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A COMPARATIVE ANALYSIS OF ENERGY AUDIT OF LADOKE AKINTOLA UNIVERSITY OF TECHNOLOGY, OGBOMOSO, OYO STATE AND UNIVERSITY OF ILORIN, ILORIN, NIGERIA

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ABSTRACT

Energy audit deals with the way of checking the way of checking energy usage and identification of how wastage can be minimized if not totally eradicated. Energy audit consists of several tasks which can be carried out depending on the type of audit and the function of audited facility. It started with review of the historical data of energy consumption which can be compiled from the electricity bills. This paper presents a comparative analysis of energy audit of Ladoke Akintola University of Technology,(LAUTECH), Ogbomoso, Nigeria and University of Ilorin,(UNILORIN), Nigeria..

A number of offices were visited in six faculties – Faculty of Engineering, faculty of Management Sciences, Faculty of Agricultural Sciences, Faculty of Environmental Sciences, Faculty of Pure and Applied Sciences and Faculty of Medical Sciences of the two universities in order to take the statistics of different electrical appliances-fans, air-conditioners ,television sets, refrigerators, printers and computer systems used and to carry out a lightning use analysis .Ratings of the electrical appliances were also recorded as well as the load connected to the equipment. The total annual energy cost was computed when T12 tube light and CFL was used. When these were replaced with T5 tube light and LED respectively, total annual energy cost was also computed for the two universities used as case studies in this research paper. Normal fans were also replaced with energy efficient fans, window ACs were equally replaced with split units while the total annual energy cost and the total cost savings were computed in each case for the two universities.

The results of the research paper shows that for LAUTECH, Ogbomoso, the total annual energy cost before and after replacing T12 tube light with T5 tube light were #177,986.16 and #124,589.52 which gave an annual cost saving of #53,396.64. In addition, before and after the replacement of CFL with LED, the total annual energy cost savings were #423,015.12 and #166,120.42 respectively giving an annual cost saving of #256,894.7. When normal fans were not replaced with energy efficient fans, the total annual energy cost was #1,762,068 and the total annual energy cost reduced to 31,409,654.4 when the replacement was done. In this case, the annual cost saving was #352,413.6. A total annual energy cost of #24,324,775.2 was obtained before replacing window AC with split units. After the replacement, the total annual energy cost reduced to #18,243,582.72 which translated to an annual cost saving of #6,081,192.5.

For UNILORIN, before and after the replacement of T12 tube light with T5 tube light, the total annual energy costs were #223,076.04 and 3156,153.36 respectively with an annual cost saving of #66,922.68.
Replacement of CFL with LED gave a total annual energy cost of #173,595.84 compared to a total annual energy cost of #446,416.08 before the replacement. This eventually translated to an annual cost saving of #272,820.24. The total annual energy cost before and after replacing normal fans with energy efficient fans were1,846,606.08 and #1,447,285.92 respectively which translated to an annual cost saving of #8,750,986.2 for UNILORIN. Replacement of window AC with split units gave a total annual energy cost of #26,252,958.6 compared to a total annual energy cost of #35,003,944.8 before the replacement. A total annual cost saving of #8,750,986.2 was obtained.

For LAUTECH, a total annual cost saving of #53,396.64 was obtained when T12 tube light was replaced with T5 tube light while it was #66,922.68 for UNILORIN which might be due to the size of UNILORIN compared to LAUTECH. By replacing the CFL with LED, the annual cost saving for LAUTECH and UNILORIN were #256,894.7 and #272,820.24 respectively due to the power requirements of UNILORIN compared to LAUTECH.. By replacing normal fans with energy efficient fans, the annual cost savings for LAUTECH and UNILORIN were #352,413.6 and #369,320.16 respectively suggesting that a much annual cost was saved in UNILORIN due to the power requirements of the university. When window ACs were replaced with split units, the annual cost savings for LAUTECH and UNILORIN were #6,081,192.5 and #8,750,986.2 respectively translating to a total annual cost saving of #6,743,897.44 and 39,460,049.28 for LAUTECH and UNILORIN respectively as well.

Keywords: Energy audit, LAUTECH, UNILORIN, Tube light, CFL, LED, Energy efficient fans, Split units.

1. Introduction.

Energy is a major concern for every country as the conventional sources of energy are depleting and at the same time there is a significant growth in the industrial loads. To link this gap there is need to search all possible energy saving alternatives. A lot of awareness has been generated in conducting energy audits to achieve energy conservation. With the beginning of energy crisis and increase in energy cost, energy audit is proving its importance. Energy plays an important role in all sectors for any country's economy. The economic development of any country is closely linked with consumption of energy. Coal and gas are conventional sources of energy and they are available in limited forms and are very important for electricity generation(Ankur et al, 2014, Gui-Bing et al, 2011,Han, 2013,Matteo et al,2014).

It is necessary to optimize the use of natural resources and avoid energy crisis with. energy consumption increasing at a very fast rate. With the advent of energy growth it has become essential to minimize energy leakage as an important infrastructure for national development. In urban areas, an erratic power supply is experienced. Energy auditing does not only save money but it also improves the quality of electrical energy supply. Energy crisis is one of the crucial problems faced by all the countries in the world today due to depletion in natural resources used for energy generation and the huge investment for generating energy from alternate resources (Kulkami and Kalpana,2013, Zhao et al, 2013, Aarti et al,2016, Mehulkumar et al,2014).

Life existence depends on energy. Human beings need energy for comfort, cooking, heating, transportation, safety etc. An illustrative example is a plant which uses the process of photosynthesis for the generation of carbohydrate in the presence of light energy.

Energy has a significant impact on every aspect of our socio-economic life. It plays a key role in the economic, social and political development of any nation. Inadequate supply of energy limits socio-economic activities, limits economic growth and adversely affects the quality of life (Toyinbo et al, 2015, Takshashila et al, 2015, Kurian et al, 2015, Vikrant et al, 2012, Callaghan and Probert, 1977).

Energy can be classified primarily as conventional and unconventional. The earlier being the most consumed form of energy such as fossil fuels and the latter being the mostly renewable form of energy. The primary source of energy are usually converted into secondary form of energy which is electricity. Electricity which as a secondary form of energy has tremendous advantage due to its convenience and flexibility (Olumide et al, 2017, Malkiat et al, 2012) The energy supply in Nigeria is inadequate and the available infrastructure for providing and extending these required energy especially to rural areas have continued to diminish and have become grossly inadequate.

Energy consumption is increasing worldwide due to increasing population, the quest for better standards of living and emphasis on large-scale industrialization in developing countries, thus sustaining positive economic growth rates. Adequate energy projections provide the foundation for daily operations, market planning, budgeting and risk management. An energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use. Energy audit is to identify and minimize the wastage of energy and to optimize its use. It is an inspection, survey and analysis of energy flow for energy conservation. Saving energy is the primary and overwhelming motivating factor for making energy improvements. Energy demand has increased as its consumption is increased, so proper energy conservation methodology has to be adopted, energy conservation avoids wasteful use of energy. Energy saving achieved through energy conservation avoids capital investment in fuel, water and land required for power plant (Zhao *et al*., 2013).

Energy conservation increases the environmental quality and increase the savings, it lowers the energy costs by preventing future resource depletion. Utilizing electric power in the proper manner without wastage is the most important task of power system engineers (Kongara et al, 2014, Chowdhury and Felice, 1983,Divine et al, 2015, Darshan et al, 2017).

II. Related works.

Malkiat et al (2012) presented a work on energy audit to reduce Lighting Cost and claims that energy audit is essential to decrease energy wastages and to reduce electrical billing. Kongara et al (2014) stated that the efficiency of the controlled lightning design would not only reduce power consumption but would also be an important energy saving component. Here comparison of the power consumption between different lightings was done and their consumption and payback period was calculated respectively. Gui-Bing et al (2011) designed an energy flow structure to show the energy distribution to find the reasons for energy losses to achieve energy conservation. Vikrant et al (2012)presented energy audit work on sub-unit like Boiler,Turbine and Generator , He also worked on the energy audit of Condenser, and Pre-heater of Panipat Thermal Power Station, the result was that overall plant efficiency at lower loads decreased, so the plant should be run at higher load. Vikas and Jitendar (2014)presented a study of dynamic responses of power plants through mathematical modeling, identification, and simulation of Rajiv Gandhi thermal power plant Hisar (600MW). From the analysis part of this work, it is concluded that the overall plant efficiency varies as the variation or small change in the output

loads. A case study done by Chowdhury and Felice (1997) showed that audit was conducted and suitable strategies of adjusting and optimizing energy were suggested so as to reduce energy requirements and hence, the total cost spent towards energy consumption.

Kulkarni and Kalpana (2013) discussed the common aspects of electrical energy management in small- and medium-sized industries. It contained the findings and the analysis of the results obtained from the electrical energy audit program employed in an industrial unit, The electrical energy audit was carried out under three major heads: (i) lighting audit, (ii) power load audit (motors, meters, etc.), and (iii) harmonic analysis.

Matteo et al (2014) presents the results of a preliminary energy audit carried out on 8 large industrial buildings of a famous car manufacturing holding in Italy. Energy demand for heating varied from 6 to just over 74 kWh in 3years among the buildings of the site.

Kurian et al (2015) did an energy audit of a campus in kerala presenting a paper that took into consideration methods of saving using a methodological approach and concluded that several energy conservation methods that are cost effective are not often implemented due to lack of internal funding, but that it is the responsibility of the energy auditor to urge the management to elaborate the advantages that can be achieved through successful implementation. Takshashila et al (2016) presented a paper on energy audit of an academic building and concluded that energy audit is an effective tool in identifying problems associated with energy management program, and also asserted that a careful audit in any organization will lead to effective management of energy system in the organization at minimum cost possible. Aarti and Sampada (2016) did analytical energy conservation to reduce the energy consumption in the Nagpur Distillers Pvt. Limited. They presented a paper that highlighted the amount of savings that can be obtained with changes in the lightning sector of the industry, so that energy crisis can be decreased to an extent.

Toyinbo et al (2015) conducted an energy audit of Obafemi Awolowo University, Ile Ife and observed that the different energy supply addressed gave a rapid increase in cost in response to the increase in the demand complexity and therefore concluded that to reduce the cost of energy, the load must be reduced drastically. Mehulkumar et al (2014) in their work remarked that energy audit is of two types which added completeness to the energy conservation proposal description. The energy audit and energy conservation measures described in their research paper did not only provide a very different perspective to the wastage and energy crisis and energy security but also an implementation platform that addressed all aspects of managing several energy sources. The approach presented in their paper was different from the approach taken in many publications that divided the research into energy conservation strategies and addressed sub-problems without demonstrating how they fit into a larger picture, based on this, key issues relating to the implementation of energy conservation proposal and methodology was discussed.

III. Materials and Method..

The following procedural steps were taken in the analysis of this research paper.

(i) Visitation to a number of offices in six Faculties- Faculties of Engineering,Management Sciences, Agric Sciences, Environmental Sciences, Pure and Applied Sciences and Basic Medical Sciences of LAUTECH, Ogbomoso and UNILORIN, Ilorin.

(ii) Taking the statistics of different electrical appliances such as T12 tube light, T5 tube light, CFL, LED, Normal fans, Energy efficient fans, Window ACs and Split units. And to carry out lightning use analysis in each of the selected offices of the two universities.

(iii) Taking the records of the ratings of each of the electrical appliances as well as the load connected to each of the appliances.

(iv) Computation of the total annual energy cost with the use of T12 Tube light, CFL, Normal fans and Window ACs.

(v) Computation of the total annual energy energy cost by replacing T12 Tube light with T5 Tube light, CFL with LED, Normal fans with energy efficient fans and Window ACs with split units.

(vi) Computation of the total cost savings for LAUTECH and UNILORIN.

(vii) Carry out a comparative analysis of the annual energy cost savings and the total cost savings for each of the universities..

IV. Discussion of Results.

The variations of the equipment ratings with the various loads- air-conditioner, CVL,T12 Tube light, television set, refrigerators, printers and computer systems for LAUTECH are shown in Figure 1.Air-conditioners have the highest wattage rating of 1500Watts followed by computer systems and printers with ratings of 250W each. CFL has the least power rating of 18W as a result of the power requirements of the equipment. The number of various equipment used in this research paper is illustrated in Figure 2. There were 396 pieces of fans, 406 pieces of air-conditioners, 396 pieces of CFL, 75 pieces of T12 Tube light, 386 pieces of television set, 219 pieces of refrigerators,189 pieces of printers and 384 pieces of computer systems. Air-

conditioners were observed to be more than any of the equipment used because of the relative importance and significant roles of the equipment in the university especially during the dry season. The ratings of the connected load are as shown in Figure 3. Air-conditioners recorded the highest connected loads of 609 Kw due to the power requirements of the appliance.T12 Tube light had the least connected load of 3 Kw as a result of its very low power requirement .Most of these appliances were replaced by energy saving appliances. The total annual energy cost before implementation of the recommendations for LAUTECH is illustrated in Figure 4. When T12 Tube light was used in the offices in LAUTECH, the total annual energy cost was #177,986.16. When CFL was used, the total annual energy cost was #423,015.12. When window AC was used in the university, the total annual energy cost was #24,324,775.2 as shown in Figure 4. On replacement of the T12 with T5 tube light, the total annual energy cost becomes #123,589.52. The total annual energy cost when CFL was replaced by LED is #166,120.42. Replacing the window AC with split AC units gave a total annual energy cost of #18,243,582.72 as illustrated in Figure 5. The annual cost savings for LAUTECH is depicted in Figure 6..When window AC was replaced with split AC units, #6,081,192.5was saved as the annual cost. which appeared to be the highest in this range. A sum of #6,743,897.14 was saved as the total annual cost when those energy consuming appliances were replaced by energy saving ones.

The ratings of the equipment used in UNILORIN is illustrated in Figure 7. Air-conditioners have the highest power rating of 1500 Kw with CFL having a least power rating of 18W. Fans, T12 Tube light, television set, refrigerators, printers, and computer systems have wattage ratings of 75W, 40W, 30W, 100W, 250W and 250W respectively. The number of equipment used as case study in this research paper for UNILORIN is illustrated in Figure 8. For fans, air-conditioners, CFL, T12 Tube light and television sets, 415, 429, 418, 94 and 427 pieces were used while 284, 189 and 385 pieces were used for refrigerators, printers and computer systems respectively. The connected loads to the appliances is shown in Figure 9. A highest load of 643.5 Kw was connected to the air-conditioners while a least load of 3.76 Kw was connected to T12 Tube light as a result of the power requirements of the appliances.

The total annual energy cost when T12 Tube light, CFL, normal fans, and window AC units were used for UNILORIN are #233,076.04, #446,416.08, #1,846,606.08 and #35,003,944.8 respectively as illustrated in Figure 10. On replacement of T12 with T5 tube light, CFL with LED, normal fans with energy efficient fans and window AC with split units, the total annual energy cost are #156,153.36, #173,595.84, #1,447,285.92 and #26,252,958.6 as shown in Figure 11. After replacing the less efficient energy saving appliances with energy saving appliances, a total of #9,460,049.28 was saved per annum for UNILORIN as depicted in Figure 12.

The comparisons of the annual cost savings between LAUTECH and UNILORIN is shown in Figure 13. On replacement of T12 tube light with T5 tube light, a sum of #53,396.64 was saved per annum in LAUTECH while a sum of #66,922.68 was saved in UNILORIN. Replacing CFL with LED, a sum of #256,894.7 was saved in LAUTECH and a corresponding sum of #272,820.24 was saved in UNILORIN. In addition, when normal fans were replaced with energy efficient fans, a sum of #352,413.6 was saved per annum in LAUTECH while #369,321.16 was saved per annum in UNILORIN.. #6,081,192.5 and #8,750,986.2 were saved per annum when window ACs were replaced with split inits.in LAUTECH and UNILORIN respectively suggesting a more annual cost savings in UNILORIN than LAUTECH which could be due to the power requirements of the university compared to LAUTECH. A total sum of #6,743,897.44 was saved per annum in LAUTECH while a total sum of #9,460,049.28 was saved per annum in UNILORIN representing 40.28% increase in UNILORIN compared to LAUTECH which could be due to the power requirements of the university.

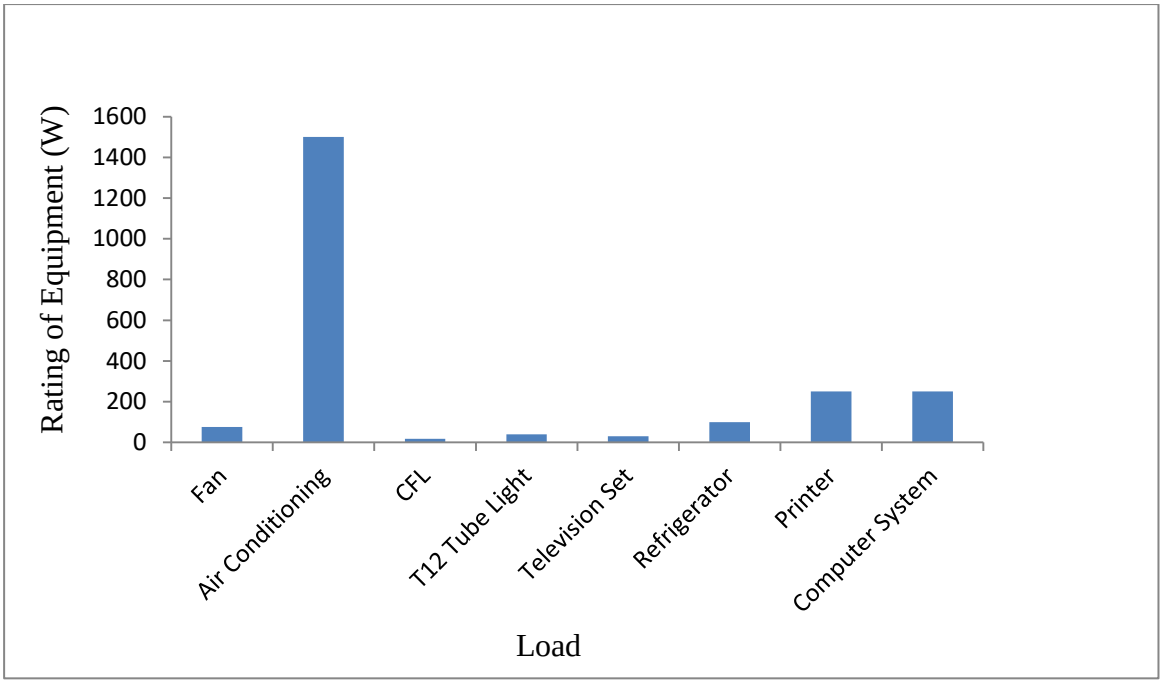

Figure 1: Graph of rating of equipment versus load for LAUTECH

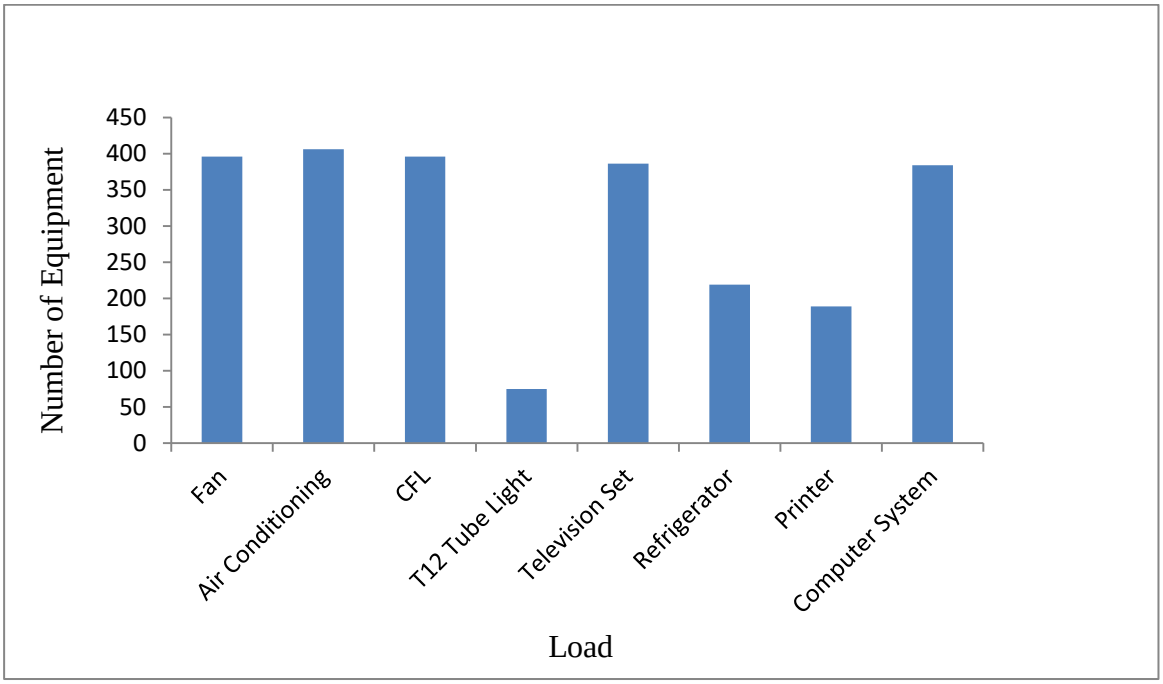

Figure 2: Graph of Number of equipment versus load for LAUTECH

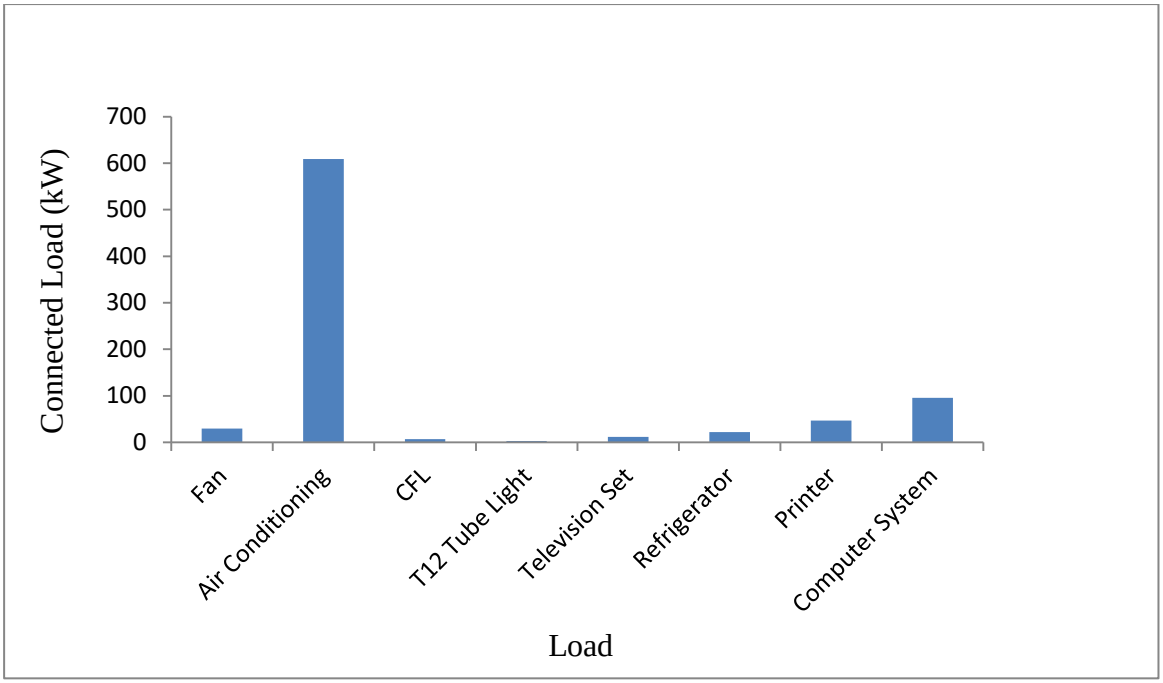

Figure 3: Graph of connected load (kW) versus load for LAUTECH

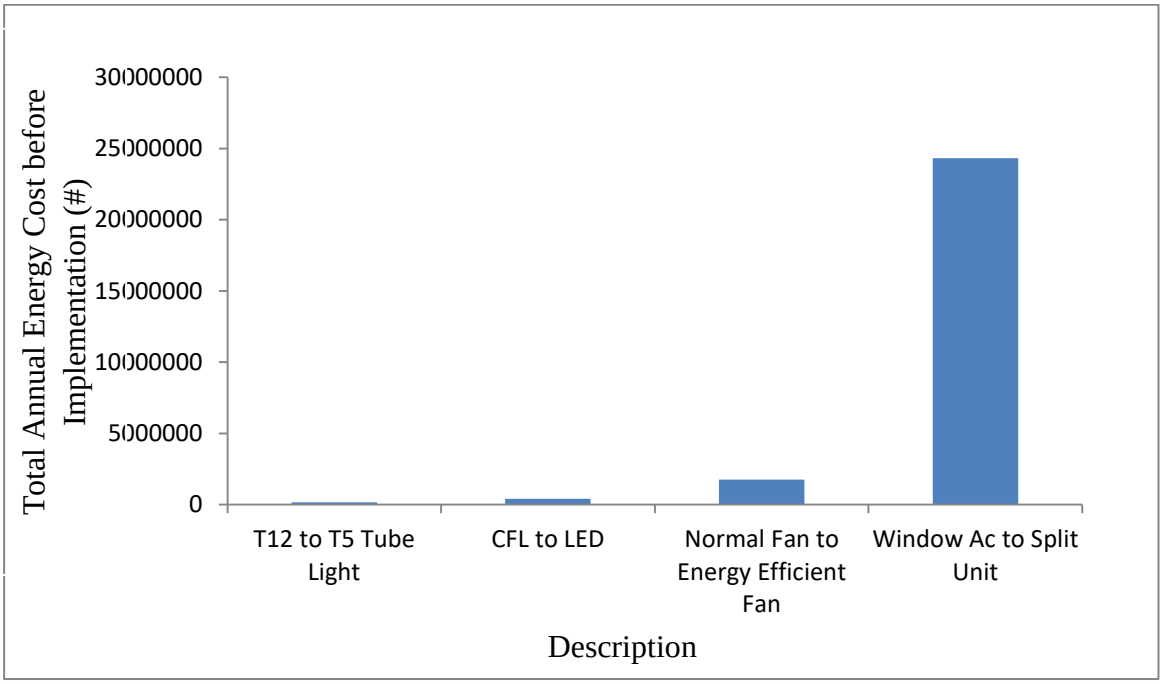

Figure 4: Graph of total annual energy cost before implementation (#) versus description for LAUTECH

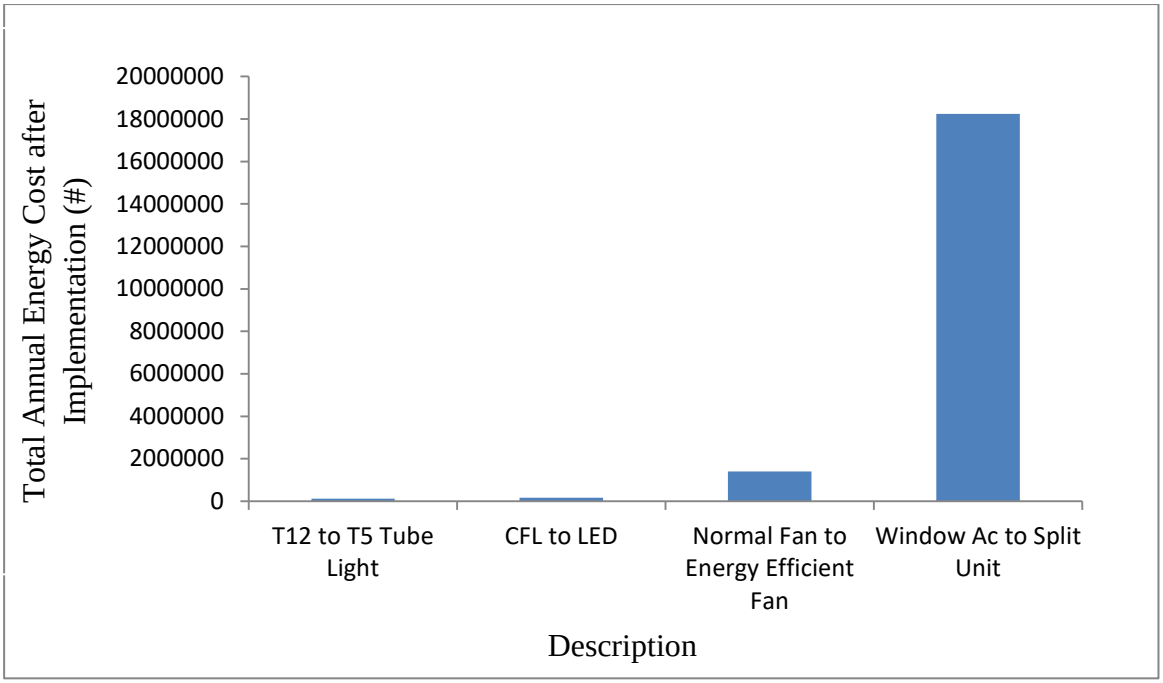

Figure 5: Graph of total annual energy cost after implementation versus description for LAUTECH

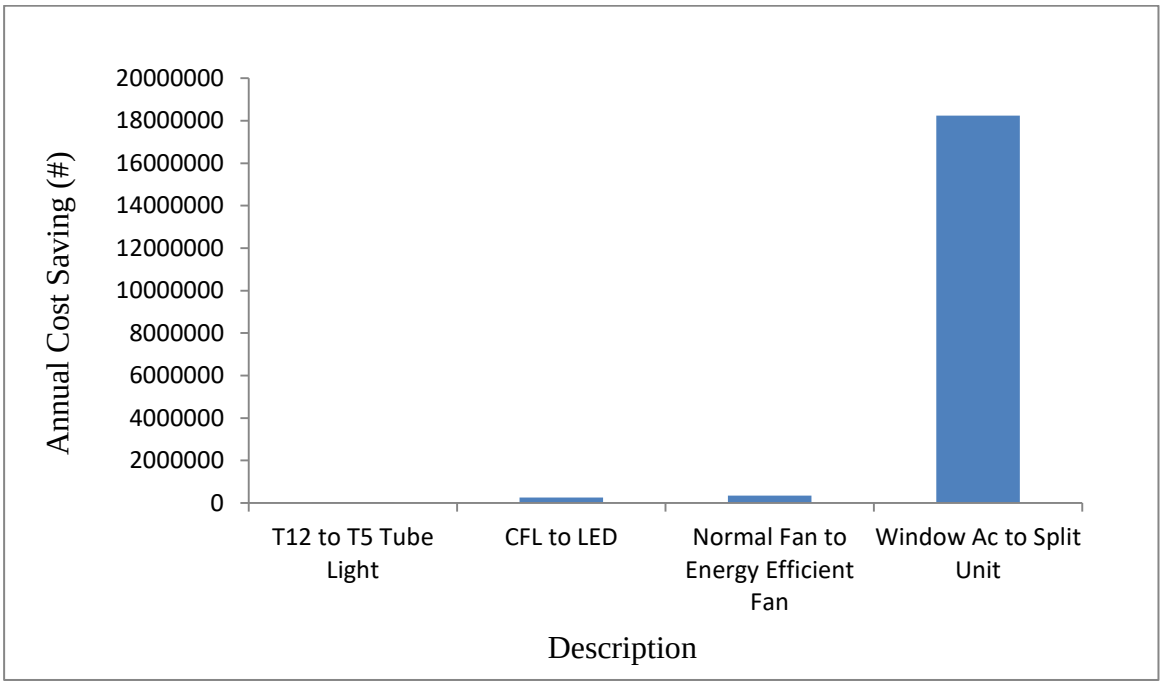

Figure 6: Graph of annual cost saving (#) versus description for LAUTECH

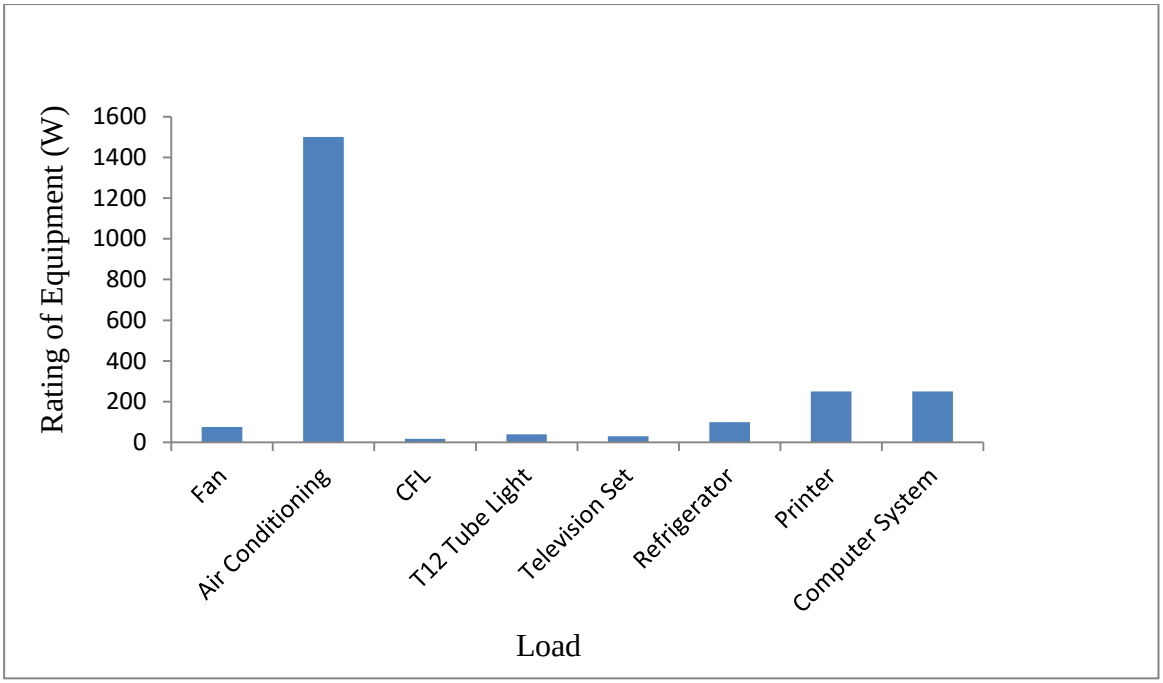

Figure 7: Graph of rating of equipment versus load for UNILORIN

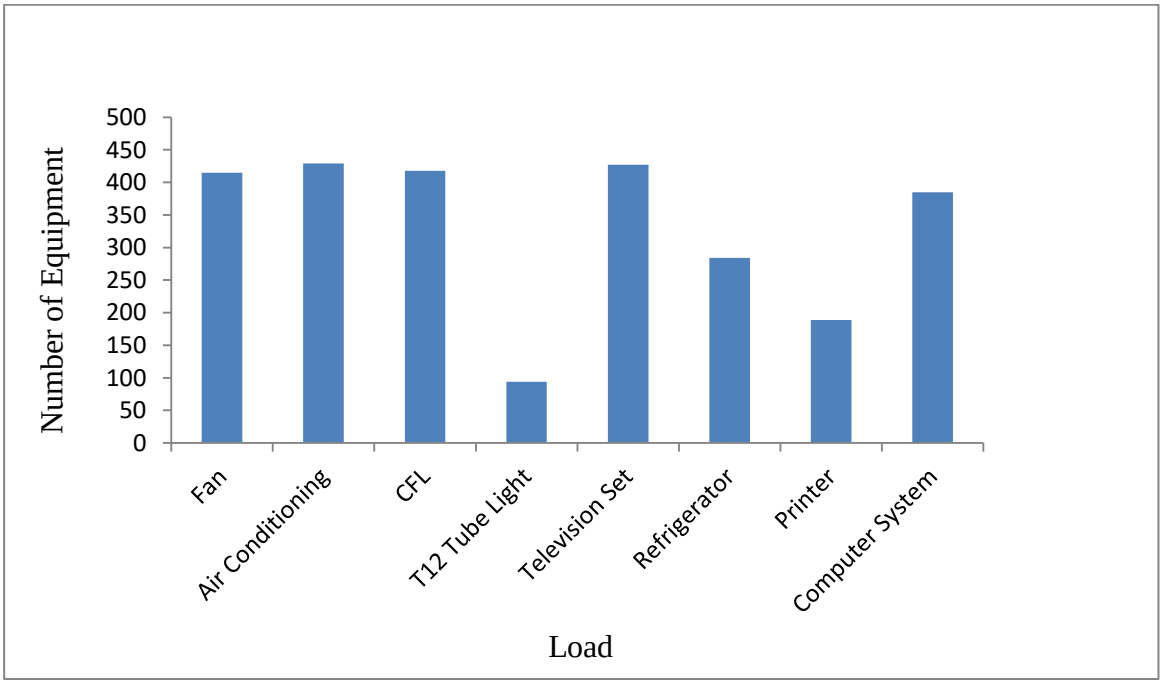

Figure 8: Graph of Number of equipment versus load for UNILORIN

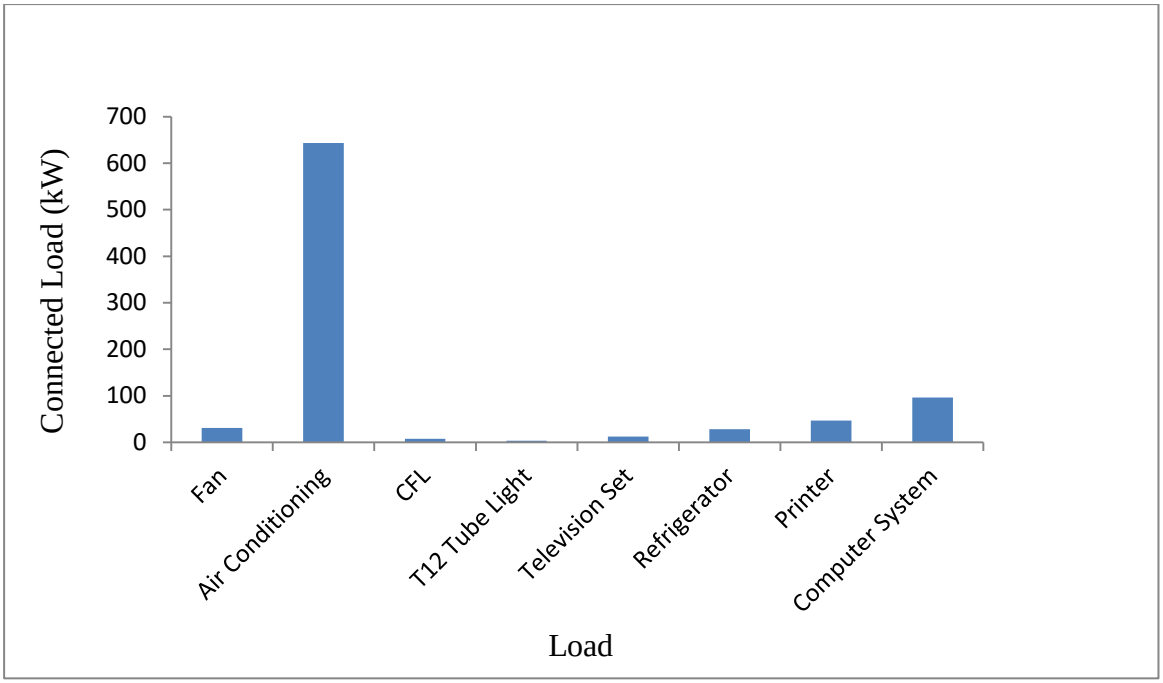

Figure 9: Graph of connected load (kW) versus load for UNILORIN

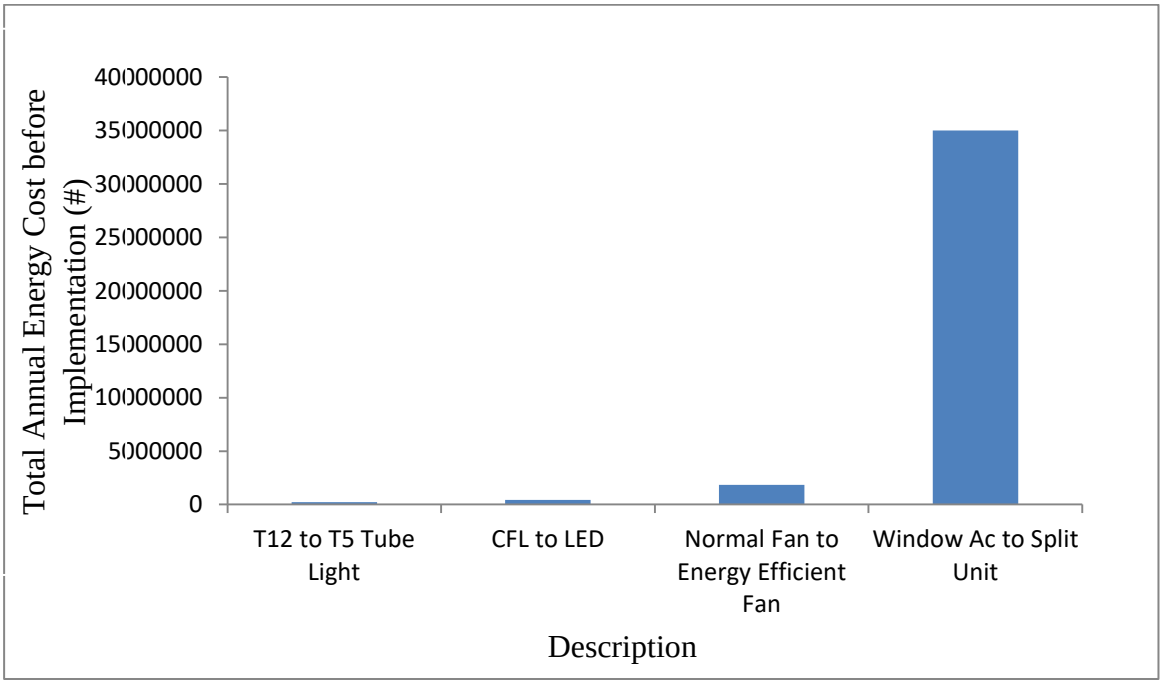

Figure 10: Graph of total annual energy cost before implementation (#) versus description for UNILORIN

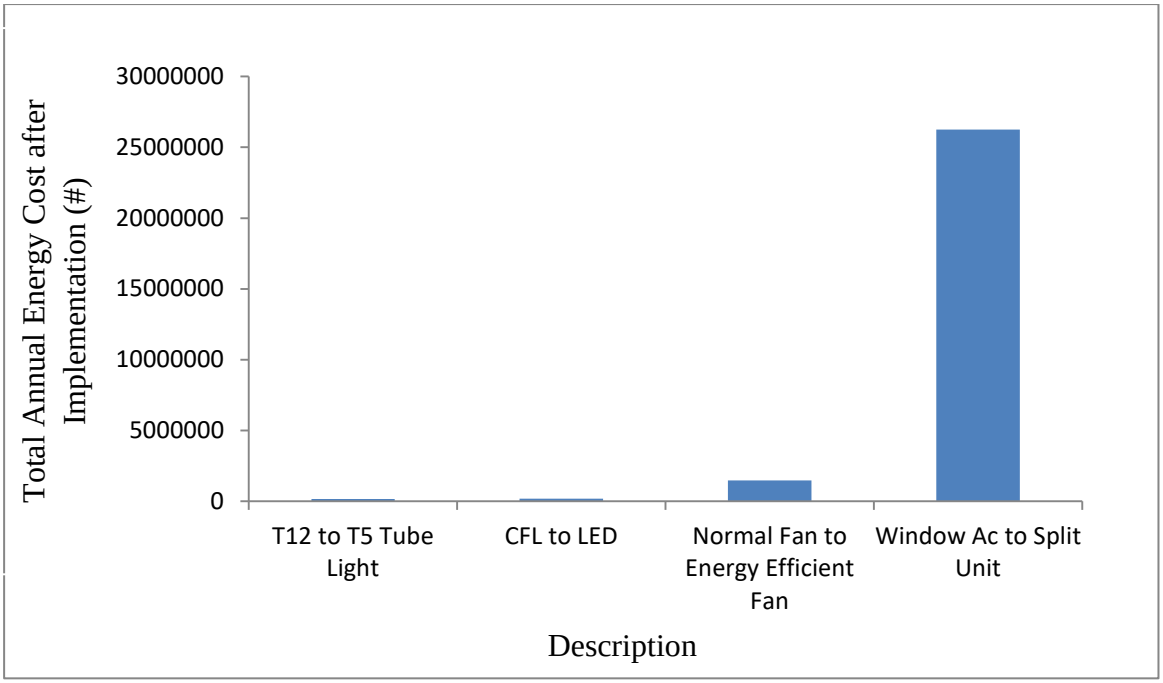

Figure 11: Graph of total annual energy cost after implementation versus description for UNILORIN

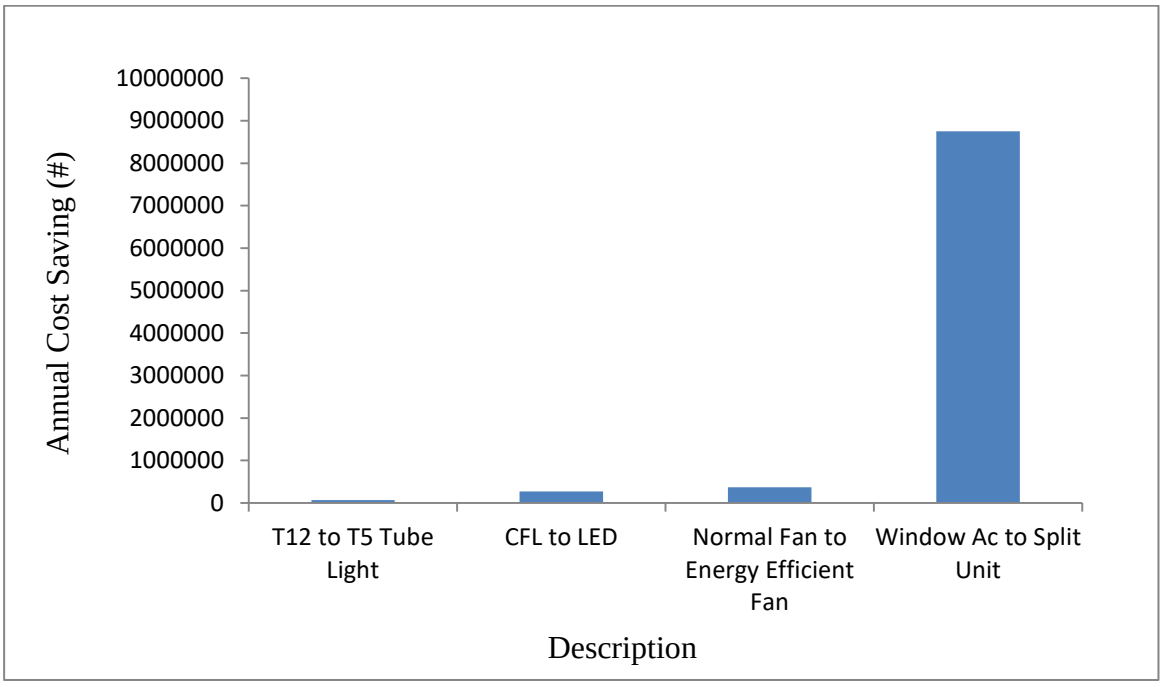

Figure 12: Graph of annual cost saving (#) versus description for UNILORIN

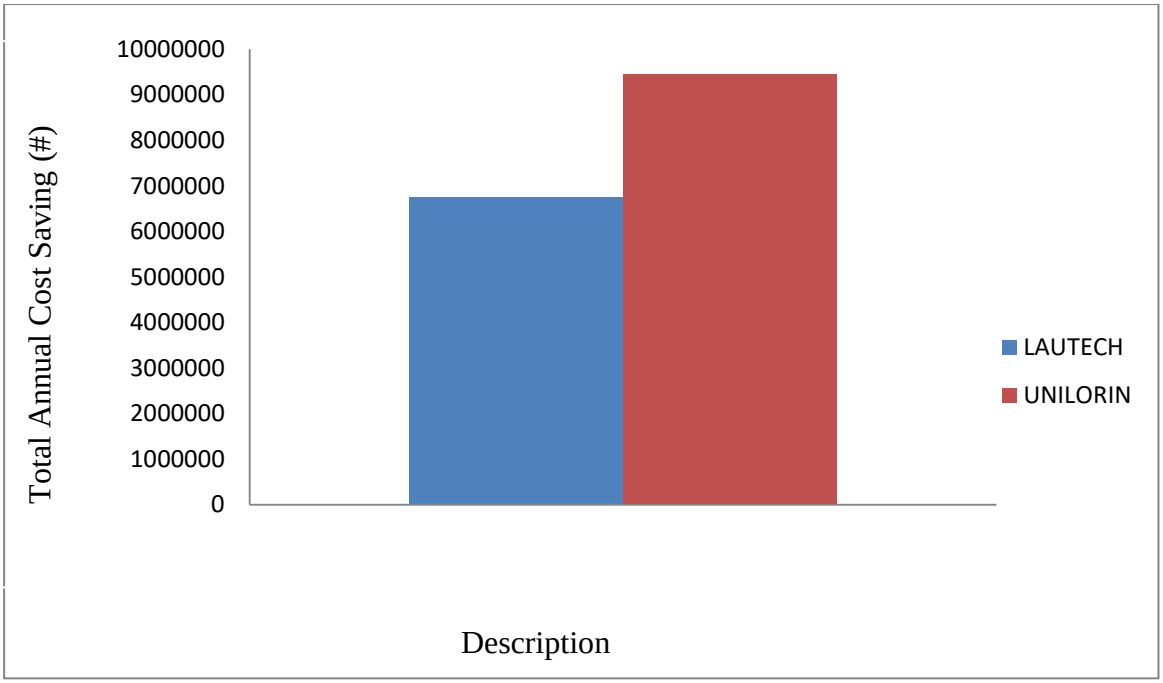

Figure 13: Graph of comparison between the total annual cost saving (#) for LAUTECH and UNILORIN.,

V. Conclusion.

A comparative analysis of energy audit of Ladoke Akintola University of Technology,(LAUTECH), Ogbomoso, Nigeria and University of Ilorin,(UNILORIN), Nigeria has been presented.
A number of offices were visited in six faculties of the two selected universities of LAUTECH, Ogbomoso, Nigeria and UNILORIN, Nigeria in order to take the statistics of different electrical appliances such as fans, air-conditioners ,television sets, refrigerators, printers and computer systems used and a lightning use analysis was also carried out. .Ratings of the electrical appliances were also recorded as well as the load connected to the equipment. The total annual energy cost was computed when T12 tube light and CFL were used. When these were replaced with T5 tube light and LED respectively, total annual energy cost was also computed for the two universities.. Normal fans were also replaced with energy efficient fans, window ACs were equally replaced with split units while the total annual energy cost and the total cost savings were computed in each case for the two universities.

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VI. Recommendations.

Based on the discussion and data from this audit survey, the following can be recommended as measures to conserve energy:

i. The school management should ensure that CFLs is replaced with LED in all the buildings, LED Bulbs are small, very efficient solid Bulbs, LED technology is advancing rapidly, with many new bulb style.LED bulbs use only 2-17 watts of electricity (1/3 to 1/30th of CFL). Although LED are initially expensive, the cost is recouped over time
ii. The management should implement policies regarding energy saving measures.
iii. The management should employ an energy efficiency manager that will be responsible for the energy situation of the school.
iv. Lights should be switched off when not in use especially during the day.
v. The management should implement an automated lighting system, which helps in switching off street lights automatically during the day.
vi. There should be proper documentation of electric energy consumption within the campus.
vii. Electric meters should be installed in each of the Hostel/Lodges, to monitor/curtail power wastages and thereby reduce energy cost on electric power.
viii. T12 tube light should be replaced with T5 Tube light, T5 tube light are considered to be of higher efficiency performance and consuming up to 28 watts T5 tube light have much longer life. Although T5 tube light are initially expensive, the cost is recouped over time.
ix. LCD monitors typically require about 30% of the power required for a CRT monitor with the same screen area. In addition, the amount of heat generated by an LCD monitor is considerably less than a CRT monitor, resulting in a lower load on air-conditioning.

VII. Contribution to knowledge.

Energy auditing will help to discover areas of energy loss, where more power is consumed in the system and where overhaul and improvements are needed thereby conserving energy and cost in the process and improving the overall performance of the system.

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