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Energy Auditing Measures for a Private Educational Institution in Sta. Ana Pampanga: A Case Study

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ABSTRACT

One of the ways to identify the areas of the building that wastes energy then reduces energy consumption is by conducting an energy audit. This study aimed to conduct an energy audit, specifically a Walk-Through Analysis, on Holy Cross College, a Type 1 Designated Establishment. Specifically, it evaluated the energy consumption practices of the institution when it comes to their lighting system, equipment usage, employee energy conservation practices, air-conditioning units, and building envelope. Aside from the result of the qualitative observations of the researchers, they also conducted a quantitative energy conservation assessment brought by the illumination and cooling systems of HCC. It was found out that there are energy saving opportunities that could be utilized by the institution to reduce their energy consumption and save utility costs. The results of the analysis showed that the ACUs of every building is the system where energy is being wasted or used inefficiently. The EEMS proposed by the researchers were all presented with references and their corresponding investment cost and level of savings. Aside from that, if every room in each building were to set their ACUs to 24 degrees Celsius, they would be able to save an approximate of 15063.84 kWh which is worth ₱ 115,153.18 monthly. Lastly, if HCC is to invest and utilize twenty-six pieces of 15W LED Bulb for replacement in the college corridor, the total investment cost would be ₱ 3,250.00 which has a return on investment of 214.2%, and a payback period of about 3 months and 25 days.

Keywords: Energy audit; Efficiency; Energy consumption; Walk-through analysis; Energy conservation; Lighting system; Quantitative assessment; Energy saving opportunities; Return on investment; Air-conditioning units.

1. Introduction

Across continents and cultures, access to electricity and fuel sources is not merely a matter of modern convenience but a determinant of quality of life, economic opportunity, and even survival. In these regions, where the absence of dependable energy infrastructure can perpetuate cycles of poverty and hinder essential services, the recognition of energy access as a vital need resonates deeply. With that, developing nations believe that it is a vital need to have both reliable and affordable energy as it can improve or save lives, at best [1]. Providing such equates to a responsibility and commitment on how to utilize the available resources in the most responsible way. According to Imperial [1], the world consumes energy mostly from hydrocarbons, and despite having noteworthy advancement in terms of energy efficiency, it is expected that the energy demand worldwide will increase by 25% from the year 2014 to 2040. Nonetheless, more than one billion people around the world still experience energy shortage, and almost 3 billion people depend on burning dirty fuels just to consume energy [2].

On average, the global energy consumption is approximately 580 million terajoules per year which is equivalent to 13,865 million tons of oil [3]. It was predicted that in 2040, this global energy consumption will increase to 740 million terajoules. Last 2022, worldwide energy consumption has increased three times from the year 1980 [4]. This means that over the past half century, energy consumption has augmented up to 25,500 terawatt hours.

In the Philippines, its leading energy source is coal – about 58% of its energy consumption comes from it [5]. Enerdata [6] states that the per capita energy consumption of such country is 0.54 toe that includes the total of 798 kWh of electricity in 2021 which is deemed to be two times lower than the average energy consumption of ASEAN countries. With that, the total energy consumption of the Philippines has increased by roughly 4% – 60.4 Mtoe, and its peak was in 2019 which was 61 Mtoe.

Pampanga, one of the provinces of the Philippines has increased its MWh offtake from 13,934 MWh in 2000 to 72,054 MWh in 2020 because of its growing population [7]. However, there was a System Loss (in MWh) at an average rate of 2.83% within the similar time interval. Additionally, according to the Department of Energy [7], around 2.22% of their energy sales were from other customers who had energy consumption through street lights, water systems, and public buildings. With regards to their forecasted consumption, it was anticipated that the MWh output will have an annual rate of 5.2% on average wherein the MWh output is expected to be within the values of 7000-10000 in 2030.

With the abovementioned information and data, it is a must for everyone to make sure that they practice energy conservation and avoid the inefficient usage of energy.

One of the ways to identify the areas of the building that wastes energy then reduce energy consumption is by conducting an energy audit [8]. The latter is done to determine the energy consumption efficiency of a residential or commercial building through evaluation, testing, and efficiency recommendations. It is mostly done by a registered energy auditor or energy adviser. Also, there are two types of energy audit: (1) Preliminary energy audit which is done through a walk-through investigation; and (2) Detailed energy audit that uses highly developed instruments such as flue gas analyser, scanner, and/or flow meter. The time that it would take for an energy audit to be done depends on the property area as well as the quantity of appliances or equipment present in it. Aside from those, the information that need to be considered are the number of windows and doors as well as the chosen type of energy audit. To infer, conducting an energy audit is done to solve energy efficiency complications as well as to identify energy-saving opportunities.

The American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) energy audit determined three levels (Level 1, 2, and 3) to do such audit [9]. The Level 1 is known as the Walk-Through Survey, is a basic assessment conducted by an energy auditor. It involves reviewing utility bills, interviewing building staff, and an inspection of lighting, building envelope to identify energy inefficiencies. The recommendations in this level could include a strategic way to use a certain device; its minimal usage must be proposed especially if it is not used that often. The output on this energy audit produces a brief report that summarizes the building's current energy performance, provides a preliminary estimate of potential energy savings, and suggests some low-cost or no-cost measures to improve efficiency.

Legally, Republic Act No. 11285, also known as Energy Efficiency and Conservation Act, aimed to institutionalize both energy efficiency as well as energy conservation to be part of life [10]. One of its policies aimed to enforce laws related to energy efficiency, conservation, sufficiency, and sustainability in the country as well as to advocate the development and utilization of renewable energy sources to ensure their sustainability [11]. Specifically, energy efficiency and conservation plans must be formulated, developed, and implemented to enhance the level of security in the field of energy supply in the country. In compliance with the policies set by this R.A., every individual who utilizes energy in the state must put into effort in maximizing the available energy resources. With that, the

Department of Energy must mandate the compliance of manufacturers, importers, as well as dealers with the Minimum Performance Standards (MEPs).

In relation to RA 11285, the Department of Energy provided different types for Designated Establishments (DE) [12]. The latter denotes to any sector – commercial, industrial, transport, power, agriculture – that are determined to be energy intensive industries. There are three different types: Other DEs must have an Annual Energy Threshold for the previous year of 100,000 kWh but less than 500,000 kWh, Type 1 DE must have 500,001 kWh to 4,000,000 kWh, and Type 2 DE must have at least 4,000,001 kWh.

The laws related to energy consumption – the development of energy conservation plans, i.e., through energy audit – persuade institutions to comply in maximizing the available energy resources. With that, to establish the context of the importance of energy audit in the Philippines, a review of related literature was done by the researchers.

Ronald Peña [13] conducted an energy audit at the Don Severino Delas Alas campus of Cavite State University located at the barangay of Bancod, Indang, Cavite. The study involved the identification of the practices of the university in energy usage, specifically in what ways was it wasted and how such waste could be eliminated. The energy audit focused on the 11 (out of 50) existing facilities and buildings of the institution. It was identified that their energy consumption was most used and wasted when the lighting systems and air-conditioning units of the university were left open even though there were no occupants, mostly during lunch time. With that, Ronald Peña specified energy efficiency measures that could reduce the utility bills which includes proper maintenance as well as operating practices.

Mark Lawrence Ical and Jay Oliveros [14] conducted an energy audit in one of the state universities in the Philippines. They specifically conducted a preliminary energy audit. After a thorough analysis of the energy consumption of the main campus of such university, they identified that on average, their monthly consumption is 32,848.221 kWh, with ACUs as the largest consumer at a rate of 54.94%. On the other hand, their lighting system has an energy utilization rate of 6.79%. They also recommended a set of Energy Conservation Measures (ECMs) which had a forecasted monthly energy savings of at most 51.3%.

The abovementioned related literature served as supporting arguments of the importance of this study which was done in Holy Cross College, Pampanga. This institution has five buildings – college, senior high school and LRC, junior high school, and elementary building. Aside from that, they also have a canteen and a chapel. This study evaluated the energy consumption of the said institution to provide a set of suggestions on energy optimization to reduce electric costs. This energy audit only tackled the following aspects of the building: lighting, air conditioning, building envelope as well as the practices of its employees and the performance of their equipment. Aside from that, the researchers also conducted a quantitative assessment for the lighting systems and air-conditioning units of the institution.

1.1. Study Objectives

In anticipation that the minimum consumption for Type 1 DE would be reduced in the coming years, a Walk-Through Analysis type of energy audit was carried out at Holy Cross College to acquire the power ratings of the electrical appliances/equipment in use. This included an inspection of the building and at the same time measuring the lighting level and room temperature in accordance with the standard. The following were the specific objectives of this study: (1) To identify the systems of every building where energy is being wasted or used inefficiently; (2) To evaluate lighting levels; (3) To evaluate room temperatures; (4) To propose improvements based on the findings; and (5) To compute the savings brought by the EEMs.

2. Structural Framework

Figure 1 shows the structural framework of the study which is adopted from the study of Kailei Wu [15] entitled "Research on the energy audit from the perspective of environmental protection". It states that energy audit can be done through the analysis of the current status of energy consumption of the target area, identify the weak links of the management of energy, determine the energy saving potential, reduce energy consumption and lastly, improve its energy efficiency. After doing such, energy conservation will be done and since energy consumption will be lessened, there will also be a decrease in harmful gas emission, mitigating harmful impacts to the environment. The effects of this energy audit could help improve the economic benefits of the area.

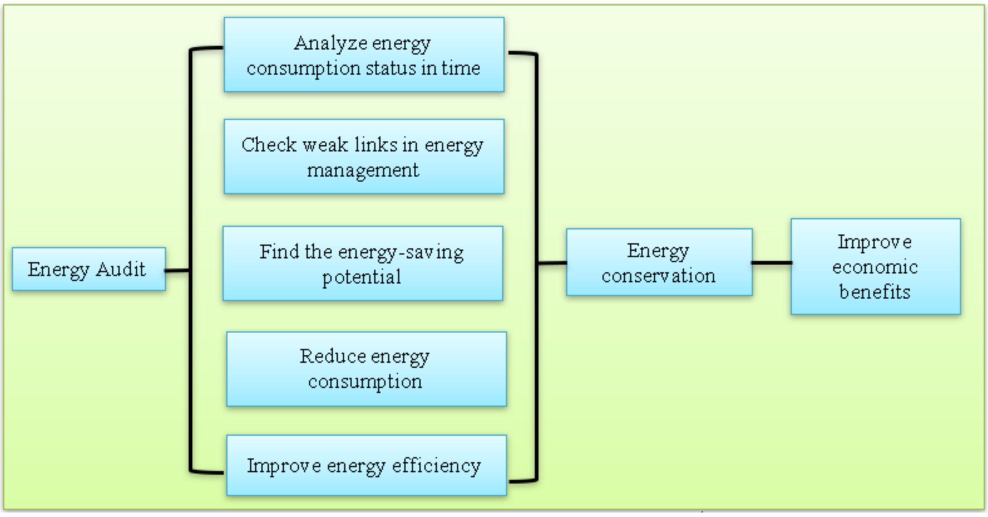

Figure 1. Structural Framework of the Study

3. Methods

This section outlines the procedures as well as the steps employed to achieve the objectives of this study. It includes the research setting, plans, and instruments that would be utilized to collect the data needed.

4. Research Design

This study was a mix of quantitative and qualitative research which involved both observation and data collection of Holy Cross College's facets related to a Walk-Through Analysis type of energy audit. Specifically, it was a combination of phenomenological design and case study wherein the former aims to explore the experiences and practices of the individuals in the research locale about their utilization of energy, and the latter aims to conduct an examination of the aspects of the research locale to provide energy efficiency measures that would personally fit the needs of the institution.

In essence, the quantitative data that this study gathered refers to the power ratings of the electrical appliances/ equipment in use – the lighting level and room temperature in accordance with the standard. On the other hand, the qualitative data refers to the inspection of the building along with the current practices of the students, teachers, and other people who are directly linked to the area of study.

5. Materials

This study utilized an Energy Audit Checklist (See Appendix A) crafted by the University of Colorado [16]. This document had 6 sections: Office Equipment, Lighting, Cooling, Building Envelope, Water, and Miscellaneous. However, this study did not tackle the two latter section, and, thus, changed with Employee.

Aside from the checklist, the following measuring devices were utilized in the energy audit:

5.1. Digital Luxmeter

The illumination levels of rooms and offices were measured using a digital luxmeter. An assessment was aided by it to determine if the existing lighting was sufficient or if adjustments were necessary. For its high sensitivity and accuracy, the digital luxmeter GM1010 was utilized in the study.

5.2. Digital Power Clamp Meter

The UT233 digital power clamp meter has been used for measuring the voltage, current, and power factor of the electrical system. It has been chosen for its intelligent, handheld, and stable power and harmonics clamp meter capabilities. A walk-through survey was done to determine the number of measuring points for each room, after which, illumination measurements were taken using a lux meter while room temperatures were recorded. These measuring devices are one of the fundamentals of an Energy Audit as they provide the necessary quantitative data to analyze, improve, and maximize the energy consumption of the research setting; they are proven to produce accurate data to enable the researchers have a reasonable baseline regarding the energy consumption of the building.

6. Computation for Energy Savings and Baseline for Lighting & Room Temperature

6.1. Energy Consumption

The energy consumption is computed by using this formula [17]:

$E = Pt$

Where: E = energy consumed by the device, in watt-hour; P = power, in watts; and t = amount of time the device is used, in hours.

6.2. Illumination Level

This research paper presented a standard for conducting energy audits in office and facility settings for optimal comfort, in accordance with the Department of Energy (DOE) [42].

a. 50 – 150 lux - circulation area and corridors

b. 100 – 200 lux - stairs

c. 300 – 750 lux - working interiors

d. 1,000 – 2,000 lux - localized lighting for exacting task

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6.3. Room Temperature Analysis

In accordance with the guidelines provided by the DOE, the room temperature should not be set lower than 24°C when utilizing an air-conditioning unit. This is intended to promote energy efficiency and reduce energy consumption, ultimately contributing to cost savings while maintaining a comfortable indoor environment [18].

6.4. Return on Investment

Return on investment will be calculated to evaluate the possible investment of the institution. It is expressed in percentage that represents the ratio of the benefits gained by the institution from their investment relative to its initial cost. After relaying the recommendations, the researchers had a forecast of the possible cost that could incur upon their implementation. This was also the basis of the researchers in computing the possible savings of the institution after such [19].

$$ROI\ (\%) = \left(\frac{Revenues\ after\ investment - Amount\ investment}{Amount\ Invested}\right) * 100$$

6.5. Payback Period

The time it takes to recover the initial investment is calculated using the formula for payback period [41].

$$Payback\ Period = \frac{Initial\ Investment}{Annual\ Savings}$$

7. Results and Discussions

Figure 2 shows the total estimated power of Holy Cross College which is 299.99 kW at peak demand. During the monitoring of actual power, the highest consumption comes from the SHS building, accounting to 47.8% or 143.48 kW, followed by LRC with a consumption of 21.8% or 65.35 kW. The JHS consumptions ranks third representing 20.2% or 60.63 kW. The remaining four buildings did not exceed a 5% demand, ranging from 1.4% to 4.4%; the canteen has the lowest demand at 1.4% or 4.1 kW, followed by the church at 1.5% or 4.35 kW, and the college building with a share of 3.0% or 9.0 kW. Lastly, the Grade School Building has a share of 4.4% or 13.08 kW.

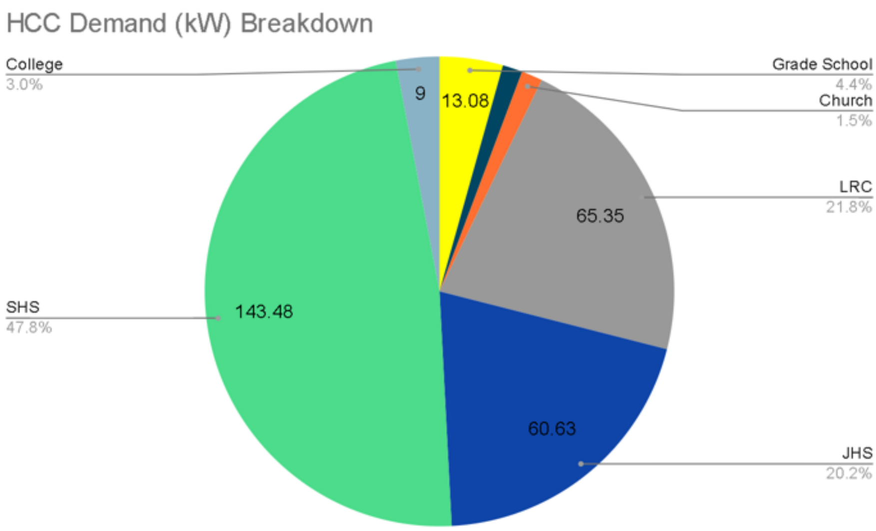

Figure 2. HCC Demand (kW)

7.1. Demand (kW) Segmentation

Table 1. College bldg. Demand (kW)

Significant Energy Use (SEU)	kW	%
Cooling/ACU	5.68	63.1%
Lighting	1.38	15.3%
Office Equipment	1.64	18.2%
Misc.	0.30	3.3%
Total Estimated	*9.0*	*100%*

Table 2. Senior HS bldg. Demand (kW)

Significant Energy Use (SEU)	kW	%
Cooling/ACU	25.70	75.3%
Lighting	2.88	8.40%
Office Equipment	3.74	11%
Misc.	1.82	5.30%
Total Estimated	*34.14*	*100%*

Table 3. LRC bldg. Demand (kW)

Significant Energy Use (SEU)	kW	%
Cooling/ACU	28.16	88.4%
Lighting	1.80	5.70%
Office Equipment	0.26	0.8%
Misc.	1.62	5.10%
Total Estimated	*31.84*	*100%*

Table 4. Junior HS bldg. Demand (kW)

Significant Energy Use (SEU)	kW	%
Cooling/ACU	4.64	61.5%
Lighting	1.04	13.8%
Office Equipment	1.37	18.1%
Misc.	0.50	6.60%
Total Estimated	*7.55*	*100%*

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Table 5. Grade School bldg. Demand (kW)

Significant Energy Use (SEU)	kW	%
Cooling/ACU	7.15	54.7%
Lighting	1.83	14%
Office Equipment	2.1	16.1%
Misc.	2.0	15.3%
Total Estimated	*13.08*	*100%*

Table 6. Chapel Demand (kW)

Significant Energy Use (SEU)	kW	%
Cooling/ACU	2.84	49.2%
Lighting	0.71	12.3%
Office Equipment	0	0%
Misc.	2.22	38.5%
Total Estimated	*4.35*	*100%*

Table 7. Canteen Demand (kW)

Significant Energy Use (SEU)	kW	%
Lighting	0.13	3.2%
Fans	0.41	10%
Refrigerator	1.25	15.3%
Freezer	1.01	24.6%
Chiller	1.13	27.6%
Misc.	0.17	4.1%
Total Estimated	*4.10*	*100%*

Table 8. Air-condition (kW)

Significant Energy Use (SEU)	kW	%
Junior HS (1^{st} Floor)	26.81	13.7%
Junior HS (2^{nd} Floor)	26.27	13.4%
Senior HS (1^{st} Floor)	32.30	16.5%
Senior HS (2^{nd} Floor)	42.48	21.7%
Senior HS (3^{rd} Floor)	20.26	10.3%
Senior HS (4^{th} Floor)	14.30	7.30%
LRC	33.51	17.1%
Total Estimated	*195.93*	*100%*

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Tables 1 to 7 show the demand segmentation each of the measured eight panel boards in Holy Cross College and identify energy-intensive components by checking the ratings. Cooling/ACU measured as the highest load, followed by lighting, then office equipment and miscellaneous some consist of (water dispenser, fans, TV).

Table 8 shows the total air-conditioning unit demand power having 195.93 kW, and it was divided to every building. During the monitoring of actual power consumption at peak demand, the most contributary energy used are ACU units at senior high school building having a total of 109.34 kW, followed by 53.08 kW of Junior High School building, and of 33.51 by the LRC building.

7.2. Walk-Trough Analysis

Table 9. The Results of the Walk-Through Analysis

		College Building	SHS and LRC Building	JHS Building	Elementary Building	Canteen	Chapel
Lighting	*Sufficient Lighting*	16/16	30/30	23/29	2/20	1/1	1/1
	LED Lights Utilization	13/16	30/30	26/29	20/20	1/1	1/1
	Well-maintained Lights	14/16	30/30	25/29	16/20	1/1	1/1
	Labelled Light Switches	2/16	0/30	2/29	1/20	0/1	1/1
	Switch Off Policy Implementation	16/16	30/30	26/29	20/20	0/1	1/1
Equipment	*Properly Working Equipment*	16/16	30/30	25/29	20/20	1/1	1/1
	Energy-saving Equipment	16/16	30/30	26/29	20/20	1/1	1/1
	Energy Conservation Policy	16/16	30/30	26/29	20/20	1/1	1/1
	Well-maintained Equipment	15/16	30/30	21/29	18/20	1/1	1/1
Employee	*Energy Utilization Reminders*	16/16	30/30	26/29	20/20	1/1	0/1
	Clearly Labelled Equipment for Efficient Energy Use	0/16	0/30	0/29	20/20	1/1	0/1

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Air-conditioning	*Proper Air Ventilation*	2/16	30/30	26/29	20/20	0/1	1/1
	Temperature of 24°C	0/16	0/30	0/29	0/20	0/1	0/1
	Well-maintained Air-conditioning Units	2/16	30/30	23/29	20/20	0/1	1/1
Building Envelope	*Properly Sealed Rooms*	2/16	27/30	16/29	20/20	0/1	1/1
	Efficient Spatial Use	16/16	30/30	24/29	20/20	1/1	1/1
	Minimized Solar Gain	6/16	25/30	15/29	15/20	1/1	1/1
	Well-maintained Windows	16/16	30/30	26/29	16/20	1/1	1/1

This table shows the results of the Walk-through Analysis performed by the researchers. Holy Cross College caters elementary to college students, and each building corresponds to such (elementary, junior high school, senior high school, and college). Aside from that, they also have a canteen and a chapel.

To be specific, the elementary, junior high school, senior high school, and college has 20, 29, 30, and 16 classrooms, respectively. The numbers above indicate the number of classrooms that complies with the set criteria. For example, in the college building, only 2 out of 16 classrooms have their light switches labelled.

Upon the analysis, it was observed that the building that has the most outstanding performance in complying with energy efficiency measures is the SHS and LRC Building, and in contrary, the buildings that do not conform to such is the JHS and elementary building.

7.3. Lighting Levels

This section presents the lighting levels of the building, including the area, average illuminance, type of lamps used, and remarks based on measured illuminance. The lighting levels were measured using the lux meter positioning one meter above the finished floor or place on a working desk. Also, if it is according to the standards mandated by the Department of Energy which is at least 300 lumens for comfortability.

Table 10. Illumination Level of College

College Building			
Location/Area	**Average illuminance (lux)**	**Installed lamps (types/watts)**	**Remarks**
Room 21	356.8	4 – 15W LED Bulb	*Sufficient*
Room 22	387.06	4 – 15W LED Bulb	*Sufficient*
Room 23	315.2	4 – 15W LED Bulb	*Sufficient*

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Room 24	320.9	4 – 15W LED Bulb	*Sufficient*
Room 25	320.66	4 – 15W LED Bulb	*Sufficient*
Room 26	344	4 – 15W LED Bulb	*Sufficient*
Room 31	326.10	4 – 15W LED Bulb	*Sufficient*
Room 32	338.9	4 – 15W LED Bulb	*Sufficient*
Room 33	301.53	4 – 15W LED Bulb	*Sufficient*
Room 34	309.9	4 – 15W LED Bulb	*Sufficient*
Room 35	337.43	4 – 15W LED Bulb	*Sufficient*
Room 36	312.2	4 – 15W LED Bulb	*Sufficient*
Room 41 & 42	287.30	4 – 15W LED Bulb	*Insufficient*
Room 43	350.5	4 – 15W LED Bulb	*Sufficient*
Room 44	310	4 – 15W LED Bulb	*Sufficient*
Room 45	317.11	4 – 15W LED Bulb	*Sufficient*
Total Estimated			16 rooms

This table shows the number of rooms and their corresponding lighting fixture installed as well as the measured illuminance in college building. It shows that the building is having only one room that is below the standard mandated by the DOE.

Table 11. Illumination level of SHS and LRC

SHS and LRC Building			
Location/Area	**Average illuminance (lux)**	**Installed lamps (types/watts)**	**Remarks**
Computer Laboratory	377	6 – 17W LED Bulb	*Sufficient*
Faculty	312.24	6 – 17W LED Bulb	*Sufficient*
Room 103	311.8	6 – 15W LED Bulb	*Sufficient*
Room 104	302.1	6 – 15W LED Bulb	*Sufficient*
Room 105	335.29	6 – 15W LED Bulb	*Sufficient*
Room 106	311	6 – 15W LED Bulb	*Sufficient*
Room 108	308.41	6 – 15W LED Bulb	*Sufficient*
Room 109	359.3	6 – 15W LED Bulb	*Sufficient*
Room 110	348.5	6 – 15W LED Bulb	*Sufficient*
Room 111	323.7	6 – 15W LED Bulb	*Sufficient*
Room 112	344.60	6 – 15W LED Bulb	*Sufficient*
Room 113	341.33	6 – 15W LED Bulb	*Sufficient*
Room 114	306.4	6 – 15W LED Bulb	*Sufficient*
Room 115	366.1	6 – 15W LED Bulb	*Sufficient*
Room 201	368.92	6 – 15W LED Bulb	*Sufficient*

Room 202	361.56	6 – 15W LED Bulb	*Sufficient*
Room 203	367.22	6 – 15W LED Bulb	*Sufficient*
Room 204	374.81	6 – 15W LED Bulb	*Sufficient*
Room 205	322.38	6 – 15W LED Bulb	*Sufficient*
Room 207	381	6 – 15W LED Bulb	*Sufficient*
Room 208	344.4	6 – 15W LED Bulb	*Sufficient*
Room 209	347.11	6 – 15W LED Bulb	*Sufficient*
Room 210	320.05	6 – 15W LED Bulb	*Sufficient*
Room 211	312.6	6 – 15W LED Bulb	*Sufficient*
Room 212	332.9	6 – 15W LED Bulb	*Sufficient*
Room 302	331.97	6 – 15W LED Bulb	*Sufficient*
Room 303	365.2	6 – 15W LED Bulb	*Sufficient*
Room 304	300.56	6 – 15W LED Bulb	*Sufficient*
Room 305	308.87	6 – 15W LED Bulb	*Sufficient*
Room 306	315.2	6 – 15W LED Bulb	*Sufficient*
Total Estimated			30 rooms

This table shows the number of rooms and their corresponding lighting fixture installed as well as the measured illuminance in SHS and LRC building. It shows that all the classrooms in these two buildings are in accordance to the standard mandated by the DOE.

Table 12. Illumination Level of JHS

JHS Building			
Location/Area	**Average illuminance (lux)**	**Installed lamps (types/watts)**	**Remarks**
Computer Laboratory	311.23	3 – 17W LED Bulb, 1	*Sufficient*
Faculty	302.02	CFL	*Sufficient*
Clinic	315.87	4 – 17W LED Bulb	*Sufficient*
Room 105	178.3	1 – 18W FL (T8), 2 CFL	*Insufficient*
Room 106	169.03	4 – 15W LED Bulb	*Insufficient*
Room 107	163.8	4 – 15W LED Bulb	*Insufficient*
Room 108	174.2	4 – 15W LED Bulb	*Insufficient*
Room 109	158.87	4 – 15W LED Bulb	*Insufficient*
Room 110	152.1	4 – 15W LED Bulb	*Insufficient*
Room 111	179.04	4 – 15W LED Bulb	*Insufficient*
Room 112	181.10	4 – 15W LED Bulb	*Insufficient*
Room 113	183.23	4 – 15W LED Bulb	*Insufficient*
Room 114	186.7	4 – 15W LED Bulb	*Insufficient*

Room 115	194.5	4 – 15W LED Bulb	*Insufficient*
Room 201	213.02	4 – 15W LED Bulb	*Insufficient*
Room 202	224.7	4 – 15W LED Bulb	*Insufficient*
Room 203	219.7	4 – 15W LED Bulb	*Insufficient*
Room 204	234.13	4 – 15W LED Bulb	*Insufficient*
Room 205	229.09	4 – 15W LED Bulb	*Insufficient*
Room 206	235.78	4 – 15W LED Bulb	*Insufficient*
Room 207	239.8	4 – 15W LED Bulb	*Insufficient*
Room 208	242.1	4 – 15W LED Bulb	*Insufficient*
Room 209	253.06	4 – 15W LED Bulb	*Insufficient*
Room 210	247.6	4 – 15W LED Bulb	*Insufficient*
Room 211	268.2	4 – 15W LED Bulb	*Insufficient*
Room 212	278.05	4 – 15W LED Bulb	*Insufficient*
Room 213	269.13	4 – 15W LED Bulb	*Insufficient*
Room 214	271.6	4 – 15W LED Bulb	*Insufficient*
Room 215	277.14	4 – 15W LED Bulb	*Insufficient*
		4 – 15W LED Bulb	
Total Estimated			29 rooms

This table shows the number of rooms and their corresponding lighting fixture installed as well as the measured illuminance in JHS building. It shows that within the building, only three rooms are in accordance to the standard of DOE.

Table 13. Illumination level of Grade School

Grade School Building			
Location/Area	**Average illuminance (lux)**	**Installed lamps (types/watts)**	**Remarks**
MIS	301.13	4 – 17W LED Bulb	*Sufficient*
Library	310.62	4 – 17W LED Bulb	*Sufficient*
Server Room	184.09	2 – 15W LED Bulb	*Insufficient*
Room 104	67.9	3 – 15W LED Bulb, 1	*Insufficient*
Room 105	72.72	CFL	*Insufficient*
Room 106	81.33	4 – 15W LED Bulb	*Insufficient*
Room 110	100.48	4 – 15W LED Bulb	*Insufficient*
Room 111	113.65	4 – 15W LED Bulb	*Insufficient*
Room 112	84.7	4 – 15W LED Bulb	*Insufficient*
Room 113	194.20	4 – 15W LED Bulb	*Insufficient*
Room 203	278.53	4 – 15W LED Bulb	*Insufficient*

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Room 204	192.2	4 – 17W LED Bulb	*Insufficient*
Room 205	141.01	4 – 15W LED Bulb	*Insufficient*
Room 206	173.16	4 – 15W LED Bulb	*Insufficient*
Room 207	188.3	4 – 15W LED Bulb	*Insufficient*
Room 208	170.94	4 – 15W LED Bulb	*Insufficient*
Room 209	114.4	4 – 15W LED Bulb	*Insufficient*
Room 210	135.9	4 – 15W LED Bulb	*Insufficient*
Room 211	197.23	4 – 15W LED Bulb	*Insufficient*
Room 213	190.77	4 – 15W LED Bulb 3 – 15W LED Bulb, 1 CFL	*Insufficient*
Total Estimated			20 Rooms

This table shows the number of rooms and their corresponding lighting fixture installed as well as the measured illuminance in GS building. It shows that the building is having only two rooms that is in accordance to the standard of DOE.

Table 14. Illumination Level of Chapel

Chapel			
Location/Area	**Average illuminance (lux)**	**Installed lamps (types/watts)**	**Remarks**
Chapel	303.28	12 – 17W LED Bulb	*Sufficient*

This table shows the corresponding lighting fixture installed as well as the measured illuminance of the school chapel. It shown that its lighting level is in accordance to the standard of DOE.

Table 15. Illumination level of Canteen

Canteen			
Location/Area	**Average illuminance (lux)**	**Installed lamps (types/watts)**	**Remarks**
Canteen	311.3	17 – 17W LED Bulb	*Sufficient*

This table shows the corresponding lighting fixture installed as well as the measured illuminance of the school canteen. It shown that its lighting level is in accordance to the standard of DOE.

Table 16. Summary of Lighting Fixtures

Location/Area	**Installed lamps (types/watts)**
College	64-15W
SHS and LRC	112-15W LED bulb,

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	8-17W LED bulb
Junior High School	115-15W LED bulb, 1-18W FL (T8), 3-15W CFL
Grade School	64-15W LED bulb, 12-17W LED bulb, 2-15W CFL
Church	12-17W, 2 spotlight
Canteen	17-15W
Corridors	237-15W LED bulb, 25-18W FL (T8), 2-15W CFL

The summary of installed lamps in the rooms of the five main buildings at Holy Cross College is shown in this table. The lamps used are commonly 15W and 17W building room.

7.4. Room Temperatures

Per the researchers' observation, the temperature in all rooms is set in High Cool at all times which is equivalent to 16 degrees Celsius. As mandated by the Department of Energy, room temperatures of the building must not fall below 24 degrees Celsius whilst taking into account both user comfort and energy saving consumption practices. The room temperatures are measured by monitoring the actual power consumption at peak demand with the use of digital power clamp meter. Also, air-condition settings are individually check per rooms.

Table 17. Summary of Room temperatures

Location/Area	**Rated Power (HP)**	**ACUs Power (kW)**	**No. of ACUs**	**Number of operation (hrs) /days**	**Set point (°C)**	**Total Power (kW)**	**Energy cost/month**	**Remarks**
Grade School	1	0.71	9	8	16°	6.39	₱ 9,615.67	*Efficient*
	1.5	1.10	13	8	16°	14.30	₱ 21,518.64	*Efficient*
	2	1.42	15	8	16°	21.30	₱ 32,052.24	*Efficient*
Junior HS	1.5	1.10	5	8	16°	5.50	₱ 8,276.40	*Efficient*
	2	1.42	27	8	16°	38.34	₱ 57,694.03	*Efficient*
Senior HS	1.5	1.10	7	8	16°	7.70	₱ 9,079.84	*Efficient*
	2	1.42	27	8	16°	38.34	₱ 45,210.53	*Efficient*
LRC	1.5	1.10	8	8	16°	8.80	₱ 10,376.96	*Efficient*
	2	1.42	23	8	16°	32.66	₱ 38,512.67	*Efficient*
College	2	1.42	4	8	16°	5.68	₱ 8,547.26	*Efficient*
Total estimated			138			179.01	₱ 240,884.24	

Table 17 shows that the total number of air-conditioning units in Holy Cross College is 138, as well as the total billings in peso of the institution in a span of one month. Celsius considering the daily operating hours (from 7:20

A.M. – 3:20 P.M per the information provided by the HCC faculty). Energy cost is computed in line with the average rate of PELCO I (Low Voltage) – ₱ 8.55 per kWh for Grade School, Junior HS, and College while ₱ 6.70 per kWh (High voltage) for LRC and Senior HS. The ACUs power were measured based on their rated power at peak demand in one hour timeframe when the air-conditioning units setting is 16 degrees. It shows that 1 Hp consumes 0.71 kW, followed by 1.5 Hp at 1.10 kW, and 2 Hp at 1.42 kW.

8. Recommendations

Based on the findings, the researchers formulated a comprehensive set of recommendations aimed at optimizing energy efficiency and reducing consumption at Holy Cross College. These recommendations are designed to address the identified inefficiencies and leverage energy-saving opportunities to achieve significant cost savings.

Table 18. The References Used by the Researchers as a Basis of their Recommendations

System	Feature	References
Lighting	Sufficient Lighting	In an Ergonomic context, sufficient lighting can lessen the possibility of acquiring eye fatigue or headaches [20]. Having a sufficient lighting will make sure that the building's lighting system is within such standards.
	LED Lights Utilization	LED lights are known to be more environmentally friendly as well as energy efficient [21]. Usually, an LED bulb emits 80% of its energy to convert into light and the remaining 20% is converted into heat. This is evidently more efficient than those of incandescent bulbs. Aside from that, a standard bulb of the latter's type can only last for about 750 hours while an LED bulb can last 100,000 hours maximum.
	Well-maintained Lights	WAC Lighting [22] stated that well-maintained lights tend to work better than those who are unclean. If the lights are clean, they will shine brighter, thus, there will be no need to turn other lights just to see things. If they are not being maintained, build-up of dust could lead to mechanical issues, urging the users to buy a new one, resulting to a non-efficient way of optimizing the use of lights.
	Labelled Light Switches	Light switch reminders such as labels or notices can significantly help in reducing light usage, thus, reducing costs brought by such, as well [23]. Such labels could be put into switch plates in a form of reminder stickers.
	Switch Off Policy Implementation	Dambrosio [24] claimed that turning off lights, aside from switching to LED light bulbs, can help in decreasing the energy consumption of an establishment.

Equipment	Properly Working Equipment	Investing to equipment and tools that are properly working is a smart, strategic way to ensure that they will work as designed in the long run [25]. Such investment contributes to the safety and productivity of the user as well as efficiency of the available resources, making sure that time and effort will be saved.
	Energy-saving Equipment	The use of energy-efficient products might cost more than those readily available in the market that does not offer such feature, but surely, they save you more money in the long run [26].
	Energy Conservation Policy	Energy conservation policy among equipment and machineries must be strictly re-enforced because according to Techmint [27], about 43% to 46% of the world energy consumption is due to the motor and motor drivers of such. This rate could be reduced if people were made aware about proper energy conservation policy among equipment and machineries usage, and if they are followed.
	Well-maintained Equipment	According to Atlas [28] if a building's equipment is properly maintained, its performance cost could be reduced. Aside from that, this provides assurance that the equipment is properly and efficiently working. Operations and maintenance practices must also be thoroughly planned as these can be one of the most cost-efficient way to ensure that the equipment will last long [29].
Employee	Energy Utilization Reminders	The best way to save energy and money caused by inefficient energy utilization in a workplace is to encourage everyone to join in in energy-saving practices [30]. The implementation of both positive and motivating energy campaigns can definitely help the top management ensure that all their energy management goals are being met.
	Clearly Labelled Equipment for Efficient Energy Use	Labels on equipment shows their energy consumption in kWh. It is deemed to be more energy efficient if it consumes less kWh [31]. With that, if such equipment are labelled, individuals will be aware of how much it would cost if they are to be turned on for a long time even if they are not in use. Labels, then, will serve as a reminder that such equipment are only encouraged to be opened only when necessary. Aside from that, Republic Act No. 1128 encourages manufacturers to attach an energy label on their products in accordance to the Philippine Energy Standards and Labelling Program [32].

Air-conditioning	Proper Air Ventilation	Air ventilation plays a very crucial role in reducing mould growth that could lead to structural damages [33]. Structural damages mean an immediate attention is needed, and to provide such, costs arise. Mold growth also means that there is a threat to the health of those exposed to it. Hence, having a proper air ventilation can prevent mould growth, simultaneously, health hazards and potential structural damages are also avoided.
	Temperature of 24˚C	HT Correspondent [34] emphasized that the lower the temperature is running in an air-conditioning unit, the more electricity it consumes, the higher the costs. With that, for instance, if the default temperature is either 20˚C or 21˚C, and increase it to 24˚C, there will be an electricity saving of 18 to 24%. In some countries like India, every ACU that they sell mandates a default temperature of 24˚C as part of their country's new energy performance standards.
	Well-maintained Air-conditioning Units	Proper maintenance of ACUs is one of the practices on how to be energy-efficient and incur low-cost utility bills [35]. If an ACU is well-maintained, there will also be less repair cost. Aside from that, Hydrokleen [36] stated that an ACU that is dirty means that it will consume more power wherein it is required to work harder, having an increment of 5-10% electricity than usual.
Building Envelope	Properly Sealed Rooms	Structures can save about 15% of utility costs brought by extreme temperatures – heating and cooling – through properly sealing such [37]. The ways to do the latter can be through adding insulation.
	Efficient Spatial Use	Space layout of a building can surely affect its energy efficiency, i.e., heating, cooling, lighting, and ventilation demands [38]. The most affected factor is the lighting wherein if the layout maximizes the natural light penetration, the use of artificial light during the day could be reduced.
	Minimized Solar Gain	Zola [39] said that if the solar gain is being controlled, an individual's dependency to air-conditioning units or other cooling system can be reduced, leading to lower utility costs.
	Well-maintained Windows	Pella Corporation [40] stated that having well-maintained windows can protect energy efficiency. If there is a build-up of dirt on a window, the heating efficiency of a house or building decreases, i.e., the dirtier the windows, the more heat from the sun comes inside. If the latter happens, individuals tend to rely on an even cooler cooling system.

Table 18 presents all the information that served as the references of the researchers in providing energy efficiency measures for Holy Cross College. This was used to make sure that all data that will be shown in the further section of this chapter were founded with basis from dissertations that are readily available and are accessible to the public.

Table 19. The EEMS for College Building

College Building			
System	**Recommendation**	**Investment Cost**	**Level of Savings**
Lighting System	Replace the 25W FL (T8) installed in corridor to 15W LED Bulb for energy saving.	Low Cost	Low
Lighting System	Set a time to regularly maintain and clean the lights being used by the building.	No Cost	Low
Lighting System	Put labels or notices on the switch plates to lessen the unnecessary use of lights.	No Cost	Medium
Lighting System	Inform the concerned individuals to turn off the lights when not in use especially during vacant hours.	No Cost	Medium
Equipment	Schedule a regular maintenance of cleaning the building's equipment such as the televisions and electric fans.	No Cost	Low
Equipment	Install a quick instruction or reminder on how to use the equipment of the building to make sure that they are being operated efficiently.	No Cost	Medium
Employee	Inform concerned individuals to turn off equipment when not in use. Good way is to make sure that they are labelled or provided with written notice about reminding such.	No Cost	Medium
Air-conditioning	Make it a habit that the temperature of the Air-conditioning units is set at 24˚C.	No Cost	Low
Air-conditioning	Put a maintenance card form that could serve as a detailed record of tracking maintenance activities.	No Cost	Low
Building Envelope	Insulate between heated or cooled spaces. The usage of black out curtains is highly encouraged. Other materials that can be utilized is through weather sealing strips, window film, or thermal film.	Low Cost	Low

Table 19 shows all the energy efficiency measures recommended by the researchers for the college building.

Table 20. The EEMS for SHS and LRC Building

SHS and LRC Building			
System	**Recommendation**	**Investment Cost**	**Level of Savings**
Lighting System	Put labels or notices on the switch plates to lessen the unnecessary use of lights.	No Cost	Medium
Lighting System	Inform the concerned individuals to turn off the lights when not in use especially during vacant hours.	No Cost	Medium
Employee	Inform concerned individuals to turn off equipment when not in use. Good way is to make sure that they are labelled or provided with written notice about reminding such.	No Cost	Medium
Air-conditioning	Make it a habit that the temperature of the Air-conditioning units is set at 24˚C.	No Cost	Low
Air-conditioning	Put a maintenance card form that could serve as a detailed record of tracking maintenance activities.	No Cost	Low
Building Envelope	Insulate between heated or cooled spaces. The usage of black out curtains is highly encouraged. Other materials that can be utilized is through weather sealing strips, window film, or thermal film.	Low Cost	Low
Building Envelope	Fix the insulation for all the Air-condition units that have gap between the wall and the window space. The usage of insulation foam is encouraged.	Low Cost	Low
Building Envelope	Removal of unnecessary items that block the doorway is highly encouraged, as well.	No Cost	Low
Building Envelope	Remind all the concerned individuals to make sure that all the doors of enclosed spaces such as classrooms are closed. Installation of automatic door closer is also another way.	Low Cost	Medium

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Table 20 shows all the energy efficiency measures recommended by the researchers for the SHS and LRC building.

Table 21. The EEMS for JHS

JHS Building			
System	**Recommendation**	**Investment Cost**	**Level of Savings**
Lighting System	Set a time to regularly maintain and clean the lights being used by the building.	No Cost	Low
Lighting System	Put labels or notices on the switch plates to lessen the unnecessary use of lights.	No Cost	Medium
Lighting System	Inform the concerned individuals to turn off the lights when not in use especially during vacant hours.	No Cost	Medium
Lighting System	Replace the old LED bulbs (end of life) to new LED bulbs	Low Cost	None
Equipment	Schedule a regular maintenance of cleaning the building's equipment such as the televisions and electric fans.	No Cost	Low
Equipment	Install a quick instruction or reminder on how to use the equipment of the building to make sure that they are being operated efficiently.	No Cost	Medium
Equipment	Remove all the non-working equipment, and if they are highly necessary, replace them immediately.	Low Cost	Low
Employee	Inform concerned individuals to turn off equipment when not in use. Good way is to make sure that they are labelled or provided with written notice about reminding such.	No Cost	Medium
Air-conditioning	Make it a habit that the temperature of the Air-conditioning units is set at 24˚C.	No Cost	Low
Air-conditioning	Put a maintenance card form that could serve as a detailed record of tracking maintenance activities.	No Cost	Low
Building Envelope	Insulate between heated or cooled spaces. The usage of black out curtains is highly encouraged. Other materials that can be utilized is through weather sealing strips, window film, or thermal film.	Low Cost	Low

Building Envelope	Fix the insulation for all the Air-condition units that have gap between the wall and the window space. The usage of insulation foam is encouraged.	Low Cost	Low
Building Envelope	Removal of unnecessary items that block the doorway is highly encouraged, as well.	No Cost	Low
Building Envelope	Remind all the concerned individuals to make sure that all the doors of enclosed spaces such as classrooms are closed. Installation of automatic door closer is also another way.	Low Cost	Medium

Table 21 shows all the energy efficiency measures recommended by the researchers for the JHS building.

Table 22. The EEMS for Grade School Building

Grade School Building			
System	**Recommendation**	**Investment Cost**	**Level of Savings**
Lighting System	Replace the old 15W LED bulbs into new 15W LED bulbs.	Low Cost	None
Lighting System	Set a time to regularly maintain and clean the lights being used by the building	No Cost	Low
Lighting System	Put labels or notices on the switch plates to lessen the unnecessary use of lights.	No Cost	Medium
Lighting System	Inform the concerned individuals to turn off the lights when not in use especially during vacant hours.	No Cost	Medium
Lighting System	Replace the old LED bulbs (end of life) to new LED bulbs	Low Cost	None
Equipment	Schedule a regular maintenance of cleaning the building's equipment such as the televisions and electric fans.	No Cost	Low
Equipment	Install a quick instruction or reminder on how to use the equipment of the building to make sure that they are being operated efficiently.	No Cost	Medium
Equipment	Remove all the non-working equipment, and if they are highly necessary, replace them immediately.	Low Cost	Low

Air-conditioning	Make it a habit that the temperature of the Air-conditioning units is set at 24˚C	No Cost	Low
Air-conditioning	Put a maintenance card form that could serve as a detailed record of tracking maintenance activities.	No Cost	Low
Building Envelope	Insulate between heated or cooled spaces. The usage of black out curtains is highly encouraged. Other materials that can be utilized is through weather sealing strips, window film, or thermal film.	Low Cost	Low
Building Envelope	Fix the insulation for all the Air-condition units that have gap between the wall and the window space. The usage of insulation foam is encouraged.	Low Cost	Low
Building Envelope	Removal of unnecessary items that block the doorway is highly encouraged, as well.	No Cost	Low
Building Envelope	Remind all the concerned individuals to make sure that all the doors of enclosed spaces such as classrooms are closed. Installation of automatic door closer is also another way.	Low Cost	Medium

Table 22 shows all the energy efficiency measures recommended by the researchers for the Elementary building.

Table 23. The EEMS for Chapel

Chapel			
System	**Recommendation**	**Investment Cost**	**Level of Savings**
Equipment	Schedule a regular maintenance of cleaning the building's equipment such as the televisions and electric fans.	No Cost	Low
Equipment	Install a quick instruction or reminder on how to use the equipment of the building to make sure that they are being operated efficiently.	No Cost	Medium
Equipment	Remove all the non-working equipment, and if they are highly necessary, replace them immediately.	Low Cost	Low

Air-conditioning	Make it a habit that the temperature of the Air-conditioning units is set at 24˚C.	No Cost	Low
Air-conditioning	Put a maintenance card form that could serve as a detailed record of tracking maintenance activities.	No Cost	Low
Building Envelope	Insulate between heated or cooled spaces. The usage of black out curtains is highly encouraged. Other materials that can be utilized is through weather sealing strips, window film, or thermal film.	Low Cost	Low
Building Envelope	Fix the insulation for all the Air-condition units that have gap between the wall and the window space. The usage of insulation foam is encouraged.	Low Cost	Low
Building Envelope	Removal of unnecessary items that block the doorway is highly encouraged, as well.	No Cost	Low
Building Envelope	Remind all the concerned individuals to make sure that all the doors of enclosed spaces such as classrooms are closed. Installation of automatic door closer is also another way.	Low Cost	Medium

Table 23 shows all the energy efficiency measures recommended by the researchers for the Chapel of HCC.

Table 24. The EEMS for Canteen

Canteen			
System	**Recommendation**	**Investment Cost**	**Level of Savings**
Lighting System	Inform the concerned individuals to turn off the lights when not in use especially during vacant hours.	No Cost	Medium
Equipment	Schedule a regular maintenance of cleaning the building's equipment such as the televisions and electric fans.	No Cost	Low
Equipment	Install a quick instruction or reminder on how to use the equipment of the building to make sure that they are being operated efficiently.	No Cost	Medium
Equipment	Remove all the non-working equipment, and if they are highly necessary, replace them immediately.	Low Cost	Low

Table 24 shows all the energy efficiency measures recommended by the researchers for the Canteen of HCC.

Table 25. Recommended Air-conditioning System Setting

Location/Area	**Rated Power (HP)**	**ACUs Power (kW)**	**No. of ACUs**	**Number of operation (hrs) /days**	**Set point (°C)**	**Total Power (kW)**	**Energy cost/month**	**Remarks**
Grade School	1	0.40	9	8	24°	3.60	₱ 5,417.28	*Efficient*
	1.5	0.54	13	8	24°	7.02	₱ 10,563.70	*Efficient*
	2	0.75	15	8	24°	11.25	₱ 16,929	*Efficient*
Junior HS	1.5	0.54	5	8	24°	2.70	₱ 4,062.96	*Efficient*
	2	0.75	27	8	24°	20.25	₱ 30,472.20	*Efficient*
Senior HS	1.5	0.54	7	8	24°	3.78	₱ 4,457.38	*Efficient*
	2	0.75	27	8	24°	20.25	₱ 23,878.80	*Efficient*
LRC	1.5	0.54	8	8	24°	4.32	₱ 5,094.14	*Efficient*
	2	0.75	23	8	24°	17.25	₱ 20,341.20	*Efficient*
College	2	0.75	4	8	24°	3.0	₱ 4,514.40	*Efficient*
Total estimated			138			93.42	₱ 125,731.06	
Total Savings			₱ 115,153.18					

Table 25 shows that the possible daily energy savings and cost savings – 15063.84 kWh worth ₱ 115,153.18 monthly – when air-conditioning units are set to 24 degrees instead of 16 degrees Celsius during the daily operation of Holy Cross College per month. The measured power in one hour timeframe is 0.40 kW (1HP), 0.54 kW (1.5HP) and 0.75 (2HP).

Table 26. Recommended Replacement of Lighting Fixture

Options/Parameters	**Existing 18W fluorescent fixture with 26W ballast**	**Replace fluorescent fixture with 15W LED Bulb**
No. of Lamps Considered	26	26
Total Lamp & ballast wattage (W)	1144	390
Annual Energy Consumption at 8 hrs/day for 198 days /yr (kWh)	1812.10	617.76
Annual Energy Cost @ 8.55/kWh (Php)	₱ 15,493.46	₱ 5,281.85

(Avg. Low Voltage rate)			
Annual Monetary Savings (Php)	**₱ 10,211.61**		
Investment Cost (Php)			
26 – 15W LED Bulb (Ecolum) at Php 125	₱ 3,250	**Return on Investment**	214.2%
Total Investment Cost (Php)	**₱ 3,250**	**Payback Period (years)**	0.32

This table shows that the payback period is approximately 3 months and 25 days to recover the initial investment in lighting fixtures with a 214.2% of return on investment. This indicates a very high return on the investment made by replacing the lighting fixtures with LED bulbs.

9. Conclusion

This study aimed to conduct a Walk-Through Analysis on Holy Cross College, a Type 1 Designated Establishment. Specifically, it evaluated the energy consumption practices of the institution when it comes to their lighting system, equipment usage, employee energy conservation practices, air-conditioning units, and building envelope. Aside from the result of the qualitative observations of the researchers, they also conducted a quantitative energy conservation assessment brought by the illumination and cooling systems of HCC. It was found out that there are energy saving opportunities that could be utilized by the institution to reduce their energy consumption and save utility costs.

The results of the analysis showed that the ACUs of every building is the system where energy is being wasted or used inefficiently. Furthermore, upon analysis, it was observed that the building that has the most outstanding performance in complying with energy efficiency measures is the SHS and LRC Building, and in contrary, the buildings that do not conform to such is the JHS and elementary building. Aside from that, upon the evaluation of the lighting levels of each of the building of HCC, it was found out that there are buildings that have insufficient lighting system. It was also found out that with regards to the room temperature of HCC, the total estimated monthly cost of the current usage of their ACUs is amounting to ₱ 242,279.29.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

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