ENERGY EFFICIENCY THROUGH LIGHTING SYSTEMS: A CASE STUDY AT THE AGRICULTURE FACULTY BUILDING, KANO UNIVERSITY OF SCIENCE AND TECHNOLOGY, WUDIL, KANO, NIGERIA

BY

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ABSTRACT

In Nigeria, there is an urgent need for energy demand as the population increases. This also results the increasing demand of lighting energy. Due to this, the lighting energy needs to have energy savings, cost savings, and reduction of greenhouse gas emission, which affects global warming. The literature reveals that the commercial buildings like universities consume a significant amount of lighting energy and this makes it as an avenue of interest in reducing lighting energy consumption. This research was aimed at exploring the use of lighting system as the way of improving energy efficiency at the Agriculture Faculty Building (AFB) Kano University of Science and Technology (KUST), Wudil, Kano, Nigeria. Three lighting systems FLT8 (usually used), FLT5 and LED (improved) were employed to identify which of them would be the most suitable for improving energy efficiency. There were three main methods followed, which are the calculation of energy usage was conducted to determine the energy consumption of each lighting system with helped off the lumen method to find the number of fittings in AFB. Meanwhile, the return on investment was obtained by using simple payback period. The findings from this study show that the FLT5 and LED lamps save more energy as compared to the FLT8. The FLT5 saves 41% of energy consumed while the LED saves 44% of the energy consumed and both reduced the CO_2 emission by more than 2 Metric tons. The findings also reached that in terms of the return on investment (ROI), although the LED can save more energy, its ROI is 12 years compared to 2 years of FLT5. Therefore, the FLT5 proved a more efficient choice to LED. Moreover, in the thirty years, projection, LED has more benefits. This helps the university and the world over in saving the energy, cost and reducing of GHG emission effects.

ملخص البحث

في نيجيريا، هناك حاجة ملحة للطلب على الطاقة خاصة مع ازدياد عدد السكان مما أدى ذلك إلى الطلب المتزايد على طاقة الإضاءة. فلذا هناك حاجة ملحة لتوفير طاقة الضوء والحد من الإسراف الزائد للطاقة ووفرة فى التكاليف إضافة إلى الحد من انبعاثات الغازات المسببة للاحتباس الحرارى.المبانى التجارية إضافة إلى الجامعات تستهلك كمية كبيرة من طاقة الضوء مما يلزم ذلك تقليل فى استهلاك طاقة الإضاءة، ويهدف هذا البحث إلى توضيح استخدام نظام الإضاءة كوسيلة لتحسين كفاءة الطاقة في كلية الزراعة بناء على الـ (AFB) لجامعة كانو للعلوم والتكنولوجيا (KUST)، بكانو نيجيريا. يستخدمون عادة ثلاث أنظمة إضاءة الـ LT8 وFLT5 ونظام الـ LED (المحسن) لتحديد ما ألا كثر مناسبة وكفاءة فى استخدام الطاقة. هناك ثلاث طرق رئيسة التي أجريت لحساب استهلاك الطاقة لكل نظام أضاءة بمساعدة طريقة التجويف والعثور على عدد من تجهيزات الـ AFB. وفي الوقت نفسه، تم الحصول على عائدات الاستثمار باستخدامها في فترات بسيطة. النتائج المستخلصة من هذه الدراسة تظهر أن FLT5 ومصابيح LEDتوفر المزيد من الطاقة بالمقارنة مع FLT8. والـ LT5 يوفرحوالى 41٪ من الطاقة المستهلكة في حين يوفر44 ٪مصباح الـ LED على44٪من الطاقة المستهلكة على حد سواء. وبهذا ساعد فى خفض انبعاث.CO2 بأكثر من 2 طن فى كل متر. وتحصلت النتائج أيضا على عائدات الاستثمار (ROI)، إضافة إلى ذلك أن الصمام يمكن أن يوفر المزيد من الطاقة، وفترات الاستخدام حوالى 12 عاما مقارنة مع سنتين عند الـ FLT5. ولذلك، أثبتت أن FLT5 أكثر كفاءة عن الـ LED وعلاوة على ذلك، يستخدم لحوالي ثلاثين عاما، إضافة إلى المزيد من الفوائد. وهذا يساعد الكثير من الجامعات فى جميع أنحاء العالم في توفير الطاقة، إضافة إلى الحد من التكلفة بجانب التخفيض من آثار انبعاث الغازات الدفيئة. المسببة للاحتباس الحرارى.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Building Services Engineering.

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M. Zainora Asmawi
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This dissertation was submitted to the Kulliyyah of Architecture and Environmental Design and is accepted as a fulfilment of the requirement for the degree of Master of Science in Building Services Engineering.

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Abdul Razak Sapian
Dean, Kulliyyah of Architecture and Environmental Design

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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This work is dedicated to my parents (Yusuf and Maryam) for their moral and financial support, and proper guidance since the cradle in the making my future better. Also, to my beloved wife (Zulaihat), my children, my relatives and finally my friends. May Allah bless all of them abundantly Amin.

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LIST OF ABBREVIATION

AC	Alternating Current
AEC	Annual Energy Consumption
AFB	Agriculture Faculty Building
BTU	British Termal Unit
CFL	Compact Fluorescent Lamp
CI	Cost of Investment
CRI	Color Rendering Index
CO	Carbon Dioxide
DALI	Digital Addressable Lighting Interface
EC	Energy Consumption
ES	Energy Saving
FL	Fluorescent Lamp
FLT5	Fluorescent Lamp Tube with Diameter 5
FLT8	Fluorescent Lamp Tube with Diameter 8
FLT12	Fluorescent Lamp Tube with Diameter 12
GHG	Green House Gasses
HL	Halogen Lamp
HVAC	American S
IIUM	International Islamic University Malaysia
IL	Incandesent Lamp
KWh	KiloWatt Hour
KW	Kilo Watt
LED	Light Emitting Diode
Lm/W	Lumen per Watt
MYR	Malaysian Ringgit
NGN	Nigerian Naira
RI	Room Index
ROI	Return of Investment
SPP	Simple Payback Period
USD	United State Dollar
U.S DOE	United States Department of Energy
U.S	United States

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The world's population is expected to increase from 7.2 billion in 2014 to 9 billion people by the year 2040. And due to this, the world's energy demand is 557 quadrillion BTUs. By 2040 the demand is expected to rise to 703 quadrillion BTUs, which is about 25 % more (Mobil Exxon, 2016). The reason why the energy demand is higher than before is due to the technological advancement in all the economic sectors, which are residential, commercial, industrial, and transportation sectors. The International Energy Agency (IEA, 2010), indicates that the annual carbon dioxide can rise up to 3 gigatons by 2030 if care is not taken.

In this 21st century, although Africa is among the lowest in terms of energy demand in the world, it is the second highest in using biomass and waste as the main primary source of energy. This makes the Africa the potential place for enormous green house gasses (GHG) emissions. The energy demand in 2014 is 33 quadrillion BTU, and it was projected to account for 31% - 83% of the increase in energy demand between 2014 to 2040. Africa uses 15 quadrillions BTU of biomass and waste higher than another method of producing energy such as oil, gas, and coal (Mobil Exxon, 2016).

Nigeria is the eighth most populous country in the world with over 170 million people, and it has between 2.5% to 2.7% per annum increase in population in the next 20 years (Ley, Karsten & Ghatikar, 2014). With the growth of the Nigerian population will also increase the emission of GHG. This is because the primary source of energy

in Nigeria given by the International Energy Agency (IEA, 2011) are biofuels and waste with 82.2% usage, natural gas 6.8%, Oil is 10.6% and 0.4% for hydropower usage. Another data by (IEA, 2015) shows that biofuels and waste increased between 2011 and 2015 from 82.2% to 85 % usage (Ezema, Olotuah, & Fagbenle, 2016). These produced carbon particles in the environment and contributed to GHG emission.

As early in the year 2016, the estimated electricity demand in Nigeria was 12,800MW, but the available capacity is approximately 4,500MW. This indicatedthat only one-third of the electricity demand for more than 170 million people with a GDP growth rate of 7% was produced (Practice, 2016). The demandfor electricity may reach 78,000MW by 2030 according to the Chairman of the Nigerian National Committee of the Energy Council (2015). There is a need to invest in power and energy sector and at the same time that improvements in energy efficiency in all economic sectors is pertinent.

Energy is crucial for us today; however, producing this energy brings about a lot of challenges to theeconomic aspect and environmental issues. Energy efficiency improvement efforts in order to overcome the problems are that through saving energy used, saving producing and consuming cost, and at the same time to save environmental hazards like reducing the emission of CO_2. There is no doubt that the world has acampaign about renewable energy so as to reduce the GHG emissions which are influencing the global warming. In finding the solution to reduce the energy use and GHG emission, the European Union identified that building contributes 40% of the total energy consumed and 36% of total carbon dioxide emission (Becchio, 2013).

As the Europe finds out that buildings are heavy energy consumers, it is very vital to know which type of building consume more. One of the studies states that commercial buildings are consuming up to 42% of the total energy supplied (Mahlia, Razak, & Nursahida, 2011). In another study in Nigeria, reveals that the commercial and public sector the second in terms of electricity consumption with 6,180GWH and residential is first with 13,568GWH followed by the industry as the third position in electrical energy consumptions with 3,931GWH (IEA, 2013).

Lighting is among the highest consumer of electricity in the world today with the demand rapidly going up. Khan, (2002), indicates that lighting consumes about 19% of all the electricity in the world and says there is the solution to achieve energy efficiency in a lighting system with the possibility of 40% saving of energy. Moreover, lighting system used the significant amount of electricity in buildings in 20-50% consumption (Muhamad, Zain, Wahab, Aziz, & Kadir, 2010). In commercial buildings such as universities, lighting can cost more than the budget of computers and book combined and consumes up to 42% of the total electricity supplied (Mahlia et al., 2011).

With the above reasons, lighting becomes the target of energy efficiency because it has the potential to save a lot of energy. This forced government, policy makers, and global lighting marketers to encourage and influence consumers to energy efficient lamps such as T5 Fluorescent and Lighting Emitting Diode (LED). Among the ways of lighting energy efficiency, is retrofitting of existing lighting systems which become the number one solution for lighting savings (Asif & Hassan, 2013). It also increases overall building sustainability and can create benefits for the public and the owners. Replacing the existing lighting system (which are old and with poor energy saving) with new and highly efficient lamps would yield the reduction of

energy consumption, cost benefits, and GHG emissions. Another way of lighting energy efficiency is using a new lighting technology system to the feature buildings because it provides reliable and much longer lifetime than the old lamps.

In the case of this study, there would be two lighting technology systems which are going to be proposed to the Kano University of Science and Technology (KUST), Wudil to be used in the Agriculture Faculty Building (AFB). The study would offer the university the choice of selecting an energy efficient lamp system of retrofitting with either Fluorescent lamp T5 (FLT5) or LED lamp against the most commonly used Fluorescent T8 lamp (FLT8).

1.2 PROBLEM STATEMENT

The rapid increment of lighting energy has direct impacts of the global warming and reducing the energy consumed by lighting system is highly recommendable. To achieve this, the use of new technology lamps is in the best position for retrofitting of less efficient lamps with the higher efficient and less consumption of energy lamps. Since it was identified that the commercial buildings (like a university) consumed a great amount of lighting energy, then they are in the best position for solving lighting energy. However, these are some difficulties faced in retrofitting of lamps are a lack of confidence in projects return on investment, lack of cost saving to the commercial buildings, lack of understanding of energy efficiency the top management, or lack of accountability from users of energy (Dickens, 2014). But, the introduction of the appropriate and best energy saving lamps with new lamps like FLT5 and LED has become imperative before it even comes to retrofitting. This study is aimed to fill the gap in this area. More so, it is to affirm the benefits of FLT5 and LED lamps.

1.3 AIM

The world today is doing everything possible in the energy sector to produce clean energy which cheap, reduction of GHG emission or improving energy efficiency. In order to reduce GHG emission reduction. In doing so, the lighting energy has the green light for energy efficiency due to a high level of lighting technology introduce by the global lamp producers. Thus, the main aim of this research is to achieve energy efficiency through the use of the lighting system whereby the different types of lighting system will be investigated and present to KUST management to select the best for them.

1.4 OBJECTIVES

There are three primaryobjectives to achieve the aim of this study.

1. To identify suitable lighting systems to reduce the energy consumption at the AFB.
2. To calculate the energy consumption and the potential energy savings between the retrofitted lamps.
3. To compare and recommend the financial benefits through cost analysis.

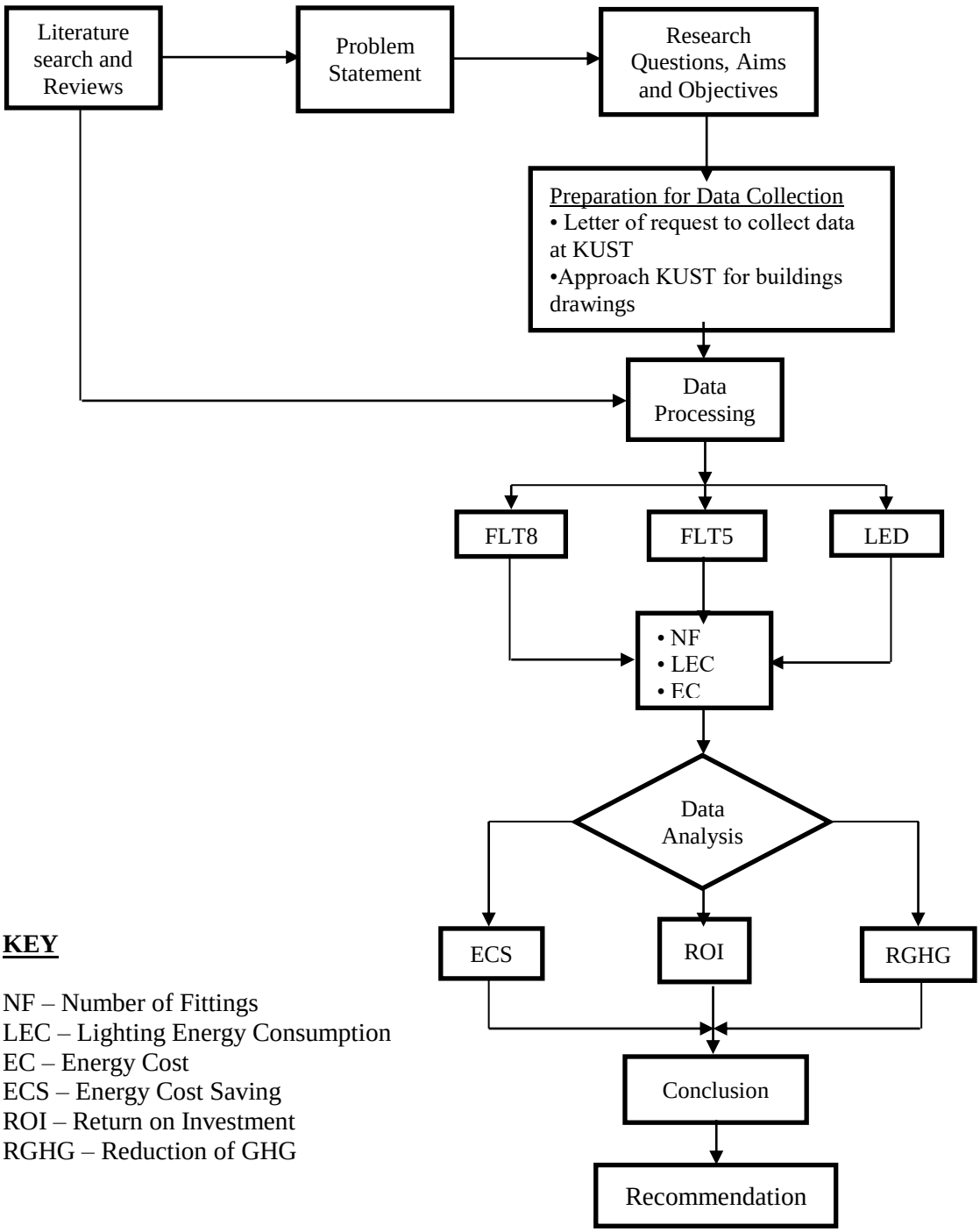
1.5 RESEARCH QUESTIONS

This research has the following questions.

- What are the lighting systems suitable at AFB?
- What is the amount of energy consumed by each lighting system, energy reduction between different types of the lamps?
- What are the financial benefits if the project is implemented?

1.6 OUTLINE OF RESEARCH METHODOLOGY

The methods to achieve both the aim and objective of this project are the lighting energy consumption and the const benefit analysis, similar to (Mahlia, Razak, & Nursahida, 2011) and Lumen Method was used to determine the lighting systems luminaires (Proposed Number of lamps). The research flow chart can be seen in Figure 1.1.



KEY

NF – Number of Fittings
LEC – Lighting Energy Consumption
EC – Energy Cost
ECS – Energy Cost Saving
ROI – Return on Investment
RGHG – Reduction of GHG

Figure 1.1 Research Flow Chart

The summary of the research flow chart can be into four stages, which are as follows:

- Stage 1: Literature review provides the appropriate method to achieve the aims and objectives of the research.
- Stage 2: Collecting Data from the site plan where the Floor area is being taken for each space.
- Stage 3: Calculation of a number of lighting fittings of the three lighting systems through lumen method, lighting energy consumption calculation of each system and cost-benefit analysis for the simple payback period and use of valuation table to give a projection.
- Stage 4: Conclusion and recommendation.

1.7 IMPORTANCE OF RESEARCH

The KUST management would benefit with the great opportunity of having the two alternative lamps proposal, which gives them a chance to select the most potential lighting system for energy saving, cost saving, reduction of maintenance lighting cost and reduction of GHG emission. However, the international community would also benefit in decreasing energy consumption and increase use of energy efficient lamps. This because IEA 2010 estimated that currently, the inefficient lighting systems consumed over 70% of lighting energy consume, and it has the effectof global climate change.

Moreover, the International Energy Agency (IEA) highlighted some of the benefits of the outcomes from energy efficiency improvement. The IEA categorised the benefits into four different levels which are; firstly, individual level like individuals, households, and enterprises, secondly, is by economic sectors, for

example, residential, industrial, and transport sectors, thirdly, is national level, such as macroeconomic benefits and benefits to domestic budgets and lastly is an international level (reflecting off the global public good of these advantages) (Ryan & Campbell, 2012).

1.8 LIMITATIONS

This research only focused on energy saving and cost saving in lighting system at AFB, KUST through the proposal of T5 fluorescent and LED lamps. The study does not consider other strategies of saving energy such as energy efficiency measures related to building envelope or mechanical systems. Furthermore, the most commonly lighting systems are old and less energy saving lamps were among the choice. This gives room for further study for considering another lighting system for further energy and cost saving in the future at the AFB, KUST.

1.9 RESEARCH OUTLINE

This research has five chapters in which each one demonstrates several topics. In short, Chapter One gives a general background of the study and provides the aim, objectives, research question, and limitation brief of research method, importance, and research outline. Chapter Two comprised of the literature review, where global and Nigeria energy challenge would be highlighted. Also, an overview, lighting energy efficiency. The research methodology would be discussed in Chapter Three. The case study of the research, data collection, and analysis are going to be presented in Chapter Four. Chapter Five comprised of the finding of the study, recommendation, and conclusion.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The chapter elucidatesliterature on the background of the thesis. The review area covers about six areas. Firstly, the global lighting energy consumption and followed by an overview of Nigeria and its energy. Thirdly, the lightingenergy at the University is elucidated where, fourthly, the need for energy efficient lighting system was also reviewed. The fifth is the energy efficiency of the lighting systems where the lighting systems, luminaire, lighting system control, and lighting design were discussed. The energy efficient lighting upgradeis also highlighted where the comparison between the traditional fluorescent lamps most commonly used in lighting systems in Nigeria, the FLT8 and the enhanced technology (FLT5 and LED), were compared. Lastly, the previous retrofitting is presented in this chapter.

2.2 GLOBAL LIGHTING ENERGY

Lighting is among the highest consumer of electricity in the world today. Today, lighting accounts for roughly 19 % (~3000 TWh) of the global electricity energy consumption and the demand is tremendously increasing. As reported by IEA the global lighting energy consumption will raise up to 4,250 kWh by 2030 if there are no proper measures in place. The projection can be seen in Figure 2.1. This can represent more than 40% increased (Ezema et al., 2016). The lighting consumption is enormous because in 2015 was estimated to be 2,650TWh annually (over 33 billion lamps operate), but now consumption by lighting increased by almost 18% in just one year