electricity consumption.

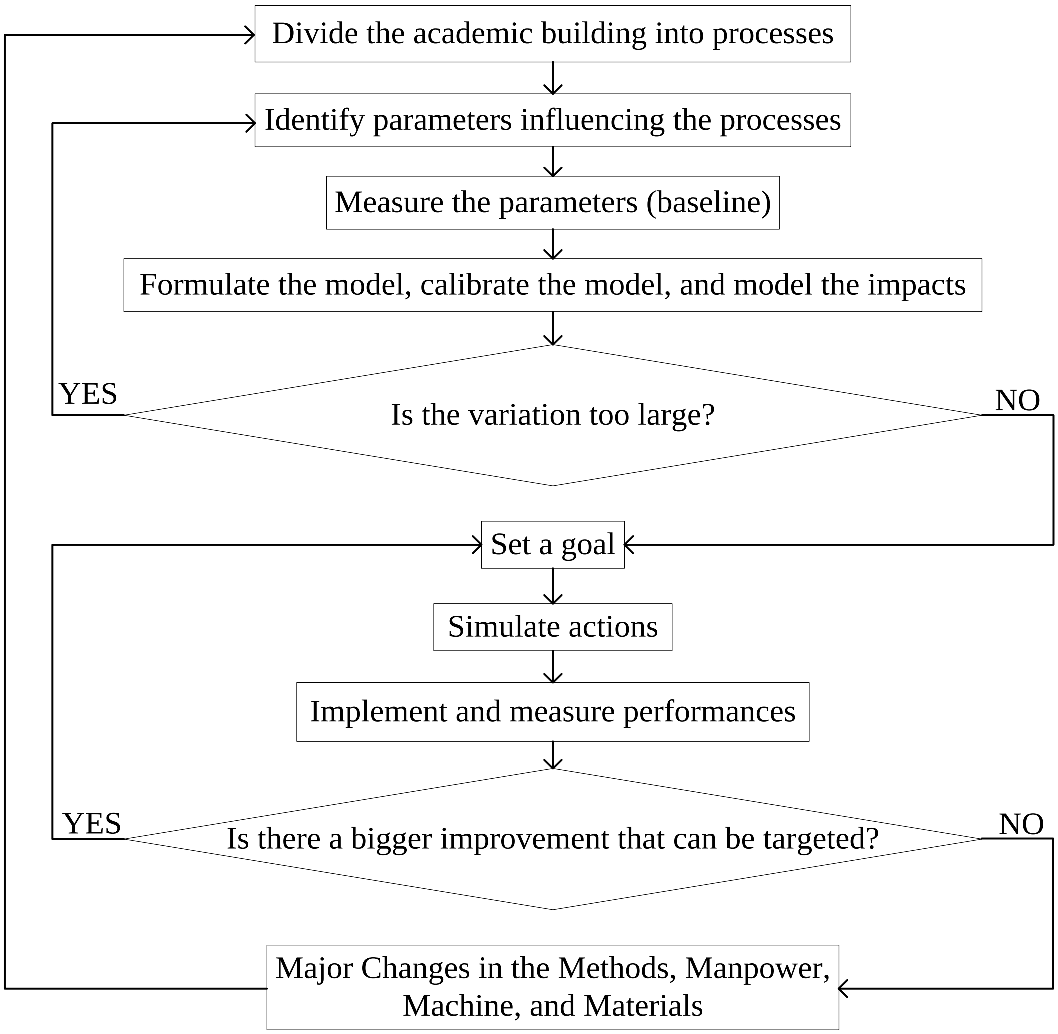

Figure 2. Energy audit framework.

3.2 Data Gathering

There were buildings with outdated building as-built plan including incomplete data on electrical wiring or rewiring. The dimensions missing were measured. It was noted that equipment data were incomplete or no inventory of equipment including data on their date of purchased, repaired, replaced, or added. The equipment specifications were taken from their nameplate or from their manufacturers. There are also institutions with incomplete or no record of electric bills. The University Utility Management Team supplied the institutions electricity consumption data from 2005 to 2012 in aggregate values with three institutions with no 2005 electricity consumption data. Although there are data gaps, the data gathering went smoothly.

It was observed that there were dilapidated air conditioners, were installed in incorrect location, and with hindered air-flow for heat transfer. There were heat infiltration in walls, ceilings, windows and doors. One institution has redundant air conditioners within the same area.

For the 10 institutions as of June 2013, there are a total of 504 installed air conditioners of which 16 are non-working. Of the 504 air conditioners, 337 are window-type, 162 split-type and 5 centralized units. A total of 493 air conditioners are using R-22 refrigerant with only 11 air conditioners using environment friendly refrigerant R410a. The average Energy Efficiency Ratio (EER) is 10.3 with a low of 9.8 to a high of 10.47.

It was also observed that some institutions have missing, defective and flickering light bulbs.

However, there are institutions operating on best practices such as properly installed air conditioners, the use of inverter air conditioner with an EER of 15, and a centralized air conditioner with EER of 13.6. One institution uses reflectorized lighting and individualized lighting. One institution operates with sufficient lighting. Another institution has appropriate classroom design for small and big classes.

3.3 Process Analysis

The modeled electricity consumptions for 2012 of the different processes were ranked from highest to lowest as shown in Figures 3 and 4 for the seven and three institutions respectively. Figure 3 shows that the ventilation and air-conditioning (VAC) is the highest at an average of 65.4 % with a minimum of 47 % and a maximum of 87 % followed by lighting at an average of 17.7 % with a minimum of 7 % and a maximum of 27 % for the seven institutions. Figure 4 shows that for the three institutions, VAC is the highest at an average of 55.9 % with a minimum of 38 % and a maximum of 69 % followed by data processing at an average of 22.4 % with a minimum of 19 % and a maximum of 26 % and then followed by lighting at an average of 17 % with a minimum of 5 % and a maximum of 26 %. The overall electricity consumption share for the ten institutions is 64.5 % for VAC, 17.1 % for lighting, 13.4 % for data processing, and the other processes accounting for 5 % are 3 % for food preparation and storage, 1.7 % for audio-visual (AV) and 0.3 % for photocopying. The electricity consumption profile for the ten institutions is shown in Figure 5.

The processes which constitute at least 80% of the electricity consumption are where the greatest potentials for electricity savings and hence where the influencing factors to electricity savings are identified.

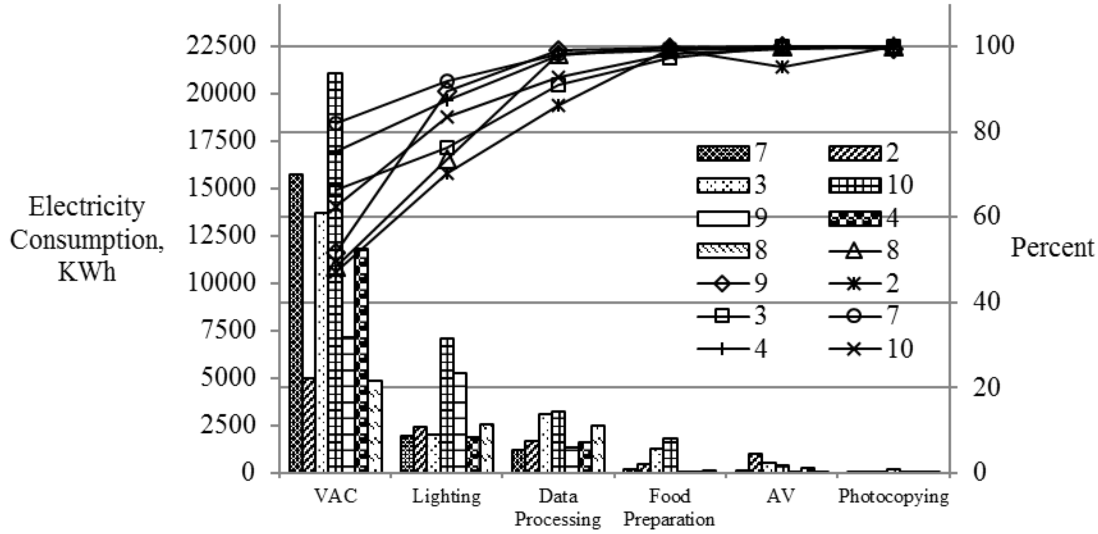

Figure 3. Energy cost centers for the seven institutions.

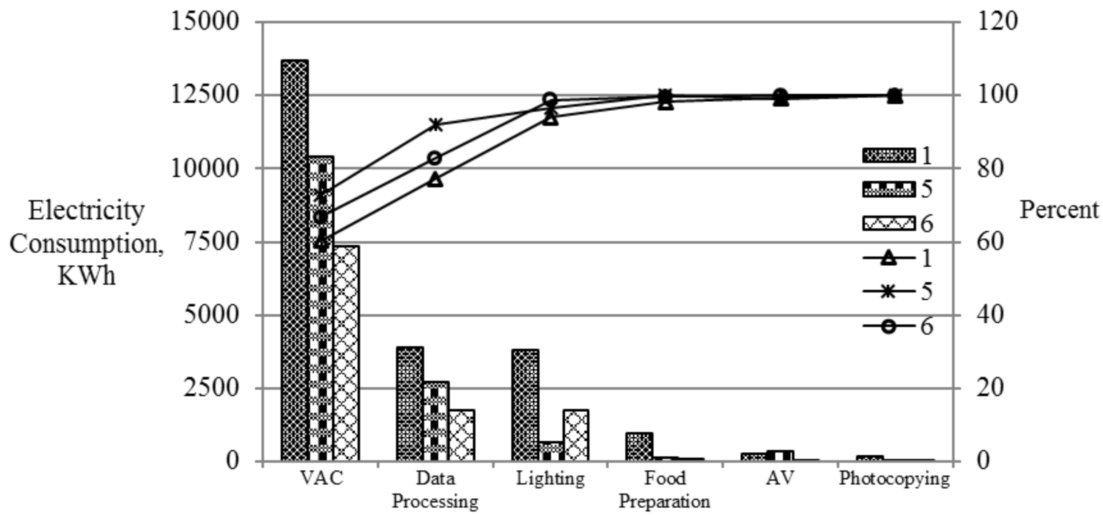

Figure 4. Energy cost centers for the three institutions.

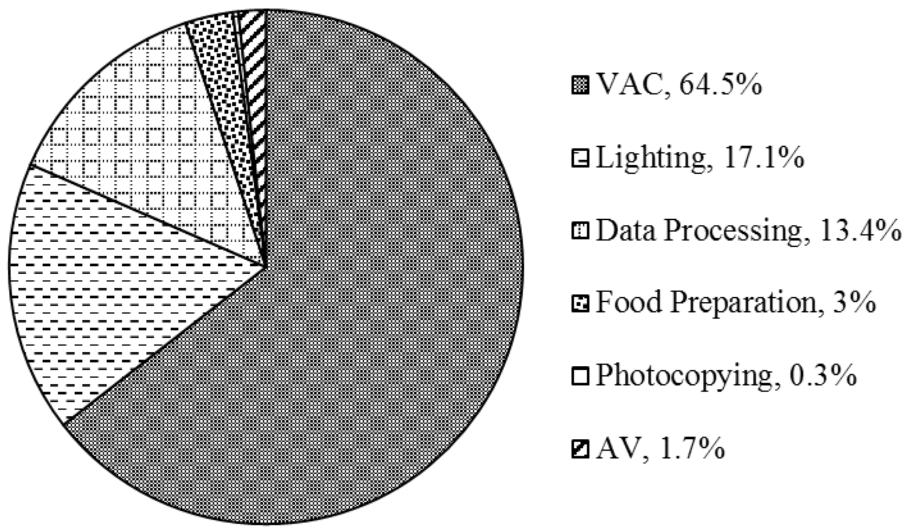

Figure 5. Energy cost centers for the ten institutions.

3.4 Energy Intensities

The energy intensity of lecture rooms averages at 2.1 KWh per month per student with a minimum of 0.7 KWh per month per student and a maximum of 4.2 KWh per month per student and with a standard deviation of 1.3 KWh per month per student. Figure 6 shows that five (5) institutions are within the range of mean to mean minus one standard deviation, one (1) institution is within the range of mean minus one standard deviation to mean minus two standard deviations, one (1) institution is within the range of mean to mean plus one standard deviation, and three (3) institutions are within the range of mean plus one standard deviation to mean plus two standard deviations. It showed that one institution (10 % of the institutions) is consuming less electricity by at least one standard deviation from the mean.

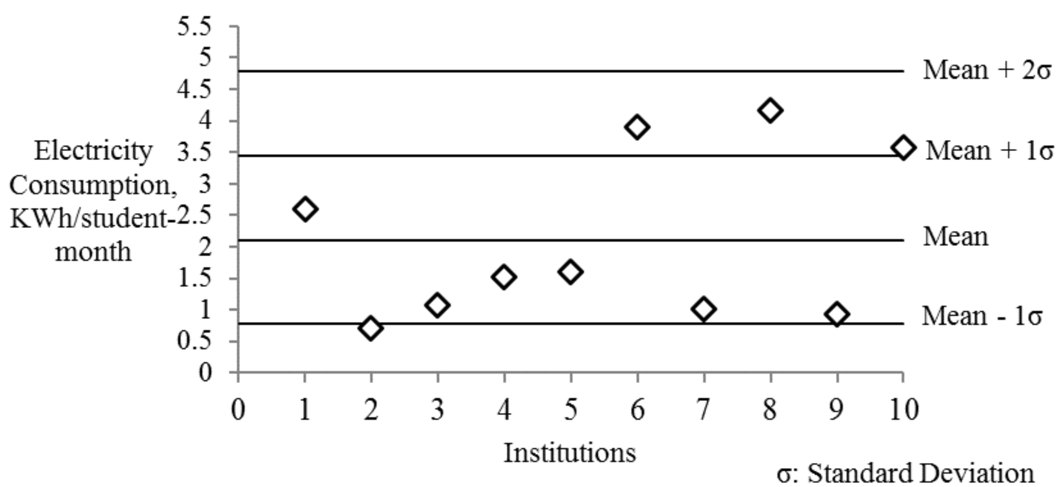

Figure 6. Energy intensity of lecture rooms.

The energy intensity of conference rooms averages at 93 KWh per month with a minimum of 69 KWh per month and a maximum of 158 KWh per month and with a standard deviation of 26 KWh per month. The number of students and guests in the conference rooms at any given time duration is not available. Figure 7 shows that six (6) institutions are within the range of mean to mean minus one standard deviation, two (2) institutions are within the range of mean to mean plus one standard deviation, and one (1) institution is above the mean plus two standard deviations. One (1) institution does not have a complete set of data. It showed that six institutions (67 % of the institutions) are consuming less electricity within one standard deviation from the mean.

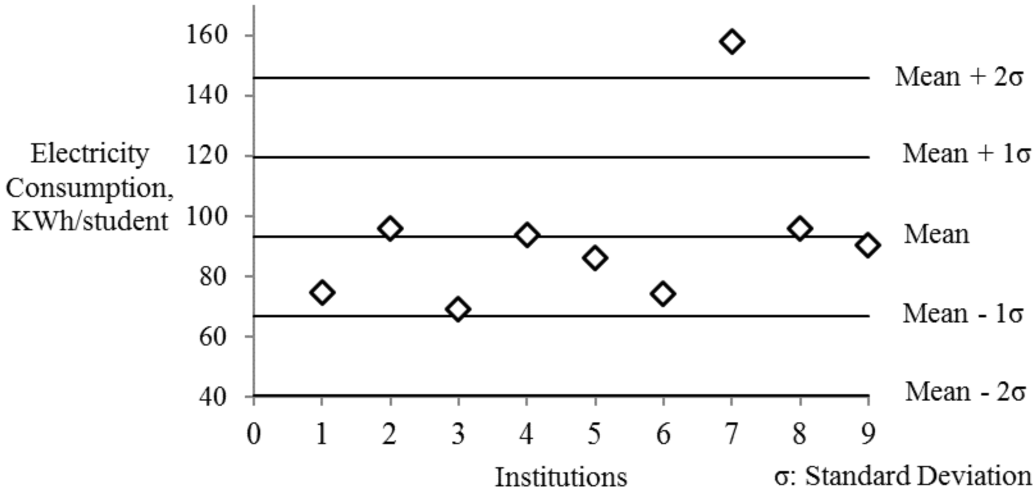

Figure 7. Energy intensity of conference rooms.

The energy intensity of libraries averages at 3,797 KWh per month with a minimum of 998 KWh per month and a maximum of 7,810 KWh per month and with a standard deviation of 2,403 KWh per month. The number of students, staff and guests inside the libraries at any given time duration is not available. Figure 8 shows that six (6) institutions are within the range of mean to mean minus one standard deviation, one (1) institution is below the mean minus one standard deviation, one (1) institution is within the range of mean to mean plus one standard deviation, and two (2) institutions are within the range of mean plus one standard deviation to mean plus two standard deviations. It showed that one institution (10 % of the institutions) is consuming less electricity by at least one standard deviation from the mean.

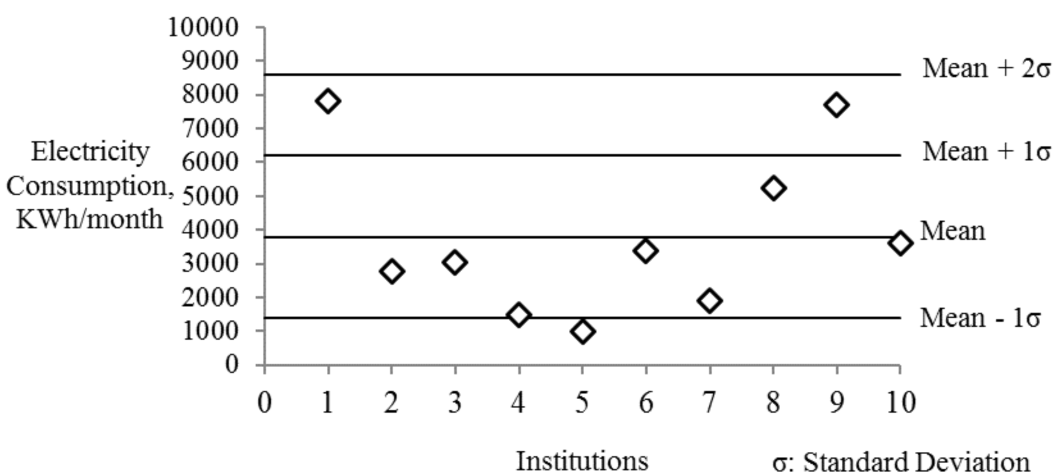

Figure 8. Energy intensity of libraries.

The energy intensity of administration rooms averages at 1,390 KWh per month with a minimum of 810 KWh per month and a maximum of 1,866 KWh per month and with a standard deviation of 332 KWh per month. The number of students, staff and guests inside the administration rooms at any given time duration is not available. Figure 9 shows that four (4) institutions are within the range of mean to mean minus one standard deviation, one (1) institution is within the range of mean minus one standard deviation to mean minus two standard deviations, three (3) institutions are within the range of mean to mean plus one standard deviation, and two (2) institutions are within the range of mean plus one standard deviation to mean plus two standard deviations. It showed that one institution (10 % of the institutions) is consuming less electricity by at least one standard deviation from the mean.

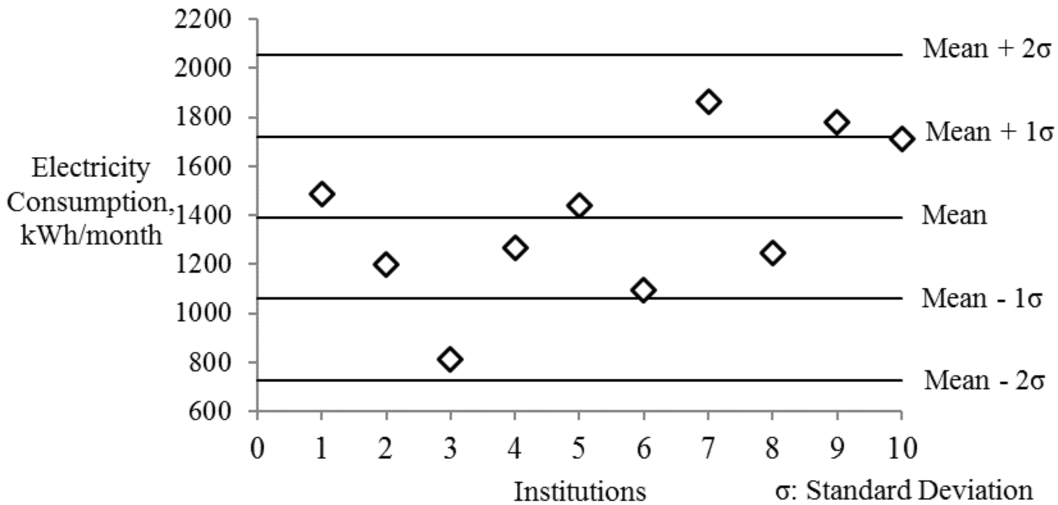

Figure 9. Energy intensity of administration rooms.

The energy intensity of auditoriums averages at 1.8 KWh per month per student with a minimum of 1.3 KWh per month per student and a maximum of 2.6 KWh per month per student and with a standard deviation of 0.5 KWh per month per student. Figure 10 shows that five (5) institutions are within the range of mean to mean minus one standard deviation, and two (2) institutions are within the range of mean plus one standard deviation to mean plus two standard deviations. Three (3) institutions do not have complete set of data. It showed that five institutions (71 % of the institutions) are consuming less electricity within one standard deviation from the mean.

3.5 Influencing Factors

From Figures 3, 4 and 5, the processes which have 80% impacts are ventilation and air-conditioning, and lighting or data processing. The influencing factors were analyzed for air-conditioning, lighting and data processing using cause and effect diagrams. Ventilation was neglected as its contribution is negligible compared to the requirements and impacts of air-conditioning. The influencing factors of the other processes accounting for 5 % of the electricity consumption such as food preparation and storage, audio-visual and photocopying, were not considered.

The comfortable level and usage factor were determined through interviews of users and ocular inspections of the buildings. The environmental conditions were determined through environmental data for the last five years. The future load was determined through interviews with building administrators and students.

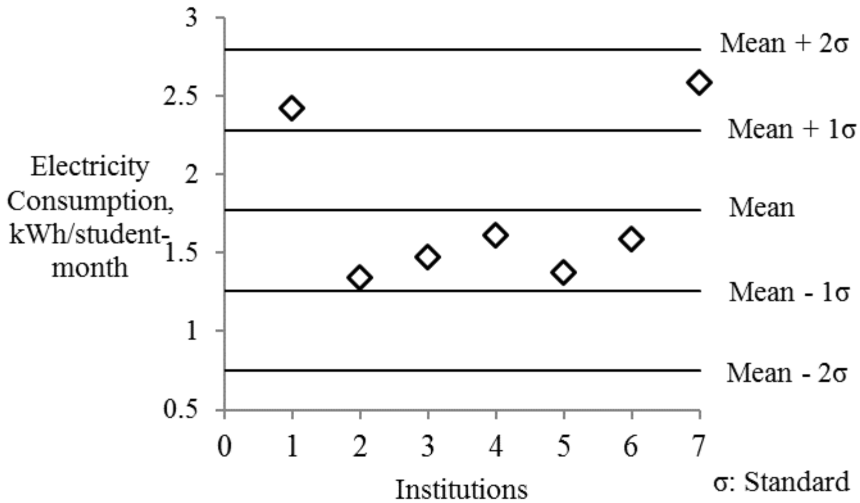

Figure 10. Energy intensity of auditoriums.

In designing the air-conditioning system, the cooling load requirements of the building, the comfortable level and usage factor of the users, the environmental conditions, efficiency and technology of the air-conditioning system, and future requirements were considered. The cooling load includes the fixed load and the variable load. However, since this is not a detailed audit and considering the factors that can be readily implemented, the fixed load only considers the building orientation, design and materials while the variable load considers the heat coming from equipment (lighting and computer systems) and people in the building.

The fixed cooling load is the sum of the load due to building orientation, design and materials. Building orientation considers location with respect to: compass points (sun and wind effects), nearby structures (shading effects) and reflective surfaces (water, sand, parking, etc.). Building design and materials consider the physical dimensions and construction materials including length, width and height of the structure; materials and thickness of walls, roof, ceiling, floors and partitions and their relative positions; and window and door types with their material, size, construction, location, and frequency of use.

The variable load includes the people, equipment, lighting and other operational conditions. The people factor considers the number, duration of occupancy and nature of activity (human body through metabolism generates heat within itself and releases by radiation, convection and evaporation) and nature of use. The heat coming from equipment (lighting and computer systems) was also considered.

The lighting factor considers wattage, type and installation, frequency of use, intensity of use and efficacy (e.g., incandescent, fluorescent, recessed or exposed).

The data processing factor considers the type, location, wattage, efficiency and frequency of use of the data processing equipment (e.g., computers, printers and others).

3.6 Energy Savings

In the simulation for building orientation, the longer side of the building oriented on a north or south has an average of 29 % energy savings compared to an east or west orientation. The building orientation is based on the master development plan, and hence, the plan has to consider where the buildings will be situated, the shading effects and reflective surfaces.

For building design, it is recommended that the building is at least 5 floors with at least 10 rooms per wing per floor, has clustered lighting lay-out in every room with power meter per room and automatic electricity controller, has less heat infiltration to the building by using rotating doors, solar control films for windows, low window to wall ratio, high exterior shading and high green ratio. The building should have photovoltaic system with rainwater harvester and gray water system.

For the equipment, Table 1 summarizes the energy savings. In air-conditioning, increasing the EER of window-type air conditioner from 10 to 13.6 would results to a savings of 80 KWh per month with a payback period of 9.5 months; using an inverter split-type air conditioner instead of the conventional-type air conditioner would save 120 KWh per month with a payback period of 8 months; and using water-cooled screw chiller instead of the air-cooled screw chiller would save 70,400 KWh per month with a payback period of 4 months. The refrigerants should have zero ozone depletion potential and below 2100 global warming potential.

For Light Emitting Diode (LED) lighting, the savings for lecture room lighting would range from 11 W compared to Compact Fluorescent Lamp (CFL) to 33 W compared to Single Tube Fluorescent (STF) with a payback period of 7.4 months; the savings for hallway lighting would range from 11 W compared to CFL to 32 W compared to STF with a payback period of 5.5 months; and the savings for outdoor lighting would range from 7 W compared to CFL to 18 W compared to STF with a payback period of 7.9 months.

For data processing, changing from Cathode Ray Tube (CRT) monitor to LED monitor would results to a savings of 10 KWh per month per monitor with a payback period of 14 months.

Considering the change of policy on air conditioners, lightings and data processing monitors and implemented in the next five years, the estimated energy savings on the fifth year of the 10 institutions is 346,764 KWh representing an average savings of almost 14 % as shown in Table 2. The actual savings is cumulative from year one to year five which would results to a higher savings.

Table 1a. Equipment Energy Savings for Air Conditioning

Windows Air conditioner						
EER	Power Input KW	Monthly Consumption KW	Market Price PhP [1]	Savings using 13.6 EER Model		
				PhP/KWh/month [10]	Percent	Payback Period Month
10	1.88	300.8	37,200	888	27	9.5
13.6	1.38	220.8	45,500			
Inverter Split-type Air conditioner						
Type	Power Input KW	Monthly Consumption KW	Market Price PhP [1]	Savings using Inverter Type		
				PhP/KWh/month [10]	Percent	Payback Period Month
Conventional	1.88	300.8	41,998	1,335	40	8
Inverter	1.28	180.5	52,498			
Water-cooled Screw Chiller						
Type	Power Input, KW Based on 20 TR cooling capacity	Monthly Consumption KW	Market Price PhP [11]	Savings using Water-cooled Type		
				PhP/KWh/month [10]	Percent	Payback Period Month
Air-cooled	19.6	3,136	721,600	17,755	51	4
Water-cooled	9.6	1,536	792,000			

Table 1b. Equipment Energy Savings for Lighting

LED Lighting					
Location	Lumen	Power W	Comparison	Market Price PhP [4]	Payback Period month
Lecture Room	640	7	40 W STF	489	7.4
			18 W CFL		
Hallway	350	4	36 W STF	350	5.5
			15 W CFL		
Outdoor	200	2	20 W STF	284	7.9
			9 W CFL		

Table 1c. Equipment Energy Savings for Data Processing

LED Monitor for Data Processing					
Type	Power Input W	Monthly Consumption KWh	Market Price PhP [13]	Savings using LED Monitor	
				PhP/KWh/month [10]	Payback Period month
CRT	80	12.8	5,000	108	14
LED	19	3	6,550		

Table 2. Institution Energy Savings.

Institution	**2012 Consumption (KWh)**	**Rate of Increase in Consumption per year (%)**	**2018 Projected Consumption (KWh)**	**2018 Projected Consumption with Policy (KWh)**	**2018 Power Savings (KWh)**	**2018 Percent Savings (%)**
1	113360	3.18	135000	109556	25444	18.8
2	360640	7.83	530000	496230	33770	6.4
3	284092	11.2	475000	393943	81057	17.1
4	173855	3.94	215000	178045	36955	17.2
5	123360	1.44	134000	118044	15956	11.9
6	305000	3.55	370000	338887	31113	8.4
7	218960	5.41	290000	248246	41754	14.4
8	101412	3.22	121000	99976	21024	17.4
9	55392	8.91	85000	51220	33780	39.7
10	132867	4.03	165000	139089	25911	15.7

3.7 Policy

The policies were developed based on the level of energy savings and the ease of implementation as shown in Table 3. The building orientation, design and materials and equipment efficiency are where the factors with greatest energy savings potentials. It is envisioned that the Design Policy which contains the minimum requirements shall be formulated by the head of the Planning and Development Office. The Implementation Policy which outlines the implementation strategy and timetable shall be executed by the head of the Administration Office. The Monitoring and Acceptance Policy which visualizes the compliance to end-user needs shall be made by the campus heads. The Compliance Policy which values the asset as per requirement shall be assessed by the head of the Finance Office. The Daily Maintenance Policy and Disposal Policy which chart the lifespan of the asset shall be drawn by the campus heads.

Other energy conservation opportunities include installing mechanical springs for automatic complete closing of doors between cooled and not cooled spaces, seal door infiltration, using light paint color for exterior walls, and growing vegetation around the building.

For the implementation priority, first, are those not involving monetary values, second, are those changes in materials and re-tooling manpower, and lastly, those changes in design, equipment and methods. All new buildings to be constructed and rehabilitated and new equipment purchases should incorporate the new specifications. Existing air-conditioners, light bulbs and computer monitors will be changed immediately to the new specifications when broken and by at least 20% yearly for the next 5 years.

Table 3. Energy Conservation Opportunities

POLICIES	ACTION	CHAMPIONS
1. Building Orientation • North-South orientation based on Master Development Plan 2. Building Design 2.1 At least 5 floors with at least 10 rooms per wing per floor 2.2 Clustered lighting lay-out in every room with power meter per room and automatic electricity controller 2.3 Design with less heat infiltration to the building • Use rotating doors • Use solar control films for windows • Low window to wall ratio • High exterior shading • High green ratio 2.4 With photovoltaic system 2.5 With rainwater harvester and gray water system	Design Policy	Vice-President for Planning and Development
3. Building Materials 3.1 Use low energy intensity materials 3.2 Use materials with high R values for doors, windows, floors, ceilings and walls	Implementation Policy	Vice-President for Administration

Table 3. Energy Conservation Opportunities (Cont)

POLICIES	ACTION	CHAMPIONS
4. Equipment Efficiency 4.1 Window-type Air-conditioner • At least 12 EER increasing by 1 every 2 years, subject to industry calibration every year • Environment-friendly refrigerant: R134a, R407c, R410a, R32 or at least equivalent • Digital controller capability 4.2 Split-type Air-conditioner • Inverter technology • All of Item 4.1 4.3 Multiple Indoor Type Air-conditioner • Variable Refrigerant Flow Technology • All of Item 4.2 4.4 Chillers • Screw Compressor • Water-cooled • At least 3 COP • Environment-friendly refrigerant: R134a, R407c, R410a, R32 or at least equivalent • Digital controller capability 4.5 Lighting • LED with efficacy of at least 90 Lumen/W with automatic electricity controller 4.6 Data Processing • LED monitors	Monitoring and Acceptance Policy	Chancellors
5. Asset Audit	Compliance Policy	Vice-President for Finance
6. Maintenance	Daily Maintenance Policy	Chancellors
7. Decommissioning	Disposal Policy	Chancellors

A checklist for the building and equipment should be implemented to be checked daily and all non-compliant should be corrected within the day.

In revitalizing the lighting system, the light requirements per standard must be met, maximizing the source efficiency and the luminaire efficiency, clustering the area according to need, automatically controlling the light source and measuring the power consumption.

For comfortable indoor environment, the air-conditioning system must meet the cooling load, humidity and filtering requirements per standard, maximizing load reduction measures and air distribution systems, maximizing the EER, and a default temperature setting of 24^{o}C.

It is very important that the end-user need assessment fully represents the need of the institution and the capacity ordered matches the need.

The Art and Science of Sustainability require the imposition of green design, the use of new energy supply such as photovoltaic and waste to power, the use of very efficient system and equipment, synergy of activities, and political will to implement energy conservation. The person, who does not follow the standards for any reason, must pay the difference in energy cost. Those units reducing their energy consumption with higher productivity should be proportionally given incentives. Energy Management is an orchestra where the president, other officials, faculty members, staff, students and visitors must play on time the right tune for energy use.

4. CONCLUSION AND RECOMMENDATIONS

1. A framework was designed for determining the electricity consumption of academic buildings based on process analysis.
2. The academic buildings of ten degree granting institutions were audited representing 42% of the total degree-granting institutions covering 14 buildings representing 28% of the total academic buildings.
3. Among the processes, ventilation and air-conditioning (VAC) registered the highest at an average of 65.4 %, followed by lighting at an average of 17.7 % for the seven institutions. For the remaining three institutions, the VAC process is the highest at an average of 55.9 % followed by data processing at an average of 22.4 % and then followed by lighting at an average of 17 %.
4. The energy intensity of lecture rooms averages at 2.1 KWh per month per student. The energy intensity of conference rooms averages at 93 KWh per month. The energy intensity of libraries averages at 3,797 KWh per month. The energy intensity of administration rooms averages at 1,390.2 KWh per month. The energy intensity of auditoriums averages at 1.8 KWh per month per student.
5. The factors influencing electricity consumption for air-conditioning, lighting and data processing were identified and effective energy management policies were formulated for implementation. The estimated savings for the ten institutions is 347 MWh representing 14 % on the 5th year.
6. It is recommended that a full-blown audit be conducted in the buildings to identify more specific interventions.
7. It is recommended that a thorough profiling of room and laboratory usages be conducted. The parameters to measure for the room include duration of usage, temperature setting, frequency of turning on, duration of turning on, frequency of opening the door, and duration of each door opening. The parameters for the people include the number of people, duration of occupancy, nature of activities and nature of use. The parameters for the equipment include type, location, wattage, frequency of use and nature of use. These studies will be able to optimize usage, space allocation, laboratory priorities, and future energy loads.

5. ACKNOWLEDGEMENTS

The author wishes to express his deepest gratitude to Emerson Climate Technologies for the professorial chair donation, to Dean Rosario I. Alonzo of the College of Education, Dean Erniel B. Barrios of the School of Statistics, Dean José S. Buenconsejo of the College of Music, Dean Mario R. Delos Reyes of the School of Urban and Regional Planning, Dean Mary Ann A. Espina of the College of Architecture, Dean Ben Paul B. Gutierrez of the College of Business Administration, Dean Elena R. Mirano of the College of Arts and Letters, Dean Leonardo C. Rosete of the College of Fine Arts, Dean Jonathan P. Sale of the School of Labor and Industrial Relations, and Dean Rolando B. Tolentino of the

College of Mass Communication for their utmost cooperation during the conduct of the study in their respective colleges and schools, to Assistant Vice President for Administration and Institute for Small-Scale Industries Director Nestor O. Rañeses for his help in using UPISSI for the initial data, Mr. Alfonso R. De Leon, Ms. Rhia Carla P. Duca, Mr. Reynaldo S. Jacinto, Mr. Jodel L. Cuasay, Ms. Cheri Anne M. Dingle, Ms. Ann Margaret N. Escalona, Ms. Gilda Asuncion C. Manegdeg and Mr. Mark Cecil M. Tano for their help in generating the data, and for Mr. Jonathan Beldia, Mr. Obet Gabriel, Mr. Ray Mateo and Mr. Jude Molina for providing information on their institutions, and the UP Diliman Utilities Management Team and the various institutions where their data and information were used, and those authors where information from their works were used. Many thanks.

6. REFERENCES

[1] ABENSON, "ABENSON," Web, 5 February 2015. <http://www.abenson.com.ph/shop/products.asp…>.

[2] Al-Daraiseh, Ahmad, Nazaraf Shah, and Eyas El-Qawasmeh. "An Intelligent Energy Management System for Educational Buildings", International Journal of Distributed Sensor Networks, 1-13, Web, 4 February 2015.

[3] Bugayong, Reynan Gabriel Napo, "Load Profiling of Electrical Energy Consumption of Buildings in University of the Philippines Los Baños", March 2012.

[4] GES, "GES 4th Generation LED Lights", Web, 5 February 2015,

[5] <http://www.gesled.blogspot.com/>.

[6] Gul, Mehreen S., and Sandhya Patidar. "Understanding the Energy Consumption and Occupancy of a Multi-purpose Academic Building." Energy and Buildings, 155-165, Web, 4 February 2015.

[7] Manegdeg, Ferdinand G., "Basic Energy and Environmental Auditing Templates for Micro, Small and Medium Enterprises", Leading through Technology, Enabling Innovations, Advancing Quality Standards, Promoting Productivity Growth, Institute for Small-Scale Industries, University of the Philippines Diliman, Philippines, February 2012.

[8] Manegdeg, Ferdinand G., "Building Energy Use", Energy Engineering 211: Energy Conservation, University of the Philippines Diliman, Philippines, June 1984.

[9] Manegdeg, Ferdinand G., "Energy and Environmental Management", Greening and Leaning through Energy and Environmental Management, Institute for Small-Scale Industries, University of the Philippines Diliman, Philippines, December 2012.

[10] Manegdeg, Ferdinand G., "Energy and Environmental Management in Air-conditioning Systems", Greening and Leaning through Energy and Environmental Management, Institute for Small-Scale Industries, University of the Philippines Diliman, Philippines, December 2012.

[11] Manila Electric Company, Bill of Institution 6, PhP 11.097/KWh per month, 6 March 2013.

[12] Trane Philippines Proposal, July 2013.

[13] University of the Philippines Diliman, Utilities Management Team, "Electricity Consumption", July 2013.

[14] VillMan, "VillMan Computers", Philippines, Web, 5 February 2015, <http://www.villman.com>.

[15] World Bank, "Energy Use (kg of Oil Equivalent per Capita)", Web, 4 February 2015, <http://data.worldbank.org /indicator/EG.USE.PCAP.KG.OE>.