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INSTITUTION-BASED ENERGY AUDIT, COST SAVINGS: A CASE STUDY OF UNICROSS

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Abstract

Tertiary institutions in Nigeria and the world in general spend huge finances to purchase energy because energy is an essential commodity for quality teaching and learning in research institutions. The epileptic nature of power in research institutions in Nigeria makes research boring and frustrating. The call for efficient use of energy is borne from the fact that the energy available is grossly inadequate, therefore, conservation can be a solution to the energy deficit. In most research institutions, energy is available in different options: Public Utility, Renewable energy systems, backup power generators, or/and hybrid systems. Due to the inadequacy of power from the grid, most institutions run diesel plants as alternative power sources, which is costliest but readily available to those who can afford it. This paper energy audit, its importance, and the advantages therefrom to the institution of higher learning. It estimates the total energy needs of UNICROSS, and proposes energy-savings and conservative options that eventually translate to huge cost savings. The work also identifies in particular energy-consuming appliances that contribute to high energy consumption, in order to substitute if possible, available ones that have energy-saving potentials. It will be noted that a lack of energy audit causes energy planners to provide either under or over-estimated energy demand values, which leads to poor power planning. Results from this work show that, if regular audit exercise is carried out, an average of about 30 % of energy would have been saved annually.

Keywords: Energy Audit, Energy Efficiency, Cost savings, Energy conservation, DSM

1. Introduction

The Nigerian Economy and the overall lifestyles of her citizen, some decades ago have been naturally modeled by very low energy costs. This was a result of the availability of abundant energy resources and naturally occurring potentially cheap energy sources globally and a low population. However, as the price of oil, natural gas, coal, and human labor as part of energy source inputs, keep rising at an alarming rate, there is a need for energy conservation in Countries, A. Lawal, and J. Akarakin,(2009). Available evidence shows that there is huge energy wastage; leaving the light on when not in use, electronic gadgets on standby mode heat losses in tungsten bulbs, and so on as reported by, Akpama, E. J. et al, (2013) and O. U. Olughu (2021). It is, therefore, very important for energy users to devise modalities for energy use reduction and conservation. These modalities should entail alternatives aimed at achieving more efficient energy solutions which will save energy and reduce costs without compromising comfort and standards, Gelings, W. C.(2017), Patterson, M. G (1996). The use of eco-friendly products and the application of known viable investments in more energy–efficient domestic and industrial processes are also encouraged, Petersen, J.E.; Shunturov, et al (2007). The increase in energy consumption is a result of economic development, and a high rate of social activities requiring huge energy consumption compared to centuries ago, E. Cagno, A. De Donatis. (2014). A typical demand response program has three important facets: the energy cost, the comfort of the consumers, and overall system efficiency.

If the cost of producing 1kW of electricity is very high, then the alternative will be to conserve, the more energy is conserved the more savings are made. In order to assess individual energy demand/use, an energy audit is performed. An energy audit according to E. Akpama, et al, (2009) is a program that helps to estimate the total energy needs in a premise, be it domestic, commercial, or industrial. It is the expectation of the energy analyst to know the energy requirements of a client looking at the various energy-consuming equipment within the premise, [8]. An energy audit is in three stages, preliminary, comprehensive, and detailed audit, Vincent Nsed Ogar, et al (2016). The objectives of an energy audit are; to estimate the total energy needs of an establishment, identify the energy consumption pattern, suggest energy efficient loads, and suggest methodologies for savings, Sambo A. S., (2007). Also, the energy audit program is to assist in developing an energy demand side management (EDSM) whose major concept is to conserve energy and save cost.

It is factual to say that, there is growing energy demand in developed and developing economies of the world. This demand creates major fiscal, environmental, and social pressures as a consequence. As energy demand is increasing at a steady pace, to create the energy mix to meet that demand and sustain economic development, a huge investment is needed. Vincent, et al (2016), opined that an increase in electricity tariff could sustain the huge cost of generation, transmission, and distribution of power to the end user. But, using energy wisely and efficiently could yield better results, Akpama, et al (2012). The demand-side energy management concept suggests the right use of energy because the energy in supply is grossly inadequate. It is very pathetic to know that, Nigeria with an estimated population of about two Hundred (200) million is still battling with power availability of 4000 to 6000MW against an estimated power demand of 100,000MW, Sambo (2007). Due to this inadequacy of supply, load shedding, overloading, and unnecessary faults become the order of the day. Energy efficiency according to Olughu (2021), offers the cleanest and most economical way to meet the growing energy demand and guarantee huge savings. One of the ways to tackle the inefficient use of energy is to change the pattern of energy usage in Nigeria to reduce energy waste because households, public and private offices, and industries have the potential for conservation. Different Countries in the world are involved in global competition in renewable energy sources projects. The EU, ECOWAS, and, the USA have developed a renewable energy roadmap, a potential cost reduction in energy purchase. Table 2, highlight different countries' vision of replacing traditional energy sources with renewables. It is interesting to note that, Nigeria, having developed a program and policy for energy efficiency still experiences huge energy waste. Also, South African Government through the Southern Africa Development Community (SADC) has gone a step further in developing policy statements on sector areas that could enhance energy conservation and efficiency, Reshimi Banerjee (2015).

University of Cross River State, (UNICROSS), is a multi-campus University comprising Calabar (main), Obubra, Ogoja, and Okuku campuses. From the data available, the cost of funding a multi-campus University like UNICROSS is very high, making UNICROSS very expensive to run. Energy conservation is a solution for energy cost reduction, making this research timely. Reduction in energy waste to save costs is a call for sustainability. Starting from demand-side-management, and increasing efficiency and reliability through energy audits will definitely result in huge savings. UNICROSS is a research Institute, consumer behavior regarding energy use is studied, but, here a different scenario is observed. The cost of energy not being directly linked to the consumer is a challenge. Energy users in the University are; Students, Staff and business operators, there is no clear-cut tariff payment. The system bears the financial burden of energy cost, it is proposed here that, there should be controlled measures to cop waste and conserve energy. Table 2, shows different electrical appliances found during the facility tour and their power ratings. A careful look at the table will guide the energy consumer to on hourly bases control overall consumption. Unicross just got approval from the National Universities Commission (NUC) to run additional fourteen (14) programs, the result of this approval is; an increase in student population, an increase in energy demand and an increased cost of power purchases. Therefore, there is an urgent need for sensitization on the efficient use of energy and conservation in the University Community. There is also a need to start developing and installing renewable energy plants for efficient electric power generation for sustainability.

Countries are developing a road map to renewable energy sustained power. Though the initial cost of these renewable is high, it is by computation that, the huge initial cost is paid off in the long run. Table 1, shows the visions and targets set by different economies to replace power generation which was originally fossil fuel with renewable energy that is more efficient, sustainable, and environmentally friendly.

Table 1: Energy efficiency program approaches in different sample Countries

COUNTRY	RENEWABLE ENERGY SOURCE	YEAR	ROAD MAP TO ENERGY EFFICIENCY
NORWAY	Hydropower, Wind, and Thermal	2016	As of 2016, 98% of electricity production in Norway came from renewables.
SWEDEN	Hydropower and Bioenergy	2012	In 2012 Sweden reached their target of 50% renewable energy 8 years ahead of schedule.
COSTA RICA	Hydro, Geothermal, Wind, and Solar power	2015	Has produced a whopping 98% of its electricity from renewable sources for over seven years in a row.
SCOTLAND	Renewable Energy	2020	Great Scot! In 2020 Scotland produced over 97% of their electricity needs from renewables.
ICELAND	Hydropower and Geothermal	2020	A combination of hydropower and geothermal power provides almost 100% of Iceland's electricity needs.
GERMANY	Renewable Power	2018	Germany's new Government has set a targets of 80% renewable power by 2030 and close to 100% by 2035.
URUGUAY	Renewable Power	2021	A 20-year effort has resulted in Uruguay generating 98% electricity from renewable sources in 2021.
DENMARK	Wind and Solar	2017	Denmark gets over 43 % of its electricity from wind and solar power and in 2017.
CHINA	Renewable Energy	2017	Wondering how the world's largest carbon emitter can also be a leader in renewable energy?
MOROCCO	Solar	2016	Morocco has harnessed the power of its ample sun supply to become a world leader in solar energy.
NEW ZEALAND	Renewable Power	2018	84% of New Zealand's electricity currently comes from renewables. New Zealand plans to be using 100% renewable electricity by 2035 .
NIGERIA	Solar and Wind	2022	In August 2022, the government launched the National Energy Transition Plan, with set targets that include generating 30,000 MW of electricity from renewable energy sources and reaching carbon neutrality by 2060.

2. Methodology

The methodology adopted for this work is as stated below;

1. Preliminary Energy assessment is carried out using equipment power ratings.
2. A comprehensive Energy Audit is conducted, and questionnaires on the

right use of energy developed and distributed to collect data for simulation

3. Faculty by Faculty assessment of energy demand compared to energy availability.
4. Statistical analysis and interpretation of the data

2.1 Concept formulation

The concept of energy audit is to assess and estimate the energy needs of a premise or client bearing in mind the collective consumption of individual electrical appliances. The power rating of each appliance and the duration of use is considered. Therefore, in carryout energy audit first, there has to be a facility tour to assess and estimate the total energy demand of the client. Energy alternatives are also sort for efficiency and conservation during this exercise. Efficient use of energy and energy efficiency awareness is a call to energy savings.

3. Data collection

Data is collected during the audit exercise. The estimate made is tabulated in tables 2 to 6 using table A in the appendix, tables 2 to 6, are samples of data from the Admin block, hostels and some high energy demand faculties. A focus on the tables show that, while a consumer has options on the choice of appliances, the power ratings of the appliances and the period used is also a potential for conservation. All electrical appliances were tabulated; lighting bulbs, air-conditioners, fans, computers, printers, photocopiers, electric kettle, pressing iron, laboratory equipment, etc.

Table 2: Electrical Appliances and Rate of Consumption

S/NO	APPLIANCES	WATT		CONSUMPTION	
		MIN	**MAX**	**MIN**	**MAX**
1	1 Ton Air Conditioner	800W	1000W	0.8 kWh	1 kWh
2	1 Ton Inverter Air Conditioner	500W	1000W	0.5 kWh	1 kWh
3	1.5 Ton Air Conditioner	1000W	1500W	1 kWh	1.5 kWh
4	1.5 Ton Inverter Air Conditioner	800W	1500W	0.8 kWh	1.5 kWh
5	2 Ton Air Conditioner	1300W	2000W	1.3 kWh	2 kWh
6	2 Ton Inverter Air Conditioner	1000W	2000W	1 kWh	2 kWh
7	32 Inch LED TV	30W	60W	0.03 kWh	0.06 kWh
8	37 Inch LED TV	60W	70W	0.06 kWh	0.07 kWh
9	Refrigerator	100W	200W	0.1 kWh	0.2 kWh
10	Projector	220W	270W	0.22 kWh	0.27 kWh
11	Photocopier	450W	500W	0.45kWh	0.5kWh
12	Printer	400W	500W	0.4kWh	0.5kWh
13	Scanner	10W	18W	0.01 kWh	0.018 kWh
14	Security lighting	200W	800W	0.2kWh	0.8kWh
15	Phone Charger	4W	7W	0.004 kWh	0.007 kWh
16	LED Light Bulb	7W	10W	0.007 kWh	0.01 kWh

17	Inkjet Printer	20W	30W	0.02 kWh	0.03 kWh
18	Electric Iron	1000W	1000W	1 kWh	1 kWh
19	Laptop Computer	40W	120W	0.04 kWh	0.12 kWh
20	Large Office Printer	600W	2000W	0.6 kWh	2 kWh
21	Fridge / Freezer	150W	400W	0.15 kWh	0.4 kWh
22	Electric Iron	800W	1500W	0.8 kWh	1.5 kWh
23	Electric Kettle	1200W	3000W	1.2 kWh	3 kWh
24	Computer Monitor	25W	30W	0.025 kWh	0.030 kWh
25	Ceiling Fan	60W	80W	0.06 kWh	0.08 kWh

i. Lighting systems

Options for lighting systems are available in the marketplace. The choice of a particular system depends on the economic status of the client, environment, electrical design, fittings, and associates. It can also be noticed that weather conditions could play a role in decision-making for a particular system. Florescent tubes, incandescent bulbs, halogen lights, compact florescent light (CFL), LEDs, energy-saving, and energy-efficient bulbs are identified as options. Another factor for choice is the area of application and the illumination requirements of the lighting system. Aesthetics and personal interest cannot be completely ruled out in this regard. The switching of appliances when not in also add to cost savings. Samples of electric bulbs are displayed in figure 1. In Unicross, it is still surprising to see 200 watts Tungsten bulbs used within the University Community. This practise should be discouraged.

ii. Air conditioner

The market is filled with different types of ACs. Putting energy conservation in place, there are energy efficient and inverter ACs being manufactured. Though, their prices are a little higher than the normal ACs, but in the long run, the cost savings from energy efficient appliances pay off the additional cost. The induction machines in the workshops are high consuming equipment, it is therefore, proposed here, that the induction motors in the workshops be replaced with high energy efficient motors for a cost savings of between 20 % to 40 % reduction depending on the type and power of the machine. Many of these motors are used for Students laboratory exercises.

Figure 1: Types of lighting systems

Apart from illumination on a work plane, the design of lighting systems can create aesthetics. Therefore, the purpose of use and desire of the end-user are among the factors for the choice in the design of the lighting system. But, the interest here is, saving energy, this has a direct link to the power rating of the lighting system. Lighting bulbs include; Incandescent lamp, Halogen lamp, Tube fluorescent lamp, Compact fluorescent lamps (CFLs), LED light bulb, Globe LED bulb, Sodium lamp, Corn lamp, LED strip light, Mercury lamp Dimmer switch, LED panel, Spotlight bulb, Circular fluorescent lamp, Twisted fluorescent lamp, Flame shape bulb, Reflector, Diode, Fluorescent lamp, Adapter. See figure 2.

In figure 2, observe that, the electric bulbs have different power rating and illumination capacity. Lighting systems are of different power ratings. The consumer has a choice of any lighting system for energy reduction. Observe particularly in figure 2, the choice of a higher rating of a bulbs for security and it is allowed to glow 24 hours against 12 hours as should be expected. For the fact security light are not needed in the day, the energy consumed in the day is huge waste. In this case, there ought to control measures to automatically control these circuit.

Figure 2: Light Emitting Diode (LED) Energy saving Bulbs

Figure 2, shows the different light emitting which very good energy savers. An LED of 15W energy saving bulbs can be compared to a 40W normal bulbs in terms of illumination.

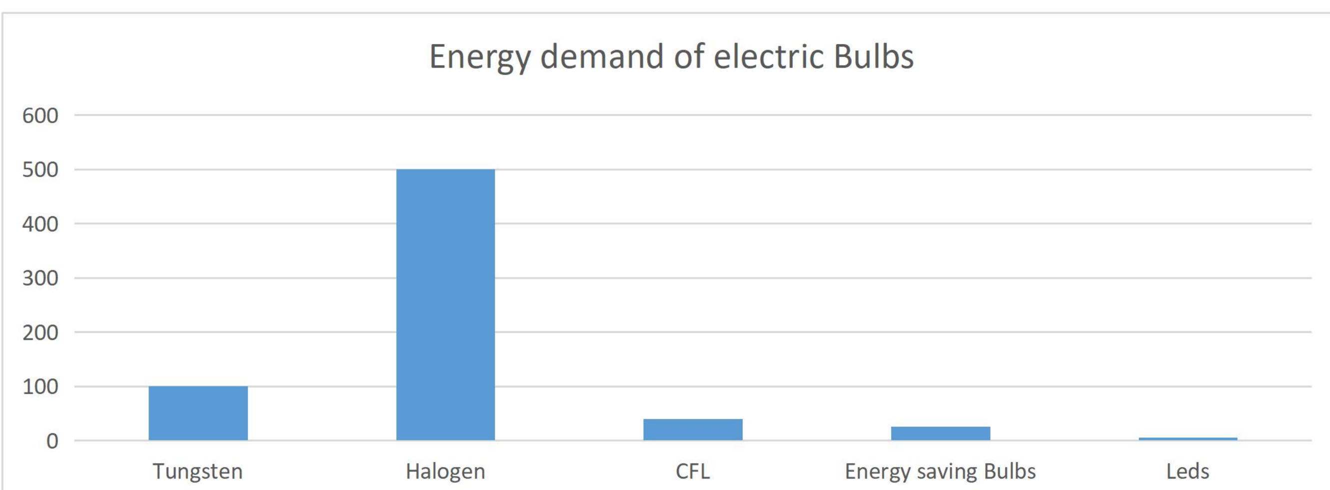

Figure 2: Energy demand of sample Electric Bulbs

4. Demand Side Management (DSM)

Energy being costly and scarce need to be managed very well. In fact part of the huge cost savings is coming from the conserved energy through DSM. Consumers are capable of controlling their consumption in order to reduce cost. Demand Response (DR) is a subset of DSM, this shows how the end-user of energy respond to realities of inadequacy of power. A consumer can participate in DR in the following ways, Bonneville, E. and Rialhe, A. (2006).

- Power consumption shifting where the end-users cooling or heating systems are shifted to a period with low demand.
- Load curtailment where the end-user's energy is reduced during peak hours.
- Use on-site power generation, such as solar cells and power banks to make the end-user less dependent on the main grid, D. Chitnis, et al (2016).

Going smart conserved energy and the institution benefit from huge savings. Many institutions are now embracing creating awareness on demand side management.

5. Energy Demand in UNICROSS

Using the installed generating plants and appliances installed in the different offices, lecture Halls, Workshops and Laboratories and Student hostels, tables 2 to 5 are generated. The total load demand in Unicross is estimated at 35,492.26kW/day. The cost of 1kWh of electricity is 22.550 Naira for household and 36.220 Naira for businesses. It is conceived by generation, transmission and distribution that, the tariff may will rise to a hundred Naira very soon. The energy demand therefore, in Unicross is 1478.844kWh, which is huge expenditure for the University.

Table 3: Energy consumption pattern in the Administrative block

AREAS COVERED	APPLIANCES	RATED POWER(W)	UNIT	TOTAL (W)	USAGE /DAY(Hr.)	KW Hours /DAY
ADMIN BLOCK	A.C	735.5	38	27,494	8	220
	Lamp	60	450	27,000	8	216
	Security lamp	100	50	5,000	8	40
	Printer	400	150	60,000	4	240
	PC (desktop	90	250	22,500	6	135
	PC (Laptop)	58	70	4,060	6	24.4
	Fan	100	350	35,000	8	280
	Photocopier	1,200	40	48,000	3	144
TOTAL						**1,299.4**

Table 4: Energy Consumption pattern in the Students' Hostels

AREAS COVERED	APPLIANCES	RATED POWER(W)	UNIT	TOTAL (W)	USAGE /DAY(Hr.)	KW Hours /DAY
STUDENTS' HOSTELS	Lamp	25	360	9,000	14	126
	Fan	100	171	17,100	14	239
	Iron	1,500	20	30,000	3	90
	Heater	2000	30	60,000	1	60
	Laptop	58	90	5,220	4	21
	Incandescent. lamp	60	1,500	92,000	14	1,200
	Fan	100	700	70,000	12	840
	Iron	1,500	50	125,000	3	430
	Cooker	2,000	10	20,000	2	40
	Laptop	58	175	10,150	4	41
	Television	60	2	120	8	0.96
Total						**3,087.96**

Table 5: Energy Consumption pattern in the Postgraduate School

AREA COVERED	APPLIANCE	RATED POWER(W)	UNIT	TOTAL (W)	USAGE /DAY(Hr.)	KW Hours /DAY
POST GRADUATE	Lamp	25	40	1,000	8	8
	Fan	100	28	2,800	8	22.4
	A.C	735.5	10	7,355	8	58.8
	PC (desktop)	90	20	1,800	6	10.8
	Refrigerator	115	8	920	6	5.5
	Printer	400	4	1,600	4	6.4
Total						**111.9**

Table 6: Energy Consumption pattern in the Faculty of Education

AREA COVERED	APPLIANCE	RATED POWER(W)	UNIT	TOTAL (W)	USAGE /DAY(Hr.)	KW Hours /DAY
FACULTY OF EDUCATION	Lamp	25	246	6,150	8	49.2
	Fan	100	173	17,300	8	138.4
	Refrigerator	80	14	1,120	4	4.5
	Computer	90	81	7,290	6	43.7
	A.C	735.5	15	11,032	8	88.3
	Laptop	56	80	4,480	4	17.9
	Photocopier	1200	2	2,400	6	14.4
Total						**356.3**

6. Simulation Result and Discussion

Investigation into this energy use in Unicross has shown that, there is huge energy loss in the University. As stated, the total energy demand, in Unicross is 1478.844kWh per day, which is huge consumption for the University. The total estimated cost of this consumption is N53,238.38 per day. It is observed that, the uncontrollable electric cooking, boiling and ironing in the hostel really affected the estimate.

The total energy needs of the University is 1478.844, resulting to an annual consumption of 539778.06kWh.
If 1kWh currently cost 36 Naira,
Then the cost for a year is, N19,432,010.16
Observing conservation saving 30 % will result N5,829,603.048
This sum can be reduced further if other saving methodologies are adopted.

Table 7: Energy Demand for 24-inch Television

SIZE	PLASMA	CRT	OLED	LCD	LED
24 inches	150 - 200	75 - 95	45 =55	34 - 40	25 -32
30 inches	150 -240	100 - 120	65 - 70	60 - 70	50 - 58
42 inches	220 -230	140 - 146	75 - 82	120 - 130	60 - 70
50 inches	300 - 350	170= 180	123= 130	150 - 160	100 - 110

The size of the television and the production technology are factors of the consumption. It follows that, the end-user can make a choice based energy conservation awareness.

Though, the structural design of building in Unicross is a factor in energy auditing, it is not considered here. Most of the structures are not energy efficient. But future designs, the authors proposed that, structural building should be energy efficient.

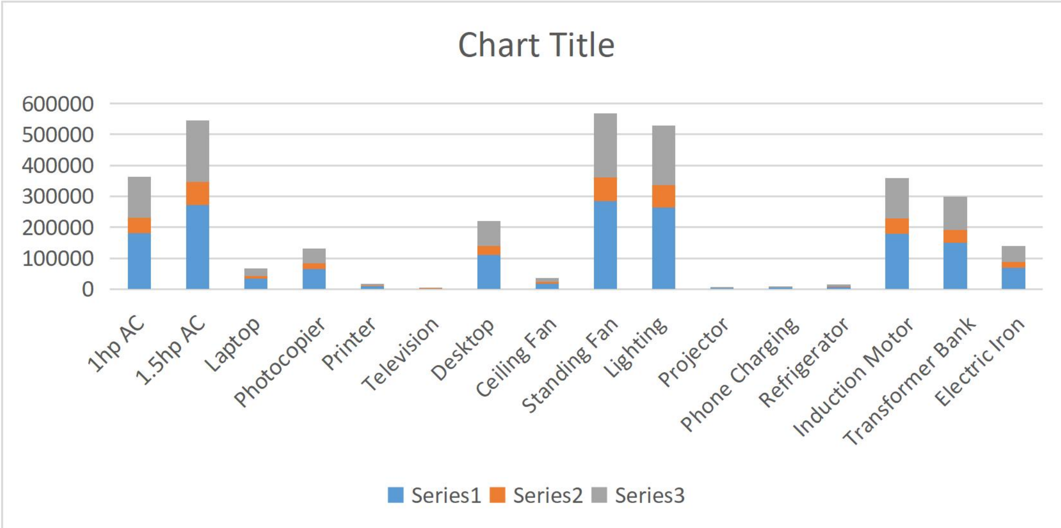

Figure 3: Energy Demand Pattern in UNICROSS

Series 1: Energy Demand without Conservation
Series 2: Conserved Energy
Series 3: Energy Demand after conservation

Figure 4, is a pie chart comparing faculty consumption. It is observed that, apart from the administrative block, Faculty Engineering energy demand is higher than other faculty's energy demand. The reason is that, Engineering has in her workshop an industrial setting, where most the equipment are driven by induction motors. The transformer trainer, induction machine trainer, the lathe machines, transmission line trainer, scanners, electric welding machines etc. are some of the equipment found in the workshops. If the normal induction machines are replaced with energy and more energy efficient motors, energy would have been saved.

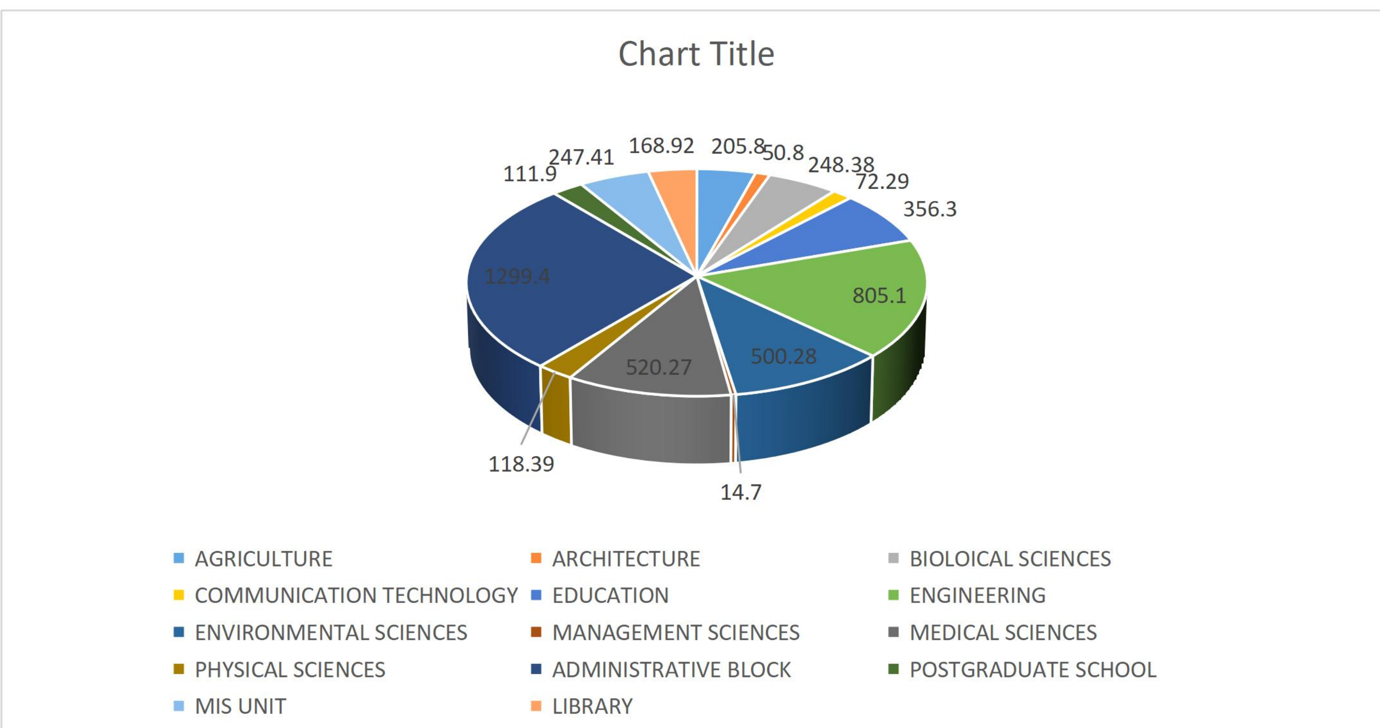

Figure 4: Faculty by Faculty energy consumption pattern

7. Conclusion

In this paper, energy audit has been conducted using the three stages of energy audit methodology. During this exercise the following observations were made;

1. Many off the lighting points were not energy efficient light (Energy Saving Bulbs), otherwise, there ought to be a 40 % reduction in consumption as regards lighting points
2. The power circuits mostly in the workshops drives normal induction motor. Otherwise, there would have 30 % energy consumption reduction when energy efficient motors are used. Normal motors are 75 – 87 % efficient while energy and more efficient motors are between 88 – 93 % efficient.
3. The air-conditioners are all normal air-conditioner for the fact that, either they are cheaper and can withstand rugged operating conditions. But, if energy-efficient air-conditioners (inverter air-conditioners) are used, about 25 % of energy would have been saved.
4. Most of the building structures in the University are not energy efficiency compliant. It is on this premise that, this proposes that, future building design should be certified by an Energy Auditor construction.

Energy audit, therefore, should be carried out either quarterly or biannually, this audit exercise is to monitor energy consumption indicators in institution, to evaluate the performance and consumption of research institutes like Unicross.

Recommendations

In this work, the following recommendations are made

A. Building Priority Area Policy Statements,

- Policy Statement on Building Code,
- Policy Statement on Periodic Audits of University Buildings
- Policy Statement on innovation of Existing Buildings
- Policy Statement on the Mix of Energy Sources
- Policy Statement on Energy Efficiency Certification of Buildings

B. Lighting Priority Area Policy Statements

- Policy Statement on Minimum Energy Performance Standards for Lighting
- Policy Statement on Government Building Lighting and Street Lighting.
- Policy Statement on the Incorporation of Natural Light in Buildings

C. Policy Statement on Appliances and Equipment

- Policy Statement on Energy Efficiency Code for University Workshop Equipment
- Policy Statement on Efficient Electric Cooking Stoves, Ironing and water boiling in the Hostels
- Policy statement on Energy efficient office electric appliances

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