Assessment of Energy Saving Potentials in Covenant University, Nigeria

Oyedepo, S.O., Adekeye, T., Leramo, R.O,
Kilanko, O., Babalola, O.P., Balogun, A.O. and Akhibi, M.O.

ABSTRACT

In this study, an energy audit was conducted at Covenant University in Nigeria looking for ways to reduce energy costs. Results show that of the total university electricity energy demand, space cooling and lighting have the highest electrical consumption (29%). In academic buildings, space cooling consumed the maximum power (49%), while lighting consumed the most power (39%) in staff quarters. Annual energy and cost savings for replacement of traditional fluorescent lights (FLTs) and incandescent bulbs with compact fluorescent lamps (CFLs) in student hostels and staff quarters are about 394 MWh, N4.8 million ($30,000) and 644 MWh, N7.9 Million ($49, 375) respectively. Consequently, for space cooling systems, the annual energy and cost savings for replacement of conventional resistance electric regulator fans with electronic regulator fans is about 367 MWh and N 9.8 Million ($61,250). A well-articulated and vigorously pursued energy efficiency policy measures in the university can result in an estimated annual savings in electricity consumption of about 16%.

Keywords: Energy saving, university campus, electricity consumption, electricity demand

INTRODUCTION

Large institutions, such as universities, consume large amounts of energy on a daily basis. Being a knowledge transfer-based institution, the energy source predominantly in use in the universities for educational aids is electricity [1]. Therefore, the issues of electric energy availability, consumption and costs in universities with resident students and staff quarters can present a formidable challenge to any responsible administration. This is because its availability or otherwise can have profound effects not only on academic activities but also on the social and economic activities in the system [2].

In tertiary institutions, there is a considerable population size, including students, academic and administrative staff, researchers and others who work or study in universities. Thus, energy needed for operations, including teaching and research, provision of support services, and for residences and hostels, it is almost comparable to a small commercial facility. Universities involve a large number of building users and facilities and thus a huge amount of energy consumption, so increases in electricity use and subsequent costs is becoming a greater concern.

The university campus, being a miniature city, consumes power for lighting, water supply, air-conditioning, ventilation, electrical heating equipment and water heaters, amongst others. Conserving this energy will lead to reduction in energy consumption, operating costs, fewer lighting fixture replacements and reduction in accumulated heat generated. This helps to both mitigate climate change and make buildings more environmentally sustainable [3].

At colleges and universities, energy consumption has a large impact on both financial and environmental interests. New construction, aging infrastructure, financial constraints, increasing energy costs, and environmental responsibility are motivating factors for university communities to re-evaluate their energy demand and related conservation programs [4].

Campus energy potential studies involve an energy auditing process that provides an opinion of the availability of energy efficiency resources on a campus and allows the development of cost and savings strategies. A campus energy potential study offers many of the same benefits as standard energy studies, such as an understanding of how efficient the campus is in energy utilization and a plan for energy reduction projects.

Unlike major economic sectors (industrial, commercial, transportation, etc.), very few campus energy potential studies had been carried out in recent past. Among the studies are the works of Unachukwu [1], Tang [4], Adelaja, et al. [5], Manjunatha, et al. [6], Choong, et al. [7], Wong, et al. [8], Aishwarya et al. [9] etc. None of these studies identified energy conservation measures, which will make the energy usage more efficient and less expensive when implemented on campus. The need to bridge this important gap has provided the impetus for the current study.

The prime objectives of the present study are: 1) to investigate energy utilization pattern in Covenant University 2) to raise awareness of the areas of energy savings at Covenant University and 3) to recommend energy conservation measures to curb excessive energy consumption in the university.

MATERIALS AND METHODS

Study Area

This study was carried out at Covenant University Nigeria. The population of the university has grown from 1392 students at inception in 2002 to more than 8319 students, 374 academic staff and 502 non-academic staff in 2011. The university is fully residential with 10 resident hostels with an estimated more than 400 rooms per hostel building. In an addition, there are two colleges, six schools and 22 departments. There are also several public and academic buildings, including a university guest house, two cafeterias, a university library, university chapel, shopping malls, lecture theatre, and sport center. The university also has 206 staff housing units of various grades such as the 1-bedroom flat, 2-bedroom flat, 3-bedroom flat and duplex. The university is indeed a mini-township.

Data Collection and Analysis

A walk-through energy audit was carried out at Covenant University to acquire the power ratings of the electrical appliances/equipment used. Additional 2002-2011 data collected include: average peak power consumed, total population of staff and faculty, total population of students and the disposable income of electricity.

Power ratings were checked against the nameplates on the machines wherever possible. In theory, the power rating multiplied by the total hours of operation would give the total energy use for the equipment. In practice, the actual energy use could be lower because actual electrical power required might be less than that shown in the manufacturer quoted power rating or the nameplate on the machine. It has been reported that the difference could be as high as 50–75% [10]. On the other hand, the actual consumption could be higher because the operation hours could be longer than officially recognized [11].

All data collected were analyzed to identify energy conservation measures (ECMs), which when implemented, will make the energy usage more efficient, less expensive and more environmentally friendly.

RESULTS AND DISCUSSION

Breakdown of Major Electricity End Users

The amount of energy use in a university campus depends on many factors. Key factors include the types of building envelope design, number of buildings such as student hostels, staff quarters, lecture rooms and so forth, student and staff population, operational efficiency of the electrical appliances, types of lamps and their efficacy, and building operation and maintenance. The first step in a breakdown of energy use is to establish a list of the major services or end users.

Campus Overview

Figure 1 shows the daily energy consumption at different locations in Covenant University. The highest power consuming location is the student hostels, followed by staff quarters. The sport center is the least power consuming location due to its small size and not having laboratory equipment or machines at this location. The student hostel category has the highest power consumption due to large number of rooms and business centers located inside the hostels. Some of these business centers use power-consuming appliances such as pressing irons, hair driers, refrigerators, hot plates for cooking and similar equipment.

Electricity Demand in Covenant University for Various end uses

Figure 2 shows energy demand in Covenant University. Both space cooling and lighting have the highest energy demand (29%). This is followed by office equipment, especially personal computers, photocopiers and printers (15%). Categories of laboratory equipment and machines is responsible for only 7% of total energy consumption and heating and cooking is responsible for only 6% of energy consumption.

Electricity Demand in Academic Buildings

Figure 3 shows demand of electric power in the various academic buildings in Covenant University. The College of Science and Technol-

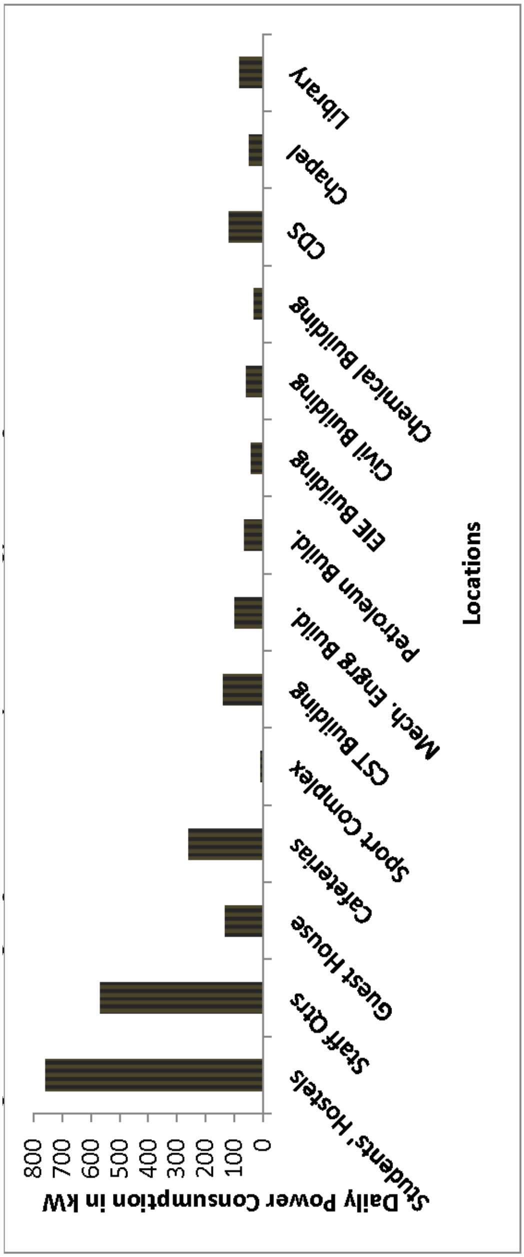

Figure 1: Daily Power Consumption at Different Locations in Covenant University

ogy (CST) building has the highest percentage of daily power consumption (21%), followed by the College of Development Studies (CDS) building (18%). The reason for this is because these buildings house up to nine departments. For example, the CST building houses the following departments: physics, chemistry, biology, estate management, architecture, building technology, biochemistry, mathematics and computer science. The CDS building houses the following departments: sociology, psychology, mass communication, business studies, political science and international relations, languages, economic, banking and finance and accounting. Some of these departments have laboratories equipped with power consuming equipment/machines for research. The civil engineering building has the least demand of electric power (9%) due to having fewer electric power consuming equipment at the time this study was carried out.

Electricity Demand in Academic Buildings for Various End Uses

Figure 4 shows electricity demand in academic areas in Covenant University. The maximum power is consumed in space cooling applications (49%) such as air circulation appliances (fans) and air conditioners. Laboratory equipment/workshop machine takes 26% of total electric power consumption in the academic buildings. Efficient utilization of energy in this section is possible by carrying out constant preventive maintenance measures of the machines/equipment, replacing worn-out parts and exchanging old machines/equipment for more efficient equip-

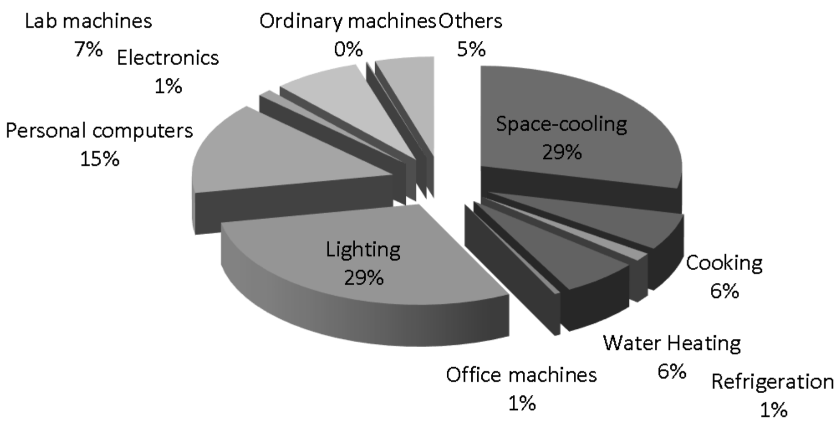

Figure 2: Electricity Demand in Covenant University for Various End Uses

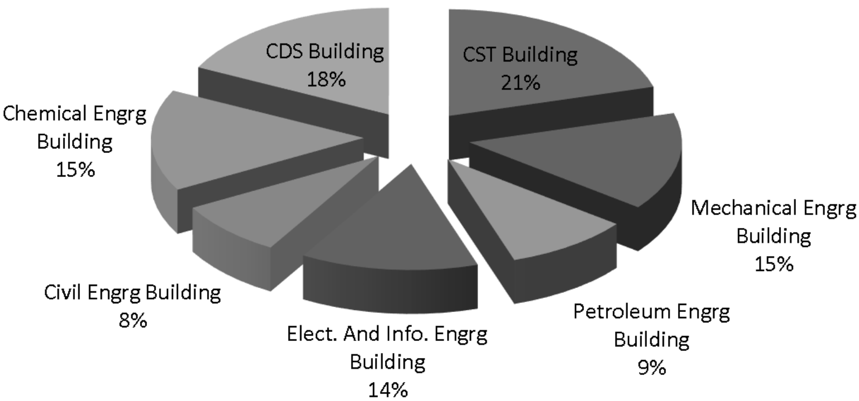

Figure 3: Electricity Demand by Various Academic Buildings

ment. Lighting, with 17% of total power consumption, is an energy user where energy efficiency can be achieved very easily by replacing old appliances by new, more efficient ones.

Electricity Demand in Residential Area for Various End Uses

Figure 5 shows electricity demand in residential areas (staff quarters) in Covenant University. Lighting application consumed the most power (39%). This is followed by space cooling application (18%) such as air circulation appliances (fans) and air conditioners. Cooking and

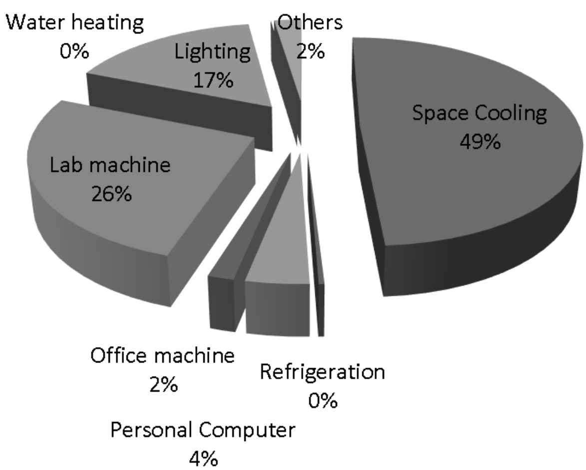

Figure 4: Electricity Consumption in Academic Buildings by Various end uses

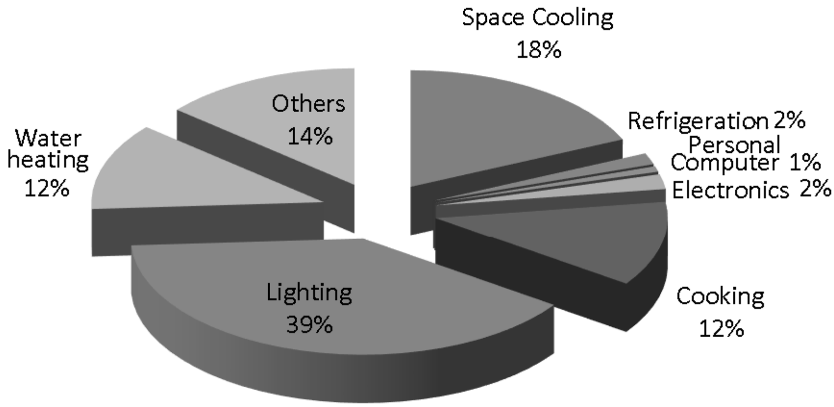

Figure 5: Residential Energy Demand for Various End Uses

water heating applications account for 12% of the total electric power consumption in the residential areas.

Annual Electricity Consumption

Table 3 shows the annual electricity consumption in Covenant University campus for the period of ten years (2002-2011). Per capita consumption of electricity in Covenant University during the period of consideration varied from 50 kWh/person to 522 kWh/person. Variation in per capita consumption of electricity is due to epileptic power supply from the national grid. The university was able to overcome the challenge of power supply from national grid in 2010/2011 when it started getting supply from a private power supply using gas generator.

Figure 6 presents the annual cost of electricity profile in millions of Naira. The marginal increase in electricity consumption from 2008 compared to the previous years is attributed to an increase in population, a growing number of staff residential and academic buildings, an increase in commercial activities and a fairly steady power supply within the campus. With the increase in electricity consumption in the university, electricity bills increased from about N27.6 million ($172,500) in 2002 to over N139 million ($ 868,750) in 2011.

The increase in electricity cost is basically due to about a 112% hike in tariff from N5.8/kWh (c3.6/kWh) in 2002 to N12.30/kWh (c7.7/kWh) in 2011. It is therefore expected that with constant year-round electricity supply, consumption and hence the energy bill will likely double the current figure. This information is very important, as it will help policy

Table 3: Annual Electricity Consumption

Year	Electricity Consumption (kWh)	Total Population	Per Capita Consumption of electricity (kWh/person)
2002	324120	1461	222
2003	331128	3093	107
2004	332004	4497	74
2005	334632	6009	56
2006	332880	6693	50
2007	3293760	7095	464
2008	3442680	7272	473
2009	2934600	8056	364
2010	3871920	7416	522
2011	3942000	8319	474

makers and all stakeholders of Covenant University to be aware of the need for the university to adopt energy efficiency measures that will not only save costs but also minimize environmental fallouts from electricity generation.

NEEDS FOR ENERGY MANAGEMENT IN COVENANT UNIVERSITY

The above facts for energy consumption in Covenant University are alarming. Such large consumption increases not only the demand for electricity, but also increases the penalty imposed. Thus the electricity consumption in Covenant University needs to be brought down. Further, the money to cover the large penalty could have been utilized for some constructive works. Thus, managing electricity usage is quite important.

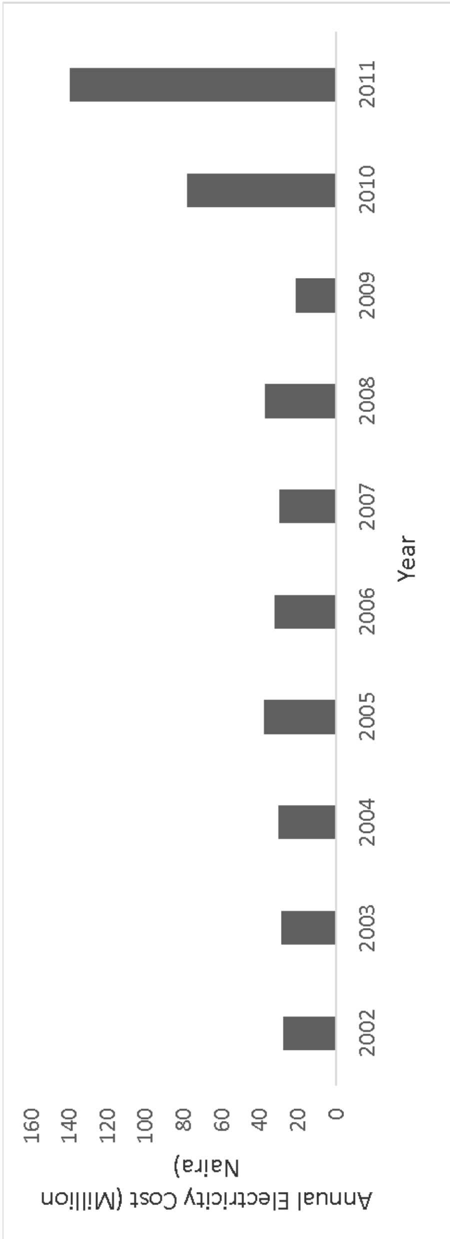

Figure 6: Annual Electricity Cost Profile

As Covenant University's enrollment grows, new buildings are constructed and there is increase in the use of technology; hence, there is significant increase in the use of electrical energy. Therefore, there is need to take measures to minimize use of electricity at every place wherever possible so as to avert unplanned power outages and reduce electricity bills.

Energy Saving Opportunity

"Electricity saved is electricity generated." In today's scenario, developing nations, such as Nigeria are facing various challenges of saving electricity. Various electric appliances that are not energy efficient ranging from lighting bulbs to space cooling systems such as fans and air conditioners have flooded the market. Requiring energy efficient devices is of utmost importance in view of the future energy requirements. The necessity for using electricity in office and household appliances like air conditioners, refrigerators and electric cookers is obvious. If these devices can be made more energy efficient, a reasonable amount of electricity can be saved in Covenant University.

In this section, selected areas of intensive energy uses are considered for energy saving potentials in the university.

Lighting

To assess the possibility of energy saving through lighting in the university, the total energy consumption by lighting and its cost for each location was calculated by the equations (1) to (3). Energy and cost savings through replacement of existing light fixtures (incandescent bulbs and FTL) with energy efficient lamps such as compact fluorescent lamps (CFLs) in student hostels and staff quarters are computed in this section.

The total energy demand (TED) in kW, which is the amount of electricity being pulled out of the power grid at any given moment, is given by:

$$TED = \frac{\text{SW}}{1000} \bullet n \times F_{\text{d}} \quad (in\ kW) \tag{1}$$

Where: n is the number of lamps, SW is the system wattage and F_d is the demand factor. F_d is the assumed average percentage of available lighting used at a building's peak time. In this study, the demand factor is taken as 100%, assuming all the lights are always switched on.

The total energy consumption from lighting (TEC) in kWh is determined as follows,

$$TEC = \frac{SW}{1000} \quad n \times h \qquad (in\ kWh) \tag{2}$$

Where: h is the total hours lighting is used during the year.

The total energy consumption cost (TECC) is computed as:

$$\text{TECC} = \text{TEC x CUE (in Naira)} \tag{3}$$

Where: CUE is the current cost of a unit of electricity in Nigeria tariff.

Figures 2 and 5 show that lighting units play major role in the consumption of electricity in the university. This energy user offers energy saving opportunities.

The common types of lighting fixtures throughout the campus are traditional fluorescent tube light (FTL) (40 W) and incandescent bulbs (60 W). Proposed lighting fixtures are the energy efficient light bulbs and appropriate lamp holders. The estimation of cost and consumption of the proposed fixtures was done using the same calculations for the existing luminaire fixtures.

In this study, the hours of operation in a year of electric appliances in student hostels and lecture rooms is assumed to be a function of period the students spend in the school. Hence, h is assumed to be 1440 hours (if students are to spend 6 months in a session, average of 8 hrs/day x 180 days). For staff quarters the assumption is an average of 8 hrs/day x 365 days = 2920 hours.

The cost of a unit of electricity in Nigeria tariff is N12.30/kWh ($0.0769 U.S. /kWh)

Student hostels and staff quarters are considered for energy and cost saving potentials by replacing current lighting fixtures with energy efficient bulbs.

Equations 1 to 3 are used to compute energy and cost savings for the replacement of 60 W incandescent bulbs and 40 W FTL with 25 W CFL in the student hostels and staff quarters. The results are presented in Table 4.

From that analysis, the annual energy saving potentials for replacement of traditional 40 W FTL and 60 W incandescent bulbs with 25W

Table 4: Energy and Cost savings for replacement of FTL (40W) and Incandescent bulb (60W) with CFL (25W) in student hostels and staff quarters

Location/Fixture Type	No of Fixture	Annual Energy Consumption (MWh)	Annual Energy Cost		Annual energy saving (MWh)	Annual cost saving	
			(M₦)	(US$)		(M₦)	(US$)
Students' Hostels							
RRF*(70 W)	4595	463.18	5.70	35,625	198.51	3.26	20,375
ERF* (40 W)		264.67	2.44	15,250			
Staff Quarters							
RRF* (70 W)	1918	392.04	4.82	30,125	168.02	2.06	12,875
ERF* (40W)		224.02	2.76	17,250			

RRF* - Resistance regulator fans, ERF* - Electronic regulator fans, M₦ - Million Naira

Whereas:
Total cost saving (Student hostels and staff quarters) = N 4,533,829.2 + 8,228,176.02 = N 12,762,005.22 ($79,762.53)
Total number of conventional FTL and incandescent bulbs = 23,114
Cost of replacing each conventional FTL and incandescent bulb with CFL (25 W) = N 500 ($3.13)
Total cost of replacing conventional FTL and bulbs = N 23,114 x 500 = N 11,557,000 ($72,231.25)
Capital cost recovery time = (11,557,000)/(12,762,005.22) = 0.91 yr.

CFL in student hostels and staff quarters is about 394 MWh and 644 MWh respectively. The annual cost saving potential for replacement of 40 W FTL and 60 W incandescent bulbs with 25 W CFL in the same locations are about N 4.8 million and N 7.9 million respectively. The capital cost recovery time for replacing all conventional FTLs and incandescent bulbs is around 0.91 year.

Space Cooling Systems

Figures 2 and 4 show that space cooling systems also consume significant amounts of electric energy. Energy and cost savings in space cooling systems are evaluated in this section.

To assess possibility of energy and cost savings through space cooling systems in the university, the same procedure for lighting is used. Energy and cost saving potentials through replacement of existing space cooling systems with energy saving space-cooling systems in student hostels and staff quarters are considered.

Replacement of Resistance Regulator Fans by Electronic Regulator Fans

The common types of fans available on the campus are resistance regulator fans with a power rating of 70 W at full speed. Replacing these fans with electronic regulator fans having a power rating of 40 W at full speed, considerable energy and money would be saved. Table 5 presents the results of energy and cost savings for the replacement of resistance regulator fans with electronic regulator fans.

SOLUTIONS TO REDUCE ELECTRICITY CONSUMPTION

Energy management and proper usage of the resources can possibly reduce energy consumption in Covenant University. The following points shed light on the ways that can be implemented profitably to lower consumption and manage electricity.

Efficient Lighting Upgrades

Energy-saving CFLs are generally considered best for replacement of lower incandescent lamps. These lamps have efficacies ranging from 55-65 lumens/watt. The average rated lamp life is 10,000 hours, which is 10 times longer than that of a normal incandescent. They offer excellent color rendering properties in addition to the very high luminous efficiency.

Table 5: Energy and cost savings for replacement of 70 W resistance regulator fans with 40 W electronic regulator fans in student hostels and staff quarters

Location/Fixture Type	No of Fixture	Annual Energy Consumption (MWh)	Annual Energy Cost		Annual energy saving (MWh)	Annual cost saving	
			(M₦)	(US$)		(M₦)	(US$)
Students' Hostels							
RRF*(70 W)	4595	463.18	5.70	35,625	198.51	3.26	20,375
ERF* (40 W)		264.67	2.44	15,250			
Staff Quarters							
RRF* (70 W)	1918	392.04	4.82	30,125	168.02	2.06	12,875
ERF* (40W)		224.02	2.76	17,250			

RRF* - Resistance regulator fans, ERF* - Electronic regulator fans, M₦ - Million Naira

Where: RRF*—Resistance regulator fans, ERF*—Electronic regulator fans, MN—Million Naira

Total number of resistance regulator fans = 6513
Cost of replacing resistance regulator fans with electronic regulator fans = N 1500 ($ 9.38)
Total cost of replacing resistance regulator fans = N 6513 x 1500 = N 9,769,500 ($ 61,059)
Capital cost recovery time = (9769500)/(5197071.72) = 1.88 yr.
Hence, the capital cost recovery time for replacing all resistance-regulated fans in the student hostels and staff quarters is around 1.88 years.

The greatest advantage of the CFLs is its energy efficiency during use, with much less energy lost to heat. The CFLs typically convert about 45% of the electricity to visible light, whereas the incandescent bulbs convert only about 10% [12]. Since the CFLs take advantage of both passive and semiconducting electronic components, they involve complex manufacturing flows and induce greater energy demand.

- **Use of time scheduling device for power supply**
  The advent of embedded systems has given a scope to make programmable devices such as the timer circuit to control the power supply. The device is programmable and each day's time table can be fed into it. The device will operate the power supply on a pre-determined schedule and turn on when there is a lecture and otherwise be switched off.
- **Use of Bureau of Energy Efficiency (BEE) Star-Rated electrical appliances**
  The university should use and promote the replacement of appliances to BEE Star-Rated appliances, which will further add to energy savings. Emphasis on using such appliances should be promoted to increase awareness of energy saving.
- **High efficiency equipment**
  High efficiency equipment reduces the energy needed to deliver a given level of energy services or produces more energy service per unit of energy. A careful observation of Figure 5 shows that space cooling, lighting and personal computers are items that consume the bulk of the energy supplied to the university, thus are areas flagged for potential efficiency improvement.
- **Reducing cooling demand (need for air conditioning)**
  In Covenant University, energy demand for space cooling can be reduced by:
  - ➢ Controlling solar gains by avoiding excessive glazing, use of shading and blinds, glazing with the lowest solar heat gains factor
  - ➢ Selecting office equipment with reduced heat output
  - ➢ Making use of thermal mass materials and night ventilation to reduce peak temperatures
  - ➢ Implementing a building design that maximizes natural ventilation (air passing from one side to the other side of the building)

- **Reducing energy use for lighting**
  Energy use for lighting in Covenant University can be reduced by
  - Appropriate window design and glass to make maximum use of daylight while avoiding excessive solar gain
  - Energy efficient lighting systems, for instance using task lighting to avoid excessive background luminance levels
- **Use of energy management device based on image processing**
  Occupancy sensing can control the lighting and power supply of any area by sensing human occupancy. The distinguishing feature is that only human occupancy is detected by using image processing and pattern recognition. This device is an efficient method to implement energy management at a low cost. The management should endeavor to install an occupancy sensor in the student hostels, lecture rooms and staff offices where a lot of energy is wasted by leaving lights on even when nobody is in the room or office.
- **Encourage energy-saving behavior**
  A number of colleges and universities are successfully using no-cost and low-cost public awareness campaigns to reduce energy use on campus. One popular—and effective—energy awareness program is the "Dorm Energy Challenge," in which residence halls compete against one another to make the largest energy reductions or simply to improve their own energy performance. Other popular programs include "Green Crib Certified" awards for students with eco-friendly dorm rooms and "Eco Reps" programs to encourage peer-to-peer sustainable behavior in residence halls. This strategy also can be adopted in Covenant University to save energy.
- **Replacing resistance regulator ceiling fans with electronic regulators**
  Electronic regulators are the latest type of regulators available in the market, which are much smaller in size than the electric resistance regulators. Electronic regulators use capacitors instead of resistors to decrease the voltage. Capacitors regulate the fan speed by regulating the waveform of power supply. These do not get heated up and thus save electricity when the fan is running at lower speeds (at higher speeds electricity consumption of fan is the same with both regulators). These regulators save up to 40% of energy consumption at speed 1 and about 30% at speed 2 compared to electric regulators.

- **Better management practices**
  Besides enhancing the efficiency of electrical appliances, better management practices should also be adopted. Students and staff should be educated to switch off the lights directly at the end of the day when not in use. It is important to unplug electrical appliances that are seldom used because these appliances will consume some energy when continuously plugged in, even when they are switched off.

CONCLUSIONS

In this study, an energy audit was conducted at Covenant University in Nigeria looking for ways to reduce energy consumption and costs. Over time, as the number of students and the use of new facilities and technology increase, the electricity consumption also will increase, and the need for energy conservation measures in the university will continue.

This study reveals that at Covenant University electricity consumption increased from 324.12 to 3942 MWh from 2002 to 2011 as the population increased from 1461 to 3197. Moreover, buildings of more functionality consume more electricity as more types of appliances are used for different functions. Space cooling and lighting have the highest percentage of electricity consumption of the total energy demand in the university.

The annual cost of electricity profile for the period under consideration (2002 to 2011) rose from N 27.6 Million ($172,500) in 2002 to over N 139 Million ($868,750) in 2011. The results of this study show that the annual energy and cost savings for replacement of traditional FTL and incandescent bulbs with CFL in student hostels and staff quarters are about 394 MWh, N 4.8 Million ($30,000) and 644 MWh, N 7.9 Million ($49,375) respectively. The capital cost recovery time for replacement of all conventional FTLs and incandescent bulbs is around 0.91 year. Considering the space cooling system (ceiling fans) the annual energy and cost savings for replacement of conventional resistance electric regulator fans with electronic regulator fans is about 367 MWh and N 9.8 Million ($61,250). The capital cost recovery time for replacement of all resistance electric regulator fans in the university is around 1.88 years.

From this study it can be concluded that the adoption of energy efficiency measures as part of the overall university developmental policy strategy would not only bring about substantial reduction in peak electricity demand, but also reduce electricity bills and conserve energy. Some of the policy options that the university can take to reduce energy spending include such measures as: enhancing the efficiency of electrical appliances, utilizing day-lighting, maximizing natural ventilation and improving management practices. Well-articulated and vigorously pursued energy efficiency policy measures in the university can result in an estimated annual savings in electricity consumption of about 16%. That can help ensure sustainable development in the university and possibly eliminate the pressure for the installation of additional diesel or gas electric generators. Energy audits of this type can be replicated at other university campus to reduce electricity bills.

References

[1] Unachukwu, G.O (2010), Energy savings opportunities at the University of Nigeria, Nsukka, *Journal of Energy in Southern Africa*, Vol. 21, No 1, 2-10.

[2] Patil T.S.I., Jadhav A.S. and Raut P.D. (2012), "An Analysis of Energy Consumption Pattern in Shivaji University Campus, Kolhapur, Maharashtra," *Golden Research Thoughts* Vol.1,Issue 8: pp.1-4.

[3] Abdelaziz E.A., Saidur R. and Mekhilef S. (2011), "A review on energy saving strategies in industrial sector," *Renewable & Sustainable Energy Reviews*, 15(1): 150-68.

[4] Tang, F.E. (2012), "An Energy Consumption Study for a Malaysian University," World Academy of Science, *Engineering and Technology International Journal of Environmental, Ecological, Geological and Mining Engineering,* Vol.6 No: 8, 99-105.

[5] Adelaja, A.O., Damisa, O., Oke, S.A., Ayoola, A.B. and Ayeyemitan, A.O. (2008), "A survey on the energy consumption and demand in a tertiary institution," Mj. Int. J. Sci. Tech., 2(02), 331-344.

[6] Manjunatha, P.M, Balachandra,T.C., Dsouza, O. and Naik, B. (2013), "Energy Audit, Conservation and Power Factor Improvement for BMSIT Campus," International Journal of Research in Engineering and Technology, Vol.2 (11), pp 354-359.

[7] Choong, W.W., Chong, Y.F., Low, S.T. and Mohammed, A.H. (2012), "Implementation of Energy Management Key Practices in Malaysian Universities," International Journal of Emerging Sciences 2(3), 455-477

[8] Wong, W.P., Liu, A.M.M. and Fellows, R.F. (2005), "Use of Electrical Energy in University Buildings: A Case Study in Hong Kong," Vol. 16(2), 7-18.

[9] Aishwarya, C., Diwakhar, R., Ganesh, S. and Harikrishna, N. (2013), "Energy Management, Conservation, Monitoring and Generation in a Campus," *International Journal of Application, Innovation in Engineering & Management*, Volume 2 (4): 553-563.

[10] Joseph C.L., Ricky Y.C.C., Tsang, C.L. and Danny H.W. L (2004), "Electricity use characteristics of purpose-built office buildings in subtropical climates," *Energy Conversion and Management* 45: 829–844.

[11] Bordass B., Cohen R., Standeven M. and Leaman A. (2001), "Assessing building

performance in use 3: Energy performance of the probe buildings," *Build Res Inf*, 29(2):114–28
[12] Tosenstock, S. (2007), "Another perspective. *Electric Perspectives*," Vol. 32, No. 5. pp. 100-105.

ABOUT THE AUTHORS

S.O. Oyedepo, Ph.D., the corresponding author, is a senior lecturer in Department of Mechanical Engineering, Covenant University. His area of specialization is thermo-fluid/energy systems.
Corresponding author's email: Sunday.oyedepo@covenantuniversity.edu.ng

T. Adekeye is an engineer in charge of thermodynamics and fluid mechanics Laboratories, Mechanical Engineering Department, Covenant University. Email: tunde.adekeye@covenantuniversity.edu.ng

R.O. Leramo, M.Eng., is a lecturer in Department of Mechanical Engineering, Covenant University. Email: Richard.leramo@covenantuniversity.edu.ng

O. Kilanko, M.Eng., is a lecturer in Department of Mechanical Engineering, Covenant University. Email: oluwaseun.kilanko@covenantuniversity.edu.ng

P.O. Babalola, M.Eng. is a lecturer in Department of Mechanical Engineering, Covenant University. Email: philipps.babalola@covenantuniversity.edu.ng

A.O. Balogun Email: balogunao@yahoo.com

M. O. Akhibi Email: akhibimo@yahoo.com