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Renewable Energy as a Solution to Nigerian Energy Crisis

Business Economics and Tourism

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“When a man feels throbbing within him the power to do what he undertakes as well as it can possibly be done, this is happiness, this is success”’.-Orison Swett. Marden-

“Each morning when I open my eyes I say to myself: I, not events, have the power to make me happy or unhappy today. I can choose which it shall be. Yesterday is dead, tomorrow hasn’t arrived yet. I have just one day, today, and I’m going to be happy in it’.-Groucho. Marx-

Vaasa, 19.05.2010

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ABSTRACT

Author	Suleiman Lawal Nadabo
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The aim of this study is to investigate the potentials of renewable energy sources in Nigeria and how to support, promote and courage the growth of renewable energy resources in Nigeria to close the gap of 60-70% of Nigerians that did not have access to energy that is environmentally friendly.

Alternative energy sources are good and wonderful options because they are limitless. We will not run out of them as we may run out of the fossils fuels which are the major sources of energy in Nigeria. Also it is not only the declining levels of fossil fuels that is the only major concern that will make Nigeria to adapt and switch to the use of renewable energy sources. Climate change, which is cause as a result of carbon emissions and environmental pollution, is drawing world attention and forcing national governments to formulate policies that will make their nations adapt the use of renewable energy sources to cut environmental pollution to the bearest minimum because global warming has become a major issue and problem of the world today and in the future.

Two different research methods were used in the empirical part of the study. At first, the structured questionnaire survey was carried out. Moreover interviews were executed. The use of both research methods proved to be useful in exploring the energy situation in Nigeria and receiving reliable results. Based on the empirical results, the energy problems are clear.

The main conclusion of the research is potential of renewable energy resources in Nigeria are put at excess of 1.5 times that of fossil energy resources, in energy terms. Solar energy would be the best solution to the crisis followed by biomass and hydro which also have significant potentials to improve and make a difference on the low level of electricity in Nigeria, with emphasis on the rural areas, through the adoption and the use of these renewable energy resources for sustainable development.

Keywords Renewable Energy, Solutions, Crisis

VAASAN AMMATTIKORKEAKOULU

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TIIVISTELMÄ

Tekijä	Suleiman Lawal Nadabo
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Tämän tutkimuksen tarkoituksena on selvittää uusiutuvien energialähteiden mahdollisuuksia Nigeriassa ja kuinka tukea, edistää ja rohkaista uusiutuvien energialähteiden kasvua Nigeriassa, jotta voitaisiin vähentää niiden 60-70% nigerialaisten määrää, joilla ei ole käytettävissä ympäristöystävällistä energiaa.

Vaihtoehtoiset energialähteet ovat hyviä ja mahtavia vaihtoehtoja, koska ne ovat rajattomia. Ne eivät lopu niin kuin fossiiliset polttoaineet, jotka ovat energian päälähde Nigeriassa. Fossiilisten polttoaineiden vähenevä määrä ei ole ainut suuri huoli, joka saa Nigerian sopeutumaan ja vaihtamaan uusiutuviin energialähteisiin. Hiilipäästöjen ja ilmaston saastumisen aiheuttama ilmastonmuutos kerää maailmanlaajuisista huomiota ja pakottaa kotimaiset hallitukset muodostamaan toimintaperiaatteita, jotka saavat valtiot sopeuttamaan uusiutuvien energialähteiden käytön, jotta ympäristön saastuminen vähenisi siedettävälle tasolle. Tämä siksi, että ilmaston lämpenemisestä on tullut merkittävä ongelma nykypäivänä ja tulevaisuudessa.

Tutkimuksen empiirisessä osassa käytettiin kahta erilaista tutkimusmenetelmää. Aluksi toteutettiin strukturoitu kysely, minkä jälkeen suoritettiin haastatteluita. Molempien menetelmien käyttö osoittautui hyödylliseksi Nigerian energiatilanteen selvittämiseksi ja luotettavien tulosten saamiseksi. Empiiristen tulosten perusteella energiaongelmat ovat selviä.

Tutkimuksen merkittävin johtopäätös on uusituvien energialähteiden lisääminen määrältään 1.5 kertaisiksi fossiilisiin energialähteisiin verrattuna. Aurinko-, tuuli- ja vesienergialla sekä biomassalla on merkittäviä mahdollisuuksia parantaa ja vaikuttaa vähäiseen energian käytön mahdollisuuteen maalaisalueilla Nigeriassa kestävään kehitykseen tarkoitettujen uusiutuvien energialähteiden adoption ja käytön kautta.

1 INTRODUCTION

The first paragraphs of the thesis tell the background of the thesis, followed by research objectives, research problems, and research questions. Thereafter, are presented the limitation, definition of key words and disposition of the thesis.

1.1 Background

Nigeria is the most populous black nation in the world and despite its huge natural resources it is still one of the poorest countries in the world with an estimated GDP per capita of \$ 2,162. For many years the country has been facing energy crisis that is hampering its economic development. Energy is one of the key fundamentals for economic development and also it is fundamental to all human activities in this era. There is an extreme electricity deficiency in Nigeria and the causes of this deficiency are related to financial, sociopolitical, and structural issues which leads the power sector in Nigeria to be recording high energy losses from power generation and billing which lead to insufficient cash generation as a result of these inefficiencies (A. Iwayemi 2008).

An estimated 60-70% of the Nigerian population does not have access to electricity. Energy demand in Nigeria is dominated by fuel wood and women and children are the most affected in the energy crisis. At present only 10 % of rural households and 30- 40% of the country's total population has access to electricity (Sambo 2007). The energy sector in Nigeria totally rely on government subsidize fuel and funding of major energy plants and energy capital projects by the federal government, states and government agencies.

Nigeria is endowed with vast oil and gas reserves and also an abundance of renewable energy potentials. Yet the country is suffering an energy crisis, which has a major impact on its ability to reduce poverty and achieve the Millennium Development Goals (MDGs).

Perhaps it is only individuals that are neither living nor doing business in Nigeria who will not know that lack of adequate energy supply especially electricity, is the major

challenge the country is facing to fully utilize its economic potentials in order to achieve economic development. This is also the most significant factor which is affecting the country's race to be one of the biggest and top twenty economies of the world by 2020. It is also evidently the issue how to find lasting and permanent solutions to the problems has remained a priority of every successive government in the last ten years.

The Nigerian government has not been able to find permanent solutions that will resolve the problems due to the adaptation of short term, hasty policies and also still undergoing energy projects which are detrimental to long term energy policies that will help the nation to achieve sustainable energy and energy efficiency. For example, what the country has done is still usage of the various alternatives that are still within the limits of fossil fuels, which are the only source that currently powers the nation economy (J. Kennedy-darling, N. Hoyt, K. Murao, A. Ross, 2008).

1.2 Research Objectives

Access to energy is fundamental for socio-economic development and poverty alleviation. A huge development challenge in Nigeria is reaching out to the 60-70% of the Nigerian population that does not have access to electricity and modern energy services. Renewable energy technology is a promising solution to the energy crisis in Nigeria. Renewable energy, apart from being sustainable and inexhaustible, it can be set up in small units and is therefore suitable for community management and ownership (Uyigwe, Agho, Edevbaro, 2007). Adopting the use of renewable energy sources will lead Nigeria to achieve stable energy supply and also achieve energy efficiency.

Alternative energy sources are good and wonderful options because they are limitless. We will not run out of them as we may run out of the fossil fuels which are the major sources of energy in Nigeria. Also it is not only the declining levels of fossil fuels that is the only major concern that will make Nigeria to adapt and switch to the use of renewable energy sources. Climate change, which is caused as a result of carbon emissions and environmental pollution, is drawing world attention and forcing

national governments to formulate policies that will make their nations adapt the use of renewable energy sources to cut environmental pollution to the barest minimum because global warming has become a major issue and problem of the world today and in the future.

The objective of this study is to investigate the potentials of renewable energy sources in Nigeria and how to support, promote and courage the growth of renewable energy resources in Nigeria to close the gap of 60-70% of Nigerians that did not have access to energy that is environmentally friendly.

1.3 Research Problems and Research Questions

The research problem of this study is *what is the potential of renewable energy in Nigeria?* Which is aim to find answers to the research questions.

- What are the economic and social factors affecting the use and growth of renewable energy sources in Nigeria?
- What are the technical related problems companies faces in building an alternative source of energy in Nigeria?

1.4 Limitation

In the course of carrying out this study, the researcher faces some problems, which prevents him from achieving the desired result. Below are the limiting factors that hinder the effectiveness of this research study.

Number of respondents and inability to co-operate fully with the researcher

This is one of the limiting factors that hinder the effectiveness of the research work; total number of the target population is small, although the sample represents the target group. Due to the population size the number of the respondents may not effectively represent the most common opinions of the population. The sample size was affected by the fact that the researcher could not physically go to Nigeria to be able to distribute the questionnaires more to the people as a result he is depending on

contacts in Nigeria and their help and also to conduct physical interviews. Most of the interviewers from government agencies were afraid in the sense that due to the sensitive nature of energy issues in Nigeria, they want to keep their secret within the organization or thought that information they will give might be used against them.

Finance and Interconnection of the Topic

Money also posed a limiting factor in which the researcher was unable to go to some areas which had been spelled out due to the lack of funds and also print as many questionnaires as possible to have a larger sample size which will truly represent the population. The interconnection of the topic is another limiting factor of the study because it hard for the researcher to concentrate only on business energy without mentioning some technical aspects of the energy system.

1.5 Definition of Key Words

Renewable Energy: Derived from resources that are naturally regenerative or are practically inexhaustible, such as biomass, heat (geothermal, solar, thermal gradient), moving water (hydro, tidal, and wave power), and wind energy. Municipal solid waste may also be considered a source of renewable (thermal) energy. (<<http://www.businessdictionary.com/definition/crisis.html>>) [Viewed 08/11/2009]

Solutions: suggested or implemented to try and solve a question or problem. (<<http://www.businessdictionary.com/definition/solution.html>>) [Viewed 08/11/2009]

Crisis: Critical event or point of decision which, if not handled in an appropriate and timely manner (or if not handled at all), may turn into a disaster or catastrophe. (<<http://www.businessdictionary.com/definition/crisis.html>>) [Viewed 08/11/2009]

1.6 Disposition of the Thesis

Chapter one gives the background information of the study and a problem of discussion of the research area, which leads to two research questions that have been mentioned earlier. Chapter two discusses the energy process and presents the four

renewable energy sources and how to generate energy from these sources. In chapter three, the reader will understand the energy situation in Nigeria, the projected energy demand and supply, factors that are affecting growth of renewable energy in Nigeria and the projected renewable energy growth. Chapter four covers and explains the methodologies that were used in the course of the research and provides information of the public institutions and the two case companies. Chapter 5 contains the results and analysis of the thesis from the data that were collected. Chapter six is the conclusion, suggestions and summary which will help further research, Nigerian public, institutions and companies that are interesting in the growth of renewable energy in Nigeria.

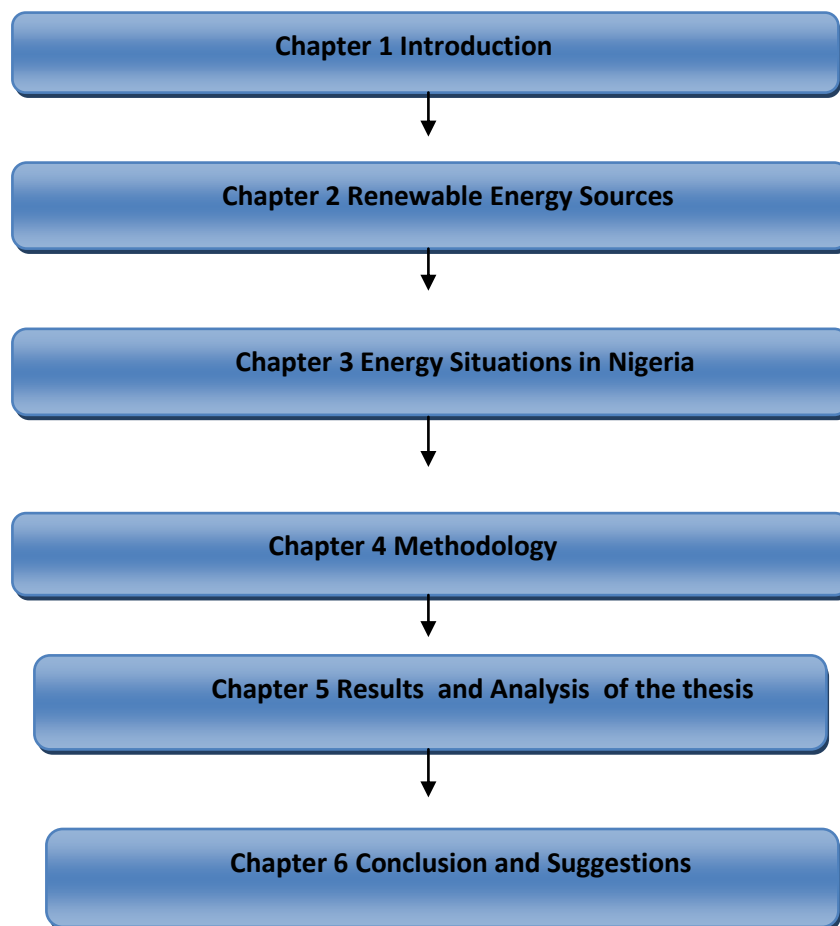


Figure 1. Disposition of the Thesis.

2 RENEWABLE ENERGY SOURCES

This chapter explains the energy process and the four renewable energy sources that the study is based upon, which are solar energy, wind energy, hydro and biomass energy. It also illustrates how to generate energy from the four renewable energy sources.

2.1 Energy Process

There are four elements involved in the energy process. Firstly, the energy source, which explains where we get our energy from. Secondly, energy production explains how energy is produced. Thirdly, energy transfer explains how the energy is going to be transferred. Lastly, energy consumption describes how to save as much energy as possible. Figure 2 is the energy process

Energy Source Energy Production Energy Transfer Energy Consumption

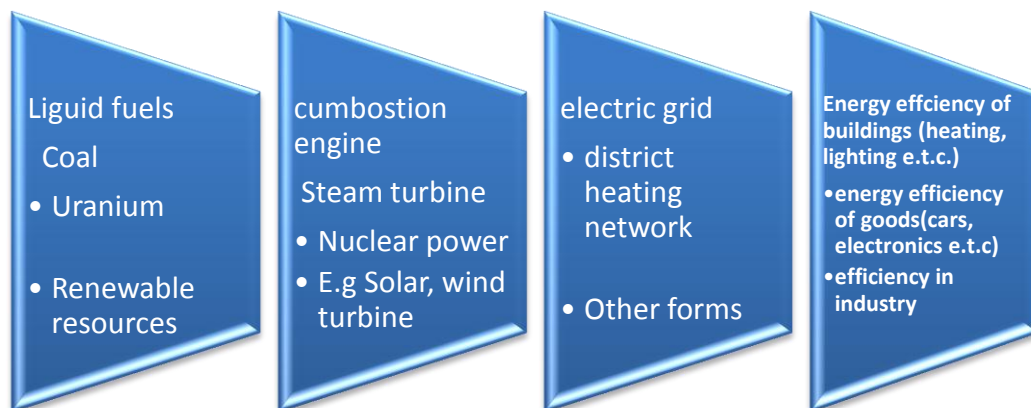


Figure 2. Energy Process (Koskinen, 2010).

It is also important to explain some key terms of electric power which will help the reader to understand more about the research work and energy field in general. Power

is the (capacity) that is measured in watts and energy is how much power is produced or used per time unit and it is measured in watt-hours.

- W= Watt; tells the power capacity
- Wh= Watt-hour; tells the amount of energy produced or consumed
- KW – kilowatt= 1000 MW
- MW – Megawatt= 1000 KW
- GW – Gigawatt= 1000 MW
- TW – Terawatt= 1000 GW

2.2 Solar Energy

Solar energy or power is the utilization of sun light for generation of electricity. The energy generation from sun can be done by a direct method using the photovoltaic (PV), or using indirect method where the sun's light or energy is focused to boil and heat water which is later used to provide power, the indirect method is called concentrating solar power (CSP). Primarily solar power refers to the use of sun radiation for generation of electricity. However, beside geothermal and tidal, all other renewable energy sources get their energy from the sun. Figure 3 illustrates how to generate electricity from the sun:

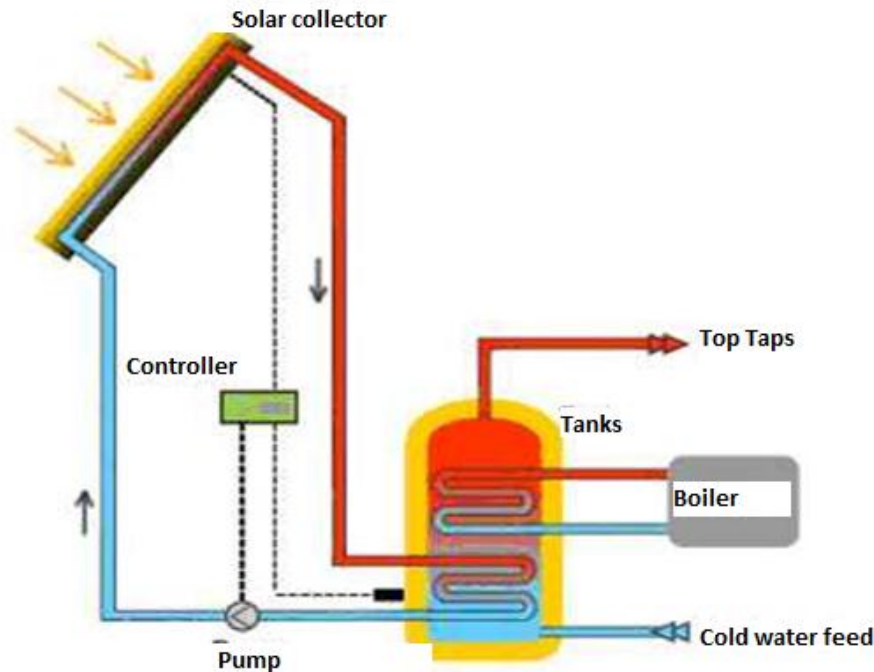


Figure 3. Generation of energy from the solar thermal method (Pwkits, 2009).

The energy influx from the solar radiation is the expression of power density that is used to indicate the number of watts per square meter (Da Rosa, 2008, p. g. 521).

Practically the radiation from the sun that Earth received originates in the photosphere, which is a thin layer that is surrounding the convective mantle of high opacity. The photospheres consist of different degree of ionization, including free electrons. (Sorenson, 2000, p. g. 21, 22, 24, 25)

2.3 Wind Energy

Wind power is the utilization and conservation of wind to provide energy for power generation for useful purposes, examples of wind power is using wind turbines for power generations, winds mills are used for mechanical power generation, wind pumps which are used for pumping water or drainage, or sails which is used to power ships by propelling it. The wind power has to be integrated for economic purpose which means all of the available output (resources) has to be taken into consideration

like hydropower and standard load management techniques for supply to meet demand. The picture below illustrates the wind turbine:



Figure 4. Wind turbine (W.Christian, 2006).

The amount of the economically extractable power that is available from the wind is said to be more than the current human power use from all sources (Sorenson, 2008). According to an estimation about 72 terawatt (TW) of wind power on Earth that is commercially viable.

The wind strength varies in different locations, an average value for a specific location does not indicate the total amount of energy that wind turbine could produce there. To ascertain the frequency of the wind speeds at a given location, a probability distribution functions is used and it often fits to observe the data accurately, because is evident that winds speeds distribution varies from location to location.

2.4 Hydro Energy

Hydro energy is the use of gravitational force of falling or flowing water to generate electricity. The hydropower is the largest and most widely form of renewable energy

sources that can be found commonly in almost every part of this world. Basically the hydropower plants are constructed and located in big dams that have high gravitational forces, the hydroelectric does not produce any waste directly or indirectly which make it to be considered the sources of energy that has lower level output of the greenhouse carbon dioxide (CO₂). The hydro power was approximated to account for 20% of the world's electricity, and also 88% of the total electricity generated from renewable energy. The picture below illustrates how to generate energy from the hydro:

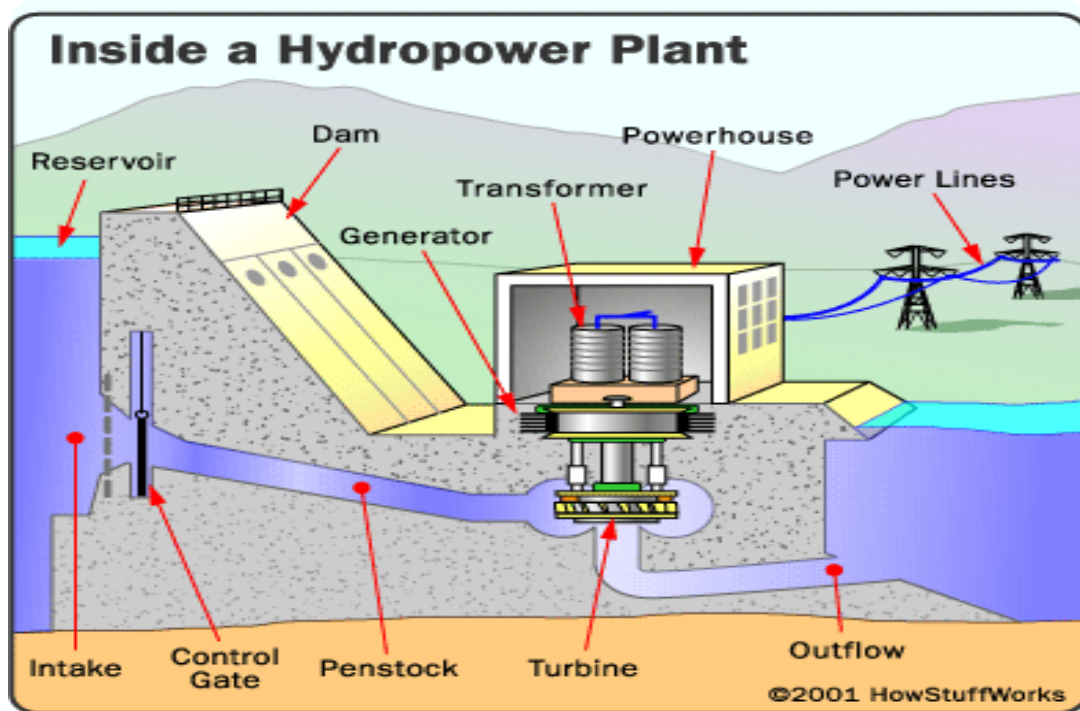


Figure 5. Generation of energy from hydro (EMT, 2009).

Basically, a majority of the hydroelectric power and energy comes from dammed water which is driving a water turbine and generator. The energy from the water depends on the volume in the difference in height and pressure between the water outflow and the source of the water. The height difference as a term is called the head. The total amount of the potential energy from water totally depends on the head (Sorenson, 2000).

The hydroelectricity storage produces electricity to supply high peak demand as a result of moving the water between the reservoirs in different levels. In the event of high electricity demand, extra generation capacity is used. In the event that there is a higher electricity demand, the water is released back inside the lower reservoir by turbine. The storage provides the most important commercial means of large-scale grid energy storage and it is enhancing the daily capacity of the hydroelectric generating system (Sorenson, 2000). The hydroelectric power generating plants that did not have reservoir capacity are term run-of-the-plants, because it is not possible for water storage. Tidal power generation plant which utilizes the daily fluctuations of water as a result of tides; the sources of tidal power are more predictable, and some conditions permit the construction and installation of the reservoirs and usually it can be dispatchable for the purpose of power generation during high demand period of electricity.

The simple formula to use when calculating the approximating electric power production in a hydroelectric plant is: $P = \rho r h g k$, P represent power in watts, ρ is the water density ($\sim 1000 \text{ kg/m}^3$), h is the height in meters, r is the flow rate of the water in cubic meters per second, g is the acceleration to gravity of 9.8 m/s^2 , and k is coefficient of ranging efficiency from 0 to 1. The efficiency most is higher with large and more modern turbines. The annual electricity that is generated from hydroelectricity energy production depends on the available supply of water. Some installations, the rate of the water flow vary by a factor of 10:1 in a year (Sorenson, 2000).

2.5 Biomass Energy

Biomass energy is a source of renewable energy that is biologically derived from living materials or organisms, like waste, wood, and alcohol fuels. The sources of biomass are specially planned to generate electricity or produce heat from them. The most commonly use biomass are dead trees, wood chips and tree trumps. It also includes plants or animals that a used for production of chemicals and fibers. It may also include waste that is biodegradable, meaning waste that is usually burnt as a fuel.

Biomass sources of energy did not include organic material like fossil fuel. The picture below illustrates how to generate energy from biomass:

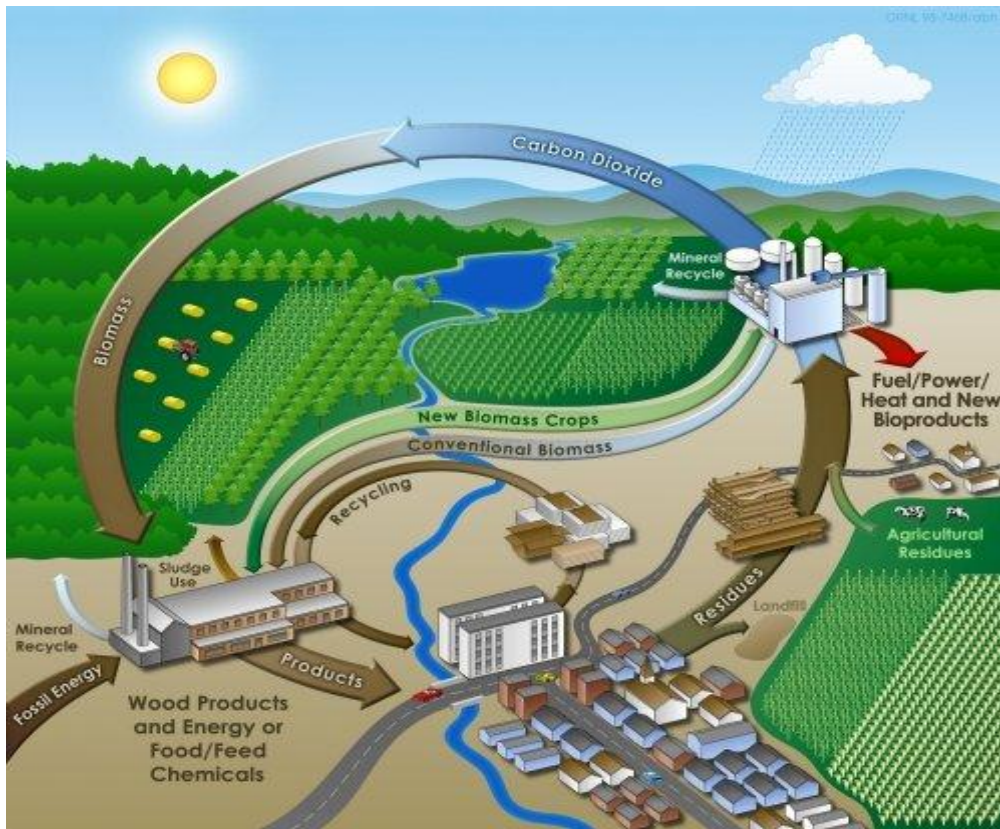


Figure 6. Generation of energy from biomass (REPP, 2009).

The biomass-based energy process usually starts with the capture of sunlight by the plants and production of chemical compounds. This is called photosynthesis, which leads to glucose. This creates biochemical transformations in a very large quantity with great commercial value. Usually, the photosynthesis proceeds with efficiencies of less than 8%. A plant is seen to be a structure that supports good organs which consist of wood and specialized leaves that perform photosynthesis and some specialized roots that collect nutrients and water. In the biomass production process, materials are usually transported from one site to another by what is known as sap, and the fruits that are involved in the process perform sexual reproduction (Da Rosa, 2008, p. 569). The roots and tubers store energy in a plant, and also energy is stored in the fruits and in the sap.

3 ENERGY SITUATION IN NIGERIA

This chapter explains the energy situation in Nigeria, the projected energy demand using Model for the Analysis of Energy Demand (MAED) that was developed by International Atomic Energy Agency (IAEA), and also the projected energy supply in Nigeria using the Model for the Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE), that was developed by International Atomic Energy Agency (IAEA) which explain the potentials of the four renewable energy sources, their utilization capacity as well as their expected future growth in Nigeria.

Nigerian economy depends heavily on oil which accounts for more than 95 percent of export income and also accounts for almost 85 percent of the nation revenues (W. Bank, 2009). Nigeria has an estimation of 36. 2 billion barrels of oil reserves as at 2009, it is 10th largest country in the world that produces oil. In addition to oil, Nigeria had proven gas reserves of more than 5000 billion cubic meters; it is the 7th largest gas reserve country in the world (CIA, 2009).

The oil and gas reserves are mainly found and located along the Niger Delta, Gulf of Guinea, and Bight of Bonny. Most of the exploration activities are focused in deep and ultra-deep offshore with planned activities in the Chad basin, in the northeast. Ignite and coal reserves are estimated at 2.7 billion tons, and tar sand about 31 billion barrels of oil equivalents, and hydroelectricity sites has been identified an estimated of 14,250MW (ECN, 2000).

Currently the installed capacity of grid electricity in Nigeria is around 6,000MW, 67 percent is thermal and the rest is hydro-based. By 2005, transmission network comprises of 6,000km of 132 KV lines, and 5,000km of 330 KV lines. The transmission channels are overloaded with low capacity of less than 4,000 MW (PHCN, 2009). The transmission channels has a poor voltage profile network especially in northern part of Nigeria, insufficient control and dispatch infrastructure, fragile and radial grid network, exceedingly high transmission losses and frequent system collapse. Table 1 is the electricity tariffs in Nigeria

Table 1. Electricity tariffs in Nigeria (PHCN, 2009).

Category	Amount (\$/kWh)
Residential with single phase meter	0.026
Residential with three phase meter	0.042
Commercial houses with single phase meter	0.052
Commercial with three phase meter	0.055
Average	0.044

The Power Holding Company of Nigeria (PHCN) business operations are inefficient due to the challenges it faces. The power and electricity system suffers from under-funding, un-recorded connections, poor maintenance and under billing as a result of un-metered connections. This also affects its utility financial performance, and also its ability to serve customer remain consistently poor for quite numbers of years.

Government of Nigeria has put efforts to undertaking comprehensive reforms aims at addressing the electricity situation in the country. The government enacted Electricity Power Sector Reform Act (2005), and also established the National Electricity Regulatory Commission to proper solutions to the problems challenging the sector. Presently, there are many investments in the power sector generation championed both by the private sector and the government. Recently, the government is investing more and more in an attempt to expand power generation targeting a cumulative capacity of over 10,000 MW by the end of 2010. And also target expansion of transmission lines withing the period to increase to over 15,000 km from 11,000 km (PHCN, 2009).

The shortage of generating capacity is negatively affecting the important sectors of the economy which is the industrial and manufacturing sectors. The industrial,

commercial and domestic sub-sectors mostly have self power generating system, as a result of this, the electrical power capacity demand in Nigeria is currently estimated at 10, 000 MW cannot be actually ascertain.

3.1 Energy Demand Projection

The energy demand projections in Nigeria were computed using Model for the Analysis of Energy Demand (MAED) that was developed by International Atomic Energy Agency (IAEA), the model include key drivers of energy demand, which is technology, demography, socio- economy. Applying MAED needs some detailed information on economy, demography, energy intensities and efficiencies. MAED gives breakdown of final consumption of country energy consumption into different sectors and individual levels of end-usage consistently. The MAED computed Nigerian energy demand projections from 2005 to 2030.

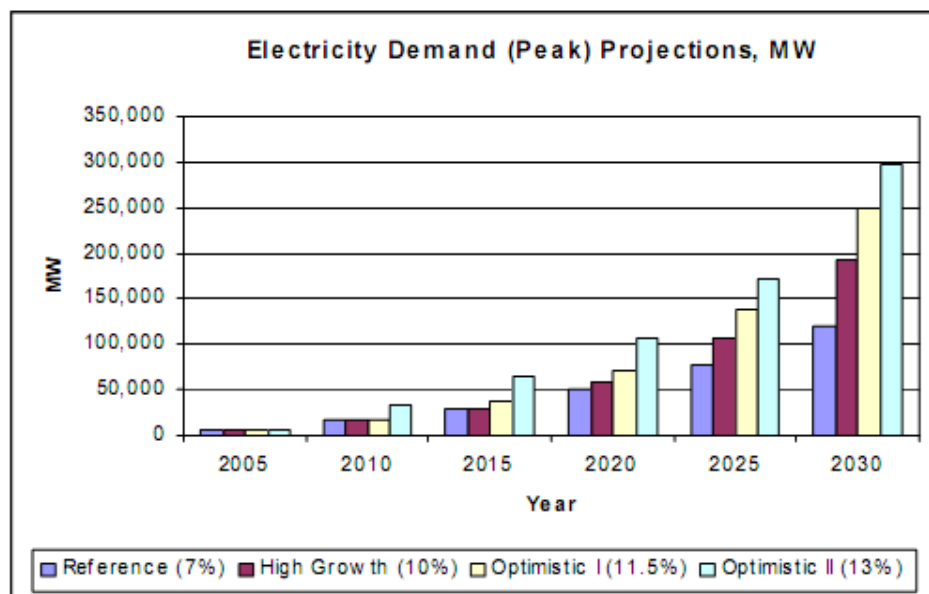
The MAED breakdown inputs in the identification of the economic, social and technical factors impacting the various categories of energy demand. Nigeria's energy demand case modelling, four economic scenarios used as follows:

- Reference Scenario: 7% GDP growth
- High Growth Scenario: 10% GDP growth
- Optimistic Scenario I: 11.5% GDP growth; and
- Optimistic Scenario II: 13% GDP growth (desired by the president to be one of the biggest economies by 2020).

Table 2. Four economic scenarios for energy demand (IAEA/ECN, 2007).

Scenario	2005	2010	2015	2020	2025	2030
Reference (7%)	5,746	15,730	28,360	50,820	77,450	119,200 MW
High Growth (10%)	5,746	15,920	30,210	58,180	107,220	192,000 MW
Optimistic I (11.5%)	5,746	16,000	31,240	70,760	137,370	250,000 MW
Optimistic II (13%)	5,746	33,250	64,200	107,600	172,900	297,900 MW

Figure 7 below illustrates electricity demand projections per scenario, MW.

**Figure 7.** Electricity demand production capacity MW (IAEA/ECN, 2007).

In the four scenarios above economic growth and structure of the economy are the key driving parameters. The projected demand of electricity has been translated into demand for grid and peak electricity demand base on the assumptions that was made for auxiliary consumption, declining non-grid generation, load factor and transmission and distribution losses.

The demand for 2005 is based on suppressed demand, because of inadequate generation, distribution, transmission and retail facilities. The suppressed demand has been anticipated to stop existing by end of 2010. The demand projections for the 13% GDP growth rate, increase from 5,746 MW in 2005 to 297,900 MW in 2030, this translate of construction of 11,686 MW yearly to meet the rising demand. The corresponding investment and operation cost for the 25 year period is US \$ 484.62 billion, this means that the nation should invest US \$ 80.77 billion in every five years to achieve the target within the stipulated period. All available energy resources in Nigeria were put into consideration to broaden the energy supply mix and also enhance energy security in Nigeria.

3.2 Energy Supply Projection

The energy supply projections in Nigeria were computed using the Model for the Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE), and also serves as tool that will utilizes the energy demand projection as an input that will provide a supply strategy. The MESSAGE is energy supplies, which represent the energy conversation and utilization of the energy system processes and their likely environmental impacts for a particular demand of final energy.

The model is used for the development medium-strategies, of the 30 years horizontal planning. The uncertainties that are associated with technological development make the time scope to be limited. The dynamics of the energy system are modelled by a multi- period approach. The mode is an optimization that set the existing and possible new technologies and selects the highest point in terms of the selected criterion mix of the technologies that will cover Nigerian demand of different types of energy

during the whole study period. The same scenarios that are used in MEAD are used here for the computation of Nigerian energy supply.

Table 3. Computation of Nigerian energy supply (IAEA/ECN, 2007).

Scenario	2005	2010	2015	2020	2025	2030
Reference (7%)	6440	15668	28356	50817	77450	136879 MW
High Growth (10%)	6440	15861	30531	54275	107217	192079 MW
Optimistic I (13%)	6440	15998	31235	71964	177371	276229 MW

Figure 8 below illustrates electricity supply projections per scenario, MW.

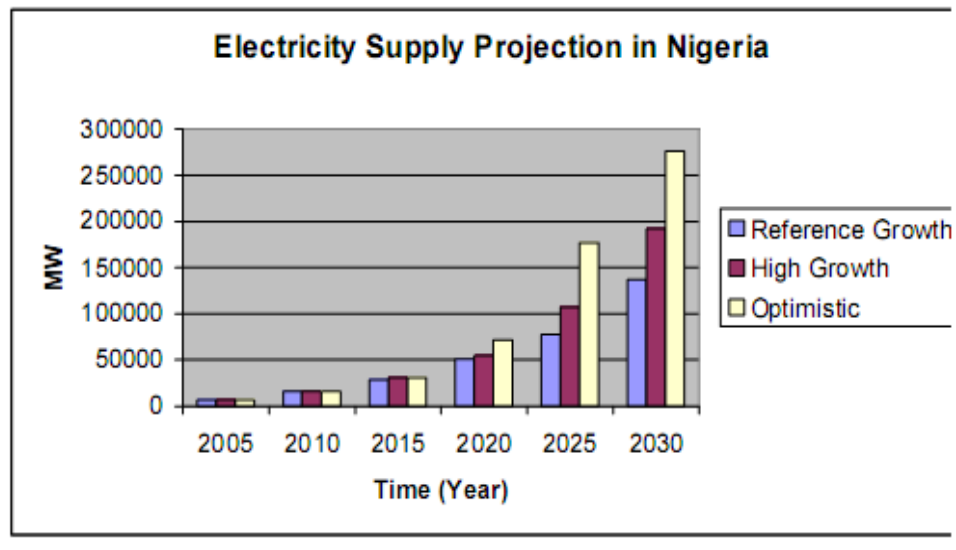


Figure 8. Electricity supply projections per scenario (IAEA/ECN, 2007).

The MESSAGE model takes into consideration demand variations of final energy forms during day, week, and year as well as the differences in political and

technological constraints of the energy supply. It is an energy and environmental impact model, which enables the user to carry out a good and integrated analysis of the energy sector environmental impacts and developments. Application of the model results in smaller cost of inter-temporal mix of the primary energy, energy conservation and also technologies that control emissions for each scenario.

3.3 Potential of Renewable Energy Sources in Nigeria

Nigeria is endowed with abundant renewable energy resources, the most important ones are solar, wind, biomass, small and large hydropower and also has the potential for hydrogen fuel, ocean and geothermal energies. The purpose of this study is to consider the potentials of the four main renewable energy sources which are solar, wind, biomass, and small and large hydro energy sources.

3.3.1 Hydropower Energy Resources in Nigeria

Hydropower energy potential of Nigeria is high and it currently accounts for about 29% of the total electricity power supply in Nigeria. The first and large hydropower supply station in Nigeria is located in kainji on the river Niger, in Niger State where it has an installed capacity of 836 MW and it also had provisions for more expansion to 1,156 MW. The second largest hydropower station is located in Jebba, Niger state with an installed capacity of 540 MW. An estimated (Aliyu, Elegba 1990) for rivers Shiroro in Kaduna State, Ikom in Cross River State and Makurdi in Benue state estimated their total capacity to about 4,650 MW. The Mambila Plateau rivers estimate was put at 2,330MW. Below *table 4* which gives the overall hydropower resources it reserves, production level and utilization in Nigeria.

Table 4. Hydropower resources (ECN, 2009).

S/N	Resource Type	Reserves (natural unit)
1.	Large Hydropower	11,250 MW
2.	Small Hydro	3,500 MW

As can be seen from the above table the overall hydropower potentially exploitable in Nigeria is put at 14,750 MW. It should be noted small mini hydropower plants that supply electrical energy are between the ranges of 15 KW to 15 MW while those that are supplying below 15 are considered as micro-mini (Sambo, Taylor, 1990). Indeed both the micro and mini hydropower systems have great advantage, over large the large hydro systems, because they are not associated with the problems of topography. The small hydropower system can be set up in most part of Nigeria so that the potential energy that can be generated in the large network of the rivers can be converted into electrical energy which will enhance and fast track the national rural electrification projects.

3.3.2 Solar Energy Resources in Nigeria

Nigeria is endowed with an annual daily sunshine that is averagely 6.25 hours, which is ranging between about 3.5 hours at the coastal areas of the northern boundary of the nations. It also has an annual average daily solar radiation of about 3.5 KWm²/day in the coastal area which is in the southern part and 7.0 KWm²/day at the northern boundary (Bala, et al, 2000). Nigeria also receives about 4909.212 kWh of energy from the sun which is equivalent to about 1.082 million tonnes of oil; this is about 4000 times the current crude oil production per day, and also put at about 13 thousand times of daily natural gas production based on energy unit.

This huge energy resources potential from the sun is available for about 26% of the day. Nigeria is also having some cold and dusty atmosphere which is experienced during the harmattan, in the northern part, which usually occurs for four months period (November to February) annually. The dust from the harmattan has an attenuating on the radiation intensity of the solar (Bala, et al, 2001).

Based on the Nigerian land area of 924 km² and an average of 5.535 KWh/m² /, the country have an average of 1831.06 kWh of incident solar energy annually. The annual insolation of the solar energy is value about 27 times the national conventional energy resources in energy units and also over 117,000 times the amount of electric power that was generated in 1998 (Chendo,2002).

About 3.7% only of the nation's land area must to be utilized in order to equal the nation's conventional energy reserve. The production level excess of 240 kWh of solar PV or 0.01 million MWh/day and the utilization level is put at excess of 0.01 million MWh/day of solar PV.

3.3.3 Wind Energy Resources in Nigeria

Nigeria, globally, is located within low moderate wind energy zone. A research was conducted about the wind energy potentials for a number of Nigerian cities which shows that an annual wind speed ranges from 3.89 m/s for Sokoto in far north to a figure of 2.32 m/s for Port Harcourt in the south (Sambo, 1996). The highest extractable per unit power for the same sites is out at about 4.51 and 21.97 watts per square meter of blade area, respectively and the maximum estimated energy obtainable a 25m diameter wind turbine that has an efficiency of 30% put at 25m height to be about 97 MWh per year in Sokoto which is located in the high wind speed regions in Nigeria, Kano has 50 MWh per year, 25.7 MWh per year for Lagos and 24.5 MWh per year for Port Hacourt (Ojosu, Salawu 1990).

3.3.4 Biomass Energy Resources in Nigeria.

Biomass energy resources in Nigeria can be identified as wood biomass, residues and waste, forage grasses and shrubs (Agricultural, forestry, industrial and municipal) as

well as aquatic biomass. The wood, Apart from being a major source of energy in form of fuel wood it is also use for commercial purposes in different forms as sawnwood, plywood, electric poles and paper products. For energy purposes, the county is using 80 million cubic meters (4719.7 kg) of fuelwood every year for cooking and other domestic purposes. The energy content that is being used from fuelwood is 6.0×10^9 MJ which only between 5-12% is the fraction that is utilized gainfully for cooking and domestic purposes.

Biomass resources in Nigeria have been estimated to be about 816 M.J. The biomass plant can be utilized as a fuel for small-scale businesses and industries. Also it could be fermented by anaerobic bacteria to produce a versatile and cheap biogas i.e Fuel Gas (Garba, Bashir, 2002). Biogas assessment in Nigeria, identified feedstock substrate that that has been considered as an economically feasible biogas programme that includes dung, water lettuce, water hyacinth, cassava leave, solid (including industrial) waste, urban refuse, agricultural residues and savage (Akinbami et al, 2001) . *Table 5* below presents the current biomass reserve, production and utilization level in Nigeria.

Table 5. Biomass resources in Nigeria (ECN, 2009).

S/N	Resource Type		Reserves (natural unit)	Production level (natural units)	Utilization (natural units)
1.	Biomass	Fuel wood	11 million hectares of forest and land wood	0.110 million tons/day	0.120 million tons/day
		Animal Waste	250 million assorted in 2001	0.781 million tons of waste/day in 2001	Not available
		Energy drops and Agric Residue	72 million hectares of Agric Land and all waste land	Excess of 0.256 million tones of assorted crops residues day in 1996	Not available

Nigeria produces about 227,500 tons of fresh animal waste daily and 1 kilogram (kg) of the fresh animal waste produce 0.03 m³ gases, then the country can produce about 6.8 million m³ of biogas daily. With increasing urbanization and industrialization, biogas production will help in reducing or even eliminating the nuisance and menace of urban wastes in many cities of the country by recycling those (Akinbanmi et al, 2001).

3.4 Factors Affecting the Growth of Renewable Energy in Nigeria

There are quite a lot of factors that affect and hinder the use of renewable energy sources in Nigeria, despite the abundance resources of renewable energy as illustrated above, the use of renewable energy it is still not growing in Nigeria. It could not be possible to list all of those factors, so only some are choosing in this research that will

help us understand the basic problems that are associated with the growth of renewable energy in Nigeria.

According to the Director General Energy Commission of Nigeria, Professor A. S Sambo on his paper about Renewable Energy Electricity in Nigeria; the Way Forward (December 2006), has identified and mentioned various factors that hinders the growth and use of renewable energy in Nigeria as follows:

3.4.1 Lack of Capacity and Standard Quality Control

The lack of capacity and inadequate expertise that must be developed, and manage the renewable energy sources better managed because the nation rely exclusively on outsourcing expertise for management of the little renewable energy sources it utilizes. There is inadequate infrastructure which makes the renewable electricity components scarce; this makes the country rely totally on imports of components for the maintenance of renewable energy electricity. Another major barrier to the development of alternative sources of energy market in the nation is the lack of established standard and quality control systems of both locally and imported manufactured technologies. Quality assurance builds consumer confidence in the new and growing market of renewable energy. The important things of standard and quality control include the perception of the potential users, bad developed regime for setting standards, certification and testing as well as professionalism among the operators and service providers.

3.4.2 Financial and Fiscal Incentives

The Nigerian energy policies on financial incentives focus mainly on centralized and conventional sources of electric power. The incentives that were established are to encourage investments in power generation that are conventional. A government subsidy on the grid power discourages and penalized investment in renewable energy solutions. There is no any government policy that gives financial support and incentives that will help the and fast track the growth of renewable energy, and also develop demand and supply of the renewable energy market in Nigeria. Financial and

fiscal incentives have a great impact in the development of renewable energy in Nigeria because it will indicate government willingness and commitments of diversifying the source of energy from total reliance on fossil fuels which is one of the key factors that is affecting the Nigerian energy sector. This lack of a level playing ground for alternative energy sources and technologies has great impact to the growth of renewable energy in Nigeria.

3.4.3 Lack of Awareness

Majority of Nigerians are not aware about the environmental impacts and economic benefits of the use of renewable energy, the public awareness of the renewable energy technologies are generally low. Consequently, the Nigerian public did not have much influence that will force the government to start taking decisive policies and initiatives that will enhance and promote the application, development, dissemination and diffusion renewable energy technologies and resources in the Nigerian energy market. The low level of awareness creates a huge distortion in the market which makes potential investors in high risk perception that are willing to invest in renewable electricity projects.

3.4.4 Deregulated and Liberalized Energy Industry

Nigerian energy sector is controlled exclusively by the government and this is one of the key factors that hinder the growth of the renewable energy sector in Nigeria, because there is no adequate institutional framework. In addition, there is no agency that is responsible for issuing licenses to companies that will provide smaller capacities of renewable energy electricity. This has also limited the penetration of renewable energy firms into the Nigerian market.

3.4.5 High Initial Investment Cost

Renewable energy is quite expensive which makes the electricity generated from the system to have high initial cost, which as a result limited the penetration of the renewable energy electricity system into the Nigerian market in consideration of the level of income of majority of the population. Small scale hydro power, residual and

central solar PV technologies, etc have not penetrated the energy supply systems in Nigeria because of their high investment cost. This has been identified as one of the key factors that are affecting the growth of renewable energy technologies in Nigeria and the widespread adoption of family-sized biogas digesters in Nigeria.

Renewable energy have high initial investments cost, this have great effects on renewable energy projects and the total cost of the energy produced per KW-h. Potential investors in renewable energy in Nigeria are not favorably disposed to small hydro, wind or power that is generated from cogeneration plants if is not profitable. The average electricity tariff in the nation is put at about #6:75 per KW-h (which is approximately 5 cents per KW-h). Typical sources of renewable power for small hydro is averagely 5-10 cents; solar PV: 20-40 cents, wind power: 6-10 cents, biomass power: 5-12 cents. Without good financial support it will be difficult to enter into renewable energy market in Nigeria.

3.5 Targets for Renewable Electricity in Nigeria

In the 2005, the federal government constituted a presidential committee which conducted study on a 25 year power development plan, and came up with a projected electricity demand profile for Nigeria approximately 15,000 MW; 30,000 MW ; and 19,000 MW in the short term, medium term and long term basis put at 10% economic growth rate scenario. Base on this projection, the Energy Commission of Nigeria conducted a study which indicated that renewable energy electricity is expected to contribute about 14% in the short term; 23% in the medium term; and 36% in the long term of the total energy and electricity supply as dictated by the National Energy Policy. The lapsing period of the short term; medium term; and long term are 2008; 2015; and 2030 respectively. Table 6 graph below illustrates the expected growth:

Table 6. Expected growth (Sambo 2006).

S/N	Resource	Short	Medium	Long
1,	Hydro (large)	1930	5930	48000
2,	Hydro (small)	100	734	19000
3,	Solar PV	5	120	500
4,	Solar Thermal	1	2	5
5,	Biomass	1	100	800
6,	Wind	1	20	40
	All Renewables	2038	6907	68345
	All Energy Resources	16000	30000	192000
	0% of Renewables	13%	23%	36%

4 METHODOLOGY

This chapter discusses the methodological choices made by the researcher. Specifically, discussion of research strategy, research methods, data collection method, methodology of the study, the public institutions and the case companies.

4.1 Research Strategy

The research strategy is defined as an overall plan, explaining how the researcher intends to find answers to the research questions (Saunders et al, 2000). According to Yin (1994) the following main research strategies that exist are; surveys, experiments, histories, archival analysis, and case studies. In addition to all these, the author mentioned that choice of a research strategy is determined by some selection criteria; the type of the research question, the level of control the researcher has over the actual behavioral events, and the level focus and attention placed on the contemporary as against historical events. *Table 7* described the relationship between the three strategies and condition by Yin (1994).

Table 7. Relevant situation for different research strategies (Yin, p.6, 1994).

Strategy	Form of Research Question	Requires Control Over Behavioural Events	Focus on Contemporary Events
Experiment	How, why	Yes	Yes
Survey	Who, what, where, how, many how much	Yes	Yes
Archival Analysis	Who, what, where, how, many how much	No	Yes/No
History	How, why	No	No
Case study	How, why	No	Yes

4.2 Research Methods

Here is introduced and compared both qualitative and quantitative research methods with each other. The qualitative and quantitative research method differs in the way they are conducted. The best way to conduct a research is to combine the research methods so that they can complement each other because it cannot be mentioned that one method is better than the other.

4.2.1 Qualitative Research Method

The qualitative research method traditionally is a way of inquiry in the social sciences and marketing research but now it has been appropriate in many different academic disciplines (Denzin, Yvonna, 2005). The aim of qualitative researchers is to gather an in-depth knowledge and understanding of human behavior and the reasons that govern such behavior. The method investigate the not only the *what, where, when* but also the *why* and *how* of decision making.

The differences of qualitative research method and quantitative research method are in the way of researching, reporting and analysis of the findings. The results of qualitative research are not reported numerically as in quantitative research. The aim of qualitative research method is not to test models and some other hypothesis statistically but rather it is based on more sources (Denzin, Yvonna, 2005). The evaluation and the classification of the results have to be in accordance with the research and the case. In qualitative research the questions are very important here are some guidelines on how to frame a qualitative research questions:

1. The foremost important thing is the definition of the research question.
2. Make the research question clear to everybody is also important.
3. Is also important to say a lot about little, instead of saying little about a lot.

On the course of carrying the research in some cases the research plan changes because some fresh ideas of findings can occur and subsequently change the research plan. The qualitative research is more flexible compared with the quantitative research method. And generally speaking quantitative research is less expensive than

the qualitative research method. The amount of information obtained from each respondent is substantial due to the small of the sample size and also it requires the researcher to have some special interview skills so that he can conduct a successful interview. The type of research in the qualitative method is exploratory and the analysis is subjective and interpretive. The method of collecting data in the qualitative research methods are in two ways interviews and observation.

In addition to these, official documents, articles, pictures which are referred to as secondary data can also be collected to support the primary data collected in exceptional cases (McDaniel, Roger, 2009). The qualitative research method as mentioned early is mostly used in social and behavioral science which makes it suitable for studying individuals, groups and organizations. The problem associated with qualitative data is few observations and also another problem concerns the data collections and the analysis, because it is usually often concluded at the same time which gives some concerns about the validity and reliability of a study.

4.2.2 Quantitative Research Method

The quantitative research method is said to be the systematic empirical findings of quantitative properties, phenomena and their relationships. The aim is to develop and use mathematical models, theories and hypothesis that affect phenomena. The process of measurement is vital to quantitative research method because it gives the fundamental connection between the empirical observation and the mathematical expression of the relationships.

Quantitative research method is more objective whereas qualitative research is more subjective. The data collected is more objective and the research subject is accurately defined and materials collected are measured numerically. The aim of quantitative research method is not to get deeper knowledge and understanding of phenomena as it is in the qualitative research method. The Result and conclusion in the quantitative research method are based on the statistical analysis (McDaniel, Roger, 2009).

Upon conclusion, the data should be reliable and valid and also it should match the purpose of the study. Basically, the means of collecting data in the quantitative research method is commonly found from secondary sources of data and in some cases self-gathered. The result of the quantitative research method is numbers and also the result is presented in tables, graphs and with percentage and other forms of statistics analysis with the help of Statistical Program for Social Sciences software (SPSS). Here are the most common used ways for gathering materials for quantitative research method:

1. Interviews
2. Surveys
3. Observation
4. Experimental cases

The common method used in gathering data is structured questionnaire. The questionnaire is designed in such a way that will make it easier for the respondents to answer the questions. The questionnaires questions are designed in a prearranged way which makes the process direct and also the questions usually have alternative answers that the respondent can easily mark (McDaniel, Roger, 2009). One of the advantages of using a well-structured questionnaire is that is very easy to manage and the data collected is reliable in most cases, and it is also easy to analyze and interpret the data.

The amount of information obtain from each respondent varies due to large of the sample size and also it requires the researcher to have little interview skills contrary to the qualitative research method. The type of research in the quantitative method is descriptive or causal and the analysis is statistical and summation (McDaniel, Roger, 2009). Different kinds of survey methods are personal interviews, telephone interviews teleconference and mail interviews, depending on the research subject. The choice of the research method is affected by the timetables, budget, respondent attitudes and the information that is needed for a study.

The research questions in the quantitative research methods commonly used are; *who, what, when, where and how much* (McDaniel, Roger, 2009). The disadvantage of the quantitative research method is that deeper knowledge and understanding of the subject may not be received through the use of the structure questionnaires. And another problem of the use of questionnaire is the sensitive or personal questions about income or religion of the respondents. In some instances, the respondent may not find any questions suitable answers in the structured questionnaires. The researcher plays a different role in quantitative research method compared to the qualitative research method because he pays more attention to the structure of the survey and also analyzing of the results of the survey.

4.3 Data Collection

Basically, there are six sources of evidence that are commonly relied on when gathering data for case studies but only four is depicted in *Table 8* (Yin, 1994). The sources are archival records, documentation, interviews, participant observation, direct observations and physical artifacts.

Table 8. Sources of Evidence Source: (Yin, p.80, 1994).

Source of Evidence	Strengths	Weaknesses
Archival Records	<ul style="list-style-type: none"> -Stable- is reviewed repeatedly. -Contain exact names, references and details of an event. -Broad coverage and long time span -Precise and quantitative 	<ul style="list-style-type: none"> -Access may be denied -Reporting bias which may reflects the bias of the author -Bias selectivity, if the collection is incomplete
Documentation	<ul style="list-style-type: none"> -Stable- is reviewed repeatedly. -Contain exact names, references and details of an event. -Broad coverage and long time span 	<ul style="list-style-type: none"> -Access may be denied -Reporting bias which may reflects the bias of the author -Bias selectivity, if the collection is incomplete
Interviews	<ul style="list-style-type: none"> -Insightful, which provides causal references -Focused directly on case study topic 	<ul style="list-style-type: none"> -Response bias sometimes -inaccuracy as a result of poor recall -Some times the interviewee gives the interviewer what he wants to hear
Participants Observations	<ul style="list-style-type: none"> -Insightful into interpersonal behavior and motives -Contextual-covers context of the event -Reality-covers the events in real time. 	<ul style="list-style-type: none"> -Bias as a result of manipulation by the investigator -Time consuming -Too much cost is involve -Selectivity- unless there is a broad coverage

The majority of the sources of evidence mentioned above will not be applied in this study for different reasons. There is no need to include participants' observations. Furthermore, the research is not focusing on the technical operations or cultural futures, so the physical artifacts will not be used. Documentation will not be used other in this research; interviews are the only sources of evidence that will be applied in this study.

There are three categories of interviews which are based on formality; structured interviews, semi structured interviews, and unstructured interviews. Questions are standardized and predetermined for the structured questionnaires. For the semi structured interviews, the questions are not standardized and list of themes is used instead of formalized questionnaire. Lastly, the unstructured interviews are usually conducted through an informal way, and lack of predetermined questions which limits the respondent to respond freely about the subject at hand (Saunders et al, 2000).

4.4 Methodology of the Studies

The aim of this thesis is to gain a deeper understanding about the potential of renewable energy and investigate how to support, promote and courage the growth of renewable energy sources in Nigeria to close the gap of almost 60-70% of Nigerians that did not have access to energy.

Due to the nature and objective of the study both the qualitative and quantitative research methods have been chosen for the study. In the qualitative approach which aims at answering questions from the public institution and the case companies, telephone and email interviews were conducted with three persons from the Energy Commission of Nigeria which is the chosen public institution, two persons from Pamtronics Nigeria Limited and Sahcofields Energy Services the selected case companies.

For the quantitative approach a structured questionnaire was prepared and sent to the respondents by email and posting and the answers are imported into the SPSS software for accurate analysis of results of the study. A questionnaire is a convenient way to conduct this research because the samples of people who answer the questions are located in Nigeria.

The advantage in using a structured questionnaire in the nature of this thesis research is the cheapest way to do research and it is also relatively fast to receive responses and also gives room for large sample to be spread over a wide area to be surveyed.

For instance, sending the questionnaires via posting and emails, also avoid the like bias that may arise as a result of face-to-face interview. Personal questions are more answered as the respondent is not in a face-to-face situation with the interviewer.

Despite these advantages in using questionnaire there are some disadvantages as well. The questions must not be complicated for every respondent to understand. The researcher may not be able to receive spontaneous answers from the respondent, and also the respondents' opportunity to discuss any questions with others before answering the questionnaire. And also in some cases it cannot be ascertain whether the named respond is actually the one that completed the questionnaire. The above mentioned disadvantages in one way or another have negative effect on the reliability and validity of the research (McDaniel, Roger, 2009).

4.5 About case companies

Here is the brief description of the public institution and two case companies.

4.5.1 Energy Commission of Nigeria

The Energy commission of Nigeria (ECN) was established in 1988, with the mandate for planning and the co-ordination of policies affecting the national energy and its entire ramification.

The commission is the highest government agency that is empowered to carry out the overall energy sector planning and policy implementation, promote the diversification of energy resources by developing and optimal utilization of all the alternative energy resources available in Nigeria which are Solar, Wind, Biomass, Hydropower, and Nuclear Energy. The head office of the commission is located in Abuja the Federal Capital of Nigeria.

The mission and vision of the commission is to ensure the efficient and cost effective assessment, development and exploitation of the energy resources in an environmentally sustainable way that will serve the interest of Nigeria and the needs

of the global community, through effective coordination and monitoring of the energy sector policies, plans, program and actions that are consistent with economic development objectives of Nigeria.

The cardinal guiding principles are the commitment to the following:

- Professionalism in all energy matters
- Commitment to the service of Nigeria
- Integrity is to preserve the services to the nation

4.5.2 Pamtronics Nigeria Limited

The Pamtronics Nigeria Limited, was established in 1993 and incorporated in 1997, the company was conceived as a multifaceted technology solutions that are cost beneficial for government parastatals, companies, non-governmental agencies and interest groups etc. The company designed and installed solar power system and the following are the core competencies of the company:

- Alternative Energy Solutions
- Custom Electronics
- Audio Visual Equipment
- Musical Equipment
- Accoustic Engineering

The company is committed to supporting the strategic growth and development of clients through the provision of the right services for customers. The mission of the company is to provide innovative and distinct information technology solutions for clients without any form of compromise, and the core values of the company are great ethical standards and undiluted integrity. The company is located in Jos, Plateau State. The company has 12 persons of technical staff and 18 non-technical staff.

4.5.3 Sahcofields Energy Services

Sahcofields Energy Services is a start-up organization in Nigeria that was established in 2006, which offers designs and advice to consumers and architects regarding

environmentally sensitive buildings as well as energy consumption recommendations. The company offers its services to architects that are constructing new businesses as well as existing building owners and owners that are looking for environmentally sound structure.

The company offers a wide range of services that are environmentally-conscious energy related to new and existing structures. The company's main service areas are passive heating, grey water and renewable energy services. The mission of the company is to provide the finest renewable energy solutions through careful analysis, attentive customer support, and cost effective solutions and their vision is to become a stable business organization that will serve vast number of Nigerians with finest green energy solutions. The company is located in Kaduna State, Nigeria. It has nine staffs.

5 RESULTS AND ANALYSIS OF THE THESIS

The data was collected by using both qualitative and quantitative research method. The idea of combining the two research methods is popularly known as triangulation, which means that one dissertation topic can be conducted and studied using a variety of approaches (Bogdan, Biklen, 2006). It is argued that combining the two research methods is the best because is highly possible to receive the best outcome of the research.

A questionnaire with 11 questions is drawn up (See appendix 1) and sent to the Nigerian public by email and using three contact persons in March 2010. A pilot test was conducted, 5 questionnaires were sent of, to test if the questions meet the objective of the study.

Table 9. Percentage rate of answers.

Questionnaire	Numbers
Sent	160
Received	84
Percentage	52,5

160 questionnaires were sent to the target population via email and posted to three contact persons who helped the researcher distribute the questionnaires to the respondents. The contact persons have experience of research work. The first person is senior accountant with State House, Abuja. The second person is a Petroleum Station Manager in one of the Nigerian National Petroleum Corporation (NNPC) Mega Station in Sokoto State. The last person is a working with Finbank in Abuja. In

addition, reminder emails were sent after two weeks of the first email. 84 answers were received from the 160 questionnaires, which put the response rate at 52, 5%.

The questionnaire was adopted from previous studies that were conducted by European school in Gladenbach whose aim is to survey the attitude of people from different countries towards renewable energy sources. It is well designed and structured in a way that it is easy for the respondents. When reading through the filled in questionnaires forms, it seems the questions were well understood by the respondents. To enable a comprehensive statistical analysis of the answers, the questions and answers were imported into the Statistical Programme for Social Sciences (SPSS). The SPSS is a programme that allows imported data to be analysed and examined through different tables and charts.

7 interview questions were developed (See appendix 2) and used for both phone interviews and email interviews. The email interview questions were sent to 4 people out of the 7 that were the target population and the remaining 3 people were interviewed via telephone (see appendix 3) for list of participants.

5.1 Validity and Reliability of the Study

The qualitative research method concentrates often on a single case in contrast the quantitative research method uses many samples. However, in the qualitative research method the low number of samples usually becomes a negative aspect of it because it is more difficult to generalize. But it should always be in mind whether the aim of the study is phenomenological attitude or positivistic orientation that determines the type of the research.

The problem associated with quantitative research method is the mistake that is commonly in the survey. For instance, the answerer may have different understanding of the questions which the answerer or the researcher may not remember of any things. In some cases there might be a mistake while entering the data in a computer. The type of questions should be logical and unambiguous, and also the answerer should understand the questions clearly, same as the researcher. The results should

not be random, which refers to that same result should be obtained if same research was repeated in the same approach. In order to minimize the common mistakes associated with quantitative research method the planning should be done carefully.

Reliability is used for testing or evaluating of quantitative research, but is commonly use in all kinds of research. The idea of having a qualitative study is to have a quality result which is the most important test of the study (Eisner, 1991, p. 58). This is in relation to the concept of a good research when reliability is the concept that will evaluate the quality of quantitative study with the aim of explaining, while the quality concept in the qualitative has the aim of generating an understanding (Stenbacka, 2001, p.551). The differences of evaluating the quality of studies in the qualitative research and quantitative research are one of the reasons that the reliability concept is irrelevant in qualitative research method. The concept of reliability is said to be misleading and have a consequences if it is set as a criterion for qualitative research method if the study is discussed with reliability (Stenbacka, 2001, p.552).

Validity describes whether the aim of the research has been achieved or not. Validity in a study is considered to be reached if the target audience and question are the right ones. To increase the validity of a study the target audience should be considered well and that the audience thoroughly represents the population. The target group is chosen randomly in quantitative research method as against the case in qualitative research method. In the course of the study, the measurement methods should remain consistent when analyzing the results of qualitative research method dependability, credibility and transferability. The dependability means that the result can be compared with prior studies on the same phenomena. The credibility means that the research is good enough and gives the correct picture of a phenomenon, while the transferability is describing if the results can be used or transferred to another or further research.

The validity and reliability of this study is supported by the facts that all the sources that were used in this thesis are relevant to the topic and also reliable. In addition, different sources with different perspectives that are related to the topic were used

when writing this thesis. Most of the information that were gathered for the theoretical part are from books; however, more scientific journals regarding the topic were used and internet sources.

The reliability of the study is reached because the target group of the study represents the ‘population’ well. Also, the questions asked from the target respondents were correct and also correlates with the aim of the study.

The reliability of the study is supported by the fact that the study is dependable since the results can be compared to earlier study results. Also, when creating both the questionnaire and the interview questions, an attempt was made that the questions were written in a clear way that they were as objective as possible not subjective. The results of the triangulation approach that were used are considered to be more reliable and objective in nature.

5.2 Success of the Study

Altogether, the research can be said to be successful because the researcher believes that the target population understood well all of the questions in both the questionnaires and interview questions. The researcher was surprised with the effort of the respondents to write down some suggestions for improvements and more elaboration for questions if they had some other answers or opinions to share.

And, also both the questionnaire and interview questions length were good since they are not too long for the respondents to lose interest or get bored with it when answering. The questions were written in a clear language and they are easy to understand, which improve positively the reliability of the study. In addition to all this, both the interview questions and questionnaire correspond well to the aim of the study. Lastly, the response can be well compared with earlier research findings of the subject.

5.3 Research Findings

The questionnaire was sent out to 160 Nigerians. 84 respondents filled out the questionnaire and sent it back, which gives a response rate of 52.5 per cent. The method used was convenience sampling method since the aim of the study is to explore rather than predict the factors that are affecting the use and growth of renewable energy sources in Nigeria. The convenience sampling method means that the respondents have been selected on the basis of their availability. Using convenience sampling method to conduct a study may lead to a very high response rate which happened in this study. Majority of the 84 respondents were between the aged of 19-25.

The first two questions in the questionnaire were aimed at collecting some background information. The first question was about the age of the respondents, and the second questions asked if the respondents know much about different sources of renewable energy. A bar diagram of each of the questions is made with the percentages presented and explained. In addition, some comments are added that have occurred from the results, the whole questionnaire is analysed.

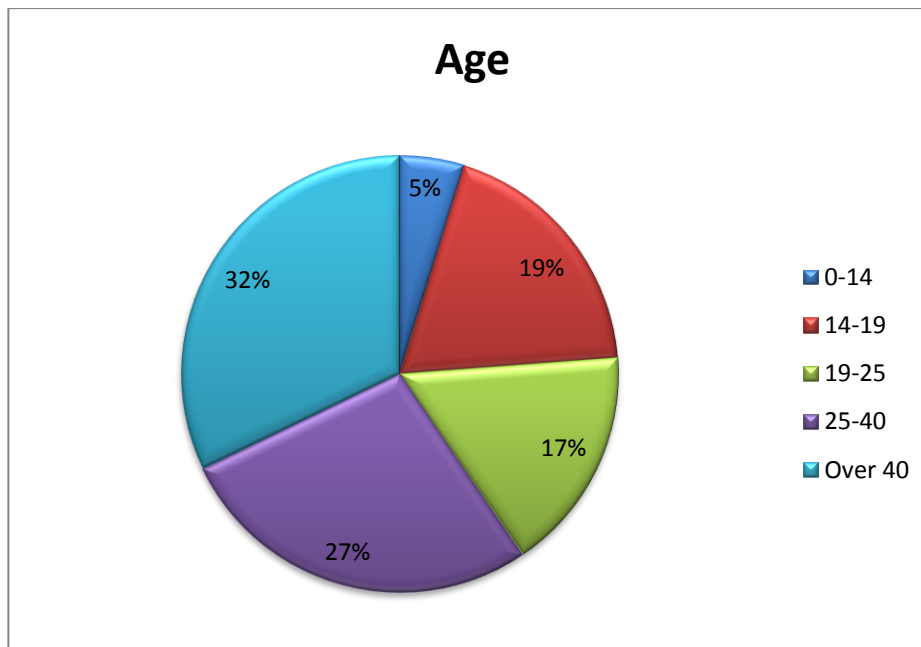


Figure 9. Age of the respondents.

Figure 9 illustrates the age of the respondents which help us to understand how the respondents' attitudes and knowledge varies with age. The highest number of the respondents fall between the aged of 19-25 totalling 27 which represents 32.14% out of the 84 answered questionnaires. Followed by 25-40 age groups, the least number of the respondents is 0-14 which filled 4 of the answered questionnaires and constitutes only 4.76% of the total respondents. The respondents' age shows that more youth in the country are paying more attention to issues that are related to renewable energy usage in the country, because of the collective global efforts on promoting the use of renewable energy to replace the conventional especially in developed world, and at the same time more attention is paying to the developing ones.

The second research question "can you list three renewable energy resources" helps us in understanding that the respondent's attitudes are based on knowledge not prejudice. 58 answered 'yes' which represents 69.05%, this indicates that the attitudes of the respondents are based on knowledge not prejudice when you relate the first questions to the second questions which complements the respondents attitudes base on their knowledge and age. This shows that awareness about different sources of alternative energy is growing when you compare the results of this study with previous studies. In addition, more work still need to be done about informing the general public on what is renewable energy and its various sources if you consider the number of the respondents that cannot list 3 sources of renewable energy which stands at 30.95%, totalling in number 26. Majority of the respondents may have basic literacy since most of them live in urban areas.

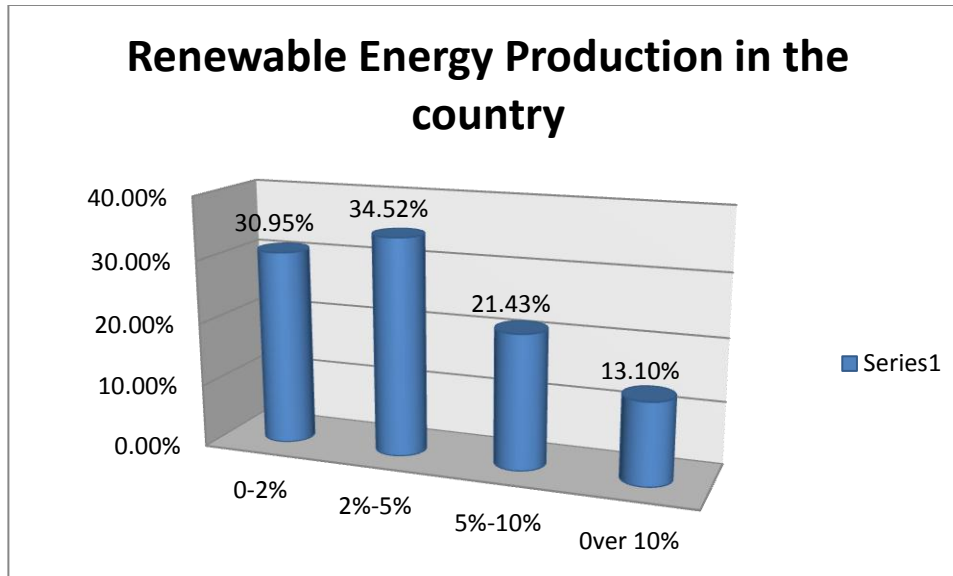


Figure 10. Opinions of renewable electricity production percentage.

The respondents were able to choose from different options for the percentage rate of electricity that is produced by renewable energy resources in Nigeria. There is a lot of variety in the answers regarding this question. The majority of the respondent i.e. 34.52% answered that 2-5% is the rate and some of the respondents think that is between 0-2%, and 21.43% answered that is between 5-10%, were as some of the respondents thinks is over 10%. Why are the answers so different from the respondents and there is not a wide gap and absolute majority between the percentages it is because most of them believe that because Nigeria is a nation that has abundant conventional energy resources and recently the government keep on investing on conventional energy sectors that aim at improving the depleting electricity situation in the country.

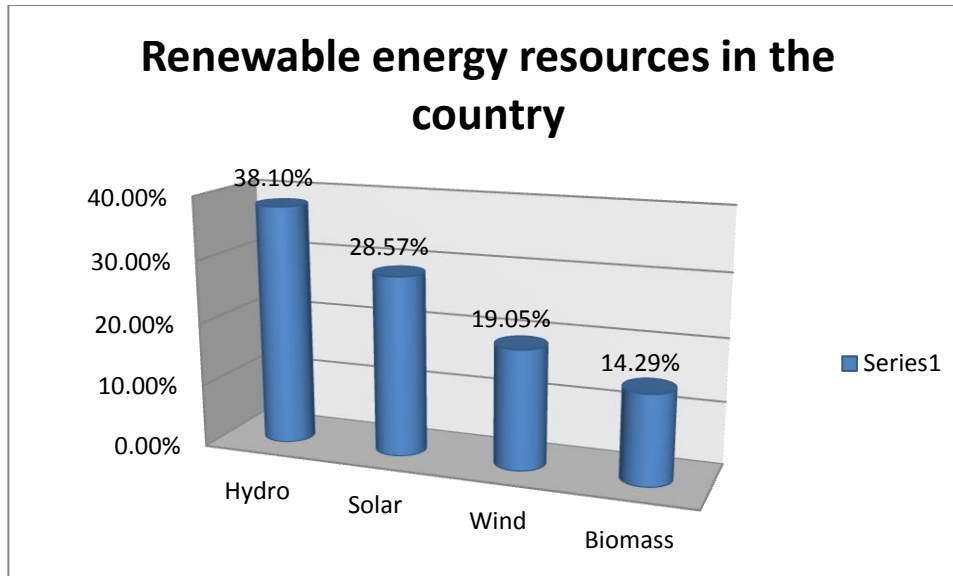


Figure 11. Popularity of renewable energy sources for electricity production.

The figure demonstrates all the four sources of renewable energy in Nigeria and the popularity of them to the respondents. This question helps us in understanding if the respondents were able to know the most common renewable energy source in Nigeria and also to distinguish between the sources. Majority of the respondents i.e. 38.10% select hydro as the most common one among the four, 28.57% answered solar due to the sun intensity in the country, 19.05% choose wind to be the most common source, and 14.29% choose biomass as their answer. Hydro is the most common source of renewable energy in Nigeria which is most favourable options from all the respondents.

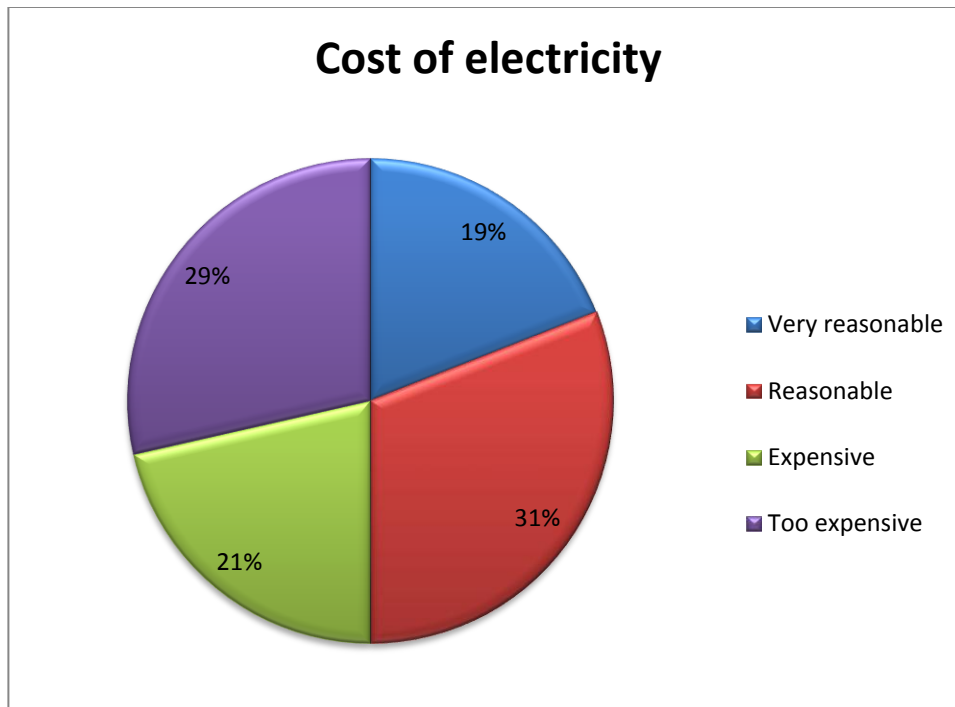


Figure 12. Opinion concerning the cost of electricity.

This question concerns the need recognition on how the respondents rate the cost of the current electricity bill which will help understand whether the population will be able to accept any increase in the electricity bill in order to promote the usage of renewable electricity energy sources in the country. 30.95% percent of the respondent thinks that the electricity billing system currently in Nigeria is reasonable compared to other Sub-Saharan African nations. 28.57% answered that is too expensive in relation to the deplorable condition of the electricity supply that is unstable, 21.43% of respondents answered expensive and 19.05% of the respondents answered that the cost of electricity is very reasonable. Nigeria is one of the countries in the world in which the government pay subsidy a in all the energy sectors of the country. Therefore, the electricity price and billing system is in a significant role concerning the promotion and of the usage of renewable energy sources in Nigeria.

“Do you pay for your electricity bill” This question was included as taking into consideration the respondents’ behaviour towards the usage and utilization of the public utilities. More than half of the respondents answered “Yes” which represents

60.71% that they do pay their electricity bills and 39.29% answered ‘No’. The percentage of respondents that do not pay their bills is quite high when you consider the cost of electricity from generation to distribution. The respondents that are not paying for their electricity bills may not have stable electricity supply. It seems that efficiency and stability is important for Nigerians before majority of the population will be paying their electricity bills.

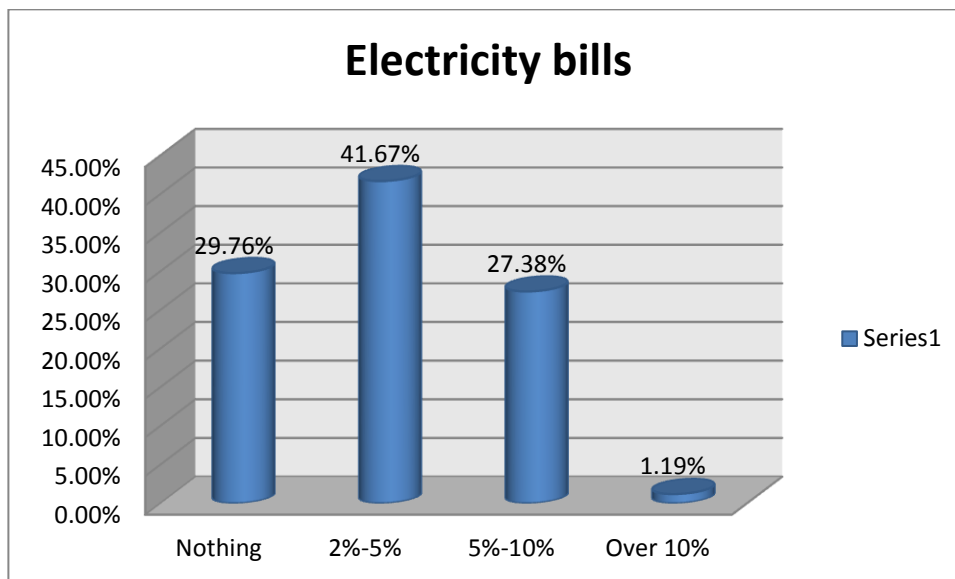


Figure 13. Opinion of payment to increase renewable energy sources.

In this question it was important to know if the respondents are willing to pay any increments that may arise in order to promote renewable sources of electricity in the country. A majority of respondents, 41.67%, answered that 2-5% increments is quite reasonable which seems to be affordable to most of the respondents, 29.76% think that nothing should be increased, whereas 27.38% answered that 5-10% is considerable and 1.19% answered that over 10% increments. The most significant thing here is that a majority of the respondents agreed that an increment should be done but the one that will be affordable to the Nigerian population, in consideration of the current economic realities of the nation.

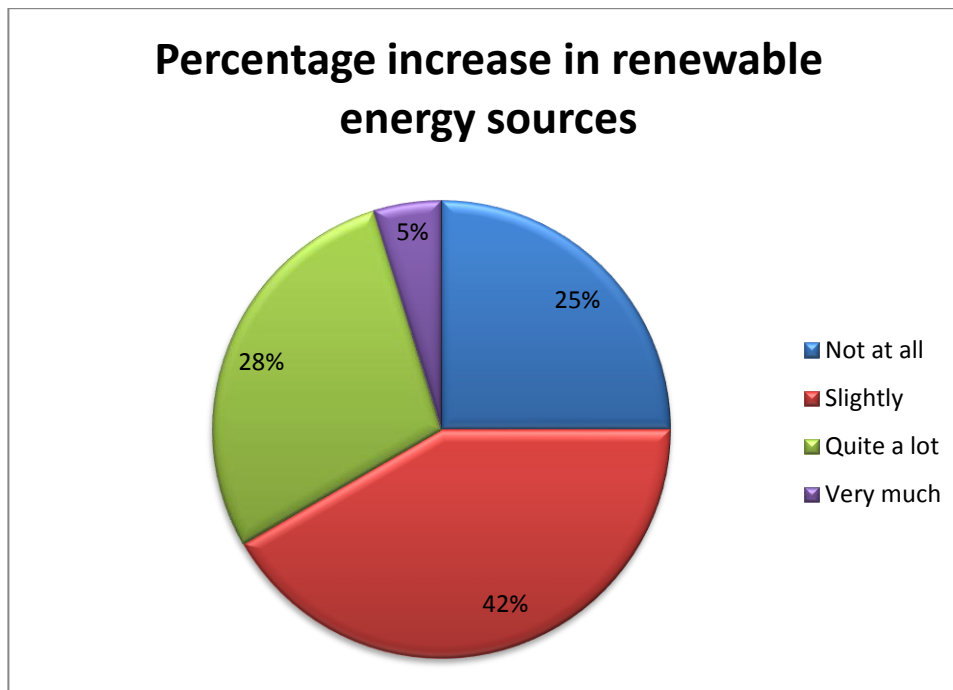


Figure 14. Opinion about efficiency of renewable energy sources.

This is an open question that was asked for the need recognition if the respondent knows much about the efficiency of usage of renewable energy sources. 41.67% of the respondents answered that it will improve the electricity situations of the country “slightly”, followed by 28.57% which thinks that it will improve the deplorable electricity situation in Nigeria “Quite a lot”, and 25.00% answered “Not at all”, 4.76% of the respondent are much passionate about the increase in the usage of renewable energy sources because they believe that it will increase the electricity situations in Nigeria tremendously. It seems that most of the respondents know that increase in the usage of renewable energy electricity in the country will improve the electricity situation in the country, which will pave way for achieving energy efficiency within shortest possible time.

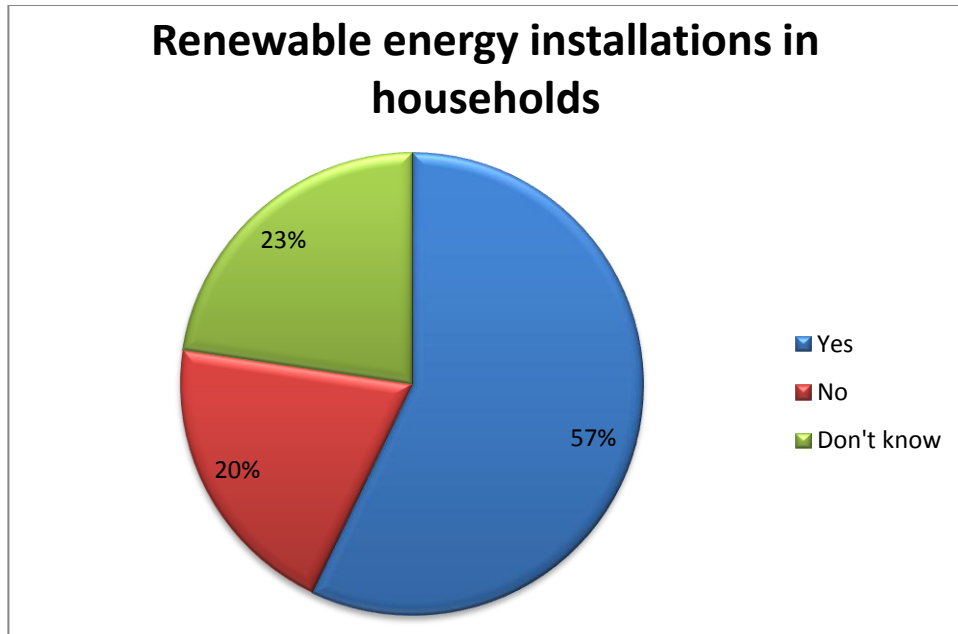


Figure 15. Preference of households for renewable energy sources.

This question helps us to understand the respondents' attitudes and readiness to accept the usage of renewable energy by patronize them directly not necessarily waiting for the governmental or public system. The respondents have various options 57.14% which are the majority answered "Yes", 22.62% are undecided whereas 20.24% are not buying home that have any renewable energy installations. It is an interesting discovery to know that the majority of the respondents are likely to buy home that have renewable energy installations, this will help companies that provide renewable energy sources in investment decisions.

"Are you aware of any grants available to help you install renewable energy or efficient energy technologies? If yes, please give details" This question helps understand if the respondent knows any government grant or support that will encourage the public to install the various alternative energy sources. 100% of the respondents answered "No". This is an interesting discovery to know that the government did not give any support for household to install alternative energy sources.

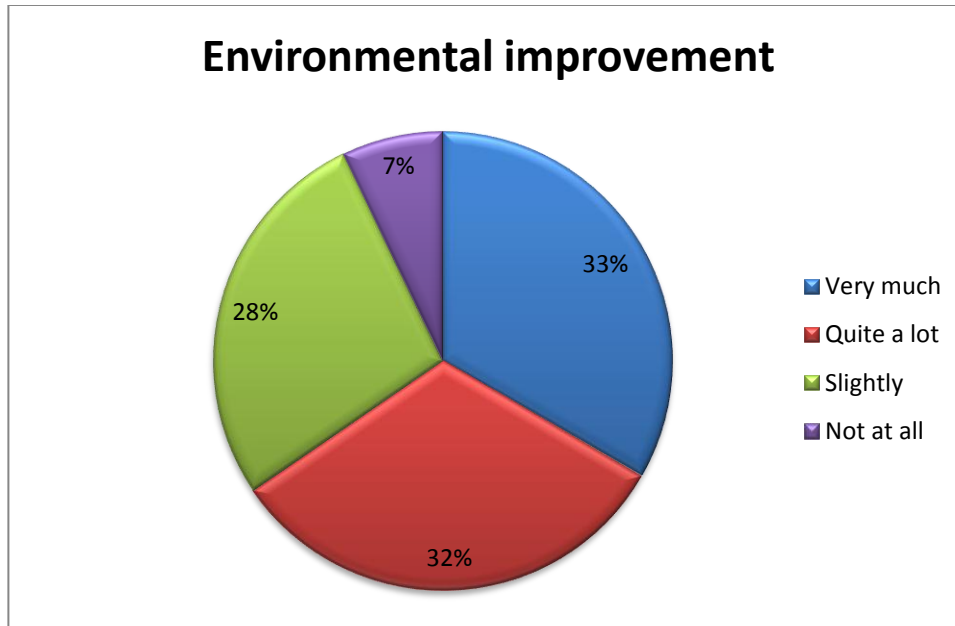


Figure 16. Opinion concerning environmental impacts of renewable energy sources.

This is an open question included for the need recognition if the respondents know much about the environmental impact of the renewable energy resources. The majority of the respondents answered “Very much”, it will improve the environment. 32.14% think that it will improve the conditions of the environment “Quite a lot”, 27.38% answered that it will improve the environment slightly, and 7.14% think it have no any positive effects to the environment. It seems quite interesting to know that a majority of the respondents are environmentally conscious which reveals that there is brighter future for improving the usage of environmentally friendly sources of energy in the near future in the country.

5.4 Comments about the Questionnaires

The questionnaire has been well executed and well analysed. The used questionnaire was the best way to explore what the population thought about the subject of the study. The questionnaire examines the respondents’ attitudes and knowledge about the various sources of renewable energy. All the elements in the questionnaire are linked to the aim of the study. Two statements are about the level of awareness of the public concerning the renewable energy, three statements are connected to the rate

and payment of electricity in the country, and also two statements in the questionnaire are about improving the supply of electricity by using renewable energy electricity sources, and the environmental impact. One statement is related to the level of acceptance and patronage of the renewable energy sources and another is about government level of participation and support for the promotion and the growth of renewable energy in Nigeria.

5.5 Questions of the Interview

Seven open questions were made altogether, which were structured to cover what is not so well covered in the questionnaire. The first question refers to the level of demand of the various sources of renewable energy in the country. The next question should give answers to the technical related problems that businesses that engage in renewable energy services faces in the country, and the next two questions are to answer the provision of necessary infrastructure and financial incentives by the government that will support the growth and investment in renewable energy in the country. Two more questions are aimed at answering the expected incentives from the government that will enhance the growth, penetration and policies that will contribute to the success of renewable energy in the country. The last but not the least, will answer the cost of renewable energy services in the country.

5.6 Results from the Interviews

After analysing the results of the interviews it can be said that there is not much differences in the majority of the interviewees' answers. The answers from the interviews are discussed below.

How demanding is renewable energy?

Five of the interviewees answered that the demand level of renewable energy in the country is average, while two argued that it is low in consideration of the large population and the electricity crisis in the country. They argue that because of the energy crisis in the country the demand level of renewable electricity sources of energy should be high.

What kind of technical problems are companies facing in building renewable energy sources?

All the interviewees answered and identified almost the same technical related factors that companies and businesses are facing in providing and building renewable energy electricity sources. The problems are as follows:

- a. High cost of investment
- b. Inadequate technical know- how
- c. Inadequate incentives
- d. Low Level of Human Capacity/Competency
- e. Lack of Local manufacturing capability

These are almost the same factors that are identify earlier in the theoretical part by A.S Sambo as the most critical issues that are affecting the growth of renewable energy in the country that requires a decisive actions taken by the government in order to promote the business and the usage of renewable electricity in the country. All the listed factors above complement the interviewers' answers of questions three and four which they all answered that there Is "No" adequate infrastructure and government incentives that will help the sector grow.

What incentives do you expect from the government to provide that will enhance the growth and the penetration of renewable energy in the country? Briefly explain

Two of the interviewees answered that the most important incentives that they were expecting from the government in other to enhance the penetration of the renewable energy in country should be waivers on import duties for renewable energy components since the country is dependent on importation of both the components and the technical know-how. Opinions of three interviewees were tax holidays for local manufacture and enhancement of policies that are centered on promotion of

renewable energy in the country. The two other interviews think what is paramount should be support for adaptation of renewable energy technology by the government which will encourage both public and private participation and adaptation of the renewable energy sources in the country.

Do you think the government policies will contribute to the success of renewable energy in the country? If yes, in what ways?

A majority of the interviewees own opinions are that the government should prioritize policies that will effectively contribute to the success of renewable energy in the country. They suggested that the government should provide a platform that can be seen as justifiable for promoting and encouraging investment in the sector. If government is able to design an effective policy framework it would attract more foreign investors that are willing to invest in the sector and it will open up the market and make it cheaper and accessible. Three of the interviewees answered that the cost of renewable energy electricity in the country is “too expensive”, and four said that it is expensive when you consider the average income of household in the country which brings the need for government financial incentives or encourage the local manufacturers so that the cost of the renewable energy electricity in the country will be reasonable and affordable for both the high, middle and lower income earners in the country.

6 CONCLUSION AND SUGGESTION

The objective of this thesis is to find out how to support, promote and encourage the growth of renewable energy sources in Nigeria to close the gap of almost 60-70% of Nigerians that did not have access to energy not only energy, but the energy that is environmentally friendly which will also help country to achieve energy efficiency that will stimulate its economic development. Both the qualitative and quantitative research method had been analyzed. A reliable conclusion can be achieved through combining of these two research methods.

6.1 Conclusion

Nigeria is a country that is blessed with abundant conventional and non-conventional energy resources (fossil fuels and renewable energy resources). There is the need to encourage evolvement of an energy mix that will put more emphasis on the need for the conservation of the fossil fuels in such a way that will lead to their continued exportation which will continue to generate revenue to the government for as many years as possible. The adoption of renewable energy solutions by the country with emphasis for rural development will lead to the internal reduction in consumption of petroleum products and gas.

The major advantages of non-conventional energy solutions (renewable energy solutions) include ease of maintenance, simplicity of the technologies as well as their environmental friendliness over the conventional energy systems (fossil fuels).

In the course of this study, the researcher finds out that the demand for electricity in Nigeria is very high; however, the supply is not adequate and constant to meet the demand which left many Nigerian citizens with no options than to be using privately owned conventional energy power generating systems. The use of the conventional power generating systems is very costly and also is not environmentally friendly.

The potential of renewable energy resources in Nigeria is put at excess of 1.5 times that of fossil energy resources, in energy terms. Solar, wind, hydro and biomass have significant potentials to improve and make a difference on the low level access of

electricity in Nigeria, with emphasis on the rural areas, through the adoption and the use of these renewable energy resources for sustainable development.

6.2 Suggestions

Based on the results of the research the following suggestions were made. It is clearly evident of the use of renewable energy solutions in the country at the moment. However, there is need for the promotion and usage of the renewable energy sources especially in the rural development. In view of this there is an urgent need for massive support from both the government and private sector for new research and development centers, and also need for an establishment of energy extension outfits. The existing research and development centers should be supported and enhanced in order to carry out quality research and development activities, while the energy extension centers should be charged with responsibilities of diffusion and demonstration activities of the renewable energy system.

Due to the reluctance of local manufacturers and entrepreneurs to adopt the mass production and commercialization of the renewable energy systems there is a need to put more efforts on training of the local craftsmen on the construction, design, operation and maintenance of the various renewable energy technologies en-use devices. In view of this, after such training programs there is a need for setting up of Renewable Energy Fund that will serve as instruments for provision of financial incentives to suppliers, local manufacturers and the end-users of renewable energy electricity with putting more emphasis to the rural areas. In addition, there is need for the provision of good fiscal incentives that will help the local manufacturers and suppliers of renewable electricity technologies components

There is a need to design a comprehensive National Energy Master-plan that will promote the energy policy for sustainability, and also massive enlightenment campaign to the public about the efficiency and environmental friendliness of renewable energy electricity sources.

All of the aforementioned suggestions, measures and implementation strategies that aim at promoting the growth and use of renewable energy systems and practices can only be achieved and realized through strengthening institutions that are responsible for sustainable energy promotions. In this regard the Federal Government should approve and release a comprehensive National Energy Policy for the country and also identify organizations at states and local government levels that will be mandated of ensuring the implementation of projects and programs of renewable energy electricity.

6.3 Summary

The aim of this thesis is to find out how to support, promote and encourage the growth of renewable energy sources in Nigeria to close the gap of almost 60-70% of Nigerians that did not have access to energy not only energy, but the energy that is environmentally friendly which will also help country to achieve energy efficiency that will stimulate its economic development. First of all, this study tells us about renewable energy in respect to solar, wind, hydro and biomass. The energy crisis Nigeria is facing despite its huge amount of conventional and non-conventional energy resources.

The study identifies the various factors that are affecting the growth of renewable electricity in Nigeria from both the companies' perspectives and the consumers' side and the various steps that should be taken by the government and the institutions that are responsible for promoting the growth and usage of renewable electricity in Nigeria. Also it makes us to understand the efficiency of renewable energy technologies and their environmental friendliness as well as the economic importance and development it brings to a nation.

In the empirical part, two research methods quantitative and qualitative research methods were used in order to receive better understanding about renewable energy situations in Nigeria, with respect to the economic and social factors that are affecting the use and growth of renewable energy sources in Nigeria and also technical related problems companies faces in building an alternative source of energy in Nigeria to achieve more reliable results. The techniques that were used were the structured

questionnaire and interviews. By combining the structured questionnaire and the interviews it can be said that new and valuable information were received concerning renewable energy issues in Nigeria. Validity and reliability of this study is high due to the combination of these two research methods and gives more value to this study.

6.4 Further Studies

The biggest limitation of this is research, is the small size of the target group. Despite the sample represents the target group. Due to the population size, the number of the respondents may not effectively represent the most common opinions of the population. The sample size was affected by the fact that the researcher could not physically go to Nigeria to be able to distribute the questionnaires more to the people as a result he is depending on contacts in Nigeria and their help and also to conduct physical interviews. More so, Interviewers from the public institutions are concerned about their security. Money, time and interconnections of the subject matter also plays a significant limiting role in this study.

Without these limiting factors, the researcher would have been able to do a more comprehensive research that will include a large sample size that will truly represents the population and put more efforts to understand the public answers to the questionnaire. Further studies could be conducted by focusing in one or two of the renewable energy electricity systems and also by paying more attention to the business energy. In addition, using large sample size and also by having face-to-face interviews in other to have in-depth information about how to promote and courage the growth of renewable energy electricity in Nigeria.

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APPENDIXES

Appendix 1. The structured questionnaire.

Appendix 2. The interview questions.

Appendix 3. List of Participants.

Research on Renewable Energy as a Solution to Nigerian Energy Crisis

Dear Respondent,

I am writing my thesis that seeks to survey your opinion on how to support, promote and encourage the growth of renewable energy sources in Nigeria to close the gap of almost 60-70% of Nigerians that did not have access to energy not only energy, but the energy that is environmentally friendly. I hope you will have few minutes to contribute to this study. I am very grateful for your time and effort when answering this questionnaire.

1. Please indicate your age grouping

Under 14 14 - 19 19 - 25 25 - 40 over 40

2. Can you list 3 renewable energy resources?

Yes

No

3. What percentage of electricity in our country do you think is produced by renewable energy sources?

Under 2% 2% - 5% 5% - 10% over 10%

4. What is the most common renewable energy source of electricity in this country?

Hydro Solar Wind Biomass

5. How do you rate the cost of electricity in your country?

Very reasonable reasonable expensive too expensive

6. Do you pay for your electricity bill at home?

Yes

No

7. How much more would be reasonable to pay in electricity bills to increase by 10% renewable energy sources of electricity in this country?

Nothing 2% - 5% 5% - 10% over 10%

8. Do you believe that increasing by 20% renewable energy sources of electricity in this country may improve the electricity supply?

Very much quite a lot slightly not at all

9. When buying a home would you be more likely to buy one with renewable energy installations?

Yes

No

don't know

10 Are you aware of any grants available to help you install renewable energy or energy efficient technologies? Please give details

Yes

No

11 Do you believe that increasing by 20% renewable energy sources of electricity in this country your local environment would improve?

Very much quite a lot slightly not at all

Thank you very much for taking part in this survey

APPENDIX 2

Interview questions:

1. How demanding is renewable energy?

Low Average High

2. Which kinds of technical problems companies are facing in building renewable energy sources?

.....
.....
.....
.....
.....
.....

3. Would say the government has provided adequate infrastructure to support the growth of renewable energy in Nigeria?

Yes No

4. Do you feel that the government incentives is been enough to encourage investment in renewable energy?

Yes No

5. What incentives do you expect from the government to provide that will enhance the growth and the penetration of renewable energy in the country?
Briefly explain

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.....

6. Did you think the government policies will contributed to the success of renewable energy in the country? If yes, in what ways?

Yes No

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.....
.....

7. How would you rate the cost of renewable energy in the country?

Very reasonable reasonable expensive too expensive

Please feel free to add comments beyond the scope of the questions given above.

Thank you very much for taking part in this survey!!!

APPENDIX 3

List of participants.

Director General	Energy Commission of Nigeria
One senior staff	Energy Commission of Nigeria
One junior staff	Energy Commission of Nigeria
Managing Director	Pamtronics Nigeria Limited
One technical staff	Pamtronics Nigeria Limited
General Manager	Sahcofields Energy Services
One staff	Sahcofields Energy services