A COMPARATIVE ANALYSIS OF HEATING VALUES OF SAW DUST, RICE HUSK AND COCONUT SHELL IN THE THERMAL GENERATION OF ELECTRICITY IN HADEJIA LOCAL GOVERNMENT, NIGERIA

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BY

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DECLARATION A

"This research dissertation is my original work and has not been presented for a degree or any other academic award in any university or institution of learning."

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13/11/2014

Date

APPROVAL

"I confirm that the work reported in this dissertation was carried out by the candidate under my supervision".

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DEDICATION

I sincerely dedicate this work to my beloved parents, Late Alhaji Umaru Mai-inji and Late Hajiya Hafsah Umar(yata) for the care, concern and courage they rendered to me and also to my venerate brothers and sisters.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

DECLARATION A i

APPROVAL ii

DEDICATION iii

ACKNOWLEDGEMENTS iv

TABLE OF CONTENTS v

LIST OF FIGURES ix

ABSTRACT x

CHAPTER ONE 1

INTRODUCTION 1

1.0 Background of the study 1

1.1 Statement of the Problem 9

1.2 General Objective: 10

1.2.1 Specific Objective: 10

1.3 Significance of the Study 10

1.4 Scope of the Study 11

CHAPTER TWO 12

LITERATURE REVIEW 12

2.0 The Electricity 12

2.1 Basic Concepts Of Electricity 13
2.2 Sources of Electricity 14
2.2.1 Fossil fuels 15
2.2.2 Oil and natural gas 15
2.2.3 Coal 15
2.2.4 Geothermal 16
2.2.5 Hydro-electric 16
2.2.6 Solar 16
2.2.7 Wind 16
2.2.8 Biomass 17
2.2.9 Tidal 17
2.3 Methods of Generating Electricity from Biomass 17
2.3.1 Combustion 18
2.3.2 Pyrolysis 18
2.3.3 Anaerobic Digestion 19
2.3.4 Gasification 19
2.3.6 Modular Systems 20
2.3.7 Landfill Gas 20
2.4 Renewable Electricity Generation by Energy Source 21
2.5 Generation of electricity from biomass in Africa 22
2.6 Available sources of biomass energy generation in Nigeria 25

CHAPTER THREE **29**

METHODOLOGY **29**

CHAPTER FOUR **34**

RESULTS AND DISCUSSION **34**

CHAPTER FIVE: **46**

CONCLUSION AND RECOMMENDATION **46**

5.1 Conclusion 46

5.2 Recommendation 47

REFERENCES 48

LIST OF FIGURES

Fig. 1. Basic stages in a complete integrated biomass to electricity system. 8

FIGURE. 2.4.1: Illustrated renewable electricity projection by energy source in a bar diagram by percentage (Department of energy, Energy information Administration, Energy Outlook). 21

FIGURE: 3.1 Experimental set up in block form for the thermal generation of electricity. 29

FIGURE: 3.2. Experimental set up for the thermal generation of electricity........30

Figure: 3.3 Milled and briquetted Rice husk Sample........31

Figure:3.4 Milled and briquetted saw dust Sample........32

Figure: 3.4 Milled and briquetted coconut shell Sample 32

FIGURE.4.4: Graph of E.M.F Against Mass of Saw Dust 37

FIGURE.4.5: Graph of E.M.F Against Mass of Rice Husks 37

GRAPH OF E.M.F VERSUS MASS OF COCONUT SHELL........38

FIGURE.4.6: Graph of E.M.F against Mass of Coconut Shell 38

FIGURE.4.10: Bar Graph Comparing E.M.F With 100g of Different Biomass........41

LIST OF TABLE

TABLE. 4.1: Table of values of Saw Dust..35

TABLE.4.2: Table of value for Rice Husks.......................................35

TABLE 4.3: Table of values for Coconut Shell..................................36

ABSTRACT

Biomass is the major energy source in Nigeria contributing about 78% of Nigeria primary energy supply. In this work a comparative analysis of the heating values of saw dust, rice husks, and coconut shell in the thermal generation of electricity was carried out. In the study different masses of biomass were used and the corresponding electromotive force in millivolts obtained. A graph of e.m.f was plotted against mass of each biomass and a gradient was obtained. Bar graphs were plotted representing the values of e.m.f and masses of the biomass. Also a bar graph comparing e.m.f of different masses of biomass was used. The research shows that Saw dust is having a gradient of 0.033Mv/g then followed by Coconut shell with gradient 0.031Mv/g and Rice husk with gradient 0.026mV/g. This shows that Saw dust is the one with the highest gradient. It is therefore, concluded that Saw dust is the most efficient of the three types of biomass in the thermal generation of electricity.

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

The world is changing drastically in scientific and technological perspectives coupled with increase in population, hence there is a need to have a diverse means of tapping electricity for the usage of the populace. Energy demand is increasing by about 2% a year, and absorbs most of the requirement for the energy development, (Vecan, 2011). New technology makes better use of already available energy through improved efficiency. This dissertation will compare the heating values of different types of biomass in the thermal generation of electricity.

The world's energy markets rely heavily on fossil fuels such as coal, petroleum, crude oil and natural gas as sources of energy, fuels and chemicals. Since millions of years were required to form fossil fuels in the earth, their reserves are finite and subject to depletion as they are consumed. The only other naturally occurring, energy resources-containing carbon resource, that is large enough to be used, as a substitute for fossil fuels is biomass. Currently, 80% of the world energy demand is met by combustion of fossil fuels which are depletable. The global energy demand is expected to grow by about 50% by 2025 (Edirin et al 2012) the major part of this increase coming from rapidly developing countries. Given the growing world population , increasing energy demand per capital and global warming ,the need for a long term alternative energy supply is clear (Vancoillie and Verholst, 2010; Sandia National Laboratories, 2010).

Renewable energy is considered to be the most important world energy resources for the future. The decrease in the fossil fuels, has lead to greater attention to the renewable energy sources such as sunlight, wind, rain, tides, and geothermal heat. Renewable energy is an alternative to fossil fuels and nuclear power, and was commonly called alternative energy in the 1970s and 1980. In 2008, about 19% of global final energy consumption came from renewable, with 13% coming from traditional biomass. Which is mainly used for heating, and 3.2% from hydroelectricity. Now renewable(small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 2.7% and are growing very rapidly. The share of renewable in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3% from new renewable (Vecan, 2011).

The term "biomass" is generic that encompasses diverse fuels derived from timber, agriculture and food processing wastes or from fuel crops that are specifically grown or reserved for electricity generation. Biomass fuel can also include sewage sludge and animal manure. Some biomass fuels are derived from trees. Given the capacity of trees to regenerate, these fuels are considered renewable. Burning crop residues, sewage or manure - all wastes that are continually generated by society to generate electricity may offer environmental benefits in the form of preserving precious landfill space or may be grown and harvested in ways that cause less environmental harm.

Plants absorb solar energy , using it to drive the process of photosynthesis, which enables them live. The energy in biomass from plant matter originally comes from solar energy through the process known as photosynthesis. The energy which is stored in plants and animals(that eat plants or other animals), or in the waste that they produce, is also biomass.

This energy can be recovered by burning biomass as a fuel. During combustion, biomass releases heat and carbon dioxide that was absorbed while the plant was growing. Essentially, the use of biomass is the reversal of photosynthesis. Is biomass energy a variety of chemical energy?. In nature all biomass ultimately decomposes to its molecules with release of heat. The release of energy from the combustion of biomass imitates natural processes. Therefore, the energy obtained from biomass is a form of renewable energy and, in principle, utilizing this energy does not add carbon dioxide to the environment in contrast to fossil fuels of all the renewable sources of energy, biomass is unique in that it effectively stored solar energy. Furthermore, it is the only renewable sources of carbon and is able to be converted into convenient solid, liquid and gaseous fuels (A. Demirbas, 2001).

Biomass can be used directly (example burning wood for heating and cooking) or indirectly by converting it into a liquid or gaseous fuel(example alcohol from sugar crop or biogas from animal waste).The net energy available from biomass when it is combusted ranges from about 8mj/kg for green wood, to 20mj/kg for dry plant matter, to 55mj/kg for methane as compared with about 27mj/kg for coal (A. Demirbas, 2001).

Biomass, mainly in the form of wood, is the oldest form of energy used by humans. Traditionally, biomass has been utilized through direct combustion, and this process is still widely used in many parts of the word. Biomass has historically been a dispersed, labor intensive and land intensive source of energy.

The earth's natural biomass replacement represents an energy supply of around 300EJ ($3x10^{21}$) a year, of which just under 2% is currently (1998) used in fuel. It is not possible however, to use all of the animal production of biomass in a sustainable manner. One analysis provided by the united nation conference on environment and development (UNCED) estimates that biomass could potentially supply about half of the present world primary energy consumption by the year 2050 (A. Dermirbas, 2001).

Biomass has great potential as a renewable energy source, both for the richer countries and for the developing world. Biomass as a fuel is still in the experimental stage and provides only about 0.25% of the total electricity generating capacity in the UK. However, this is likely to increase for a number of reasons. One reason is that Europeans and UK legislation aim to encourage less polluting methods of waste disposal, and one viable option is to burn the waste to generate power. Another reason is that biomass power system will become more affordable as technology improves.

Biomass is used for facility heating electric power generation, and combined heat and power. Biomass can be converted to other forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Rotten garbage, and agricultural and human waste, all release methane gas called "landfill gas" or "biogas". Crops, such as corn and sugarcane, can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel can be produced from leftover food product like vegetable oils and animal fats. Biomass conversion to liquid (BTLS) and cellulosic ethanol are still under research.

At present, most biomass power plants burn lumber, agricultural or construction/demolition wood wastes. Direct Combustion power plants burn the biomass fuel directly in boilers that supply steam to the steam-electric generators as are used to burn fossil fuels. With biomass gasification, biomass is converted into gas methane that can then fuel steam generators, combustion turbines, combined cycle technologies or fuel cells. The primary benefit of biomass gasification, compared to direct combustion, is that extracted gasses can be used in a variety of power plant configurations.

The fact that biomass technologies use combustion processes to produce electricity, they can generate electricity at any time, unlike wind and most solar technology. By using easily renewable plant material for energy generation, biomass technologies help protect the environment by reducing dangerous greenhouse gas emissions, preserving important wildlife habitat and limiting the environmental damage associated with the extraction and combustion of traditional fossil fuels and nuclear power.
These biomass technologies are used in the production of clean transportation fuels, electricity, chemicals and much more. By replacing more polluting forms of energy generation, biomass resources have helped United state reduce its dependence on Persian Gulf oil while

creating jobs and fueling economic growth. Across United state, biomass power plants currently represent 11,000 MW - the second largest amount of renewable energy in the nation (Osaghea, 2009).

Compared to these, bio resources are renewable with a cycling time less than 100 years. It is the most developed renewable energy source providing 35% and 3% of the primary energy needs of developing and industrialized countries respectively . With 70% of India's population still in rural areas, there is tremendous demand on resources such as fuel wood, agricultural residues, etc. to meet the daily fuel requirements. About 13.01% of the energy in India is derived from bio resources . Dependence on bio resource to meet the daily requirement of fuel, fodder, etc. in rural areas is more than 85% while in urban area the demand is about 35% (Ramachandra, 1997).

Biomass is all non-fossil organic materials that have intrinsic chemical energy content. They include aquatic and terrestrial vegetation and all waste biomass such as municipal solid wastes, municipal bio--solids and animal wastes, forestry and agricultural residues and certain types of industrial wastes. Unlike fossil fuels, biomass is renewable in the sense that only a short period of time is needed to replace what is used as an energy resource. Biomass is a renewable energy source because the energy it contains comes from the sun. Through the process of photosynthesis, chlorophyll in plants captures the sun's energy by converting carbon dioxide from the air and water from the ground into carbohydrates, complex compounds composed of carbon, hydrogen and oxygen. When these carbohydrates are burned, they turn back into carbon dioxide and water and release the sun's energy they contain. Bioenergy is regarded as "green" energy for several reasons. Recent study on energy utilization in Karnataka considering all types of energy sources and sector wise consumption reveals that traditional fuels such as firewood (7.440 million tones of oil equivalent--43.62%), agro residues (1.510 million tones of oil equivalent8.85%), biogas and cow dung (0.250 million tones of oil equivalent (1.47%) account for 53.20% of total energy consumption in South West India (Boyle, 1996).

The collection of biomass fuels can have significant environmental impacts. Harvesting timber and growing agricultural products for fuel requires large volumes to be collected, transported, processed and stored. Biomass fuels may be obtained from supplies of clean, uncontaminated wood that otherwise would be landfilled or from sustainable harvests. In both of these fuel collection examples, the net environmental plusses of biomass are significant when compared to fossil fuel collection alternatives. On the other hand, the collection, processing and combustion of biomass fuels may cause environmental problems if, for example, the fuel source contains toxic contaminants. Agricultural waste handling pollutes local water resources, or burning biomass deprives local ecosystems of nutrients that forest or agricultural waste may otherwise provide (Boyle, 1996).

Generally, the figure below shows the generation of electricity in a summarizes form from biomass.

Electricity generation is considered the most lucrative opportunity for commercial exploitation of biomass, by virtue of the high value of electricity . Biomass to electricity schemes already provide over 9 GWe of world-wide generating capacity (A.V et al, 2002). These systems burn various biomass and wastes (mainly wood) in boilers to raise steam that is used to drive a steam turbine. This technology is established but far from ideal for biomass fuels. Generating capacities are constrained by the local availability of feedstock and at low plant sizes steam turbine plant are inefficient generators with high capital costs (A.V et al, 2002).

Increased efficiencies and decreased capital costs may be possible if the solid biomass feedstock is first converted to an intermediate liquid or gaseous fuel that may then be used in gas turbines or engines (A.V et al, 2002). The integration of sustained feed production, feed conversion and high efficiency electricity generation as shown below may be the key to generating electricity from biomass at a lower cost than is currently possible.

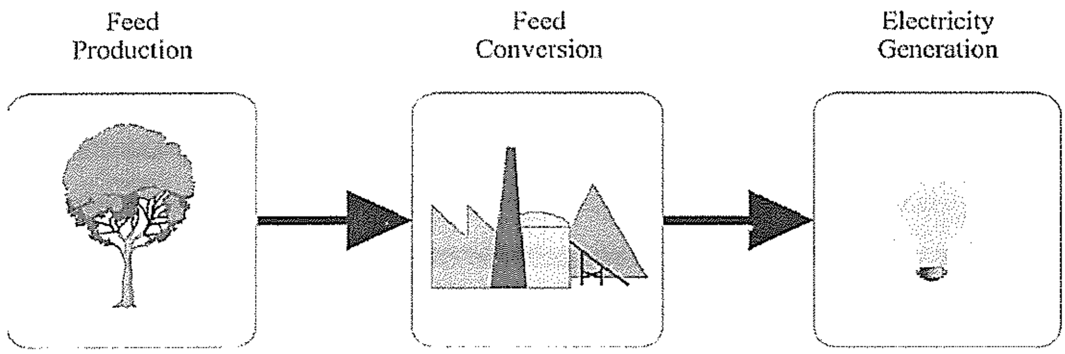

Fig. 1. Basic stages in a complete integrated biomass to electricity system.

This feed production stage is the primary sources of the biofuel and the feed conversion is the second complex stage where the conversion of these biomass takes place there by leading to the generation of electricity. Hence, this is a summarize integrated biomass to electricity generation.

Different methods can be use to generate electricity but due to some factors such as complexity of the materials or method to be use, expensiveness of the materials and the availability of the materials makes the gap to be wide between the existing research and the available research carried out in the area.

1.1 Statement of the Problem

Hadejia is a highly fertile area with abundant biofuels ranging from forestry by products, animal husbandry and agricultural produce such as rice ,sugar cane ,wood, sorghum, wheat ,maize ,barley ,straw, potato, yam, animal manure, grass species, hemp etc. This locality depends solely on fossil fuel as the only source of electricity, rather than exploiting the most effective biomass source in generating electricity.

Analysis of the heating values of some biomass materials in thermal generation of electricity is a fundamental input towards finding among the available biomass the one that is more efficient in generating electricity. To the best of my knowledge no work has been done to find out the most effective among the available biofuels in Hadejia.

1.2 General Objective:

The general objective of this study is to compare the heating value and efficiency of three types of biofuels in generating electricity.

1.2.1 Specific Objective:

More Specifically the study is intended to:

(i) Determine the efficiency/heating value of rice husk, saw dust and coconut shells.

(ii) Determine the highest heat valued biofluel.

1.3 Significance of the Study

Generating electricity from biomass sources will be of tremendous importance to the locality and the state at large as it will stimulate research in materials available for the energy generation. Private organizations or firms can make use of the findings to generate electricity on a large scale by using most efficient biofuel. As biomass is often a byproduct, or residue or waste product of other processes such as farming animal husbandry and forestry, which in theory there is no competition between fuel and production, although this may not always be the case, that is it is cheaper and readily available . The study will however compare the three biofuels as sources of heat energy to generate electricity.

This comparative study will serve as an opener for finding and recommending the most effective biofuels in the generation of electricity in the locality and the state at large as biomass has the advantage of dispatchability (controllable and available).Hence it can be use for commercial scale facility rather than utility scale.

1.4 Scope of the Study

The study was conducted at Hadejia local government, Jigawa state. The town is located in the eastern part of Jigawa state in Northern Nigeria .It has a population of one hundred and four thousands two hundred and eighty six peoples (104,286) as of 2006 census (National population commission draft book, 2006). It lies between 10^0 E longitude to 12^0. 25s N and 12^0.30s N latitude.

The area is ecologically important as it has rivers and is upstream from Hadejia- Nguru wetlands. It has a good rich land for the production of Agricultural produce, forestry by product and animal husbandry, hence it will serve as very rich source of biomass. The materials for the study include Saw dust, Rice husk and Coconut shell.

The study which is intended for the comparison of the types of biofuels for the generation of electricity was conducted between April 2013 to August, 2013.

CHAPTER TWO
LITERATURE REVIEW

2.0 The Electricity

According to Thales of Miletus a pre-socratic greek philosopher, it appears that Westerners know as long ago as 600B.C that amber becomes charged by rubbing. There was little real progress until the English scientist William Gilbert in 1600 described the electrification of many substances and coined the term electricity from Greek word for amber. As a result, Gilbert is called the father of modern electricity .In 1660 Otto Von Guericke invented a crude machine for producing static electricity. It was a ball of sulfur, rotated by a Crank with one hand and rubbed with the other. Successors, such as Francis Hauksbee, made improvement that provided experiments with a ready source of static electricity. Today's highly developed descendant of these early machines is the Van de Graaf generator, which is sometimes used as a particle accelerator. Robert Boyle realized that attraction and repulsion were mutual and that electric force was transmitted through a vacuum. Stephen Gray distinguished between conductors and non conductors. C.F. Du Fay recognized two kinds of electricity, which Benjamin Franklin and Ebenezer Kinnersely of Philadephia later named positive and negative.

Progress quickened after the Leyden jar was invented in 1745 by Pieter Van Musschenbroek (National high magnetic field laboratory, 1800E).

2.1 Basic Concepts Of Electricity

Electricity is the set of physical phenomena associated with the presence and flow of electric charge. Electricity gives a wide variety of well-known effects, such as lightning static electricity, electromagnetic induction and electrical current. In addition, electricity permits the creation and reception of electromagnetic radiation such as radio waves.

In electricity, charges produce electromagnetic fields which act on other charges. Electricity occurs due to several types of physics:

- Electric charge: a property of some subatomic particles, which determines their electromagnetic interactions. Electrically charged matter is influenced by, and produces, electromagnetic fields.
- Electric current: a movement or flow of electrically charged particles, typically measured in amperes.
- Electric field an especially simple type of electromagnetic field produced by an electric charge even when it is not moving (i.e., there is no electric current). The electric field produces a force on other charges in its vicinity. Moving charges additionally produce a magnetic field (Solymar,1984)

Electric potential: the capacity of an electric field to do work on an electric charge, typically measured in volts.(Sears, et al 1982).

electromagnets: electrical currents generate magnetic fields, and changing magnetic fields generate electricity. An electric circuit is an interconnection of electric components such that electric charge is made to flow along a closed path (a circuit), usually to perform some useful task (Berkson and William 1974).

The components in an electric circuit can take many forms, which can include elements such as resistor, capacitor, switches, transformers and electronics.

In electrical engineering, electricity is used for:

- Electric power where electric current is used to energize equipment;
- Electronics which deals with electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes, and integrated circuits, and associated passive interconnection technologies.

These are some of the basic concept of electricity.

2.2 Sources of Electricity

Sources of electricity are everywhere in the world. Worldwide, there is a range of energy resources available to generate electricity. These energy resources fall into two main categories, often called renewable and non-renewable energy resources. Each of these resources can be used as a source to generate electricity, which is a very useful way of transferring energy from one place to another such as to the home or to industry.

Non-renewable sources of energy can be divided into two types: fossil fuels and nuclear fuel.(Ibidapo and Ajibola, 2011) have identified many sources of generating electricity.

2.2.1 Fossil fuels

Sources of electricity include fossil fuels which are found within the rocks of the Earth's crest. They are called fossil fuels because they are thought to have been formed many millions of years ago by geological processes acting on dead animals and plants, just like fossils. Coal, oil and natural gas are fossil fuels. Because they took millions of years to form, once they are used up they cannot be replaced.

2.2.2 Oil and natural gas

Oil and gas are chemicals made from molecules containing just carbon and hydrogen. All living things are made of complex molecules of long strings of carbon atoms. Connected to these carbon atoms are others such as hydrogen and oxygen. A simple molecule, called methane (CH_4)), is the main component of natural gas.

Crude oil (oil obtained from the ground) is a sticky, gooey black stuff. It contains many different molecules, but all are made of carbon and hydrogen atoms.

2.2.3 Coal

Coal, mainly consists of carbon atoms that come from plant material from ancient swamp forests. It is a black solid that is reasonably soft, and can scratch it with a fingernail. It is strong enough to be carved into shapes. There are different types of coal. Some contain impurities such as sulphur that pollute the atmosphere further when they burn, contributing to acid rain.

2.2.4 Geothermal

Geothermal power uses the heat that comes from deep rocks under the surface of the Earth. The temperature of the Earth increases towards its centre. The hot water or steam that comes from deep within our planet can be used to generate electricity.

2.2.5 Hydro-electric

Hydro-electricity is generated from running water. Dams are built across a lake or river in a valley to trap water. The water flows through tunnels and turns the turbines which generate electricity.

2.2.6 Solar

The Sun releases an amazing amount of energy due to the nuclear fusion of hydrogen taking place within its core. Solar panels, called photovoltaic cells are used to convert the Sun's energy into electric energy. The Sun can also be used to heat water passing through special solar collectors.

2.2.7 Wind

Wind is made when the Sun heats the Earth and the area above land gets hotter than the area above water. The hot air above land rises upwards leaving an area of low pressure. Cooler air moves into this area of low pressure resulting into wind which can be used to turn wind turbines and generate electricity.

2.2.8 Biomass

Biomass uses the energy from plants and waste materials to make electricity. For example, wood or animal droppings can be burnt to make steam that turns turbines to make electricity. Biomass combustion, however, emits CO_2 and other pollutants

2.2.9 Tidal

Tidal energy comes from the movement of water in the sea by the tides. These tides happen twice a day. The flow of water that is created by the tides is used to turn generators that make electricity.

2.3 Methods of Generating Electricity from Biomass

According to the U.S. Department of Energy (DOE), biomass recently surpassed hydropower as the largest domestic source of renewable energy, and consumption by electric utilities is expected to double every 10 years through 2030.The methods of generating electricity can be split into two different groups. There are the dry processes consisting of combustion and pyrolysis and wet processes consisting of anaerobic digestion, gasification and fermentation.

2.3.1 Combustion

The most obvious way of extracting energy from biomass is by use of the technology of direct combustion. Which is straightforward and commercially available. Combustion systems come in a wide range of shapes and sizes burning virtually any kind of fuel, from chicken droppings and straw bales to tree trunks, municipal refuse and scrap tyres. Some of the ways in which heat from burning wastes is currently used include space and water heating, industrial processing and electricity generation. One problem with this method is its very low efficiency. With an open fire most of the heat is wasted. One method of improving the efficiency in developing countries is to build stoves out of mud and scrap iron.

2.3.2 Pyrolysis

A wide range of energy-rich fuels can be produced by roasting dry woody matter like straw and woodchips. The process has been used for centuries to produce charcoal. The material is pulverized or shredded then fed into a reactor vessel and heated in the absence of air. Pyrolysis can also be carried out in the presence of a small quantity of oxygen ('gasification'), water ('steam gasification') or hydrogen ('hydrogenation'). One of the most useful products is methane, which is a suitable fuel for electricity generation using high-efficiency gas turbines.

2.3.3 Anaerobic Digestion

Biogas is produced when wet sewage sludge, animal dung or green plants are allowed to decompose in a sealed tank under anaerobic (oxygen-free) conditions. Feedstock like wood shavings, straw and refuse may be used, but digestion takes much longer. Each kilogram of organic material (dry weight) can be expected to yield 450-500 litres of biogas (Ibidapo and Ajibola, 2011). The residue left after digestion is a potentially valuable fertilizer or compost. Fermentation of sugar solution by natural yeasts yields ethanol. Suitable feedstocks include crushed sugar beet and fruit. Sugars can also be manufactured from vegetable starches and cellulose by pulping and cooking, or from cellulose by milling and treatment with hot acid. After about 30 hours of fermentation, the brew cantains 6-10 per cent alcohol, which can be removed by distillation as a fuel.

2.3.4 Gasification

This process, usually using wood, produces a flammable gas mixture of hydrogen, carbon monoxide, methane and other non flammable by products. This is done by partially burning and partially heating the biomass (using the heat from the limited burning) in the presence of charcoal (a natural by-product of burning biomass). The gas can be used instead of petrol and reduces the power output of the car is reduced by about 40%. It is also possible that in the future this fuel could be a major source of energy for power stations.

2.3.5 CO-FIRING

Co-firing substitutes biomass for a portion of coal in an existing power plant furnace, significantly reducing toxic emissions

2.3.6 Modular Systems

Modular systems employ some of the same technologies mentioned above, but on a smaller scale that is more applicable to villages, farms, and small industry. These systems are now under development and could be most useful in remote areas where biomass is abundant and electricity is scarce. There are many opportunities for these systems in developing countries

2.3.7 Landfill Gas

Landfill gas uses a similar technology to anaerobic digestion and it carries the same benefits. It occurs as a by-product of the decomposition of solid waste and consists of 50 percent methane (natural gas), 45 percent carbon dioxide and 4 percent nitrogen. Additionally, it helps to reduce landfill waste by using the waste stream for electricity generation.

2.4 Renewable Electricity Generation by Energy Source

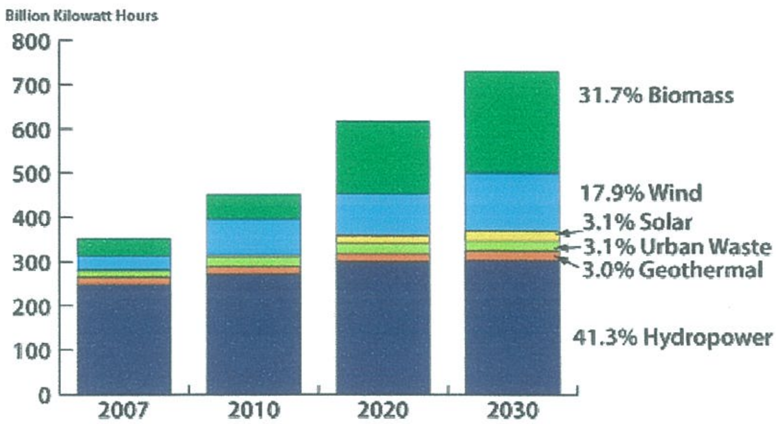

FIGURE. 2.4.1: Illustrated renewable electricity projection by energy source in a bar diagram by percentage (Department of energy, Energy information Administration, Energy Outlook).

Electric energy from a power plant is measured in kilowatt-hours (kWh) and is priced in ¢/kWh. (Department of Energy, Energy Information Administration, Energy Outlook 2009).

Fig. 2.5.1 shows that biomass is expected to be the second-largest source of renewable electricity generation (behind hydropower) through 2030. Of all the renewable energy sources, biomass is projected to be the fastest growing, going from 11% of the total in 2007, to more than 41% in 2030.

Electricity generation from biomass, both dedicated and co-firing, is expected to grow from 39 billion kilowatt-hours in 2007 to 231 billion kilowatt-hours in 2030. This co-firing has been tried successfully in Brazil.

2.5 Generation of electricity from biomass in Africa

Africa has a high potential of renewable energy in terms of its biomass resources mostly in the rural areas. The climatic condition which varies across the continent allows for the growth of trees and other types of biomass.

Africa is a very large continent it has many countries. It is blessed with huge energy resources. In 2004, the proved oil ,gas and coal reserves were 9.4%,7.9% and 5.5% of the world total respectively. The hydropower potential of the continent amounts to 13% of the world's potential. In the African continent energy is acquired mainly from biomass 47%, oil 24.8% coal 16.5%, gas 10.4% and other renewable sources (Osaghea, 2009).

There are different technologies for the production of energy from biomass sources. These technologies involve the combustion or gasification of biomass to produce either steam or a clean gas that can be used in a steam or gas turbine to generate electricity

There are many plants that were installed in many parts of the global world purposely for the energy production from different biomass. In different countries of Africa many such plants have been installed. An example is the installation of a 35kw down draft gasifier in Seychelles which uses wood and coconut shell as fuel for electricity production (Osaghea, 2009). In the Eastern part of Africa like in Burundi it also has an installation in Tora village which has a capacity of 36kw down draft gasifier for industrial electricity production using peat. In Mali, in western part of Africa, there is the installation, in Dogofiri community, of a gasifier for the production of 160kw using rice husks as a fuel(Osaghea, 2009). In Mauritus, in the northern part of Africa, the country which is devoid of any fossils fuels, about 300GWh of the country electricity is from bagasse residue (Osaghea, 2009). Eleven cane sugar factories are in operation and ten of them export electricity to the grid (Stephen et al, 2003).

There are so many plants that have been installed in other less developed countries of the world, India, Thailand, Brazil, Indonesia and Malaysia. These plants use the biomass resources available in these areas for electricity production(Osaghea,2009).

The African continent's electricity consumption was the lowest in the world at only 514kwh per capita as at 2002. The Scarcity of the generated electricity coupled with poor economy standard of the populace make it to be very difficult to find and use in most of the African countries. The International Energy Agency (IEA) reports shows that in 2002, access to electricity ranges from 70% to over 95% in Northern Africa, and to an average of 23% in sub-saharan Africa. These results do not reflect disparities between countries(for instance less than 4% in Uganda compared to 66% in South Africa or 100% in (Mauritius) and between urban and rural areas, where in the latter access can be low as 1%(Osaghea,2009).

Energy from biomass accounts for more than 30% of energy consumed in Africa and more than 80% in some countries, such as Burundi(91%),Rwanda and Central Africa(90%),Mozambique(89%), Burkina fasso (87%),Benin(86%), Madagascar and Niger 85%. From 1994 to 2004, primary energy consumption in Africa has increased by 24%(Osaghea,2009).

Africa is estimated to have about 82 millions tons of biomass resources with an average growth of 1.7 billions tons. This rate growth affords nearly three times the per capita wood demand in the continent at current consumption level. In most part of the continent Forestry by product were not properly utilized in tapping their energy(Osaghea, 2009).

Even though, there are abundant energy resources in Africa but it is the continent which is generating only 3.1% of the world electricity this makes it to be the least among all the regions world wide. It was stated that the this situation has not improved for over ten years and it was even projected that it may reach many more years the production will be at stand still or slowly (Osaghea, 2009).

Electricity is generated mainly from coal (46%), gas(23%), hydro(18%), oil(11%), and nuclear (2% in South Africa only).The renewable sources such as solar, geothermal, wind etc play an insignificant role so far, despite some noteworthy initiatives such as the development of wind farm in Egypt, Morocco, Algeria and South Africa (Osaghea, 2009).

On the continent, there are marked disparities; South Africa alone generates close to half of the total African electricity. Many African countries rely heavily on hydropower(70% to 80% for their electricity generation).

According to (Osaghea, 2009),the bulk of the region generating capacity and transmission network was built in the 1950s and 1960s.The continued under-investment in maintenance and renewal has left many

African countries in worsening energy situations. Technical and non-technical losses typically exceeds 20%, power outrages, black outs and power surges are common place, while load shedding in times of drought are routine.

With 13.1% of the world total energy production Africa consumes only 5.5%.The energy consumption per capita is 58.15kw/h per year, which is far lower than the world average of 13956kw/h per capita per year, making the continent lag behind all others in energy (Osaghea, 2009). Moreover, there is a need for the African countries to double their effort in exploiting the available sources to generate electricity.

2.6 Available sources of biomass energy generation in Nigeria

Nigeria is located in sub-sahara Africa ,between latitude 4 and 14 and longitude 2 45 and 14 3E, it has a population of over 100 million, with a population growth rate of 3.3%.At present, about 40% of the total population have access to grid electricity, of this only 6% in rural areas where a large percentage of the population live (Osaghea,2009).

Nigerias climate permits the cultivation of a variety of crops. As in other west Africa states, rain fall is heavier in the south, where the forest and savannah benefits from abundant precipitation are relatively short dry seasons, (Mother land, 2005). The crops grown include cassava, yam, cocoyam, and sweet potato. Tree crops like cocoa, palm oil, rubber and timber. The northern part of the country experiences less rain. The region lies mostly in the Sudan savannah and Sahel savannah, where the crops cultivated are millet, cowpeas, sorghum, rice, cotton and groundnut (Osaghea,2009).

Therefore, biomass resources in the country include agricultural crops, wood, grasses, and shrubs, residues and waste (agricultural, forestry, municipal, and industrial), and aquatic biomass. The total biomass potential in Nigeria was estimated to be $1.2x10^{-12}$ j in 1990 (Obio and Fagbenle, 2004), in 2005 research revealed that bio-energy resource/potential of Nigeria stood at: Fuel wood 13,071,464 hectares, animal waste, 61 million tones per year, crop residues 83 million tones (Agba et al..,2010).

In North America, 62% of all residue occur between October and December while in Nigeria , about 80% of the residue occur between April and September (Odia, 2006).

Nigeria has a total of 1,160 constituted forest reserves covering a total area of 10,752,702 hectares representing about 10% of the total land area (Ojonigu et al 2010, Oladipo, 2010). All these sources can be use to generate heat and electricity.

(Von Braun and Abila, 2010) classified Nigeria as one of the countries with very high potential for energy crops production, hence with potentiality of tapping or generating electricity from these sources.

Nigerian current major source of energy are from the combustible renewable oil and natural gas. The combustible renewable dominates as the principal source of primary energy for majority of Nigerians. Energy supply from this source has increased over the years from about 44000GWh in 1971 to about 93000GWh in 2003 corresponding to an increase of 111%.This increase is mainly due to the increase in population which on the long run has caused an increase in pressure on the use of renewable mainly in the form of wood-fuel as a major source of energy supply (Osaghea, 2009).

The other sources of energy supply are the oil and natural gas. The supply of energy from these sources for domestic need is low. About 95% of the countries revenue comes from these sources (Osaghea,2009).

The electricity supplies from hydropower has increased considerably over the years. It has increased from about 2000GWh in 1971 to about 7000GWh in 2002, although this is not enough to provide all the potential users partly because of the continuously increasing number of inhabitants and partly the excessive energy losses in the transmission and distribution (IEA energy statistics 2007).

In Nigeria the power sector Is presently being manage by power holding company, plc (PHCN), formally national electric power authority (NEPA).As an integrated utility company providing generation, transmission and distribution services.

Nigeria has a grid capacity of 4000MW, as at 2003, but the present peak demand is about 6000MW far higher than the generating capacity. The demand has been estimated to increase to about 8000MW in the year 2007 and 1000MW in the year 2010. Subsequently, the country may face serious power shortage due to low electricity generation in years to come (Osaghea,2009).

This problem of energy generation may be due to lukewarm attitude of the government on domestic energy production, very low participation of private sector or their partial participation and investment, improper policy regulation and institutional frame work, above all insufficient and in adequate utilization of the available biomass sources for the energy generation. Hence this study make use of rice husk, saw dust and coconut shell in the thermal generation of electricity , and it will serve as a means of selecting the most efficient among the selected biofuels.

CHAPTER THREE

METHODOLOGY

There are many ways to generate electricity from biomass. Among them are direct-fired or conventional steam approach, pyrolysis, co-firing, biomass gasification , anaerobic digestion, landfill gas collection and modular system. These were described in details in chapter two. The study was conducted at Hadejia municipal, Hadejia local government jigawa state, Nigeria.

However, this study employed direct-fired method for the generation of electricity.

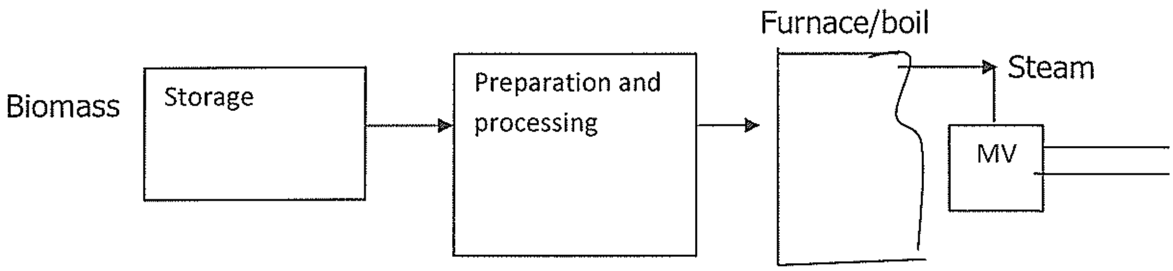

FIGURE: 3.1 Experimental set up in block form for the thermal generation of electricity.

Above is the experimental set up in a block form which shows the

biomasses saw dusts, rice husks and coconut shells, how they are stored, and processed(dried and milled) and a required quantity of each biomass was measured and put in a furnace with a boiler containing measured quantity of water which was heated to produces a steam that blew a thermopile which subsequently generated an electromotive force (emf) which is detected using a digital multimeter in milli volts (mV). The e.m.f was recorded when it reached peak or maximum stage before it falls or decreases.

Rice husk, saw dust, and coconut shell were used for comparative analysis of their heating values in the thermal generation of electricity. Car body filler container of about four (4) liters was used as a boiler/furnace, were at the centre a small hole was made and a nut and bolt was fixed and soldered, for accessibility of water also at the middle a small pipe with a rubber host was fixed for the steam outlet that will blow the dynamo, then the electromotive force (e.m.f) was obtained using digital multi meter which has a full scale deflection of(0 – 200mV).A picture of this system is shown below

FIGURE: 3.2. Experimental set up for the thermal generation of electricity.

When the biomass is directly fired, or burnt it must first be dried , as it will burns more efficiently, sized into smaller pieces, and briquetted. Briquetting is a densification process of loose organic materials aiming to improve handling and combustion characteristics.

The samples used were Rice husk, as shown in figure 3.3;Saw dust, figure 3.4; and coconut shell, figure 3.5; respectively.

Figure: 3.3 Milled and briquetted Rice husk Sample

Above is the sample of rice husks which was milled and the particles appeared to be very small in size. This is one of the sample used for experiment it was milled and dried so that it can easily be use for burning and obtaining an accurate result.

Figure:3.4 Milled and briquetted saw dust Sample

The figure above also shows sample of saw dust when milled has appeared to be finest than the particles of rice husks and coconut shell. The sample was also milled and dried so as to hasten its burning and make the result to be more accurate.

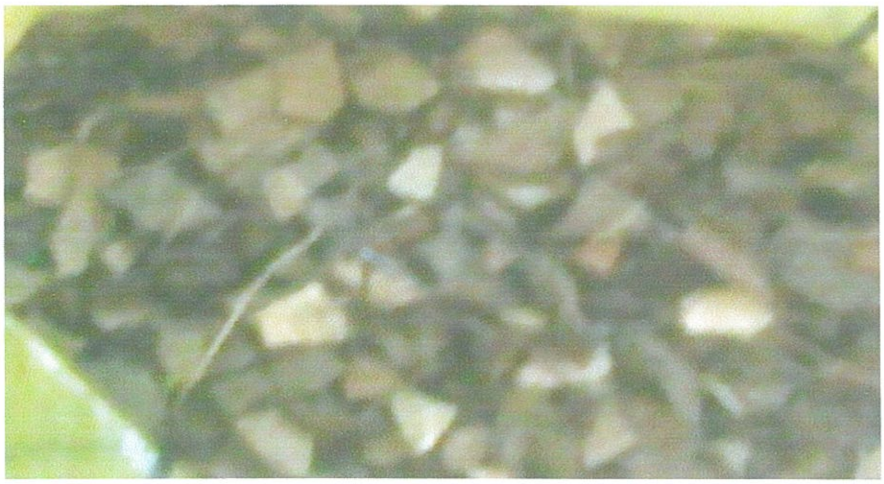

Figure: 3.4 Milled and briquetted coconut shell Sample

The figure sample of coconut shell despite been milled appeared to be bigger than the sample particles of rice husks and saw dust, this may be due to the facts that it is stronger than the other biomass. The sample was milled and dried so that it can easily be burnt to obtain accurate result.

When the preparation is complete different quantity of each biomass ranging from 100g, 200g, 300g, 400g and 500g was measured using weighing balance and put in a furnace, about 25ml volume of water was put in a boiler and heated that generated a steam as per each quantity of biofuel which eventually heated the thermopile and generated electricity. In each case the electromotive force (e.m f) was determined and the initial and final temperatures was taken and recorded likewise the time of the experiment was noted through out the experiment .

The set up above shows how the experiment was conducted. The process was repeated with different masses of the biomass and the electromotive forces (e.m.f) obtained respectively. Data obtained was analyzed using Microsoft Excel.

CHAPTER FOUR

RESULTS AND DISCUSSION

The experiment was performed at an interval so as to avoid or minimize instrumental and other possible errors.

The parameters considered in the experiment were masses of the biomass measured in grams,(gm),the initial and final temperatures of the water as Θ_1 and Θ_2 in degree Celsius(^{0}C) and the volume of the water in milliliter ,(ml) while the time in seconds(s) was considered to be constant throughout the experiments.

For all the measured parameters different values were obtained according to the quantity of the used biomasses, an average of two(2) readings for each parameter was considered moreover, reading of the final temperature was taken as the water boils and releases steam. The slope or gradient which is the ratio of the change in Y-value over the change in the X-value was obtained for each biomass likewise the point of intercept was determined. It was visualized that the steepness of the graph becomes higher at the highest value of the corresponding electromotive force and masses of biomass. All the graphs have Y-intercept where the graph crosses Y-axis that means X is zero. It is the gradient that manifest the most efficient among the three biomass. Moreover, different masses was used so as to obtained a diversed values that will give an accurate and reliable result. Hence the result was recorded accordingly .Below is the table of values of the experiment.

TABLE. 4.1: Table of values of Saw Dust

S/N	MASS(gm)	E.M.F(mV) ± 0.1mV	INITIAL TEMPERATURE Θ_1 (^{0}C) ± 0.1^{0}C	FINAL TEMPERATURE Θ_2 (^{0}C) ± 0.1^{0}C	H=MC Δ Θ
1	100.0	7.2	30.0	100.0	6300
2	200.0	9.1	32.0	99.5	12060
3	300.0	13.2	30.0	100.0	18900
4	400.0	16.0	30.0	98.5	24480
5	500.0	20.2	30.0	100.0	31500

This is the table of the values obtained for rice husk

TABLE.4.2: Table of value for Rice Husks

S/N	MASS(mg)	E.M.F(mV) ± 0.1mV	INITIAL TEMPERATURE Θ_1(^{0}C) ± 0.1^{0}C	FINAL TEMPERATURE Θ_2(^{0}C) ± 0.1^{0}C	H=MC Δ Θ
1	100.0	5.2	30.0	100.0	1309
2	200.0	8.3	30.0	100.0	2618
3	300.0	10.0	29.5	99.5	3927
4	400.0	14.2	30.0	100.0	5236
5	500.0	15.2	28.5	100.0	6732

TABLE 4.3: Table of values for Coconut Shell

S/N	MASS(gm)	E.M.F(mV) ± 0.1mV	INITIAL TEMPERATURE $\Theta_1(^0C)$ ± 0.1^0C	FINAL TEMPERATURE $\Theta_2(^0C)$ ± 0.1^0C	H=MC ΔΘ
1	100.0	10.1	30.0	100.0	11690
2	200.0	11.0	30.0	100.0	23380
3	300.0	15.2	29.5	100.0	35571
4	400.0	19.2	29.5	98.5	46092
5	500.0	22.0	30.0	100.0	58450

For each biomass a graph of electromotive force was plotted against mass and a gradient is also obtained.

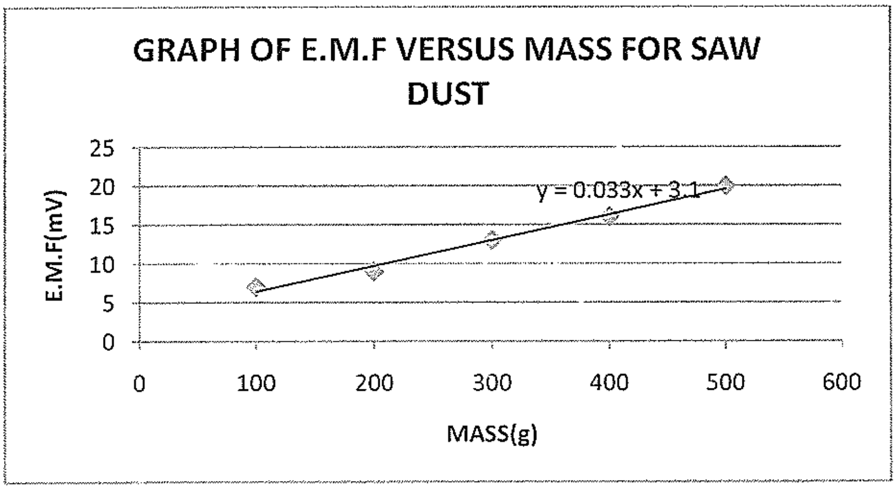

FIGURE.4.4: Graph of E.M.F Against Mass of Saw Dust

From the above graph one can see that the minimum electromotive force (e.m.f) was 7Mv and the maximum electromotive force (e.m.f) was 20Mv at the mass of 100g and 500g respectively. The gradient was 0.033mV/g with an intercept of 3.1mV.

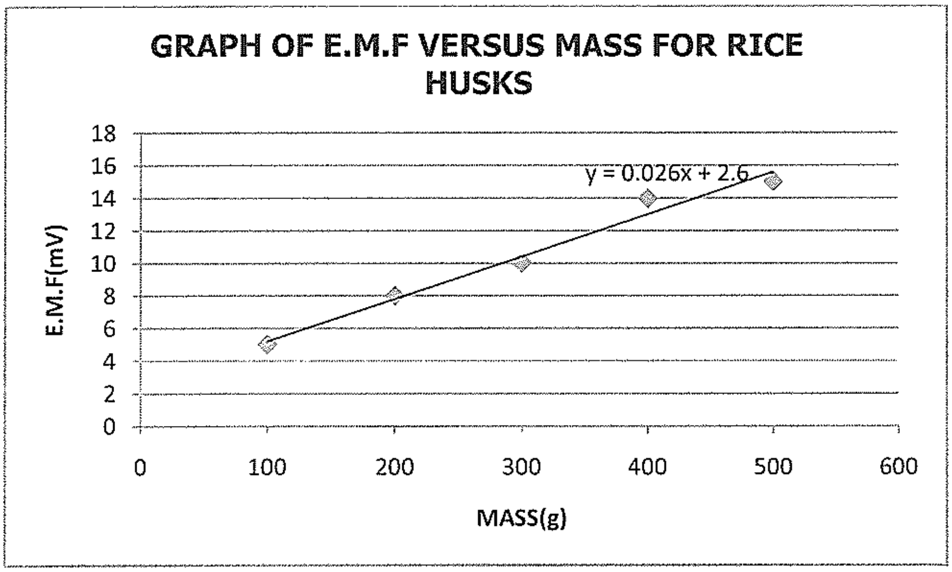

FIGURE.4.5: Graph of E.M.F Against Mass of Rice Husks

From the graph above it can be seen that the minimum electromotive force (e.m.f) was 5mV and the maximum electromotive force (e.m.f) was 15mV at mass of 100g and 500g respectively with a gradient of 0.026mV/g and an intercept of 2.6mV.

GRAPH OF E.M.F VERSUS MASS OF COCONUT SHELL

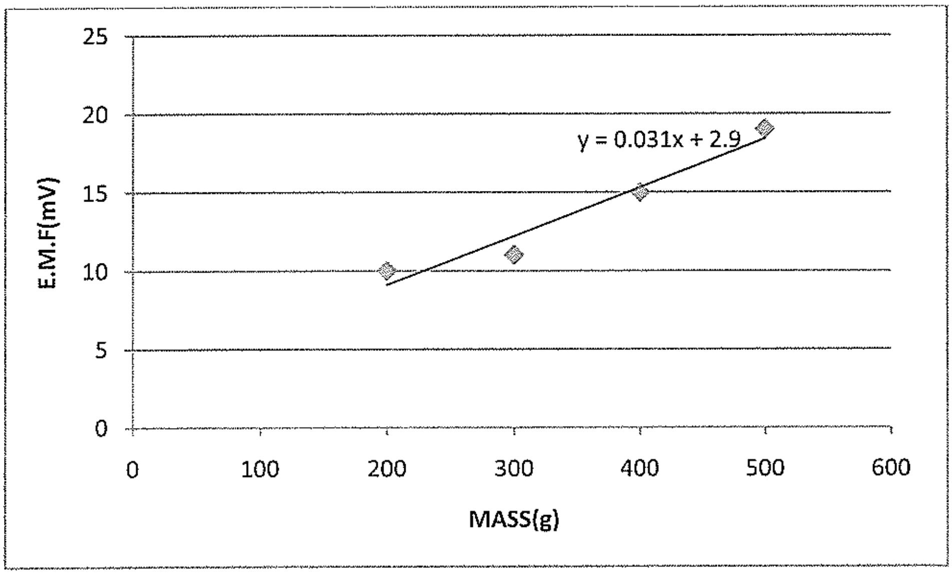

FIGURE.4.6: Graph of E.M.F against Mass of Coconut Shell

From the graph also it can be seen that the minimum electromotive force (e.m.f) was 10mV and the maximum electromotive force (e.m.f) was 22mV at mass of 100g and 500g respectively with a gradient of 0.031mV/g and an intercept of 2.9mV.

Generally, the gradient of the three (3) biomass used shows that saw dust is having 0.033mV/g, rice husks with 0.026mV/g, and coconut shell with 0.031Mv/g.

The result therefore, indicated that saw dust is having the highest gradient of 0.033mV/g followed by coconut shell with 0.031mV/g and rice husks with 0.026mV/g. This results indicated that saw dust is the most efficient in the thermal generation of electricity then followed by coconut shell and then rice husks.

The obtained values of e.m.f against masses of different biomass were represented using bar graph for the rice husks, saw dust and coconut shell.

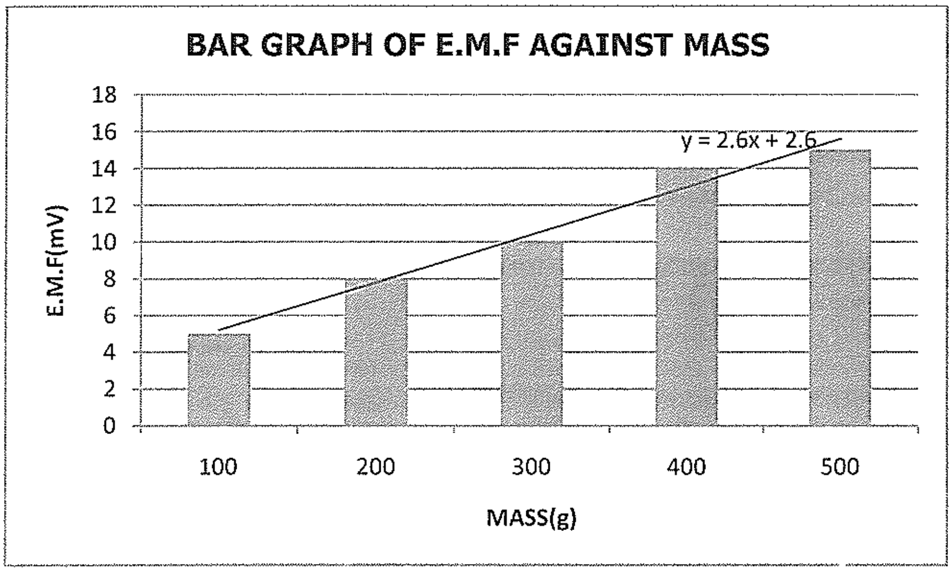

FIGURE.4.7 Bar graph of E.M.F Against Mass of Rice Husks

The bar graph represent the linear graph of the values of electromotive force (e.m.f) and mass(g).The graph indicated an increase in mass goes with increase in electromotive force.

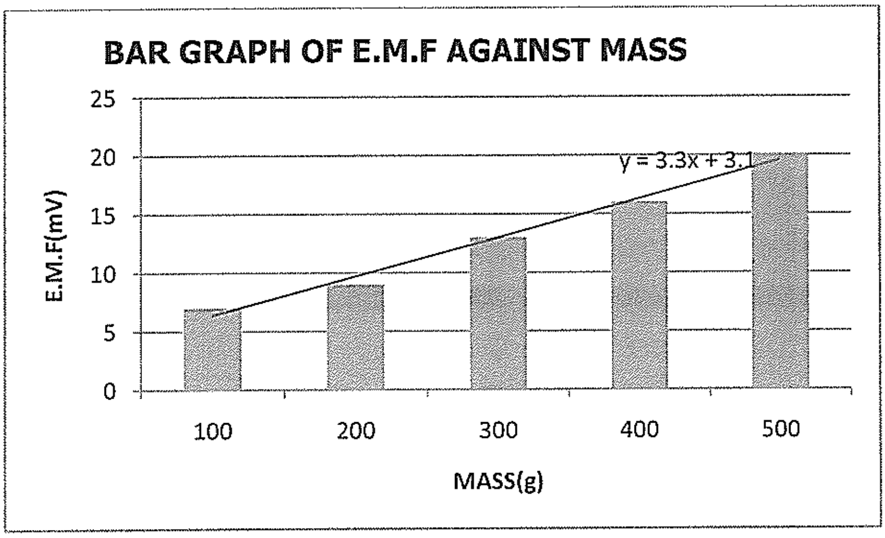

FIGURE.4.8: Bar graph of E.M.F Against mass of Saw Dust

The bar graph represent the linear graph of electromotive force(e.m.f) and mass(g).The bar graph shows that increase in mass goes with the increase in electromotive force.

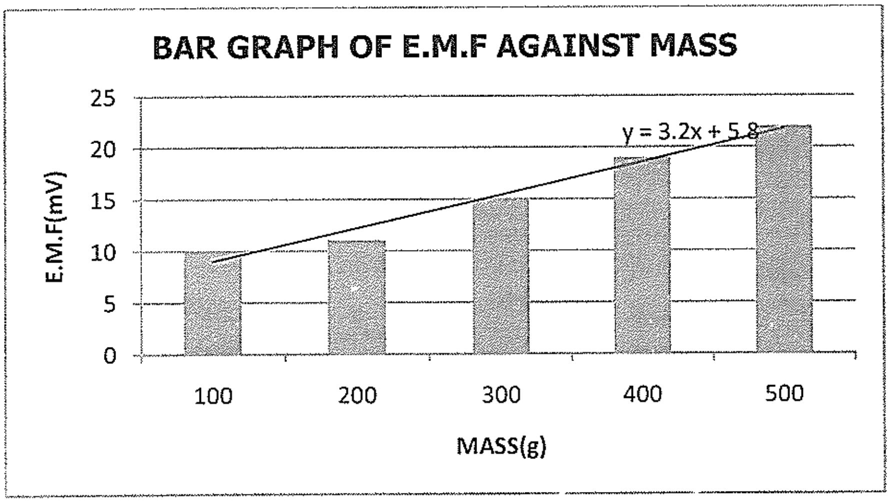

FIGURE.4.9: Bar Graph of E.M.F Against Mass of Coconut Shell

The bar graph represent the linear graph of electromotive force (e.m.f) and mass(g).The bar shows increase in mass goes with an increase in electromotive force. The different masses of100g, 300g and 500g of saw dust , rice husks and coconut shell were plotted in a single bar graph to compare their e.m.f. The graphs obtained were shown below.

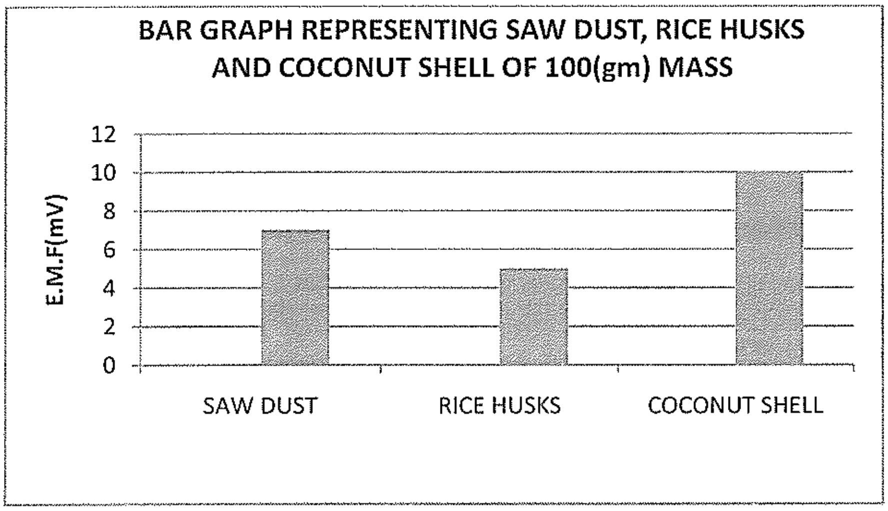

FIGURE.4.10: Bar Graph Comparing E.M.F With 100g of Different Biomass

It is visualized that Coconut Shell gives highest e.m.f than Saw Dust and Rice Husks at 100g mass.

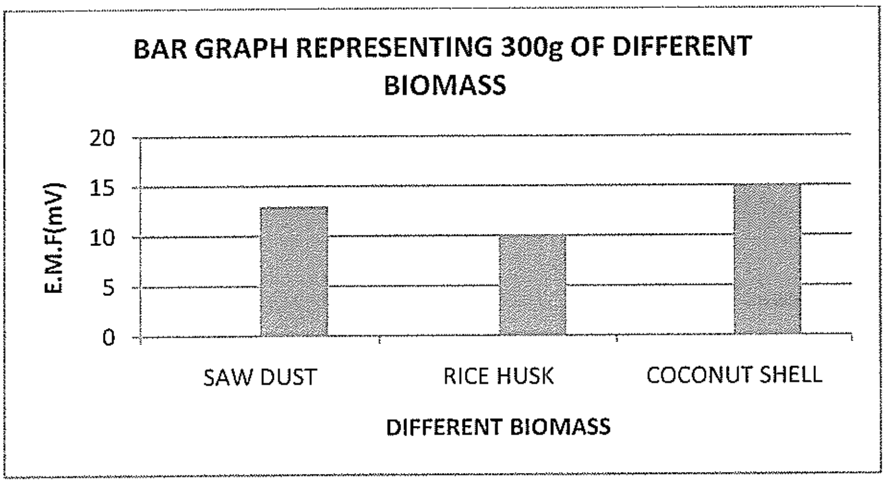

FIGURE.4.11: Bar Graph Comparing E.M.F With 300g of Different Biomass

It is visualized that the Coconut Shell gives the highest e.m.f than Saw Dust and Rice Husks at 300g mass.

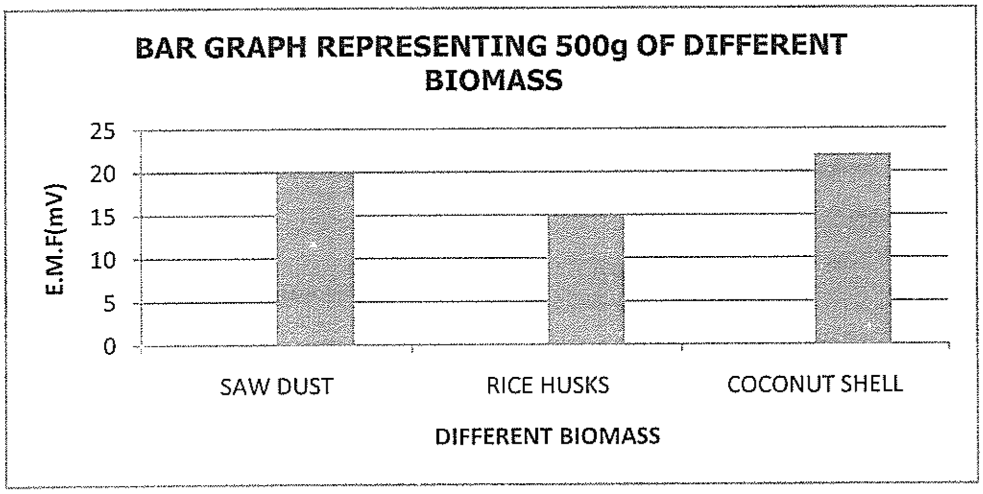

FIGURE.4.12: Bar Graph Comparing E.M.F With 500g of Different Biomass

It is also visualized that the Coconut Shell gives the highest e.m.f than Saw Dust and Rice husks at 500g mass.

The above figures compare different masses of biomass with their e.m.f, according to the bar diagram coconut shell is having the highest electromotive force then followed by saw dust and then rice husks.

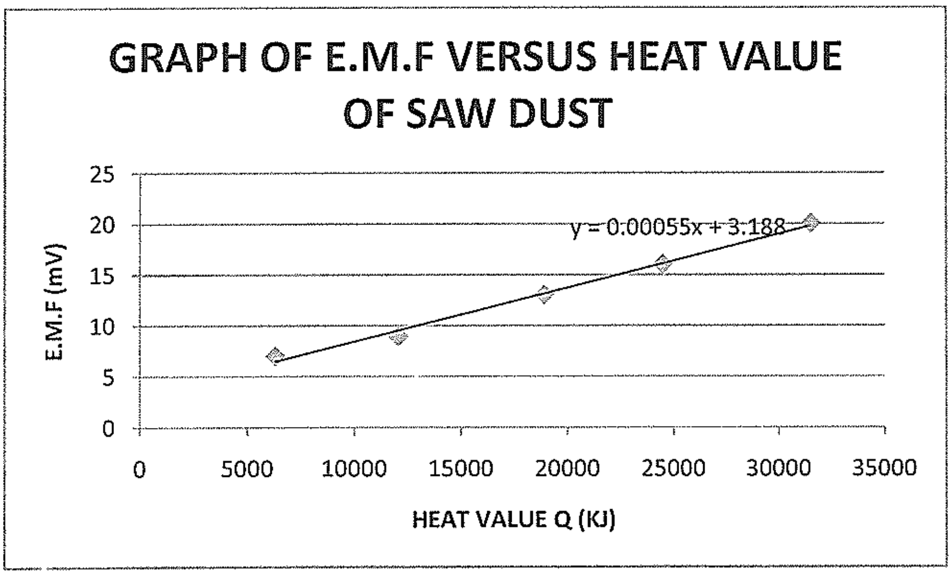

FIGURE.4.13: Graph of E.M.F Against Heating Value of Saw Dust

From the graph as the electromotive force increases the heating value of saw dust equally increases. Saw Dust is having a gradient of 0.00055mV/kj and an intercept of 3.188mV, it has a specific heat capacity of 0.9kj/kg^{0}c.

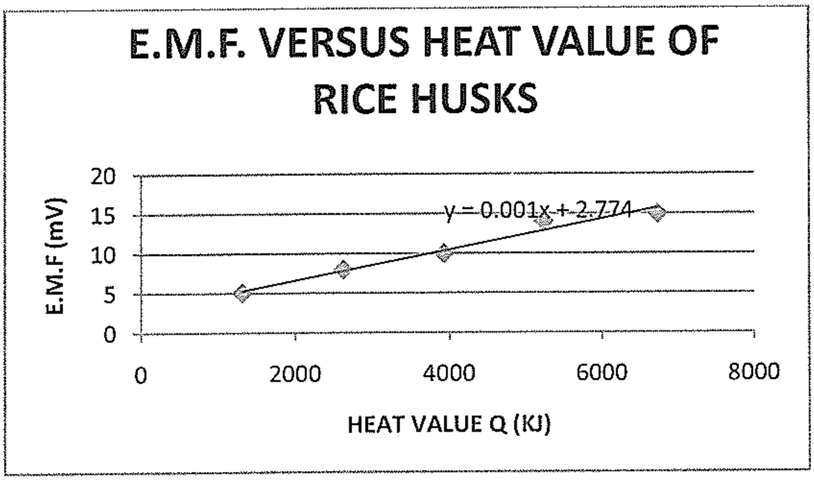

FIGURE. 4.14: Graph of E.M.F Against Heating Value of Rice Husk

From the above graph of electromotive force against heating value of rice husk it can be seen that as e.m.f increase the heating value of rice husk also increases, it has a gradient of 0.001mV/kj and an intercept of 2.774mV.It has a specific heat capacity of 0.187kJ/kg^{0}c.

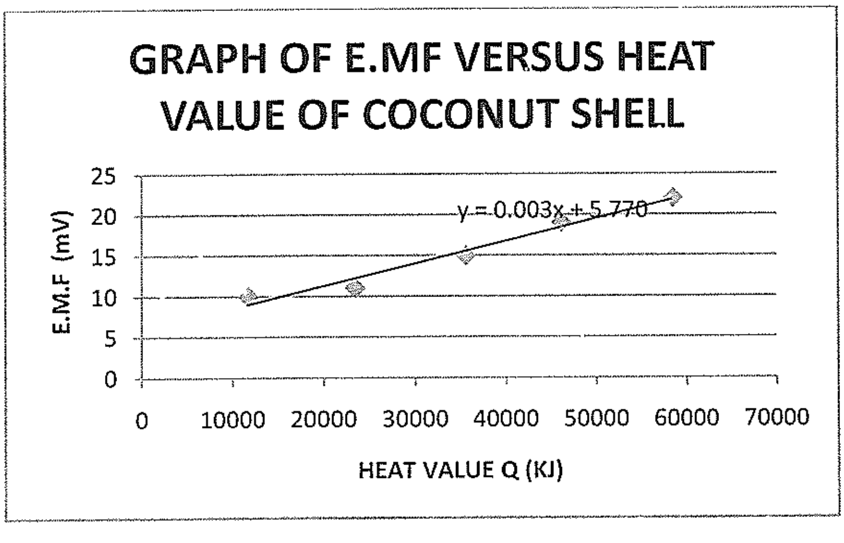

FIGURE.4.15: Graph of E.M.F Against Heating Value of Coconut Shell

From the above graph one can see that as the electromotive force increase the heating value of Coconut Shell also increases. It has a gradient of 0.003mV/kj and an intercept of 5.770mV, with specific heat capacity of 1.67kJ/kg^{0}c

CHAPTER FIVE:

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this dissertation a comparative analysis of the heating values of saw dust ,rice husks and coconut shell in the thermal generation of electricity was carried out. Different masses of the biomass were used, namely; 100g,200g,300g, 400g and 500g and for each biomass a corresponding value of the electromotive force was measured using a digital multimeter in millivolts and other parameters considered were initial and final temperature in degree Celsius, time and volume of water in seconds and milliliter respectively.

It was observed that there was a relationship between the slope or gradient and efficiencies of the biomass, this was justified in each obtained graph as the mass was increased there was equally an increases in the electromotive force and hence a higher gradient was obtained this signifies that the gradient has a relationship with the efficiency of the biomass. It can be deduced that Saw dust with gradient 0.0033mV/g followed by Coconut shell with 0.0031mV/g and than Rice husk with 0.0026mv/g is the most efficient biomass in the thermal generation of electricity than Coconut shell and Rice husk.

In conclusion therefore, Saw dust is recommended to be use in the thermal generation of electricity.

5.2 Recommendation

i. Further research should be carried out with these biomass on a large scale, this will give room for the exploitation of these available resources in this locality.

ii. There is a need to explore more of the available biomass so as to further find out the most effective among them since they are affordable, efficient and abundant sources of domestic electricity.

iii. For all different samples, not all was burnt, so I suggest in future one to measure the input sample and the left over sample and then this makes the difference in masses as the actual burnt that generated the e.m.f. as the researcher does not burnt all the biomass since reading was taken when the meter shows peak value

iv. Finally, I recommend saw dust to be use in the thermal generation of electricity since it has the highest gradient.

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