Comprehending the energy consumption pattern of occupancy of an academic structure

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Abstract. The energy consumption in the Covenant University campus community has been investigated. A tour round the structure was undertaken to ascertain the consumption culture and to identify lapses on energy usage. An energy consumption pattern roadmap is necessary in accounting on how energy is used up and decision on utilizing redundant energy. This is the focus of the research work to provide an insight to the rate of energy utility. The electrical energy demands are going to get increased in future. Measures are to be taken to minimize use of electricity everywhere so as to reduce undesirable financial load. It is advisable to carry out energy assessment in the campus from time to time, to achieve more effective and proficient use of energy.

Keywords: energy consumption; energy utility; redundant energy; energy assessment.

1.0 Introduction

Energy conservation is an intrinsic notion in building professionals that takes cognizance of the material make-up would-be structure that will achieve minimal energy consumption. Specialists also seek to solve the problem of redundant energy caused by human activity in operating electrical devices. Reducing unutilized energy is a crucial focus of every establishment which is similar to reducing green gas energy emission so that energy consumption cost is reduced [1-2]. Energy efficiency is indeed a global concern [3-4]. It is revealing to state that when energy is saved, carbon emission concern is reduced [5]. Human is actually at the consumption end of the energy system and a contributor to the rise in CO₂ level [6-8]. It is important therefore to investigate her activities in solving energy consumption [9]. It is believed that if each person is in the practice of consciously turning of switch whose energy is not needed, more energy will be saved and more available in the Nation [10-12]. This can be achieved especially at work place if there is awareness through motivation to do things rightly and taking personal responsibility [13-15]. This notion is validated when an experiment was conducted on use of offices by employee called the “experimental group” and the other group not monitored called the “control group” seem to consume energy than the former that is aware that it is under check [16-17]. The method of feedback in campaigning for energy conservation to checkmate energy consumption proved successful [18-20]. A separate research group pointed out that business organizations contribute to redundant energy use and global warming, but seems to be ignored in energy behavior research [21-22]. Building structures are the focal customers of energy especially when incorporated with refrigeration and air conditioning system for thermal satisfaction [23]. An efficient strategy will be required to reduce space equipment energy demand [24-25]. An approach to optimize energy conservation in building equipment such as Heating Ventilation and Air Conditioning (HVAC), an evolutionary programming in resetting the devices was adopted which led to 7% savings without extra cost [26-28]. A parallel method of programming indoor consumption of a building in Greece and Saudi Arabia proved to be one of the solutions to energy utilization [29-32]. The objective of this study is to identify areas of energy wastage and estimate energy saving potential in the university facilities; recommend economical methods to advance the proficiency of energy use in these facilities; evaluate application costs and payback periods for each exploit; and record important data made through these events.
2.0 Energy evaluation and management

Energy consumption represents an important part of operative cost in plant, machinery and administrative organization. Hence, energy evaluation is required to possibly reduce its significant consumption [33]. It is perceived that there will be shortage of energy in the near future which necessitates energy evaluation to minimize underutilization [34]. A solar liquid desiccant system was designed as a replacement to vapour compression cycle (VCC) to remove humidity from an office. This achieved 10% reduction in relative humidity and nearly 8 years payback period when compared to VCC [35]. Natural convection proves a reliable solution to energy consumption and a healthy thermal comfort [36].

3.0 Method of study

The method of study involved observations, recording and data collection and analysis for each of the selected facilities in Covenant University campus. A realistic assessment of sustainability problems and potentials for improvement of the campus facilities was performed. The facilities selected for this study are Covenant University Guest House, Cafeteria 1, and Cafeteria 2.

4.0 Results and discussion

4.1 Energy Usage pattern

The analysis of Covenant University’s electricity bill yielded consumption data for the entire Covenant University campus on a monthly basis. This allowed for evaluation of electricity consumption trends throughout the school year.

4.2 Monthly Analysis

Through the detailed analysis of Covenant University’s electricity bill, a general electricity consumption data was obtained, and a trend in its use, established. Table 1 below shows the monthly energy consumption of Covenant University from January 1, 2014 to December 31, 2014. Unit Cost of Electricity = 31.64 Naira/kWh

| Month    | Energy Consumption (kWh) | Monthly Cost (Naira) |
|----------|--------------------------|----------------------|
| January  | 488700                   | 15,462,468           |
| February | 569900                   | 18,031,636           |
| March    | 680300                   | 21,524,692           |
| April    | 749800                   | 23,723,672           |
| May      | 462900                   | 14,646,156           |
| June     | 367900                   | 11,640,356           |
| July     | 322500                   | 10,203,900           |
| August   | 533200                   | 16,870,448           |
| September| 662100                   | 20,948,844           |
| October  | 654500                   | 20,708,380           |
| November | 716600                   | 22,673,224           |
| December | 461000                   | 14,586,040           |
| Total    | 6,669,400                | 211,019,816          |

Table 1 above indicates that 211,019,816 Naira was the total electricity cost in 2014. If above 5% of this money can be kept, valued at 10,000,000 Naira, this will cater for the cost of over twenty student’s whole basic stipend in a year.
In Figure 1, in the month of January where there are less sunshine hours and more electrical gadgets turned on, consumption was about 488.7 MWh, while August of similar year had a record well over 533.2 MWh. The consumption in the months of January to April is found to increase steadily. The consumption in April is seen to be the highest with a consumption of 749.8 MWh, because this is when the exams take place on the school calendar and all students are present on campus. Generally, students use equipment more during this period to help prepare for exams. More computers are in use for longer period of time, lighting systems are used more often, especially during night hours. The initially low consumption can be explained similarly, that not all students resume from the beginning of the semester due to registration issues or incomplete payment of fees. This means fewer population and activities and therefore lesser consumption of electricity. After April, the consumption falls gradually during the vacation period, where people and activities are relatively fewer than other periods of the school year. On the chart, it can be seen that July has the lowest value with a consumption of 322.5 MWh. It then rises again in August after the vacation period when students resume again for the next semester, and electrical appliance, device and equipment use spring up again, thus raising the monthly energy consumption. November marks the end of this semester on the school calendar and has the highest consumption during this semester or period. The energy consumed is 716.6 MWh. Exams also occurs at this period which is responsible for the higher consumption of electricity as explained previously. The semester break occurs in December where the consumption falls again to a consumption value of 416 MWh.

4.3 Tuition Week versus Semester Break
A week during normal school teaching session is compared to a week during the semester break to draw out reasonable conclusion in the variation of electricity usage as considered in Figure 2. The period from March 23, 2015 to March 29, 2015 was chosen as the tuition week, and the week during the semester break was from December 22, 2014 to December 28, 2014.
Advanced populace and extra events add to greater electricity consumption in Covenant University school community. Consumption during the tuition week is higher than the week of the semester break because there is lesser use of appliances, air conditioners, lighting and other equipment.

4.4 Tuition Weekday versus Tuition Weekend
Seasonal variation in electricity was studied both in class session in weekdays and off period in weekend in figure 3; variations are noticed in the hourly consumption. The consumption methods show several peaks and troughs all through the day.

4.5 Load Management
Load management basically aims to improve system Load Factor. Peak demand is measured every half hour in a month of 72 hours; the highest measurements will be taken as the peak demand. Average demand can be calculated by dividing kWh consumption by the number of hours.

\[
\text{Load Factor} = \frac{\text{Average demand}}{\text{Peak demand}} \tag{1}
\]

From the daily demand curves shown in Figure 3, peak period occurs between 6:00PM and 10:00PM on Sunday, while on Wednesday it occurs between 8:00AM and 5:00PM. The average values of demand in MW
during peak period on Sunday, is 1.288 MW. Whereas the peak demand on Sunday during peak period, is 1.43 MW.

As a result the Load Factor $= \frac{1.288}{1.43} = 0.90$

Also, the average demand on Wednesday is 1.513 MW, and the peak demand on Sunday during peak period, is 1.59 MW.

As a result, the Load Factor $= \frac{1.513}{1.59} = 0.95$

In both cases, there is no maximum demand tariff, and the peak demand is out of peak period.

The recommended light levels for different places is shown in the table below:

| Place                      | Recommended Illumination Level (Lux) |
|----------------------------|--------------------------------------|
| Registration office        | 300                                  |
| Lecture hall               | 300                                  |
| Cafeteria                  | 100                                  |
| Student activity building  | 300                                  |
| Financial office           | 300                                  |
| Library                    | 300                                  |
| Machine Laboratory         | 500                                  |

As seen from table 2, the recommended illumination level for Cafeteria is 100 Lux, but measurement from the lux meter gave a reading of 250 Lux in the halls in both cafeterias. Therefore, there is a prospective for energy saving by replacing incandescent bulbs in the halls in both cafeterias with one that gives about the same intensity as the recommended illumination level.

In Cafeteria 1, there are 18 incandescent bulbs in the main hall which draws a power of 100W. while cafeteria 2 has 29 incandescent bulbs in 4 halls which draws the same power.

The total number of incandescent bulbs in both cafeterias is 47. Assuming there is a one-for-one replacement of the incandescent bulbs with Flourescent Tube that draws 36W, but gives an illumination of 100 Lux. Then:

$\text{Saving Power} = \text{Saving power in each lamp} \times \text{Total number of lamps}$

$= (100 - 36) \times 47 = 3,008 \text{ W}$

Suppose eight hours daily operation in seven days a week during 40 weeks yearly, then: The total annual energy saving $= 3,008 \times 8 \times 7 \times 40 = 6,737,920 \text{ Wh}$.

The annual saving in cost $= 6,737.92 \text{ kWh} \times 31.64 \text{ Naira/kWh} = 213,187.79 \text{ Naira}$

No investment cost is required. Cost could be saved right away after implementation.

4.6 Energy-resourceful lighting systems

Enhancements in the energy efficiency of lighting systems have made available several opportunities to lessen electrical energy usage in buildings. Incandescent lamps are the smallest amount to purchase but costly to control. They are produced by tiny coils of tungsten wire that glows when powered by electricity. They have short lifespan. The common types are standard, tungsten halogen, and reflector lamp. Fluorescents are powered by electric current conducted through mercury and inert gases. It’s used usually indoors and is 4 times as efficient as incandescent bulbs. HID’s (high intensity discharge) bulbs, have the highest lifespan and efficiency. They are commonly used for outdoor and large indoor areas. Examples are mercury vapour, metal halide, and high pressure sodium. They have 75-90% savings when they replace incandescent lamps. Low pressure sodium work like fluorescents, but produce artificial lighting. It renders all colours in tones of yellow and grey. CFLs that is, compact fluorescent lamps are house hold names, and they combine the efficiency of fluorescent lamps with the popularity of incandescent fixtures. They are ¾ times less in wattage compared to incandescent lamps, and save up about 75% of initial lighting energy as shown in table 3. The illumination produced by low power CFL’s and LED lights, is more than or equivalent to the conventional incandescent
lamps, that consumes several times more power for the same illumination. An 18W Compact Fluorescent Lamp provides the same illumination as a 100W incandescent lamp, and lasts for hours.

4.7 Replacement of Large Incandescent Bulbs:
Saving Power = saving power in each lamp × number of lamps

\[
\text{Saving power} = (100 - 15) \times 59 = 5,015 \text{ W}
\]

Suppose eight hours daily operation in five days a week during 40 weeks yearly, then: The total annual energy saving = \(5,015 \times 8 \times 5 \times 40 = 8,024,000\) Wh.

The annual saving in cost = \(8,024 \text{ kWh} \times 31.64 \text{ Naira/kWh} = 253,879.36\) Naira

Investment cost = 100 Naira × 59 = 5900 Naira

Payback period (in years) = Investment cost ÷ Annual energy saving cost

\[
\text{Payback period} = \frac{5900}{8,024} \approx 0.73 \text{ years}
\]

Table 3: Summary of potential saving by replacing incandescent lamps with CFLs

| Measure                  | Power (W) | Number | Total Investment (Naira) | Saving Power (W) | Annual Energy Savings (kWh) | Annual Cost Savings (Naira) |
|--------------------------|-----------|--------|--------------------------|------------------|----------------------------|----------------------------|
| Replacing Small Incandescent Bulb | 60        | 300    | 30000                    | 13,500           | 21,600                     | 683,424.00                  |
| Replacing Medium Incandescent Bulb | 75        | 12     | 1200                    | 720              | 1,152                     | 36,449.28                   |
| Replacing Large Incandescent Bulb | 100       | 59     | 5900                    | 5,015            | 8,024                     | 253,879.36                  |
| Total                    | 371       | 37,100 | 19,235                   | 30,776           | 973,752.64                 |

4.8 Use of electronic ballast for small fluorescent tube (2Ft.):

Power drawn with magnetic ballasts = 54 W

Power with more efficient electronic ballast = 22 W

Saving Power = Saving power in each lamp × Total number of lamps = \((54 - 22) \times 531 = 16,992\) W

Suppose eight hours daily operation in five days a week during 40 weeks yearly, then: The total annual energy saving = \(16,992 \times 8 \times 5 \times 40 = 27,187,200\) Wh

The annual saving in cost = \(27,187.2 \text{ kWh} \times 31.64 \text{ Naira/kWh} = 860,203\) Naira

Investment cost = 200 Naira × 531 = 106,200 Naira

Payback period (in years) = Investment cost ÷ Annual energy saving cost

\[
\text{Payback period} = \frac{106,200}{860,203} \approx 0.12 \text{ year}
\]

4.8.1 Use of electronic ballast for long fluorescent tube (4Ft.):

Power drawn with magnetic ballasts = 100 W

Power with more efficient electronic ballast = 40 W

Saving Power = Saving power in each lamp × Total number of lamps = \((100 - 40) \times 136 = 8,160\) W

Suppose eight hours daily operation in five days a week during 40 weeks yearly, then: The total annual energy saving = \(8,160 \times 8 \times 5 \times 40 = 13,056,000\) Wh

The annual saving in cost = \(13,056 \text{ kWh} \times 31.64 \text{ Naira/kWh} = 413,091.84\) Naira

Investment cost = 200 Naira × 136 = 27,200 Naira
Payback period (in years) = Investment cost ÷ Annual energy saving cost = 27,200 ÷ 413,091.84 = 0.065 year

Table 4: Summary of potential saving by replacing magnetic ballasts with electronics

| Measure                | Power (W) | Number | Total Investment (Naira) | Saving Power (W) | Annual Saving Energy (kWh) | Annual Saving Cost (Naira) |
|------------------------|-----------|--------|--------------------------|------------------|----------------------------|---------------------------|
| Short fluorescent tubes| 54        | 531    | 106,200                  | 16,992           | 27,187.2                   | 860,203                   |
| Long fluorescent tubes | 100       | 136    | 27,200                   | 8,160            | 13,056                     | 413,091.84                |
| Total                  | 667       | 133400 | 25,152                   | 40243.2          | 1,273,294.84               |

In Covenant University Guest House, there are 3 conference halls; Hall A, Hall B and Hall C. So, occupancy sensors may be installed in these halls. As an example, Hall A is observed for one day, and the total time calculated where no one is in the hall despite the lights still turned on, was nearly 3 hours. Hall A and Hall C both contain 10 100W incandescent lamps, while Hall B has 6 75W incandescent lamps. Altogether, 26 lamps are the total number of fixtures. Suppose that 3 hours of the lamps are the dissipated time for each hall daily, and as before suppose 5 days in a week, where there are 40 weeks in the academic year, and then the dissipated energy yearly is:

**Hall A:**
Annual energy dissipated in Hall A = Total Power × Yearly time = 600W × 3 × 5 × 40 = 360,000 Wh
If occupancy sensors are installed in this hall, the saving cost will be: Annual saving cost = 360 kWh × 31.64 Naira / kWh = 11,390.40 Naira

**Hall B:**
Annual energy dissipated in Hall B = Total Power × Yearly time = 720W × 3 × 5 × 40 = 432,000 Wh
If occupancy sensors are installed in this hall, the saving cost will be: Annual saving cost = 432 kWh × 31.64 Naira / kWh = 13,688.48 Naira

**Hall C:**
Annual energy dissipated in Hall C = Total Power × Yearly time = 600W × 3 × 5 × 40 = 360,000 Wh
If occupancy sensors are installed in this hall, the saving cost will be: Annual saving cost = 360 kWh × 31.64 Naira / kWh = 11,390.40 Naira

Total Annual saving cost in A, B, and C = 11,390.40 + 13,688.48 + 11,390.40 = 36,469.28 Naira
Investment cost = Cost of occupancy sensor × Total number of halls
Investment cost = 2000 Naira × 3 = 6000 Naira
Payback period (in years) = Investment cost ÷ Annual energy saving cost = 6000 ÷ 36,469.28 = 0.16 year
Table 5: Summary of potential saving by using occupancy sensors in halls

| Conference Halls | Power (W) | Number | Total Investment (Naira) | Power (W) | Annual Energy Saving (kWh) | Annual Cost Saving (Naira) |
|------------------|-----------|--------|--------------------------|-----------|----------------------------|----------------------------|
| Hall A           | 100       | 6      | 2000                     | 600       | 360                        | 11,390.40                  |
| Hall B           | 60        | 12     | 2000                     | 720       | 432                        | 13,688.48                  |
| Hall C           | 100       | 6      | 2000                     | 600       | 360                        | 11,390.40                  |
| Total            | 26        | 6,000  | 1,920                    | 1,152     |                            | 36,469.28                  |

4.8.2 Energy savings from daylighting controls

Cafeteria 1 design is a means of reducing dependency light bulbs by using daylight controls. As seen in the picture above, the lights are turned off because of the sufficient amount of light coming in through the windows. This generally occurs from early in the morning until about 5:30PM where the amount of light coming in is reduced, and light bulbs are then turned on to make up for the insufficient illumination.

![Figure 4: Use of daylight control in Cafeteria 1](image)

By proper design, cafeteria 1 and cafeteria 2 can make use of daylighting controls effectively. Cafeteria 1 has just one main hall, while cafeteria 2 has three halls, namely: Hall 1, Hall 2, Hall 3, and Staff Hall. Suppose six hours daily operation in five days a week during 40 weeks yearly, then the dissipated energy yearly is: Annual energy dissipated in main hall without daylighting controls = Total Power × Yearly time = 1800 W × 6 × 5 × 40 = 2,160,000 Wh

If daylighting controls are used in this hall, the saving cost will be: Annual saving cost = 2,160 kWh × 31.64 Naira / kWh = 68,342.4 Naira

Cafeteria 2

Annual energy dissipated in Hall 1 without daylighting controls, Annual energy dissipated = Total Power × Yearly time = 900 W × 6 × 5 × 40 = 1,080,000 Wh

If daylighting controls are used in this hall, the saving cost will be: Annual saving cost = 1,080 kWh × 31.64 Naira / kWh = 34,171.2 Naira

Annual energy dissipated in Hall 2 without daylighting controls, Annual energy dissipated
If daylighting controls are used in this hall, the saving cost will be: Annual saving cost = 1,200 kWh × 31.64 Naira / kWh = 37,968 Naira

Annual energy dissipated in Hall 3 without daylighting controls, Annual energy dissipated = Total Power × Yearly time = 1000W × 6 × 5 ×40 = 1,200,000 Wh

If daylighting controls are used in this hall, the saving cost will be: Annual saving cost = 1,200 kWh × 31.64 Naira / kWh = 37,968 Naira

Annual energy dissipated in Staff Hall without daylighting controls, Annual energy dissipated = Total Power × Yearly time = 500W × 6 × 5 ×40 = 600,000 Wh

If daylighting controls are used in this hall, the saving cost will be: Annual saving cost = 600 kWh × 31.64 Naira / kWh = 18,984 Naira

Total Annual saving cost in four Halls = 68,342.4 + 34,171.2 + 37,968 + 37,968 + 18,984 = 197,433.6 Naira

No investment cost is required. Cost could be saved right away after implementation.

Table 5: Summary of potential saving by using daylighting controls

| Conference Halls | Power (W) | Number | Total Investment (Naira) | Total Power (W) | Annual Energy Dissipated (kWh) | Annual Cost Saving (Naira) |
|-----------------|-----------|--------|-------------------------|----------------|-------------------------------|--------------------------|
| Main Hall       | 100       | 18     | 0                       | 1800           | 2,160                         | 68,342.4                 |
| Hall 1          | 100       | 9      | 0                       | 900            | 1,080                         | 34,171.2                 |
| Hall 2          | 100       | 10     | 0                       | 1000           | 1,200                         | 37,968                   |
| Hall 3          | 100       | 10     | 0                       | 1000           | 1,200                         | 37,968                   |
| Staff Hall      | 100       | 5      | 0                       | 500            | 600                           | 18,984                   |
| Total           | 47        |        | 0                       | 4,700          | 5,640                         | 197,433.6                |

4.8.3 Office Equipment

Over the last decade, the energy used by office equipment has increased significantly and currently accounts for more than 7 percent of the total commercial sector electricity use. Recognizing this problem, the U.S. Environmental Protection Agency (EPA) in cooperation with the U.S. Department of Energy (DOE) has launched the Energy Star Office Program to increase the energy efficiency of commonly used office equipment such as computers, fax machines, printers, and scanners. To help consumers in identifying energy-efficient office equipment, Energy Star labels are provided to indicate the energy saving features of the products. It is estimated that Energy Star-labeled products can save as much as 75 percent of total electricity use depending on the type and the usage pattern of the office equipment. Almost all office equipment manufacturers currently integrate power management features in their products. For instance, computers can enter a low-power “sleep” mode when idled for a specific period of time. Similarly, copiers can go into a low-power mode of only 15–45 watts after 30–90 minutes of activity.

4.8.4 Replacement of motors

Given Covenant University drive towards sustainable development, CRT monitors as inefficient as they are, are no longer used on campus. Instead, they have been replace with the more efficient LCD screens. In the facilities, there are four computers in the whole of cafeteria 1, eleven in cafeteria 2, and five in the Covenant University guest house, all having LCD monitors. Altogether, the total sum equals twenty computers in the three facilities.

4.8.5 Energy consumption in active mode:

Power drawn from screen in active mode = 30 W

Saving Power = Power consumed by each screen × Total number of screens = 30 × 20 = 600 W
Suppose six hours daily operation in five days a week during 40 weeks yearly, then: Annual energy consumption = $600 \times 8 \times 5 \times 40 = 960,000 \text{ Wh} = 960 \text{ kWh}$

The annual saving in cost = $960 \text{ kWh} \times 31.64 \text{ Naira/kWh} = 30,374.4 \text{ Naira}$

**First case: screen saver mode:**

Power drawn from screen in screen saver mode = $25 \text{ W}$

Saving Power = Saving power in screen saver mode $\times$ Total number of screens = $(30 - 25) \times 20 = 100 \text{ W}$

Suppose one hour is saved daily, from putting desktop monitors in screen saver mode when not in use, five days a week during 40 weeks yearly, then:

The total annual energy saving = $100 \times 1 \times 5 \times 40 = 20,000 \text{ Wh}.$

The annual saving in cost = $20 \text{ kWh} \times 31.64 \text{ Naira/kWh} = 632.8 \text{ Naira}$

No Investment cost is required. Cost could be saved immediately.

**Second case: turn-off mode:**

Power drawn from screen in turn off mode = $2 \text{ W}$

Saving Power = Saving power in turn off mode $\times$ Total number of screens = $(30 - 2) \times 20 = 560 \text{ W}$

Suppose thirty minutes is saved daily, from putting desktop monitors in screen saver mode when not in use, five days a week during 40 weeks yearly, then: The total annual energy saving = $560 \times 0.5 \times 5 \times 40 = 56,000\text{ Wh}.$

The annual saving in cost = $56 \text{ kWh} \times 31.64 \text{ Naira/kWh} = 1771.84 \text{ Naira}$

No Investment cost is required. Cost could be saved immediately.

**Table 6: Summary of potential saving in desktop power management**

| Mode            | Power (W) | Total Investment (Naira) | Saving Power (W) | Annual Energy Saving (kWh) | Annual Cost Saving (Naira) |
|-----------------|-----------|--------------------------|------------------|---------------------------|----------------------------|
| Screen Saver    | 25        | 0                        | 100              | 20                        | 632.8                      |
| Turn-off mode   | 2         | 0                        | 560              | 56                        | 1771.84                    |
| **Total**       |           | **0**                    | **660**          | **76**                    | **2404.64**                |

**4.8.6 Thermostat Temperature Regulation**

It was noted in a thermal comfort survey conducted in Malaysia that 80% of occupants were thermally comfortable when the air temperature was below 28.69°C [37]. Besides, the work of [38] reported that every increase of 1°C in thermostat settings may conservatively reduce the energy consumption by 6% after deducting the amount of energy spent on providing a higher air velocity. The work of [39] which studied thermal comfort in a campus classroom stated that further 10% of energy saving was achievable by raising the thermostat set-point to 26°C, which was identified as the neutral temperature for the Taiwanese. Covenant university guest house has the highest number of air conditioners in a facility, and are often switched on from 8 a.m. to 5 p.m. during working days. There is a total of 128 air conditioners in the guest house alone. In order to conserve energy usage and maintain good thermal environment, the return air temperature of the centralized split-unit air conditioner in the guest room was maintained at 26°C with moderate air velocity, which is a 10°C difference as compared to the conventional settings of 16°C, because the people in the tropics generally preferred cooler indoor environment, as reported in some of the earlier studies [40,41].

A typical ceiling mounted air conditioner has an input power of 1,800 – 2,600 W, depending on its model and brand. The air conditioners installed at the guest rooms were Panasonic air-conditioner, and they had an input power of 2000 W. By assuming 6% reduction in input power for each 1°C increase in return air temperature with higher air velocity settings, a 10°C temperature rise would conservatively result in a reduction of 60% in total energy consumption. The daily potential saving in energy consumption concerning the use of air conditioners in
the guest rooms was approximately 20 kWh, with reduction of 12 kWh for each air conditioner. The energy saving achievable by maintaining the return air temperature at 26°C is presented below:

With a set temperature of 16 °C,

\[
\text{Total Power} = 2000\text{W} \times 128 = 256,000\text{ W}
\]

Suppose ten hours daily operation in five days a week during 40 weeks yearly, then:

\[
\text{Annual energy consumption} = 256 \times 10 \times 5 \times 40 = 512,000\text{ kWh}
\]

By assuming 60% reduction in input power by 10 °C temperature rise,

\[
\text{New set temperature} = 26 \degree\text{C}
\]

\[
\text{New input power} = 2000 - 60\% = 2000 - 1200 = 800\text{W} \times 128 = 256,000\text{ W}
\]

\[
\text{Total Power} = 800\text{W} \times 128 = 102,400\text{ W}
\]

Suppose ten hours daily operation in five days a week during 40 weeks yearly, then:

\[
\text{Annual energy consumption} = 102.4 \times 10 \times 5 \times 40 = 204,800\text{ kWh}
\]

Annual energy saving = 512,000 kWh – 204,800 kWh = 307,200 kWh

The annual saving in cost = 307,200 kWh \times 31.64\text{ Naira / kWh} = 9,719,808\text{ Naira}

| Table 7: Summary of potential saving by regulating air-conditioning temperature |
|-------------------------------|-------------------|-------------------|-------------------|-------------------|
| Power (W) | Number | Total Investment (Naira) | Saving Power (W) | Annual Energy Saving (kWh) | Annual Cost Saving (Naira) |
| Set thermostat temperature to 26 °C | 2000 | 128 | 0 | 1200 | 307,200 | 9,719,808 |

4.8.7 Maintenance of Air-conditioner

Maintenance lifestyle is seen in painstaking exercise of maintenance activities such as biweekly cleaning of air conditioner filters, routine replacement of filters to improve efficiency.

| Table 8: Total summary of potential savings for each recommended measure |
|-------------------------|-------------------|-------------------|-------------------|-------------------|
| Measure | Annual Energy Saving (kWh) | Annual Cost Saving (Naira) | Investment (Naira) | Payback Period (year) |
| Reduce light intensity | 6,737.92 | 213,187.79 | 0 | Immediate |
| Replace incandescent lamps with CFLs | 30,776 | 973,752.64 | 37,100 | 0.04 |
| Replace magnetic ballast with electronics | 40243.2 | 1,273,294.84 | 133,400 | 0.12 |
| Use occupancy sensors | 1,152 | 36,469.28 | 6,000 | 0.16 |
| Use daylighting control | 5,640 | 197,433.6 | 0 | Immediate |
| Measure                                      | Annual Energy Saving (kWh) | Annual Cost Saving (Naira) | Investment (Naira) | Payback Period (year) |
|----------------------------------------------|----------------------------|----------------------------|--------------------|-----------------------|
| Reduce light intensity                       | 6,737.92                   | 213,187.79                 | 0                  | Immediate             |
| Replace incandescent lamps with CFLs         | 30,776                     | 973,752.64                 | 37,100             | 0.04                  |
| Replace magnetic ballast with electronics    | 40243.2                    | 1,273,294.84               | 133,400            | 0.12                  |
| Use occupancy sensors                        | 1,152                      | 36,469.28                  | 6,000              | 0.16                  |
| Use daylighting control                      | 5,640                      | 197,433.6                  | 0                  | Immediate             |
| Use screen savers in desktops               | 20                         | 632.8                      | 0                  | Immediate             |
| Turn off desktop screen from power button   | 56                         | 1771.84                    | 0                  | Immediate             |
| Maintain air return temperature at 26°C      | 307,200                    | 9,719,808                  | 0                  | Immediate             |
| **Total**                                    | **391,825.12**             | **12,416,350.79**          | **176,500**        |                       |

5. Conclusion
It is seen that as the electrical energy demands are going to get increased in future, Covenant University has to take actions to minimize use of electricity at unnecessary places, as well as to reduce unwanted financial burden on students in the form of fees. It is recommended to carry out energy assessment in the campus occasionally, to achieve more effective and efficient utilization of energy. Also, this type of audit can be replicated at other higher education institute to lessen electricity bills.

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