RENEWABLE ENERGY SOURCES - A VIABLE TOOL FOR SUSTAINABLE ENERGY DEVELOPMENT IN NIGERIA.

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Abstract

The growth, development, and technological advancement of any country are hinged on the growth and development of the country's energy sector. Energy is the mover of technology, economy, and industrialization. The relevance of the energy sector to Nigeria, as such, can never be overemphasized and no level of attention given to it will ever be too much. This is because it directly or indirectly impacts on every other sector of the economy. It is an important contributing feature in the development of any country or region or community. This paper presents renewable energy sources (solar, small- hydro, biomass, geothermal and wind) as a viable tool to fast tracking the development of the energy sector. The fossil fuel based energy sector is laden with environmental and climatic challenges like the release of greenhouse gases. Total amount of generated power stands below 4000 MW, which is grossly inadequate to meet the current energy needs of the nation. The potential of renewables is very high and its negative impact on the environment minimal.

Keywords: renewable- energy source, solar power, wind power, biomass, fossil fuels

Introduction

Energy can be said to be the ability to do work. This can be in many forms: electrical, mechanical (potential and kinetic), chemical, nuclear etc. These various forms of energy are often inter convertible. That is one form can easily be converted into another for example: chemical to electrical, mechanical to electrical and vice-versa.

Since energy is the ability to do work, it follows that no work can be carried out without the usage of energy. As such this underscores the essence and relevance of energy.

The consumption of energy the world over, is enormous, and will continue to rise on account of the following:

(a) Energy needs per person will continue to increase.

(b) World population will continually be on the increase

(c) Technology advancement and development

(d) Industrialization and provision of infrastructure

In this paper, the viability and relative abundance of renewable energy sources are explored with a view to proffering solutions to the lingering energy crisis the nation of Nigeria is currently faced with.

For ease of readability the paper is sectionalized with section 1 as the introduction, section 2 deals with the energy sources and options available in the country and their relative quantities. The potential hazards of overdependence on the fossil fuels are explored in section 2 also, while section 3 analyses the renewable energy sources (wind, solar, biomass, small-hydro, geothermal). Discussion and Recommendations on the viability of the renewables as a viable option is studied in section 4 and 5 respectively. And finally conclusion is drawn in section 6.

Energy Sources

Energy sources can be either conventional or non conventional. Conventional sources of energy are: coal, oil, natural gas, hydro, and an example of non-conventional source is the solar.

They can also be said to be renewable and non renewable sources. Renewable are those that can be recycled or are naturally replenished like; solar, hydro, wind etc while non renewable are those that can be used up with time, examples are the fossil fuels.

The crude oil reserve in Nigeria is estimated at 37.2 billion barrels, 2.79% of world's reserve and the natural gas reserve estimated at 197 trillion cubic feet, 2.9% of world reserve, while the coal reserve is estimated at 2.75 billion metric tons. These fossil fuels (crude oil,

natural gas, and coal), being the major source of the country's energy are more than adequate to meet much of sub-Saharan African energy demand for several decades.

Problems of over dependence on fossil fuels

i. Depleting nature of fossil fuels: Fossil fuels are being used up (depleted) so fast, much faster than they are building up. This has created fears world over that these energy sources will soon finish and thus will lead to energy crisis.

ii. Environmental problems: The fossil fuels are mostly trapped beneath the earth surface, thus the exploration and harnessing of them have made the earth more vulnerable to issues like erosion, landslides, etc.

iii. Pollution: The byproducts of these energy sources are mostly hazardous to the environment, leading to air, soil and water pollution.

Renewable Energy

Renewable energy sources are energy sources that can be recycled (or renewed). In order words, these sources of energy are inexhaustible. Most of the developing and developed countries have abundant renewable energy sources including solar, wind, geothermal biomass, and small hydro.

About 16% of the global final energy consumption comes from renewables with 10% coming from traditional biomass, which is mostly used for heating and 4% from hydroelectric.

In electricity generation the share of renewables is about 19%. The markets for renewable technologies have continued to grow. This is as a result of concerns in climatic change, high oil prices and increasing global support by various governments. Nigeria has a huge supply of renewable energy sources. These energy sources play significant roles in four distinct areas: electricity (power) generation, heating, transport, rural power supply.

Electric power generation: The renewables help boost the fossil fuel-based generated power to meet demand of electric power. Countries like Iceland, Paraguay, Norway and Brazil derive almost all their electric power from renewable.

Heating: Domestic and industrial heating needs are largely being met by renewables today in many countries.

China has the largest portion installed in multi-family apartment buildings meeting hot water needs of about 50-60 million households in the country. Biomass and Briquette are increasingly being used to supply heat in most residential apartments and also for cooking.

Transport: Bio-fuels include a wide range of fuels derived from biomass, examples are, liquid fuels (Bio-Ethanol) oils (Bio-Diesel). Bio-Ethanol can be used as fuel for automobiles. They find wide application in countries like USA, Brazil. They have played a major role in the decline in oil consumption in many countries. In 2009, 93 billion liters of bio-fuel produced worldwide displaced estimated 68 billion liters of gasoline, equal to about 5% world gasoline production.

Rural (off grid) power: Many parts of most countries are often off the grid as such reaching them with adequate power demands lots of many processes. Renewable power supply impacts significantly on these communities by providing their energy (power) needs. These of grid supply can be small to medium plants (station) thus generating adequate power for basic needs.

About 1.3 billion people around the world don't have access to grid electricity though they are very poor. This people pay more for lighting and cooking than people in reach countries because they use inefficient kerosene lamps. Solar power costs half as much as lighting with kerosene (Kelvin, 2012). It is estimated that 3 million households get power from small solar photo voltaic (PV) systems.

Kenya is world leader in the number of solar power systems installed per capital. Other sources include small-hydro, biomass cook stoves. Over 160 million households use these sources.

Nigeria has very attractive levels of these renewables as stated in (Ibitoye and Adenikinju, 2007).

Solar radiation -estimated at 3.5 – 7.0 KWh/m^2/day

Wind energy - estimated at 150,000 Terra Joules per year

Biomass energy - estimated at 144 million tons per year

Geothermal energy -no estimate for this is currently available

Hydro energy - estimated at 14,000MW.

Small Hydro - estimated at 734MW.

Wind energy:

This is simply energy as a result of air in motion; energy from the wind is as a result of uneven heating of the earth's surface by the sun. The rates of absorption of the sun's heat by the land (earth) and water (seas) are unequal so the

air above the land heats up much faster than that of air over the waters during the day and expands thereby rising to make room for more dense cooler air to settle on the surface of the land. As a result of these air movements the land is often cooler than the water (seas) in the day time. This movement of the wind is basically harnessed by wind vanes into electric energy. That is, the kinetic energy of the wind produces a rotational movement of the wind vanes. The wind vane rotation gives rise also to the rotation of the wind turbines connecting the rotor side of an electric generator. Present day wind turbines generators are mounted on towers 50 or more meters above the ground level and away from high rise buildings or tall obstacles capable of obstructing air flow. The high mount is always to move the blades of the vanes to the area of high wind speed. The amount of power transferred to the turbine is directly proportional to the blade (vane) area (i.e. area swept out by the blades of the vane). Density of air and the cube of the wind speed. The power in the wind is given as: : $P = \frac{1}{2}\alpha\rho\pi\ r^2v^3$

Where α = an efficiency factor of the turbine, ρ = density of air, r = radius of the vane blades, and v = speed of air.

Because of the fact that the power generated is a function of the cube of the wind speed, this implies that as the speed varies (say doubles) the power produced becomes 8 x the previous. For this reason the wind turbines are often situated in areas where the wind speed is high and more consistent such as offshore and high altitudes (like mountains, hills). Typical capacity factors are 20 - 40% with upper values of the range in particularly favorable sites.

Global wind energy utilization has tremendously grown in the past decade that today wind technology is the most developed and consequently the cheapest renewable technology energy source in the world. Wind energy technology costs are becoming more and more competitive with established conventional sources of energy.

In Nigeria, wind energy is known to have been used for pumping water as early as the 1960's. Hundreds of these wind pumps were manufactured locally and installed mostly in the Northern part of the country. However, the low level of technological development in this area has made wind energy utilization for power generation practically very small and insignificant (Renewable energy status). The wind speeds at some parts of the country are moderate, and are mostly more consistent in the coastal areas of the South and the hilly areas of the north. The

long term technical potential of wind energy is about five times the total global energy currently produced; or about 90 times current electricity demand.

The figure 1 below depicts a wind farm for power generation.

Fig. 1: A typical wind farm

Currently there are no wind farms in the country for power generation. However, recently some states in the northern part of the country have reached advanced stages in their bid to tap of the huge supply, doubtless in no distant time pockets of wind farms will abound in these regions.

Solar power

Solar energy is simply energy from the sun. The quantity of energy radiated by the sun is enormous. It radiates an amount of energy in one year more than people have ever used since the beginning of times. It is this energy source that sustains life on the planet earth and contributes directly or indirectly to the formation and harnessing of all other sources of energy be it renewable or non renewable. About 174 Peta watts (PW) of incoming solar radiation called insolation at the upper atmosphere are received by the earth (Wikipedia). Of this amount, 30% is reflected back while 70% is absorbed by clouds, oceans and land masses. The annual average solar radiation is 5.4 KW/m^2 day (Agbo, and Oparaku, 2006).

Harnessing this energy content in the sun's radiation is presently being accomplished by two major means. (a) Use of solar photovoltaic and (b) Use of solar thermal (heat engines)

These technologies are broadly categorized as either passive or active solar depending on the manner they capture, convert, and distribute solar energy. Active solar technologies include the use of photovoltaic panels and solar thermal collectors to harness energy.

While passive solar technologies include orienting a building to the sun, selecting materials with favorable thermal mass or light display properties and designing spaces that naturally circulate air (Philbert, 2009)

The solar thermal

This is the process of generating power be deploying the heating effect of sunlight. Fluids are heated up to produce steam to drive turbines for large scale centralized generation. As early as the 7th century B.C, people have used magnifying lenses to concentrate the light into beam so that they could cause wood to catch fire. The solar thermal process works on this principle and makes use of solar collectors or solar concentrators. Collectors are devices that collect the sun's rays from a large area to focus it on a small blackened receiving area. Concentrators also work by collecting sunlight from a large area focusing it on a small area. They use lenses or mirrors. Solar thermal concentrators or collectors called parabolic dishes (troughs) are used to concentrate and channel the sunlight (heat) on to large water body to heat it up to steam, the steam produced is now channeled through pipes with enough torque to turn the turbines connecting the rotor of the generator thus generating electricity. Typical examples are: the parabolic disks thermal plant and the central tower power plant both of which are located in California's Mojava Desert. The parabolic disks thermal plant provides electricity to power over 350,000 homes while the central tower power plant supplies about 10,000 homes (Ibidapo – Obe, and Ajibola, 2011).

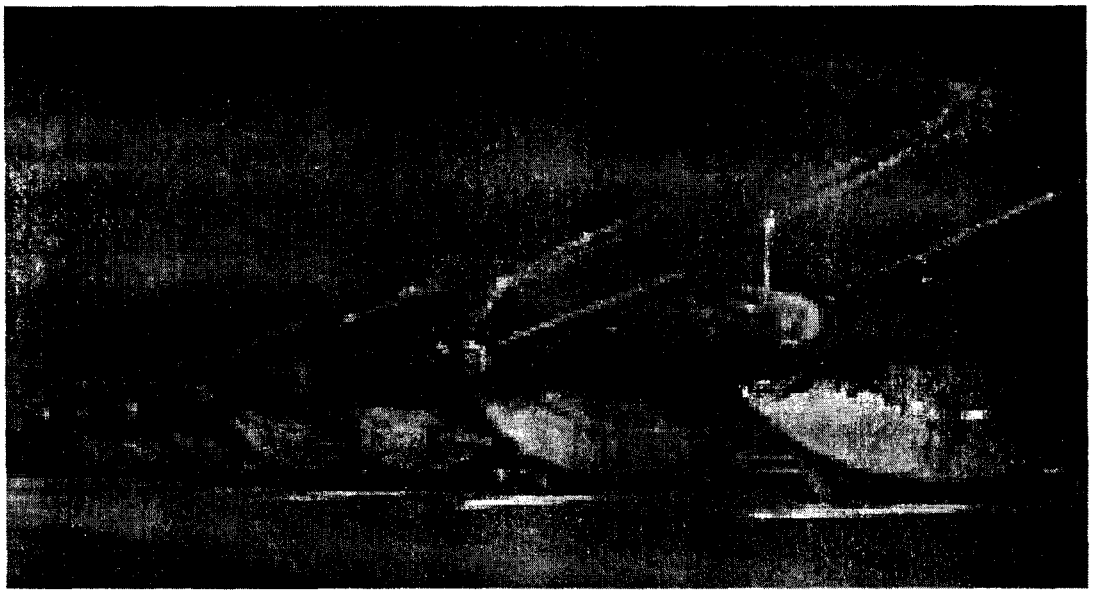

Figure 2: the concentrating solar power.

The figure 2 shows the parabolic dishes for steam generation. A lot of advancements have been made globally in solar thermal technology. Some tested and proven applications like solar water heating, solar refrigeration, and solar drying. Considerable and commendable research work has been done in this area. The National Centre for Energy Research and Development (NCERD) at Nsukka, Nigeria is recognized internationally for the research and development works on solar absorption, refrigeration.

The solar photovoltaic (photo cell)

This technology converts sunlight directly into electrical energy. Photocell is the basic building block of a photovoltaic system. They vary in size from about 1cm to 10 cm, typically they produce about 1 to 2 watts. Depending on the energy the energy requirements many cells are electrically connected into a packaged weather tight condition called a module. Modules can also be connected to give rise to an array (Agrafiotis, 2005).

These photo cells (modules) are integrated into systems with many components added. Thus they are made of balance of systems (BOS), consisting of mounting structures for modules,

power conditioning equipment, tracking structures and storages devices. They could be for standalone (small scale) or large scale connected to national grid. (Owolabi, 2008).

Decades ago, solar cells were used as backup power source to the vanguard I satellite, that enabled transmission for over one year after its chemical battery was exhausted. This success hence inspired many Soviets and American satellite to be solar powered, photo voltaic is still playing vital roles in telecommunication industry, offshore grid-applications, navigational buoys etc (Ibidapo-Obe, and Ajibola, 2011).

Multi-mega watt P.V plants are becoming common for large scale power generation. Typical examples are the 14MW power station in the Clark County, Nevada, USA and the 20MW site in Beneixama Spain were both completed in 2007.

As one of the tropical countries, Nigeria lies approximately between 4° and 14° above the equator. An estimate of 20MJ/m^2 per day of solar insolation is received on the average depending on the time of the year and location (Adeyemo, 1997) and (Abe, and Adetan, 2008).

According to (Abe, and Adetan, 2008), using solar appliances with 5% efficiency to cover 1% of the country's surface area will produce 2.541×10^6MWh of electricity. The sun shines very generously in Nigeria. Since its climate varies from tropical to subtropical, the temperature in the North ranges between 32°C to 42°C all year round.

The amount of solar energy available in Nigeria is so much that it amounts to about 9,000 times the average annual consumption of all forms of energy in the country.

Despite this abundance, many parts of the country lie in darkness, many industries and businesses are either relocating to other neighboring countries or are grounded on account of power problems.

As a country Nigeria is far behind most developing countries in photovoltaic technology. Local research and development activity in this area is scarce. As a result of the fact that the PV technology is imported, the cost of acquisition is usually prohibitive. Also contributing is the current low level of awareness of the usefulness, and efficiency of the technology (Sambo, 2005) and (Owolabi, 2008).

Over 70% of the Nigerian population lives in the rural areas with little or no access to grid – supplied electricity. Connecting these communities to the

national grid will prove to be very expensive because of the spread and nature of these communities. This thus makes renewable energy options a very viable and attractive one.

Rays of hope are however beaming as regards the use of photo voltaic as many government projects in some states like Enugu, Anambra, Lagos, Ekiti (popularly known as the solar state) are deploying these sources to provide power for street lighting, rural water supply schemes, and for domestic uses usually off the grid (stand alone). A lot still needs to be done to properly take advantage of the abundant availability of solar in the country.

According to 2011 projection by the International Energy Agency; solar power generators may produce most of the world's electricity within 50 years, thus reducing drastically the emissions of green house gases that harm the environment. With an average annual growth rate of about 63.6% for the past few years, this projection is achievable.

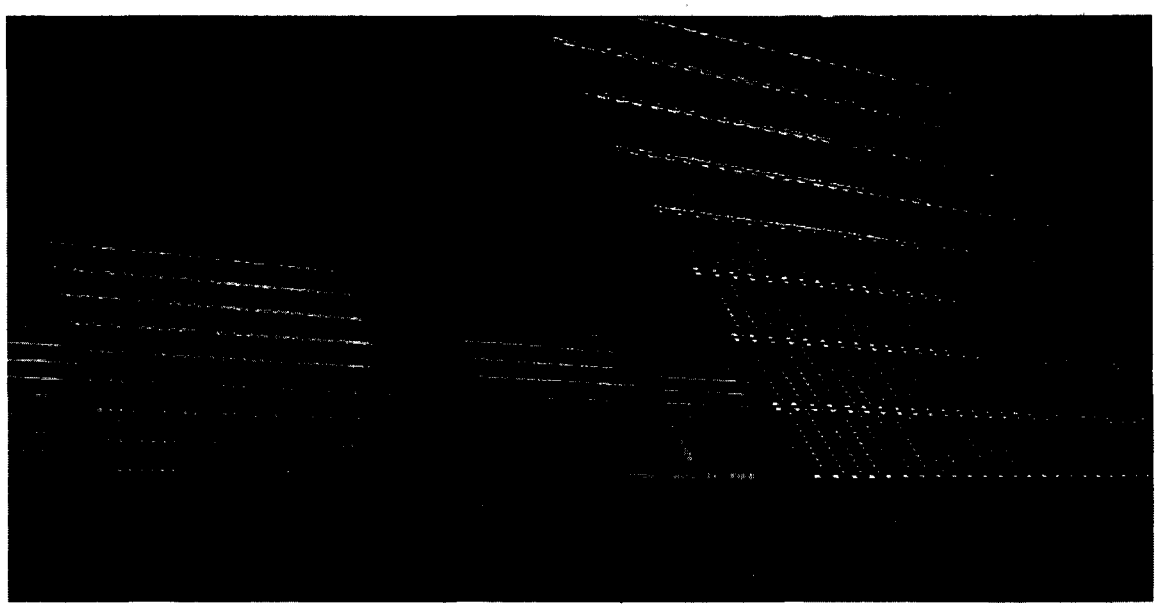

Figure 3: A solar power field.

The figure 3 shows a typical PV panel for power generation.

Small-Hydropower

Small or Micro Hydro stations are usually hydroelectric power installations which typically produce up to 100KW of power. Most developed in places with abundant supply of water as remote – area power supply. This is purely different with the

hydro-power which is used for large-scale hydroelectric dams.

With an abundant supply of rainfall, dams, rivers and streams distributed all over the country. Nigeria indeed has a great opportunity to tap these resources. Currently about 14 percent of the total exploitable hydro-potential is being utilized leaving a staggering 86% untapped. There are only about six hydropower schemes in Nigeria: four of which are located in plateau state, one each in Sokoto and Kano States. These schemes supplied uninterrupted power to the local communities. They were constructed in 1923 and 1964 and till date no new small-hydro power plant has been constructed despite the huge potential and advantages it offers.

Adequate and strategic implementation and construction of small-hydro power stations especially in rural areas that are off the grid will definitely impart positively on the economy of the country.

Biomass

Biomass is the organic matter formed by photosynthesis – a process that converts solar energy into stored chemical energy. Biomass energy is the energy derivable from garbage such as dead trees, left over crops, wood chips, household trashes, charcoal, animal dung etc. Presently they are the most important sources of energy for rural households, agricultural production and rural industries.

The main source of fuel for over 70% of Nigerians is wood. Annual production of biomass is very great since 94% percent are engaged in crop farming and about 68% in livestock faming.

Various forms of biomass abound for differing end uses: biofuel, improved wood stoves and biomass briquetting. Liquid biofuels include: biogas, landfill gas and synthetic gas. Liquid biofuels are gradually being used to replace conventional gasoline, petrol, thus reducing the carbon dioxide emission by automobiles. Bioethanol is widely used in Brazil and USA.

It is mostly made by fermenting sugar cane.

Biodiesel is made from vegetable oils, animal fats or recycled greases. Can be used as fuel in its pure form but is often used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel powered automobiles. It is the most common biofuel in Europe.

Geothermal Power

Thermal energy is the energy that determines the temperature of matter. Geothermal energy is thus the energy derivable as a result of the temperature gradient existing between the earth's core

and its (earth's) surface. At the very core of the earth which is about 4,000 miles down, the temperature is about 9,000 degrees Fahrenheit. This high temperature and pressure often cause some rocks to melt and become magma. This magma then convects upwards and towards the earth surface and could beat up water to steam which can be used to drive turbines for power generation. The earth's geothermal energy originates from the planet formation and radioactive decay of minerals.

This energy source is sustainable, reliable and cost effective. Though there is release of greenhouse gases trapped deep within the earth, but they are much lower per energy unit than those of fossil fuels.

This technology finds application both for large scale power generation and also for domestic heating, cooking etc. Large scale generation through geothermal power plants abound in many countries with USA leading with an installed capacity of 3,086 MW as at 2010.

Currently, in Nigeria there is not much information on this alternative source of energy supply. The necessary research and development in this regard is lacking.

Discussion

Having presented energy situation in the country which is largely dependent on fossil fuels and the attendant environmental challenges they pose to the nation, both to human and non human resources, it becomes very glaring that if the nation will forge a head to make meaningful progress in its quest for industrialization, and to join the top 20 world economics in the world; that something positively drastic and holistic must be done to the energy sector. Improving the existing power plants though will create immediate improvement on the current existing conditions but will mean little in the light of the energy needs required to drive the economy. Currently less than 40% of the entire population is on the national grid and the rest are at the mercies of either imported power generators or other means which make life even more expensive since they spend more on the essential energy acquisition to meet their basic needs.

The renewable energy sources charts the path out of the present impasse the energy sector is saddled with, because of its attendant benefits:

1. Its renewable nature: renewables abound in nature and replenish themselves. In other words they

do not get exhausted

2. Its environmental benign nature: they are mostly environment friendly; they do not degrade the environment.
3. They are not subject to price fluctuations and fixing that is common with fuel oils.
4. Their technology and cost though initially high promises to be cheaper because of low maintenance costs on the long run.
5. They are particularly suited for areas that are off the grid since transmission and distribution of energy generated from fossil fuels can be difficult and expensive because of the nature of settlements.

Because of these reasons, many countries are rapidly adopting renewable technology to complement and eventually dominate their power generation.

However relatively few developing countries have adopted the public policies needed for the widespread development of renewable energy technologies and market, which is dominated by Europe, Japan, and North America. The exceptions are Brazil- which is the world's leading biofuel (Bioethanol) provider, Kenya- the world leader in the number of solar power systems installed per capita (thought not the number of watts added). Over 30,000 small solar panels are sold annually. More of them now adopt small solar power yearly than make connections to their national grid.

Conclusion

Nigeria in no doubt is a great nation and blessed with enormous amount of renewable energy sources to make it a world exporter of energy. What has befallen the world's most populous black nation is more of lack of the will on the part of leadership to extensively embark on and aggressively sustain the development of the energy sector needed for rapid industrialization and development. Energy is a sine qua non to any country with the noble aspirations of development. Renewable energy as presented in this article is a sure way to achieving Nigeria's dream of joining the world's top 20 economies come 2020. The unreliability of supply and decline in the conventional Fossil fuel based generation with its attendant environmental and pollution matters coupled with population explosion makes it even most imperative for government and private concerns alike to

invest in, and develop alternative (renewable) sources of power supply. In this paper various renewable energy sources (wind, solar, small- hydro, biomass and Geothermal) have been explored, their relative abundance and spread in the country also analyzed. The renewable energy option for power generation in Nigeria to solve the lingering energy crisis in Nigeria is thus proposed.

Recommendations

Because of the obvious advantages of renewable energy sources as alternative sources of energy for power generation in Nigeria it is therefore the recommendation of the authors that Nigeria as a matter of urgency should:

- Review the existing national policy on renewable with a view of implementing same.
- Encourage and create the right atmosphere for these alternative energy sources to thrive.
- Sponsor and invest in research and development especially as it relates to renewable. Institutionalization of the National Energy Policy and the.
- Establishment of a Renewable Energy Fund to serve as the instrument for the provision of financial incentives to local manufacturers, suppliers and users of RE electricity, especially with reference to the rural areas.
- Provision of adequate fiscal incentives to local suppliers and manufacturers of RE electricity system components.
- Sustenance of the energy sector reforms by successive governments.

However, there had been a lot of factors hindering the large scale up take of renewable sources of energy in Nigeria. Some of them are:

1. Policy and regulatory
2. Technological
3. Institutional
4. Financial and market
5. Socio-cultural.

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