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ENERGY CONSUMPTION AND CONSERVATION OPPORTUNITIES IN INSTITUTIONAL BUILDINGS FOR SUSTAINABLE ENERGY PRATICES

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ABSTRACT

The basic objective of modern society are low carbon and energy saving. There is a need to change the traditional high energy consuming building into modern novel energy saving buildings. In this paper, energy conservation opportunities in institutional blocks of buildings were evaluated and initiatives for enhancing energy use efficiency in the institution were identified. The study was carried out by collecting data via checklist, questionnaire and measurement using clamp ammeter. Energy and cost savings opportunities were analyzed using simple formulae. Results show that, Space cooling systems have the highest energy consumption with an average energy consumption of 5319kW (39%) followed by lighting fixtures with 1567.4KW (36%) and plug load appliances with 563kW (24%). Retrofitting of aged and oversized space cooling system and lighting fixtures with energy efficient systems were initiated, an energy and cost saving opportunities of about 4903kWh, 1337kWh and ₦128, 949 and ₦35,163 respectively were achieved. It is therefore concluded that, the institution has ample energy saving opportunities. Establishment of energy management practices through retrofitting in the institute will guarantee good energy savings opportunities with enormous reduction in green house gas emission.

KEY WORDS: *Energy Consumption, Energy Conservation, Institutional building, Sustainable Energy Practices*

INTRODUCTION

The continuous consumption of energy since the last century increases the concentration of CO_2 in the atmosphere. Increase in global temperature results in the climatic change, ecological destruction, and endangers the basic human living environment (Kavousian and Rajagopal 2013). However, with the increasing prices of energy and its sources, such as petroleum, gas and electricity, the problem of energy saving is located in front of every industry. Abimaje and Akingbohungbe (2013) observed that the building industry is one of the targets energy saving, because its consumption is more than 30% of the total energy consumption and it is consumed by non- industrial buildings, including houses, offices, schools, hospitals and so on.

In recent years, the situation of electrical shortage in Nigeria and greenhouse emission around the globe has become more serious which calls for immediate action to develop alternative sources of energy to reduce consumption, (Oyedepo, 2013). Although "this trend can partly be offset by considerable improvement on the existing building energy conservation strategies, through materials used in building, insulation, day lighting design and

usage, effective energy management practice" (Hinge, 2004). International energy agency (IEA) estimated the potential for efficiency improvement to be in the range of 20-50% of the final consumption.

Jollands, Waide, Ellis, Onoda, Laustsen and Tanaka (2010) stated that energy efficiency polices would help in saving an average of 20% of the final energy consumption in five major sectors, namely buildings, equipment lighting and transport in institutions. Also, Hong, Chou and Bong, (2000) in their work, observed that substantial energy savings can be achieved through conventional building design/envelope and careful planning for energy efficiency.

Electricity consumption in national research institute for chemical technology (NARICT) blocks of buildings is mainly for lighting, comfort cooling water pumping and general research activities. It serve as the main driver in the provision of support services such as operation of plug loads appliances and other social activities. Electricity bill in the institution did not pose much concern due to low tariff and fuel prices. However, the situation has change with the recent increase in electricity price and its effect to the environment. Energy consumption and energy bills have continue to rise, the effect of these to the institution was that it will be left with huge amount of overhead in the face of rising in energy price, adopting of energy conservation measure in all NARICT building blocks presents a resonable and cost-effective meances of achiving energy consumption reduction and maintaing quality service delivery.

The purpose of this study is to evaluate the energy conservation opportunities of NARICT blocks of buildings with a view to addressing energy wastage and leakages.

LITERATURE REVIEW

Energy Efficiency in Buildings

Energy efficiency means improvement in practices and products that reduce the energy necessary to provide services like lighting, cooling, heating. Energy efficiency products basically help to do more work with less energy (Oyedepo, 2012). Building envelop was found to be one of the factors militating against efficient utilization of energy. This includes all interior and the exterior element of the building such as: fenestration, walls, doors, roof coverings and sub-structure. All these components must work together to keep the building warm in the winter and cool in the summer (Unachukwu, 2010).

The amount of energy consumed by various building component varies depending on their design, fabrication of the systems and how they are operated (Uduma & Arcisewski, 2010). Oyedepo (2012) posited that heating and space cooling systems consume high amount of energy. However to control/reduce energy consumption a programmable thermostats and proper energy management systems must be put in place as it will reduce the amount of energy use significantly. However, Akinbami (2013) also suggests that some buildings use zone heating and cooling systems, this enhance the reduction of heating and cooling in unused areas of the building. In public buildings the common fuel types used are natural gas and electricity. Thus, Kanika (2017) highlighted that many buildings can utilize another energy source form locally generated group or district form of energy in form of heat and or power. This can be applicable in big cities, university campus where building structures are sited close to each other and where it has more efficient to have a centralized space cooling or heating system which distribute energy in form of steam/or chilled water to a number of buildings.

Also, Unachukwu (2010) observed that efficient energy use include not only the physical or technical efficiency of equipment and systems, but also the overall economic efficiency of the system. Furthermore, initiating energy efficiency measures as part of institutional energy policy wouldl cut down the emission of greenhouse gases from utilities since every kW/h of electricity consumed or

saved is equivalent to the emission (or avoidance of the emission) of 0.44kg CO_2 (Etiosa, 2010). Etiosa (2010) highlighted that efficient energy has become the key driver to sustainable development in many economies in the world. Improving energy efficiency, i.e. obtaining more final energy services from less energy sources is the surest and most direct way of increasing sustainability of the use of energy resources and decreasing the negative aspects (environmental pollution) and financial costs associated. The economic potential of even more efficient use of energy will continue to grow with new technologies and with cost reduction resulting from the economy of scale (Oyedepo, 2012).

Energy Efficiency Potential

According to International Energy Agency (IEA) sees potential for efficiency improvements to be in the range of approximately 20-50% of the total final energy consumption. Hye and Hae (2017), observed that lack of information on the return period of an energy reduction investment or an energy saving strategy is a stumbling block for people to invest in energy saving processes. However, Yun, Kim and Kim. (2012) postulated that a change in the occupancy patterns of a building with respect to the initial design settings might result in higher rates of energy consumption for lighting purposes, which could potentially represent up to 50% energy savings. The cost of collecting the energy data or installing new energy-efficient equipment is hard to recognize as a cost saving investment when compared with the simple purchase of energy. This can be a greater obstacle to small and medium-sized enterprises. To overcome this, financial information such as lifecycle cost should be gathered for the decision making process of the building design.

METHODLOGY

National Research Institute for Chemical Technology (NARICT) is the study area located along old Kano road (Basawa) about 11KM form Zaria metropolis. The Institute contains various blocks of buildings such as Administrative block, Works and Maintenance Division, Library complex, Entrepreneurship development center, Laboratories, Clinic and multipurpose hall among others. Ten blocks of buildings constitute the population of this study.

A walk- through energy audit was carried out in order to determine the power rating of electrical appliances/ equipment used and electric power consumed in the blocks of buildings. In this study, the data collected include average power consumed per month and pattern of consumption. The study was conducted using checklist and measurements with instrument (clamp ammeter). Data collected were analyzed to identify energy conservation opportunities that when implemented would block energy leakage and make energy usage more efficient, less expensive and more environmental friendly. The consumption by appliances as well as their cost saving opportunities were presented in form of charts and tables. However, cost savings opportunities for energy consuming appliances were achieved through the following equation:

TECC = TEC x CUE
Where:
TECC = Total Energy Consumption Cost
TEC =Total Energy Consumption
CUE= Current Cost of a unit Energy

However, in this study, hours of electrical appliance and fixtures in the study area were assumed to be a function of the period the end-user spends in office. Thus, h is assumed to be an average of 5hrs/day/5 working day for space cooling consumption and 9hrs/day/5working day for lighting. A unit cost of energy per kilo watt is ₦26.37.

RESULTS AND DISCUSSION

The energy consumption pattern of the equipment and appliances is presented in Figure 1 and includes that four different types of use. It has different percentage distribution of the energy consumption on the basis of the average of the ten blocks of buildings studied. Figure 1 represents the percentage

consumption by energy consumption appliances. Air conditioning system and lighting system have the highest percentage consumption of 39% and 36% respectivly, while plug load appliances have a total energy comsumption of 24%.

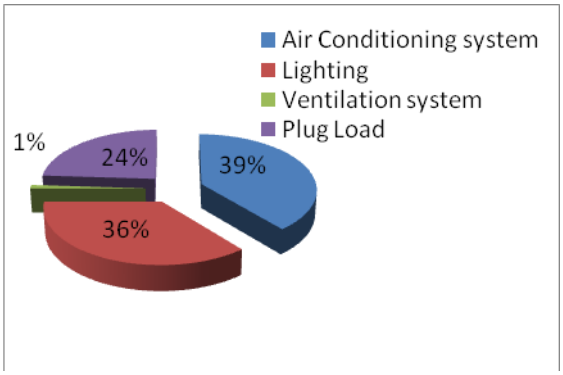

Figure 1: Energy Consumption for various End-Users

Energy Consumption by Various Blocks of Buildings

Figure 2 shows percentage consumption in the variouse bolcks of building in NARICT. Administrative block and industrial chemical laboratory has the highest precentage of monthly energy consumption of 30% and 14% respectively. Petrol chemical laboratories 1,2 and 3 have a total energy consumption with 17% per month while environmental technology laboratory have the least consumption per month. However, it is deduced from the foregoing that, this may be due to the extensive use of equipment and appliances such as desktop computer, server, refrigerator e.t.c., that are necessities for modern office to function effectively.

Estimation of Energy Saving Opportunities in NARICT Blocks of Buildings

Lighting and cooling system play a major role in the consumption of electricity in NARICT blocks of building as shown in Figure 1. This area offers several energy and cost saving opportunities, the common types of light fixtures and cooling systems throughout the institute are compact florescent lamp (CFL) and 1.5-2.0hp (Horse Power) air conditioning system. The total cost for each blocks of building were estimated using simple equation and the possible energy saving was ascertained.

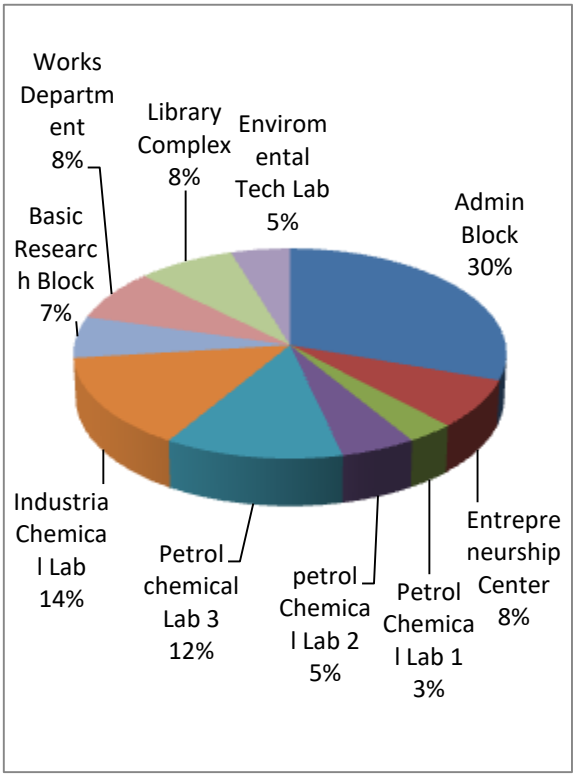

Figure 2: Percentage Energy Consumption by Various Blocks of Buildings

Table 1: Energy and Cost Saving Opportunities as result of Retrofitting Air Conditioning Systems

Location	Energy Consumption (Kwh)		Energy Savings Opportun-ities (Kwh)	Energy Savings %
	Before Retrof-itting	After Retrof-itting		
Admin Block	**2954**	**1969**	**985**	**20**
Ent Center	**1772**	**886**	**443**	**9**
Petrochemical	**1034**	**689**	**345**	**7**
Industrial Lab	**1477**	**985**	**492**	**10**
Industrial Lab	**1378**	**689**	**689**	**14**
Works	**1182**	**788**	**394**	**8**
Library	**866**	**591**	**275**	**6**
Library	**984**	**492**	**492**	**10**
Enviro Lab	**1034**	**689**	**345**	**7**
Total	**12681**	**7778**	**4903**	

Source: Field Survey (2018)

Table 1 present energy saving opportunities for the retrofitting of energy consuming air conditioning systems with energy efficient

ones, from Table 1 Administrative block, Industrial Chemical laboratory and library, have the highest energy saving opportunities of 985kWh, 689kWh and 867kWh respectively. The total monthly energy saving opportunities for replacing this system is 4903kWh with a cost- saving opportunity of ₦128,949 per month.

Based on the result obtained, in Figure 1 lighting fixtures also consume significant amount of electric energy. To assess the possibility of energy and cost-saving for lighting fixtures in the blocks of buildings, the same procedure for space cooling was adopted and the result was presented in Table 2. The monthly saving opportunities were found to be 1337kWh with a cost savings opportunities of about ₦35,163 per month if all CFL were to be rerofitted with LED lamp.

Table 2: Energy and Cost Savings for Replacement of Compact Florescent Lamp

Location	Energy Consumption (kWh)		Savings Opport-unities (kWh)	Energy Savings %
	Before Retrof i-tting	After Retrof i-tting		
Admin Block	**346**	**149**	**197**	**15.0**
Admin Block	**374**	**198**	**179**	**13.4**
Entr Center	**280**	**149**	**131**	**10.0**
Petro chemical	**542**	**287**	**255**	**19.1**
Industrial lab	**231**	**99**	**132**	**9.9**
Works	**231**	**99**	**132**	**9.9**
Library	**280**	**149**	**131**	**9.8**
Basic Research	**161**	**69**	**92**	**6.9**
Enviro Lab	**187**	**99**	**88**	**6.6**
Total	**2632**	**1298**	**1337**	**100.6**

Source: Field Survey (2018)

CONCLUSION

The study has shown that air-conditioning systems have the higest consumption of energy with 12681 kWh/month follow by lighting fixtures with an average consumption of 2632kWh/month. Energy saving opprotunities of 4903kWh and 1337kWh from air-conditioning systems and lighting fixture were achieved after retrofitting with a monthly costs savings of ₦12,8949 and ₦35,163 respectively. It has become evident that a periodic energy audit is an appropriate strategy to optimize energy consumption in institutional buildings.

RECOMMENDATIONS

i Maximizing energy effficiency through green building policy and retrofitting of overage appliances and systems should be adopted.

ii Reducing energy consumption through attitudinal change of end users should be encourage through-out the institution.

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