Assessment of Energy Wastage and Saving Potentials for Higher Educational Institutional Buildings in South Western Nigeria

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Abstract. The study assessed the energy wastage areas in Higher Education Institutions (HEIs) Buildings in South Western Nigeria; factors influencing the energy wastage and energy saving opportunities available in the study area with a view to promote energy conservation and cost savings. The study adopts the use of stratified simple random sampling techniques and the administration of two hundred (200) open ended questionnaire on the respondents who are mainly students, teaching and non-teaching staff in the physical planning, works and maintenance service department. Data obtained from respondents was analyzed using descriptive statistics and mean score index (MSI). Findings revealed that energy wastage are common with lighting consumption (MSI 4.59), poor controls and regulators for both lighting and other appliances in HEIs (MSI 4.57). Lighting related operations also exert significant impacts on energy wastages as six out of the thirteen major energy wastage areas are connected to it. The major factor influencing energy wastage are due to poorly designed HEIs buildings (MSI 4.62) and all other factors aside this need to be adequately considered in future designs for effective energy management. Findings further revealed that HEIs buildings require sound energy policy, improvement on passive building designs principles are critical to the reduction of energy wastage and hence should be adhered to since it has potential to saves cost. The study recommends the usage of metering system to determine energy consumed in each facilities/building, using scheduling devices with intelligent building designs for power supply and controls during peak and off peak period, implementing standard Energy Policies and creating awareness for students and staffs on energy usage and cost savings benefits and provisions.

1. Introduction
Energy usage in buildings account for the highest energy consumption compared to energy usage in other sectors [1]. Energy is used in buildings basically as operational energy; for the maintenance and servicing of a building throughout its useful life, and the embodied energy; that is, the total energy required for the production of buildings using plants, equipment and various building materials [2]. Energy used during service of buildings is for various purposes such as lightings, heating, ventilation and air conditioning, hot water heater, security, cooking and for powering of appliances [3].
In recent years, Educational Institution Buildings in Nigeria is faced with dynamics of energy demand in the sub-sector as a result of rapid growth of the energy user. This remarkable growth of the sub-sector is due to population increase as well as the need for improved performance of key academic functions is responsible for high increase in energy consumption when compare with other sectors of the economy. This sub-sector depends on energy supply for virtually all activities and operations that includes teaching and learning aids, lightings, heating, air conditioning systems, laboratory equipment and powering of machinery used for researches, training, practical and demonstration as well as other support services [4, 5].

Recent reports indicated that institutional buildings, mostly universities and other institutions consumes copious amount of energy daily and that energy consumption by these institutions has grown to be comparable to commercial sector energy usage [6, 7, 8, 9]. According to [8], the amount of energy used in educational institutional buildings primarily depends on the building design, population of staff and students, the types of lamps and electrical appliances used. The diverse ways in which energy is used in the institutional buildings is changing rapidly, but of particular interest is the pattern of energy consumption by the university community, especially staff and students who mostly use basic institutional fittings such as lightings, fans and air conditioning systems in addition to personal appliances which includes (hot plates, electric cookers, computers, micro waves, scanners, copiers, rechargeable appliances, refrigerators, television and pressing iron) for personal comfort and academic support activities. The characteristic increase in population of the academic institution community is having tremendous effect thus leading to increase in energy consumption over the past couple of decades.

However, [10] estimated that 25 percent of energy used in schools is wasted. [11] pointed out that unconcerned and unconscious behavior as well as bad attitude of both students and staff towards energy wastage is increasing directly in response to population increase. He further stated that unimplemented energy policies in schools, use of inefficient design technologies, lack of awareness and information on energy usage and cost, poorly design buildings, poor controls and settings and most importantly non-payment of energy bills by building occupants in schools contribute to the problems of energy consumption in institutional buildings, resulting to increasing running and administrative cost in most institutions [12].

Higher Educational Institutions energy saving is a giant innovation, rich of huge potentials to reduce energy wastage; it is an effective option to reduce the energy bottleneck constraints and can significantly reduce energy shortages. Going by the current rate of development of Nigeria educational sector, effort towards energy savings possesses a huge potential through reduced energy bills thereby contributing to ameliorating the current economic challenges. In view of this scenario, this study assessed the existing spectrum of energy wastages in education institutional buildings. It also examined the factors influencing energy wastages and assessed the areas of energy saving opportunities for educational institution buildings in Nigeria with the benefits to achieving cost savings and environmental sustainability.

2. Methodology
The research used stratified simple random sampling, a method of probability sampling that allows for improved precision. The population was divided into non-overlapping groups and then simple random sampling was performed to select appropriate sample size along a relevant dimension, which included federal, state and privately owned tertiary institutions and this was based on the number of group that exists in the population. Ten (10) institutions were selected within the study area as sample population, a total of two hundred (200) numbers open ended questionnaires were used as sample size was administered mainly to students, teaching and non-teaching staff in the works and maintenance department and physical planning unit of each institution to provide information. Data obtained from respondents was analyzed using descriptive statistics and mean score which is also referred to as Users Agreement Score (UAS) using the following formulae

Formulae for Mean Score:

\[ \text{Mean score} = \frac{\sum WV}{N} \]

Where, \( \Sigma WV = \text{Summation of weight value} \)
\( \Sigma (\text{Numbers of Respondents X Rating Weight}) \)
\( \Sigma (1 \times F1) + (2 \times F2) + (3 \times F3) + (4 \times F4) + (5 \times F5) \)
\( F1 \) to \( F5 \) = Frequency of Response (1 to 5) on the Likert scale
\( 5 = \text{Very Common}, 4 = \text{Common}, 3 = \text{Indifference}, 2 = \text{Less common}, 1 = \text{Not common} \)
\( N = \text{Total number of respondents} \)
3. Data Presentation and Analysis

The following data in Tables 1 to 5 are presented to give insight to effort made to obtain reliable data from respondents.

Table 1 below revealed the gender representation of the respondents to be 65% male and 35% female, thus showing that the percentage representation of male respondents is more than that of the female in the selected sample size.

| Sex of Respondents | Frequency | Percentage (%) |
|--------------------|-----------|----------------|
| Male               | 130       | 65             |
| Female             | 70        | 35             |
| Total              | 200       | 100            |

It is shown in Table 2 that 32% of the respondents were HND holders, while 25% possess Bachelor’s Degree (B.Sc/B.Tech), 19% hold Master Degree (M.Sc./M.Tech) and 5% of the respondents had PhD degrees and both undergraduate and postgraduate students make up 19% of the respondents.

| Academic Qualifications | Frequency | Percentage (%) |
|-------------------------|-----------|----------------|
| HND                     | 64        | 32             |
| B.Sc/B.Tech             | 50        | 25             |
| M.Sc/M.Tech             | 38        | 19             |
| Ph.D                    | 10        | 5              |
| Undergraduate           | 38        | 19             |
| Total                   | 200       | 100            |

It can be seen in Table 3 showing the Age Distribution of Respondents that none of the respondents age falls below twenty one years, 15% fall between twenty one years and twenty nine years of age, 40% were between thirty and thirty nine years, 36% were between age forty and forty nine, and 9% were above the age of fifty. The frequency and percentage distribution above therefore, clearly indicate that the available respondents have the prerequisite knowledge and are capable of providing detail information for this research.

| Age Range/Description | Frequency | Percentage (%) |
|-----------------------|-----------|----------------|
| Below 21 years        | 0         | 0              |
| 21 -29 years          | 30        | 15             |
| 30-39 years           | 80        | 40             |
| 40-49 years           | 72        | 36             |
| Above 50 years        | 18        | 9              |
| Total                 | 200       | 100            |

The placement of respondents in the organization/institution shown in Table 4 revealed that, 15% of the respondents are teaching staff, 65% are non-teaching staff, 10% are undergraduate and postgraduate students and 10% are business and ventures owners within the institutions environment. The result shows that Non-teaching staff has the highest percentage representation with 130 target audience who were mainly staff from Works, Maintenance and Services Departments and Physical Planning Units who have direct contact with energy usage in the studied institutions on a routine basis.

| Status in Campus | Frequency | Percentage (%) |
|------------------|-----------|----------------|
| Academic staffs  | 30        | 15             |
| Non-academic staffs | 130   | 65             |
| Students         | 20        | 10             |
| Business Venture owners | 20 | 10 |
| Total            | 200       | 100            |

Data on residence of respondents in the institution in Table 5 reveals that 45% of the respondents resides in the institutions staff quarters, 10% stays in the institution hostel accommodation, 5% stays...
in the post graduate hostels, while 40% of the respondents lives off campuses probably due to lack of provisions of staff quarters. The 45% of the respondents living in staff quarters having the highest percentage representation makes the information supplied adequately reliable as a result of relative continuous stay on campus enabling the acquisition of relevant information required.

Table 5. Residence of Respondents in the Institution

| Location of Stay in Campus | Frequency | Percentage (%) |
|---------------------------|-----------|----------------|
| Staffs quarters           | 90        | 45             |
| Hostels                   | 20        | 10             |
| Post graduate hostels     | 10        | 5              |
| Off campus                | 80        | 40             |
| TOTAL                     | 200       | 100            |

Duration of residence on Campus by respondents is contained in Table 6. It shows the number of years stayed in campuses by the respondents. A total of 19% of the respondents have stayed between 0 and 4 years. This group of respondents is mainly students. It is further observed that 30% have stayed in the campus between 5 to 10 years while 21% have stayed in the campus between 10 to 15 years. Also, it is observed that 15% of the respondents have been on campus for 16 to 20 years, while 15% have also stayed in campus for 26 years and above. The relevant background of respondents therefore, strongly suggests the reliability of information gathered from the experienced respondents that have practical presence on the campuses.

Table 6. Duration of Residence on Campus

| Numbers of Years | Frequency | Percentage (%) |
|------------------|-----------|----------------|
| 0-4 years        | 38        | 19             |
| 5-10 years       | 60        | 30             |
| 10-15 years      | 42        | 21             |
| 16-20 years      | 30        | 15             |
| 26 years above   | 30        | 15             |
| Total            | 200       | 100            |

3.1 Energy Wastage areas in Educational Institutions Buildings

The identified and evaluated thirteen (13) means of energy wastage in educational institution buildings in Nigeria are contained in Table 7. After due analysis of data, the results contained in Table 7 revealed that, the most critical area of energy wastage in the higher education institutions in South Western Nigeria is leaving lights turned on in an unoccupied spaces mostly in Lecture halls and classrooms and hostels accommodations with the highest mean score (MS = 4.59).

The line of wastage was observed to continue in decreasing order for cases of leaving fans running in an un-occupied space with (MS = 4.57), leaving Air Conditioners (AC) on in empty offices with (MS = 4.53), high level of usage of fans and ACs over natural ventilation (MS = 4.27), leaving security lights turned on during day time with (MS = 4.26), Faulty lighting controls and switch in buildings (MS= 4.23), running fans with no control regulators with (MS = 4.22), simultaneous running of multiple appliances in hostels and staff quarters with (MS= 4.08), leaving plug appliances in socket unused (MS = 4.07). The results further revealed that while energy wastages are mostly common with lighting consumption, poor controls and regulators for both lighting and other appliances in Higher Education Institutions, lighting related operations exert significant impacts on energy wastages as six out of the thirteen major energy wastage areas (1st, 5th, 6th, 10th, 11th and 13th) are connected with lighting, more so that the highest ranking wastage area has to do with leaving lights on in unoccupied spaces.

Table 7. Area of Energy Wastage in Educational Institutions Buildings in Nigeria

| Variables                                | Mean Score | Rank |
|------------------------------------------|------------|------|
| Leaving lights on in an empty space      | 4.59       | 1st  |
| Leaving fans running in empty space      | 4.57       | 2nd  |
| Leaving Air conditions on in empty offices | 4.53       | 3rd  |
| High-level usage of fans & ACs over natural ventilation | 4.27       | 4th  |
| Leaving security and street lights on in day time | 4.26       | 5th  |
| Faulty lighting controls and switches in buildings | 4.23       | 6th  |
| Running fans with bad regulators and controls | 4.22       | 7th  |
3.2 Factors Influencing Energy Wastages

The results of evaluation of factors influencing energy wastage in the educational institutions buildings in South Western Nigeria are contained Table 8. The factors are critical for energy consumption consideration in the adoption of smart building technologies. Ten (10) variables were identified and each indicator was rated by respondents using the five point Likert scale: The table revealed that, the major dominant factors influencing energy wastage in the study area was as a result of poorly designed HEIs buildings with average (MS = 4.62), followed by lack of improved sensors to monitor and regulate lightening consumption.

The other factors of energy wastage are in decreasing order with lack of information and awareness on energy usage and its cost implication with (MS  = 4.54), Non metering of each facilities and buildings (MS = 4.52), In-effective energy policies on buildings design and usage (MS = 4.52), lack of controls and behavioral attitudes towards energy savings (MS = 4.42), lack of energy regulations and policies for students living in hostels accommodation (MS = 4.38), lack of improved software for institutional buildings design and operations and usage of inefficient appliances (MS = 4.26), lack of passive glazing materials for building designs was the least with (MS = 4.25).

All other factors aside poorly designed HEIs buildings need to be adequately considered during design phase for effective energy wastage management. This perhaps explains the highest ranking of poor designs of HEIs buildings. Furthermore, the major factors as agreed by the respondents from the study areas that are influencing energy wastage could reduce wastages when considered along with adoption of smart building technologies in institutional buildings especially with a view to minimize the energy consumption during peak period.

### Table 8. Factors Influencing Energy Wastage in Educational Institutional Buildings in South West Nigeria

| Variables                                                 | Mean Score | Rank |
|-----------------------------------------------------------|------------|------|
| Poorly designed HEIs buildings                            | 4.62       | 1-   |
| Lack of improved sensor to monitor energy consumption     | 4.61       | 2-   |
| Lack of information and awareness on energy usage and cost| 4.54       | 3-   |
| Non-metering of each facilities to measure energy usage   | 4.52       | 4-   |
| In-effective energy policies in HEIs buildings            | 4.52       | 5-   |
| Poor controls and behavioral attitudes of occupants       | 4.42       | 6-   |
| Lack of energy usage rules for students living in hostels | 4.38       | 7-   |
| Lack of improved software for HEIs design & operations    | 4.30       | 8-   |
| High usage of inefficient appliances in HEIs              | 4.26       | 9-   |
| Lack of passive glazing materials for windows and buildings| 4.25       | 10-  |

3.3 Evaluation of Energy Saving Opportunities for Educational Institutional Buildings

In Table 9, existing energy saving opportunities that are deemed to be peculiar to higher education institutional buildings are examined. Fifteen (15) identified variables were ranked using five point Likert scale. The table shows that the most preferred potential savings technique to reduce energy wastage is the implementation of energy saving policies. The other energy savings opportunities that could be adopted decreased in ranking from adopting independent metering system for each buildings and facilities, hostels, staffs quarters and ventures (MS = 4.63), the use of improved switch, sensors and controls systems to regulate lightening consumption (MS = 4.59), encouraging energy savings behaviors among staffs and students (MS = 4.51), adopting natural ventilation and lightening over mechanical ventilation.

### Table 9. Energy Saving Opportunities to be utilized in Higher Education Institutional Buildings

| Variables                                               | Mean Score | Rank |
|---------------------------------------------------------|------------|------|
| Poorly designed HEIs buildings                          | 4.62       | 1-   |
| Lack of improved sensor to monitor energy consumption   | 4.61       | 2-   |
| Lack of information and awareness on energy usage       | 4.54       | 3-   |
| Non-metering of each facilities to measure energy usage | 4.52       | 4-   |
| In-effective energy policies in HEIs buildings          | 4.52       | 5-   |
| Poor controls and behavioral attitudes of occupants     | 4.42       | 6-   |
| Lack of energy usage rules for students living in hostels| 4.38       | 7-   |
| Lack of improved software for HEIs design & operations  | 4.30       | 8-   |
| High usage of inefficient appliances in HEIs            | 4.26       | 9-   |
| Lack of passive glazing materials for windows and buildings| 4.25       | 10-  |
Implementation of energy savings policies in institutions 4.66 1-
Metering each department & facilities for energy usage 4.63 2-
Improved sensors to regulate lighting consumption 4.59 3-
Encouraging energy savings behaviour among students & staffs 4.51 4-
Adopting natural ventilation and lighting over mechanical 4.44 5-
Efficient lightening upgrades to energy saving lamps 4.40 6-
Using scheduling devices for power supply 4.38 7-
Passive building designs 4.36 8-
Passive glazing materials for building and windows 4.35 9-
Introducing energy savings education into teaching 4.35 10-
Good landscaping design and building envelope 4.34 11-
Switching from electricity streetlights to solar control sensors 4.34 12-
Replacing resistance regulators ceiling fans with electronic regulators 4.32 13-
Efficient heating and cooling technology with efficient appliances 4.30 14-
Selecting offices equipment with reduced heat emission 4.29 15-

(MS = 4.44), efficient upgrades from incandescent bulb to compact florescent lamp (MS = 4.40), uses of scheduling devices for power supply during vacations and off peak hours (MS = 4.38), passive building design for comfortable indoor environment (MS = 4.36), passive glazing materials for buildings and windows (MS = 4.35), introducing energy saving education into teaching (MS = 4.35), good landscaping design and building envelope (MS = 4.34), switching from electricity running street lights to solar with time control sensors (MS = 4.34), replacing resistance regulators ceiling fans with Electronic Regulators (MS = 4.32), efficient heating and cooling technologies with efficient appliances (MS = 4.30), scored least was selecting offices equipment with reduce heat equipment (MS = 4.29). From the respondents point of view it can be deduced that higher education institution energy policy, improvement on passive building designs principles are critical to the reduction of energy wastage and hence should be adhered to since it saves cost while other factors which involves the adoption of energy efficient technology for HSIs buildings are very costly to acquire.

4. Conclusion and Recommendation
The following conclusions are drawn from findings on the assessment of energy wastage and saving potentials for educational institutional buildings in South Western Nigeria;

• In appraising existing spectrum of energy wastes in institutional buildings of selected tertiary institutions in South western Nigeria, wastages associated with switching artificial light on in an unoccupied room spaces especially lecture halls and class rooms was the most critical means of energy wastages, while leaving appliances plugged in sockets unused was responsible for the least energy wastage. Furthermore, in the list of means through which energy is wasted in buildings, lighting related means collectively accounted substantially for energy wastages.

• Examination of factors influencing energy wastages revealed that poorly designed HEI building mostly affected energy wastages.

• The most preferred potential savings technique to reduce energy wastage is the implementation of energy saving policies.

In the lights of the findings, the following recommendations are made:

• The usage of metering system to determine energy bills in each facilities/ department should be implemented to know which areas consumes energy most.

• Using scheduling devices with intelligent building designs for Power supply and controls during sessions and vacations.

• Encouraging building management System (B.E.M.S) in institutions.

• Provisions of standards controls to all lightening and ventilating equipments.

• Switching off all unused lightening during the days and utilization of natural lightening during peak period.
Avoiding the usage of electric cookers and stoves in student’s hostels accommodation and implementing standard Energy Policies.

Awareness should be provided for students and staffs on energy usage and cost savings benefits attached in cutting energy bills and wastage to minimum.

Provisions of passive glazing materials for building and windows and selecting offices equipment with reduced heat equipment.

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