

Renewable Energy Sources for the Present and Future: An Alternative Power Supply for Nigeria

Ebuefe Abinotami Williams¹, Raimi Morufu Olalekan² & Ebuefe Ibim Yarwamara³, Oshatunberu
Modupe⁴

¹ Department of Geography and Environmental Management, Niger Delta University, Nigeria

² Department of Community Medicine, Environmental Health Unit, Faculty of Clinical Science, Niger
Delta University, Nigeria

³ Department of Art & Social Science, School of Foundation Studies, College of Health Technology
Otuogidi-Ogbia Town, Bayelsa State, Nigeria

⁴ Department of Environmental Health, College of Health Sciences and Technology, Ijero-Ekiti, Ekiti
State, Nigeria

Received: June 22, 2019 Accepted: August 5, 2019 Online Published: August 30, 2019

doi:10.22158/ees.v2n2p18

URL: <http://dx.doi.org/10.22158/ees.v2n2p18>

Abstract

It is estimated that at least 600 million people in Africa lack access to electricity and three out of five people don't have access to electricity in Sub-Saharan Africa. Though Africa is rich in a wide range of energy resources including solar, bio, natural gas, oil, coal and Uranium, the continent is far from energy self-sufficiency. Addressing climate change will require deep and quick reductions in fossil fuel use so that the systems developed around producing, transporting, and consuming energy are decarbonized by the middle of the century. In the ongoing age, sustainable power source has taken another swing to limelight on the planet, particularly in developed and emerging nations, as it assumes a noteworthy part both in economy and the general job of the world. Significantly, Nigeria an oil-rich country, comes as no surprise that almost all of her energy consumption comes from non-renewable energy sources as coal, natural gas and oil, and as such it is highly vulnerable to shocks due to overdependence on the fossil sources; often time is controlled by the international market. On the whole, the fossil fuel is expected to span only but a millennium (1700-2700) of human civilization while the imperative of an energy shortage situation is felt in every sector of the country considering the poor electricity consumptions in the country, which has reflected on the country's economy and productivity rate. In revamping the economic sectors in Nigeria, the need for an alternative energy sources that is augmentable in supply keeping in view sustainable development as the hallmark for all sector development. Thus far, Nigeria ought to likewise be opened to universal investments as this would help support the improvement of its assets. This paper, therefore, supports no other sources but renewable

energy in promoting the countries productivity at all segments. It further stressed on the implementation of the country's Renewable Energy Master Plan (REMP) to meet global competitors by the year 2030. Similarly, senior political figures, policymakers and CEOs should engage in a policy dialogue by identifying unique opportunities and best practices for developing and investing in Nigeria and in Africa's energy markets for "...without this energy supply, the sophisticated skills of the industrial world are merely a burden in the struggle for survival."

Keywords

climate change, energy self-sufficiency, renewable energy, fossil fuel, power supply, energy markets, decarbonized, Niger Delta

1. Introduction

Energy and public health among its various welfare effects is closely linked together at all scales and its use is central to human activity and can be viewed as the progressive development of new energy sources and their associated conversion technologies, from household and community to regional, national and global. Energy and its systems have a central role in social, economic development and human welfare. Though Africa is rich in a wide range of energy resources including solar, bio, natural gas, oil, coal and Uranium, the continent is far from energy self-sufficiency. As noted by the International Energy Agency (IEA) at least 600 million people in Africa lack access to electricity, and "three out of five people don't have access to electricity in Sub-Saharan Africa". Similarly, United Nations Development of Economic and Social Affairs (UN DESA) also state that "...85% of the 1.2 billion people who lack access to electricity and 78% of the 2.8 billion who still rely on unsustainable solid biomass as fuel for cooking and heating, live in rural areas..." (UN DESA, 2014). This is unacceptable in economic and moral terms and no country should take its electricity and security issue as an excuse, with many African countries reluctant to liberalize their electricity sectors due to energy security concerns, private investment and security were not mutually exclusive (<https://www.aa.com.tr/en/africa>). Thus far, the time is right to tap into alternative power supply potential which tends to play a key role in a clean, secure and affordable energy future. This can help tackle various critical energy challenges which offers ways to decarbonise a range of sectors including long-haul transport, chemicals, iron and steel where it is proving difficult to meaningfully reduce emissions. It can also help improve air quality and strengthen energy security. Despite very ambitious international climate goals, global energy-related CO₂ emissions reached an all-time high in 2018. Schematically, outdoor air pollution which knows no borders remains a pressing problem, with around 7 million people dying prematurely yearly; that's 18,000 deaths daily. What's worse, 92% of people around the globe don't breathe clean air which is driven by fossil fuel usage that simultaneously drives climate change and contaminates our air. Unfortunately, nine out of ten people breathe polluted air daily (WHO, 2016; www.who.int/news-room/details). In 2019, air pollution is considered by WHO as the greatest environmental risk to health and a major global health hazard with low and middle income countries

bearing the pollution brunt (Raimi et al., 2018; Olalekan et al., 2019).

Admittedly, most of the resources used like petroleum, natural gas, coal are not sustainable sources of energy. Numbers of countries in the world including Nigeria are currently passing through the critical phase of population explosion and the growing population demands more energy inputs. With this, the current population estimate range from 198 to 210 million people, growing at the rate of 3.2% per annum, Nigeria faces the challenge of population impact on its poor infrastructural development (Raimi et al., 2017; Olalekan et al., 2018; Raimi et al., 2018; Raimi et al., 2019; Olalekan et al., 2019; Raimi et al., 2019). Despite her rich natural resources, Nigeria has a per capita income of around \$390 and life expectancy of 45 years (World Bank, 2006). A more graphic comparative data on the socio-economic condition of Nigeria and Electricity access in the year 2009: Africa and other regional aggregates is presented in the Table 1 and Table 2 below:

Table 1. Comparative Data on Socio-economic Condition of Nigeria and Other Developed Countries

Indices (2006)	Nigeria	Malaysia	UK	USA
Population (millions)	201	25.2	59.4	293.5
GNI per capita (atlas method, US\$)	390	4,650	33,940	41,400
Human Development Index (HDI)	158	61	15	10
Poverty (Head Count Ratio)	92.4	9.3
Literacy (% of population age 15+)	67	89	95	95
GDP (US\$ billions)	72.1	118.3	2,140.9	11,667.5

Source: Adapted from World bank, 2006

Table 2. Electricity Access in the Year 2009: Africa and Other Regional Aggregates

Country	Population without electricity (millions)	Electrification rate (%)	Urban electrification rate (%)	Rural electrification rate (%)
<i>Africa</i>	<i>587</i>	<i>41.8</i>	<i>68.8</i>	<i>25.0</i>
North Africa	2	99.0	99.6	98.4
<i>Sub-Saharan Africa</i>	<i>585</i>	<i>30.5</i>	<i>59.9</i>	<i>14.2</i>
Developing Asia	675	81.0	94.0	73.2
China & East Asia	182	90.8	96.4	86.4
South Asia	493	68.5	89.5	59.9
India	288	75.0	94.0	67.0
Latin America	31	93.2	98.8	73.6
Middle East	21	89.0	98.5	71.8

Developing countries	1,314	74.7	90.6	63.2
World*	1,317	80.5	93.7	68.0

* World includes OECD and Eastern Europe / Eurasia.

Source: Adapted from US Energy Information Administration, World Energy Outlook 2011.

Total use of energy is related to population growth and economic output, but there is much variation in the effectiveness of energy use across societies (Grubler et al., 2012). The amount of energy used, as well as the quality of energy, drives economic productivity; more efficient and flexible energy sources (liquid fuels and especially electricity) are associated with higher productivity (Toman & Jemelkova, 2003). Currently, approximately 65% of all global primary energy is consumed in the industrialized countries that make up the Organization for Economic Cooperation and Development (OECD) and the former Soviet Union (FSU), with per capita consumption averaging five times that of developing countries (World Bank, 2001). Contributions to GHG emissions follow a similar pattern. Per capita energy consumption in North America is more than 25 times that of the poorest nations in sub-Saharan Africa, 20 times the per capita consumption in India, and 10 times that in China (World Bank, 2001). Global carbon emissions are approximately one metric ton of carbon per year per person (tC/person-year). Per capita emissions in the United States are more than 5 tC/year compared to approximately 0.6 tC/year in developing countries as a whole, and they are less than 0.2 tC/year in the 50 developing nations with lowest emissions (Baer et al., 2000). Coupled with low levels of per capita energy consumption, fuels and energy conversion technologies currently used in developing nations result in much higher exposure to local pollution. Therefore, from an environmental health perspective, energy options in developing countries are of notable importance because of lack of access to clean energy sources and technologies. Further, the most rapid future growth in energy consumption is expected to take place in developing countries, as a result of both population growth and economic development (Reddy et al., 1996; Reddy, 2000).

However, Nigeria suffers from poor infrastructural development including road networks which are still underdeveloped and there are a host of communities and cities cut off from each other due to unassailable transportation networks and electricity/power supply etc. The education system is under-funded and illiteracy rate is up to 40 percent. More than two-thirds of Nigerians are poor. In 1980 an estimated 27 percent of Nigerians lived in poverty. By 1990, 70 percent of the population had income of less than \$1 a day and the figure has risen since then (NEEDS, 2005). Nigeria has one of the worst health care systems in the world and the doctor-patient ratio is about 1:1000. The public sector is very weak and on top of these, corruption threatens to crumble the country. As such, compared to the Western standard, there is a total collapse of government in Nigeria. The three major sectors of the economy are oil and gas, financial services and telecommunications. These sectors co-exist with thriving traditional agricultural and trading economies. This context of poverty, poor infrastructure and weak institutions provides a fertile ground for more vulnerability and to the ongoing impacts of climate

change (Raimi et al., 2018; Olalekan et al., 2019).

Interestingly, to have any chance of preventing runaway climate change and keeping human-caused temperature increases to no more than 1.5 degrees Celsius (°C), societies must commit to rapid and deep decarbonization that will transform global and domestic energy systems. The threat of climate change demands a major energy transition (Anita, 2015). However, a clear route from fossil fuels to clean energy has been slow to materialize (Cameron & Emma, 2017). A prominent yet contested route for facilitating a conversion to clean energy involves the use of so-called “bridging” fuels (Christian, 2014), such as unconventional gas. As with other bridging fuels, their promotion and commodification rests on the argument that no single energy source can currently ensure accessible, reliable, and affordable energy, while also slowing the emissions lock-in of coal power (Michael et al., 2016). Nonetheless, unconventional gas provides a less carbon-intensive fuel source (relative to other fossil fuels), while still being abundant and feasible to access. Schematically, the newfound popularity of unconventional gas has generated concerns regarding risks of high methane emissions, subsidence, changes in the use of food-producing land, water pollution, and reduced water availability (Maria et al., 2014; Morufu & Clinton, 2017; Raimi & Sabinus, 2017; Raimi et al., 2017; Olalekan et al., 2018; Olalekan et al., 2018; Raimi et al., 2019; Raimi et al., 2019). Globally, the demand for energy remains on the increase and according to Monique Barbut, CEO and Chairperson, Global Environment Facility *“Between now and 2030, energy demand is projected to grow by 1.6% annually, adding up to a dramatic 45% increase. Meanwhile, energy demand in developing and transition countries is predicted to grow even faster than in developed countries. Such rapidly growing energy demand is particularly challenging given that most of the world’s population still rely on energy from limited fossil fuel sources and traditional biomass.”*

Complete energy decarbonization would result in an unprecedented change to the world’s “social metabolism”, (Manuel et al., 2015) altering not only the amount of fossil fuel based energy the world consumes, but also entire social and economic systems involved in resource extraction, processing, delivery and use (Shelley, 2018). These systems include the human societies that have been built around providing the labour and capital necessary for fossil fuel exploitation, as well as the natural environments that have supported, and been degraded by fossil fuel extraction and combustion (Gonzalez & Toledo, 2017). The energy transformation necessary to mitigate climate change will profoundly alter societies and the natural world (Clark et al., 2013). Energy decarbonization has the potential to bring much more justice, opportunity, and sustainability to communities around the world. However, this will not happen without an intentional focus on the full social metabolism of the energy system. Given the current fossil-fuel-dominated energy portfolio and projections for the development of renewable energy technologies, it is inevitable to conclude that fossil fuels will continue to supply an important percentage of the growing global energy needs during the next few decades. Nevertheless, electricity generation, industrial processes, and transportation consume the most energy as well as contribute the most to greenhouse gas (GHG) emissions, in particular carbon dioxide (CO₂) (Raimi et

al., 2018). Interestingly, energy development is essential and a primary input for almost all economic activities and is therefore vital for improvement in quality of life. Virtually, all human economic sectors utilised energy for its growth; such sectors includes industrial, commercial, transportation, telecommunications, wide range of agricultural and household services which has compelled us to focus our attention to ensure its continuous supply to meet our ever increasing demand (Al-Bajjali & Shamayleh, 2018) (Figure 1). This global picture is not quite different when compared with the situation in Europe where the major drivers of GHG are the energy and transport sectors with forestry having little or no contributions (Figure 2). Though deliberate efforts have been made by the Government to provide power to all Nigerians in order to spur development and improve livelihoods. The main sources for the country's power production and hydropower, petroleum and Natural Gas. It is projected that the country's energy requirements will substantially increase. The country's energy policies must therefore ensure a robust and efficient energy system that is secure and sufficient. There are multiple energy sources, and the technical processes for harnessing, usage and impact on the environment vary from one energy type to another. The 2007 policy Guidelines on Energy takes cognisance of the need to protect the quality of the environment and the population from hazards of energy exploitation and utilisation. It further aims at improving the nations technical capacities in the energy sector for the state security, self-reliance and economic competitiveness, with increasing emphasis on renewable energy to facilitate green economic growth.

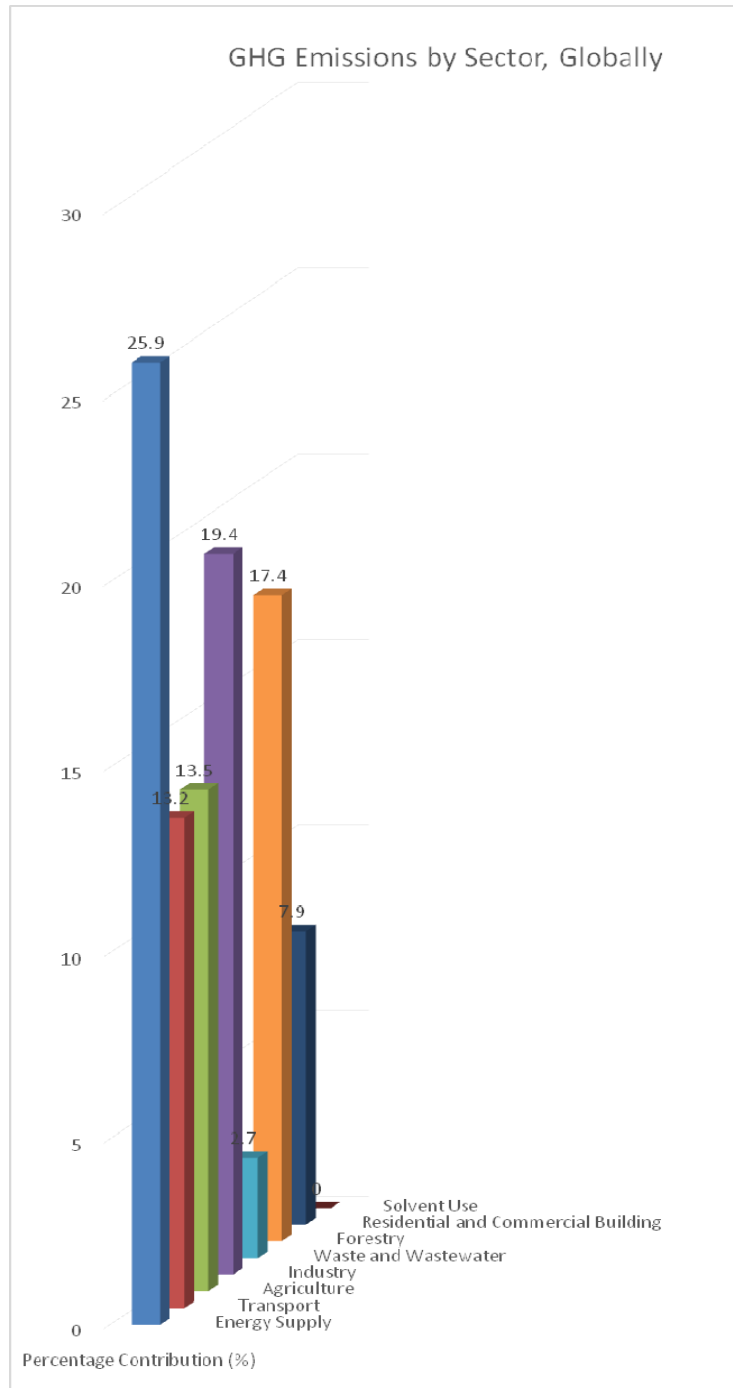


Figure 1. GHG Emissions by Sector, Globally

Sources: Data from Climate Change 2007; Raimi et al., 2018 and Greenhouse gas and emission trends and projections globally in Europe (2007)

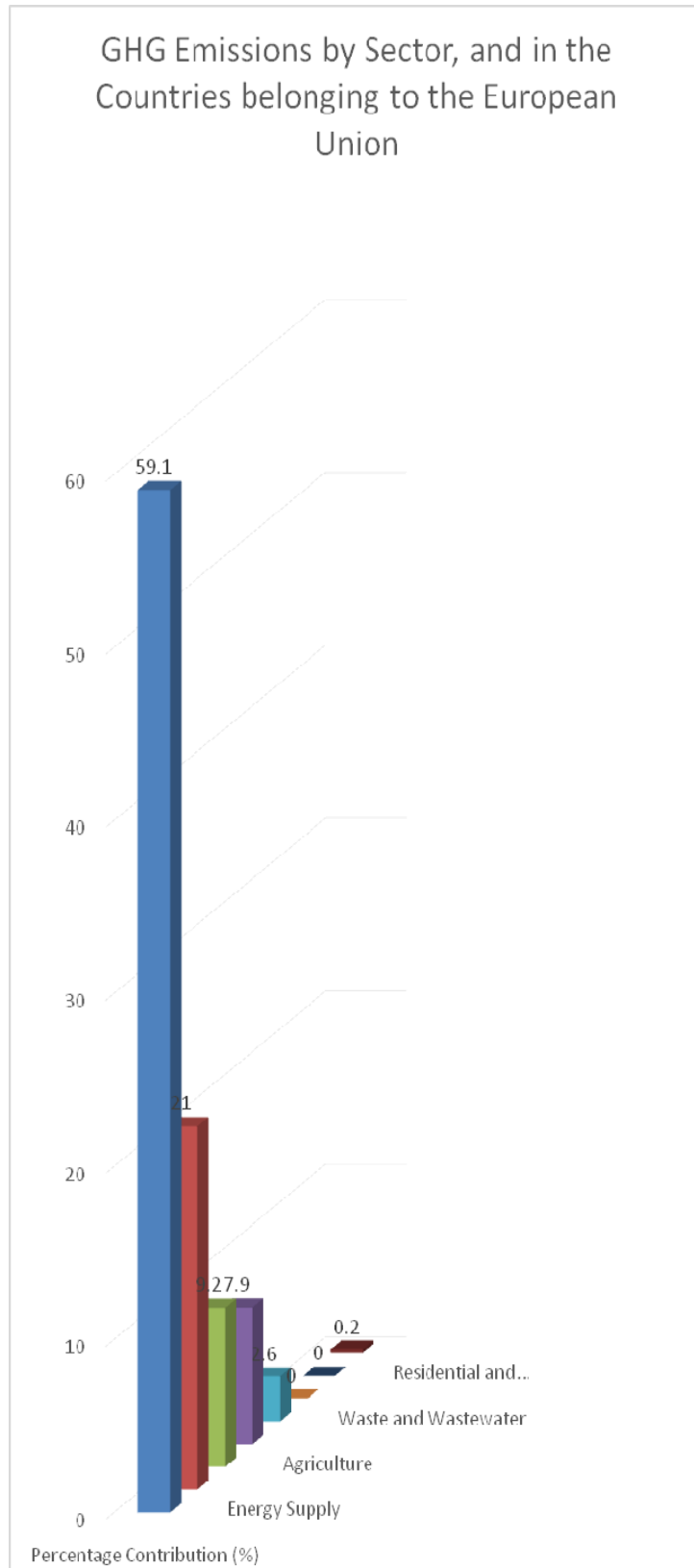


Figure 2. GHG Emissions by Sector, and in the Countries belonging to the European Union
 Sources: Data from Climate Change 2007; Raimi et al., 2018 and Greenhouse gas and emission trends and projections globally in Europe 2007

According to Dhameja (2013), energy demand is not an exception to the economic theory of limited means and unlimited want as in the place of exploitation. The energy resources have been growing overtime and has resulted in gradual depletion of the scarce reserves. The critical linked between energy and economy has exposed the vulnerability of nations to the volatile energy situation; which has reflected on the key factor in deciding the product cost at micro levels as well as indicating the inflation and the debt burden at the macro levels (Ibid, 2013). In view of this, the Nigerian government spent over \$356billion on fuel subsidy in five (5) years (2010-2014) (Bayagbon, 2018); and is currently spending ₦3.76 billion daily on fuel subsidy (Chijioke, 2018) in managing fuel cost and inflation in Nigeria.

Recently, the imperatives of an energy shortage (depleting energy crisis) situation confronting the world community has led to the formulation of a new energy policy framework of energy conservation within which the rate of growth and pattern of energy consumption could be regulated. This steady increase in gap has not only compelled technocrats and decision markers in the industry to develop new measures of energy conservation but also to have systematic approach towards present trend of energy consumption through energy auditing and application of modern techniques and methods for minimizing energy wastage. Thus, relying solely on fossil fuels for the country energy supply will not be enough to meet the energy needs of the country. Hence, the need for renewable energy sources considering the insurmountable factors confronting the energy supply in Nigeria such factors according to Oricha and Olarinoye (2012) including government policies; economic factors, natural factors, society/community factors, efficient technology and security.

Nigeria is blessed with abundant of natural and human endowment, capable of transforming the Nigerian power sector. The power sector who rely solely on fossil such as Coal, Oil, Gas and Water is vulnerable to shock because of the hovering change in crude oil price in the international market (Newsom, 2012; Shaabona & Potinrinac, 2018). Undoubtedly, the sector has witnessed a very insignificant amount of growth which has invariably affected its production capacity. In spite of the fundamental changes over the past few years in the Nigerian Electricity Supply Industry (NESI) under the government privatisation reform program in the global power industry even with the present 23 grid connected generating plants supplying power in the country; the total electricity consumption per capita in the country remain 1000KWh- which compares poorly with 4,500KWh; 1,934 and 1,379KWh in South Africa, Brazil and China respectively (Akuru & Okoro, 2012; Nwagbo, 2017). There is no gainsaying, the fact that a large percentage of Nigerians (over 85million and more than 60%) do not have any form of accessibility to power and this in no small way affects their productivity and that of the country at large (NERC, 2008; Oricha & Olarinoye, 2012).

Paul (2017) stresses that, constant power supply is the hallmark of a developed economy and any nation whose energy need is epileptic in supply prolongs her development and risk-losing potential investors. In Nigeria, there are few things that may discouraged investors as far as infrastructural development is concerned, which is nothing other than the amount of losses an investor would incur

since the electricity system in the country is outdated (Ubari, 2013). Most interestingly, is that Nigeria has been ranked as the second worst nation in power supply by the year 2017 as power dropped 3,851 Megawatts from the 16,000GWh (www.vanguardngr.com/2018/01/nigeria), which is unequally distributed in the country. In view of the above, this paper address and redressed the importance of alternative renewable energy generation sources in the country's power supply and utilisation to enhanced productivity in Nigeria particularly in the Niger Delta region.

The Niger Delta is a region located in the South-South Geopolitical zones of Nigeria, covering about 8% of the country's landmass (Wifa, 2018). The region is known as the storehouse of Nigeria's crude oil which accounts for approximately 90% of foreign exchange, paradoxically however, the region is yet in her own pervasive local poverty due to deep-rooted mistrust, frustrated expectation, unfavourable and erratic government policies, oil politics which is restlessly driven by powerful interests, the government and the oil firms, unprecedented restiveness etc, among leading factors is the power outraged, which has consistently drag on the region's economic performance and expectation for development (Raimi et al., 2019 in print). If all things been equal, the adoption of renewable sources of energy will reshape the economic productivity in the region, considering the vast opportunity for its adoptions. However, the current proposal for climate change mitigation is a portfolio of technologies that must be urgently and concurrently implemented. This portfolio includes renewables, energy storage, energy efficiency, bioenergy, nuclear energy, clean power generation, transportation, electrification and carbon capture, utilization, and storage (CCUS), among others. However, it is important to understand that many of these technologies still require significant advances before they can be considered safe, reliable, and economically profitable.

2. Energy Policy/Plan

Energy access for all is the single most important component of any development strategy. In the words of Gerald Foley— *"...without this energy supply, the sophisticated skills of the industrial world are merely a burden in the struggle for survival."*(Gerald, 1992). Worldwide energy consumption and demand are growing up since past 50 years and according to Monique Barbut, *"Between now and 2030, energy demand is projected to grow by 1.6% annually, adding up to a dramatic 45%increase. Meanwhile, energy demand in developing and transition countries is predicted to grow even faster than in developed countries. Such rapidly growing energy demand is particularly challenging given that most of the world's population still rely on energy from limited fossil fuel sources and traditional biomass."* The situation is worrisome leading nations to deregulate their power sectors to expand energy service to include renewable energies, attract private investment and attract independent power purchasers to the market. These appear to be essential for renewable energy development, even though privatization of the power sector is inherently biased against capital intensive investment in renewable energy. To create a favourable investment climate for private sector involvement in the delivery of clean and decentralized energy, a framework of laws, regulations and policies that is long term,

consistent, possess strong governance conditions, clear administration procedures, low transaction costs, strong public acceptance and enforcement is critical (Xiadong, 2007). In effect, to sustain the expected fast pace of industrialization in the future, reliable and appreciable supply of renewable energies is needed.

In addition, the National Energy Policy establishes guideline for the protection of the environment in the exploitation of Nigeria's fossil. It also emphasizes the exploration of renewable and alternative energy sources, primarily solar, wind and biomass. Nigeria envisions a peaceful and prosperous nation driven increasingly by renewable energy. By the middle of the century, sustainable and affordable renewable energy will provide half of a country's total energy demand, thereby contributing to the country's effort to keep GHGs at barest minimum. The country's Renewable Energy Master Plan (REMP) has several pertinent specific objectives which if achieved will enable Nigeria to address climate change risks in the energy sector, as well as ensure that the country meets its increasing energy demands. In particular the country will be able to pursue an economic development path that is less dependent on fossil fuels (e.g. oil).

Policy, according to Thomas Birkland, is about problem solving, and is shaped by social, institutional, political, and economic factors. Public Policy as applicable in this context, serves as a guide to decision making that would affect a greater variety of people and interests. This is why government and the policies made by government are sometimes so controversial, frustrating, and at the same time very important since the public is the source of political authority (Birkland, 2014). These various policies on renewable energy in Nigeria are faced with challenges of non-adoption, non-implementation, non-binding, erratic and inconsistency because it varies from one government to the other. Where a government can easily discard existing policies to pave way for new ones, it becomes extremely difficult to attract investors whose investments are needed to bolster the sub-sector, which according to a 2011 Report by the International Centre for Energy, Environment and Development (ICEED), requires an estimate of about US \$200 billion to improve Nigeria's infrastructure for power, transport and water (Ewah Eleri et al., 2011). These policies must be transformed to provide concrete solutions to the energy crisis in Nigeria.

Moreover, National policies and law play pivotal roles in the expansion of the renewable energy market as they have the capacity to either stimulate or stifle improved energy access. However, Nigeria lacks an appropriate legislation that would address fairness and open access to the grid, robust feed-in-tariffs, simplified licensing process, renewable portfolio standards, capital reliefs, incentives, capacity building, standards and codes specification, research and development; these factors are important to drive the renewable energy market. A National legislation on renewable energy should align with articulated policy statements to create a favourable investment climate for private sector involvement in the delivery of clean and decentralized energy. Nigeria needs a legally enforceable codified document that would promote energy services for both the urban population and the rural dwellers; policies alone, cannot deliver on this. It is believed that, law has the propensity of propelling the development of

renewable energy, which in turn can improve energy access and cause socio-economic development in the nation.

2.1 Renewable Energy over Non-Renewable Energy

Economy of a nation refers to total wealth of that nation measured in Gross Domestic Products (GDP) or Gross National Product (GNP). Where there is an increase in GDP/GNP in a country, it is obvious that there will be imbalance in the demand and supply of energy as increase in GDP/GNP means more use of materials for production activities. Dhameja (2013) opined that, the quest of meeting various human needs, man over-exploited the natural resources with total disregard to the incalculable harm being caused, leading to disastrous consequences, which has called for the post 1992 UN Conference on Environment and Development (UNCED) held in Rio de Janeiro, focused on the restrictions on the release of greenhouse gases, that can only be achieved through renewable sources of energy.

Renewable Energy refers to energy (like solar, wind, geothermal, ocean tide, biomass) obtained from energy sources whose utilization do not result in the depletion of the earth's resources. However, renewable energy is replaceable on a human time scale, having the inherent ability to reappear, or replenish themselves by recycling, reproduction or replacement, hence remained augmentable in flow. Other energy sources are non-augmentable having some impact on the environment. Fossil-fuel, coal, oil and natural gas do substantially more harm than renewable energy source by most measures including air and water pollution, damage to public health, wildlife and habitat loss, water use, land use and global warming emissions (Raimi et al., 2018). In contrast, most renewable energy sources produce little to no global emission even when including "Life Cycle" emission of clean energy (i.e the emission from each stage of technology's life-manufacturing, installation, operation and decommissioning). The IPCC (2011) opened that, the global warming emission associated with renewable energy are minimal. For instance, burning natural gas for electricity releases between 0.6-2 pounds of carbon dioxide, equivalent to per Kilowatt-hour (CO₂E/KWh), Coal emits between 1.4-3.6 pounds of CO₂E/KWh; while Wind is responsible for only 0.02-0.04 pounds of CO₂E/KWh on a life-cycle basis, Solar 0.07-0.2 CO₂E/KWh, Geothermal 0.1-0.2CO₂ E/KWh, and Hydroelectric 0.1-0.5 CO₂ E/KWh. Increasing the supply of renewable energy would allow us to replace carbon intensive energy sources and significantly, Nigeria global warming emissions. For example, a 2009 UCS analysis found that a 25 percent by 2025 national renewable electricity standard would lower power plant CO₂ emissions 277 million metric tons annually by 2025 (UCS, 2009). Further, the air and water pollution emitted by coal and natural gas plants is linked with breathing problems, neurological damage, heart attacks, cancers, and premature death (Raimi et al., 2018). The study of Epstein et al. (2011) proved that an estimated life cycle costs and public health effects of coal and gas is 74.6 billion dollar every year. In Nigeria the annual women death of 90,000 is linked to smoke inhaling form kitchen operation (Nigeria Current, 2014).

Renewable energy industry is more labour intensive, unlike fossil fuel industry that are typically mechanised and capital intensive, thereby creating more job opportunities. For instance, in 2016, the

wind energy industry directly employed over 260,000 full-time, equivalent employees in a variety of capacities (Wiser & Mark, 2017); while Geothermal alone employed 5,800 (Geothermal Energy Association, 2010); In contrast to the 160,000 employed by coal industry (Dept. of Energy, 2017). In 2017, the global employment from renewable energy was 500,000 according to Channels TV (2018). Again, Renewable Energy provides an affordable electricity prized if properly harnessed since the fuel is free. For instance, the Channels TV (2018) put the prize ratio differences between non-renewable energy to renewable energy as 50%. In Nigeria, single room pay monthly electricity bill fall between ₦3000-₦5000 irrespective of her epileptic nature, whereas Solar Power Box supply by MTN cost 2000 only with constant power supply. This lag provides readily market for investors. In the U.S; over 500 factories invested into Wind Project, yielding about 13billion (Wiser & Mark, 2017); Furthermore, renewable energy creates Economic Ripple effects, that is benefiting unrelated local businesses from increased household according to the EPA (2010).

Renewable energy sources create readily income for individual and government in the form of property and income taxes. For instance, the Nigerian government saves over 1.4 trillion naira from fuel subsidy removal annually (Bayagbon, 2018); and if such gesture continues and possibly, the quest for renewable energy sources is achieved, then the country's reserved will be robust. Another advantage is that, the renewable energy industries are economical and multipurpose, because the same piece of land can be used for electricity generations as well as agricultural activities. Furthermore, renewable energy are distributed including modular. Distributive because it spans through large space of land with vase alternatives. Modular because power generation is sequentially connected, hence a break off in one solar panel or wind fan will not obstructs power supply; thereby encouraging constant power supply.

2.2 Sources of Renewable Energy

Renewable sources of energy offer several potential advantages. They do not irreversibly deplete finite resources, and most have a lower climate footprint than do fossil fuels. If managed well, they can pose minimal health risks and can yield social and economic benefits. Whether the benefits are realized depends strongly on how renewable energy is produced. No energy source is free of health and environmental impacts. Issues of land use, maintenance, materials inputs, and energy storage raise concerns about environmental, occupational, and community health impacts.

2.3 Wind Turbine

Wind energy is a manifestation of the solar energy and globally, wind power is one of the most expanded renewable and sustainable energy sources. Wind has the potential to supply a significant portion of world energy needs and provides a small but growing segment of electrical energy, reaching 2% to 3% globally (with higher proportions in some countries, such as nearly 26% in Denmark, 16% in Spain and Portugal, and 12% in Ireland) (REN21, 2012). Harnessing power from the wind is one of the cleanest and most sustainable ways to generate electricity as it produces no toxic pollution or global warming emissions. Wind is also abundant, inexhaustible, and affordable in the Niger Delta which makes it a viable and large-scale alternative to fossil fuels. In 1980s, wind energy generation of the

world was 10 megawatts and in the year 2000 it was 14,000 megawatts (Dhameja, 2013); and according to the Financial Time World Renewable Energy Conference held in Brussels, Belgium, in 1999; and the Green Piece International Estimates that if the trend continuous, wind power could supply 10% of the world's electricity and create 1.7million new jobs by 2020 (Christopherson, 2013). This effort would reduce global emissions of carbon dioxide (CO₂) by 10 billion metric tons. On a more perspective, every 10,000 Megawatts of wind generated capacity reduces carbon dioxide emissions by 33 million metric tons if it replaces coal or 21million metric tons if it replaces mixed fuels. Wind energy source is ideal particularly for mini-industries, rural areas, remote areas and forest houses. Again, a Wind Energy Mapping Project conducted by the Federal Ministry of Science and Technology in 2002 to identify potential sites for exploitation which showed that wind energy could be harnessed in the northern border regions and some coastal States. As early as the mid-1960s, in the northern region of Sokoto and Garo, over 20 homes and a school used windmills to pump water but the following decades saw the prices of fossil fuel drop and therefore with cheap energy, wind power was not an appealing alternative; investments in windmill ceased as the infrastructure deteriorated. The reasons for this under development may lie in the lack of awareness, promotion and practical government support in form of subsidies or substantial facilitation for the import of the technology (Mshelia, 2012). Electricity generation from wind energy requires more investment even though, today, there is a 10MW wind farm at Lambat, and Rimi in Katsina State (Sambo, 2010). Health benefits of wind power include the absence of greenhouse gas and other pollutant emissions during operation (although some emissions are associated with manufacturing the equipment), as well as the absence of aroutine waste stream.

2.4 Solar Power

Solar energy has the maximum potential of all sources of depleting fossil fuels as it has the maximum potential of all the sources of renewable energy (Paul, 2017). Three technologies are used to generate electricity from solar radiation: photovoltaic (PV) cells, which generate electricity directly; concentrating solar power thermal systems, which use a liquid to transfer absorbed heat to a steam generator that drives a turbine; and solar towers, which are effectively chimneys in which rising hot air powers turbine generators. Solar energy echnologies have been deployed in both small-scale (mainly rooftop) applications and in large-scale electrical production. Like wind, the sun provides a tremendous resource for generating clean and sustainable electricity. The current situation of renewable energy in Nigeria shows that, there is an annual average of daily solar radiation of as high as 7kwh/m²/day in the coastal regions of Nigeria. This means that the annual average of daily hours of sunshine varies from 9 hours in the north and up to 4 hours in the south. The total available solar radiation in Nigeria could provide 120,000 times the total amount of electricity currently generated in the country. Also, sunlight received during day hours and clear sky has power density of between 0.4KW/m² and 1KW/m². In Nigeria, the current annual fossil fuel production in the country of 258.62million barrels and 4.11x10¹⁰ litres of crude oil amount to 4.2x10⁵GWh of electricity production and out of the 5% technical

potential of solar energy in the country only $1.5 \times 10^{18} \text{J}$ is useful annually (Oyedepo, 2012; Nwagbo, 2017; Premoboere & Raimi, 2018), hence there is more to solar energy exploitation in the country. The major energy routes of solar energy utilization were; direct passive heating of building, farms, green houses, water; solar thermal electric power plants using steam cycle or binary cycle; solar photovoltaic power plants using several PV cells connected in series. The former is economically competitive in mini-industries, remote areas, satellite power supply, forest houses, mountain areas etc. For instance, the fee ratio between the NEPA to solar is about 50% in Nigeria (The Channel, 2018). Thus far, solar PV systems are gaining grounds in Nigeria and can be found in Sokoto, Sokoto State; Uyo in Akwa-Ibom State, Solar PV for Telecommunication along Kaduna-Abuja Road and Solar PV at Ilaje, Ondo State (World Alliance for Decentralised Energy, 2009).

The major health concern from solar power relates to the life cycle of PV cells. These are typically made with crystalline silicon and, depending on the technology used, include compounds such as copper indium diselenide (CIS), copper indium gallium diselenide (CGS), gallium arsenide (GaAs), and cadmiumtelluride (CdTe). Silica mining is associated with risk of silicosis, a type of pneumoconiosis (Leung et al., 2012). PV manufacturing, like semi conductor manufacturing, may entail exposure to toxic metals (cadmium, arsenic, chromium, and lead) and gases (arsine, phosphine, and silane) (Fthenakis et al., 2008; Taylor, 2010), available data suggest that environmental emissions are generally low (Fthenakis et al., 2008), although waste management and end-of life product disposal remain challenges (Silicon Valley Toxics Coalit, 2009). Overall the health impact of solar power is likely to be far less than that of any of the fossil fuels.

2.5 Geothermal Energy

Geothermal energy is the energy that lies embedded within the earth's crust. There is increase in temperature of the earth with increasing depth below the surface; such heat is stored in the earth's crust as thermal energy which constitutes an inexhaustible source of energy term as geothermal energy. The most widely developed type of geothermal power plant (known as hydrothermal plants) are located near geologic "Hot Spot" where hot molten rocks are close to the earth's crust and produce hot water. According to Khitoliya (2002), deposits of hot water and steam at relatively lesser depth (3000m) can be extracted from such deposits by means of production wells. The technology for its use is either through direct steam, flash or binary which required a cooling technology in the form of water-cooled or air-cooled. Energy supply through geothermal is ideal for major and mini industrial activities, and domestic uses etc. Furthermore, from the 2012 Renewable Energy Master Plan, (draft revised edition), there is no programme target nor a projected electricity supply from geothermal energy. Does this mean Nigeria has no plan for harnessing resources from geothermal energy? Advocates of geothermal energy believe that Nigeria is well endowed with the resource and should take advantage of it. According to Timothy Oladimeji "Geothermal energy is a renewable resource, and production from individual geothermal reservoirs can be sustained for decades and perhaps for centuries." He pointed out that "compared to other types of power plants, geothermal plants have relatively little effect on the

environment, and geothermal power plants have been successfully operated in farms, in sensitive desert environments and in forested recreation areas.” Geothermal energy in Nigeria is yet to evolve; it should also be given adequate attention just like solar and hydro power energy (Segun, 2013).

2.6 Biomass for Electricity

This is energy sources from green plants. Green plants capture solar energy through the process of photosynthesis and convert it into organic matter. This organic matter is known as biomass and is basically a form of solar energy, which is converted into chemical energy by the green plants i.e. solar energy in the form of chemical energy. Bio energy is generated when this biomass is burned in the form of wood, charcoal and agricultural waste or animal. Biomass power plants share some similarities with fossil fuel power plants; since both involved combustion of a feedstock to generate electricity. Biomass plants raise similar but not identical concerns about air emissions and water use as fossil fuel plants. On the contrast, the feedstock of biomass plants can be sustainably produced, while fossil fuels are non-renewable. Its production sources include energy crops (Switchgrass), agricultural waste, manure, forest products and waste, and urban waste. The present contribution of biomass energy is between 4% and 18% of total primary energy consumption of various developed and emerging countries respectively. The situation is likely to be changed dramatically and rapidly during coming years with increase in the biomass energy consumption from 25% to 40% by 2015 (Khitoliya, 2004). Biogas has a high calorific value (5000 to 5500Kcal/Kg) which can be used for cooking processes, operating small engines when properly utilised can aid productions in Nigeria.

2.7 Hydro-Energy

Hydrogen as a non-conventional energy resources has a tremendous potential as it can be produced from water which is available in abundance in nature. It has a very high energy content and its burning is non-polluting according to Paul (2017). Hydrogen can be produced from fossil fuels, but it is usually obtained from water by means of electrical energy which in turn may be generated from geothermal energy, wind energy, solar energy etc. The total hydroelectric power potential in Nigeria is about 8,824MW and only 24% large scale and 4% small hydroelectric power potential have been exploited (Oyedepo, 2012; Nwagbo, 2017), hence more of the country’s hydro energy capacity remained unexploited. Hydrogen energy can be used for generating electricity for operating domestic appliances and mini industry.

Some of the full advantage of this increasing momentum include.

Hydrogen is versatile. Technologies already available today enable hydrogen to produce, store, move and use energy in different ways. A wide variety of fuels are able to produce hydrogen, including renewables, nuclear, natural gas, coal and oil. It can be transported as a gas by pipelines or in liquid form by ships, much like liquefied natural gas (LNG). It can be transformed into electricity and methane to power homes and feed industry, and into fuels for cars, trucks, ships and planes.

Hydrogen can enable renewables to provide an even greater contribution. It has the potential to help with variable output from renewables, like solar photovoltaics (PV) and wind, whose availability is not

always well matched with demand. Hydrogen is one of the leading options for storing energy from renewables and looks promising to be a lowest-cost option for storing electricity over days, weeks or even months. Hydrogen and hydrogen-based fuels can transport energy from renewables over long distances from regions with abundant solar and wind resources, such as Nigeria, Australia or Latin America, to energy hungry cities thousands of kilometres away.

Hydrogen can be used much more widely. Today, hydrogen is used mostly in oil refining and for the production of fertilisers. For it to make a significant contribution to clean energy transitions, it also needs to be adopted in sectors where it is almost completely absent at the moment, such as transport, buildings and power generation.

There have been false starts for hydrogen in the past; this time could be different. The recent successes of solar PV, wind, batteries and electric vehicles have shown that policy and technology innovation have the power to build global clean energy industries. With a global energy sector in flux, the versatility of hydrogen is attracting stronger interest from a diverse group of governments and companies. Support is coming from governments that both import and export energy as well as renewable electricity suppliers, industrial gas producers, electricity and gas utilities, automakers, oil and gas companies, major engineering firms, and cities. Investments in hydrogen can help foster new technological and industrial development in economies around the world, creating skilled green jobs particularly for the growing youth population in Nigeria.

2.8 Hydro-Kinetic Energy

This deals with the energy sources from waves and tidal/power which encompasses an array of energy technologies; many of which are in the early stages of development. The difference in the level of ocean water between high tide and low tide results in the ocean tide energy which is renewable. Tidal energy is a form of hydro energy occurring with every tide. The rise and fall of tidal water are maximum near seashore and river mouths (bays), so the choice of hydro-energy situations in the Niger Delta region of Nigeria is economically. The estimated tidal power in the world is about 3000×10^9 MW. Out of this about 1000×10^9 MW is of shallow tides (<2m) and is not favourable for conversion and only about 2000×10^9 is likely to be usefully extracted. Hydro-Kinetic energy is ideal for industrial and domestic uses.

3. Effective Support Feats of Renewable Energy in Nigeria including Niger Delta

Researchers have established that renewable energy is available in Nigeria (Newsom, 2012; Shaabona & Potinrinac, 2014; Nwagbo, 2017). The effectiveness of renewable energy includes the following: availability of waves for potential hydro-kinetic energy productions and the abundant of wind is an added advantage in the Niger Delta considering her geographical location in supporting hydro-kinetic and wind farm. The intensity of the sun is very high and its durations in most part of the year could spine through ten (10) hours of the day (November-April and August) in the Niger Delta, hence supporting solar farm for electricity supply in the Niger Delta. Again, the Niger Delta region is located

within the Tropical Rainforest readily supporting the regular supply of feedstock for the biomass industry (Eli, 2012).

Similarly, revolutionary strategies to increase national sustainable energy production by alternative power supply including biomass waste management and reusing it in systematic form may help to reduce dependability of Nigeria on other fossil fuel consumption. Alternative power supply technology is also a good option of sustainable energy and can be easily implemented in a country like Nigeria (Figure 3).

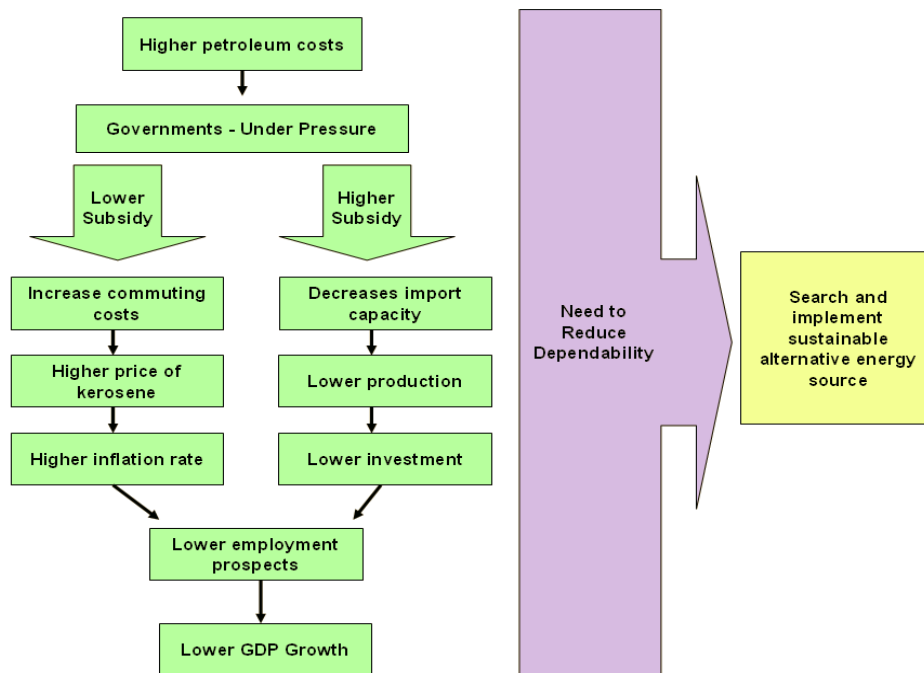


Figure 3. Strategy for Possible Government Stress Reduction

Sources: Adapted from Gauri et al., 2013

4. Barriers to the Development of Renewable Energy in Nigeria

The introduction of renewable energy in generating electricity or providing energy is not new to emerging countries including Nigeria. With the abundance of renewable energy resources, energy crisis should not be experienced, however, this is not the case. The following are barriers to the development of renewable energy in Nigeria:

Lack of an Institutional Framework: The Energy Commission of Nigeria (ECN), Nigeria Atomic Energy Commission (NAEC), Nigerian Nuclear Regulatory Agency (NNRA), Nigerian Electricity Regulatory Commission (NERC), Nuclear Power Plant Operating Organisation (NPP-OO) and National Emergency Management Agency (NEMA), Nigerian Environmental Standard Regulatory Commission (NESREA) etc provide for responsibilities by different agencies in carrying out activities for the development of renewable energy technologies. This is a problem because co-ordination

especially in the exchange of information between government ministries, parastatals and agencies is erratic, uncoordinated, weak and rather complex. The proper harmonisation and synergy of a specific agency robs the sector of a driving force for its growth and development. It is therefore important that an agency is given the mandate to propel the sector.

Lack of Public Awareness: The awareness of the opportunities offered by renewable energies and its related technologies is low among private and public sectors. This lack of information creates a market gap that results in what renewable energy is perceived to be. It is believed that, renewable energy technologies are not yet mature for the Nigerian environment, it is expensive and suited only for the wealthy few. These and many more perceptions need to be corrected and the gap filled with the dissemination of information on renewable energy resources, availability, benefits, opportunities and potentials. Awareness in this respect is paramount to building public confidence and acceptance of these technologies.

Non-Implementation of Existing Policies: The problems or challenges the agencies face are multi-sectoral. They range from Government policies down to community or societal apprehensive of public utilities. Government policies are erratic, lack implementation and uncoordinated. In turn, these result in apparent lack of very reliable database. Also, the several policies on renewable energy are most often not implemented due to lack of political will. A certain degree of policy short sightedness characterizes the implementation of policies of the country as very few concrete actions are taken to build the groundwork for meeting future energy security, as well as economic, social and environmental challenges (Energy Commission of Nigeria and United Nation Development Programme, 2005).

Research and Development Shortfalls: Research and development activities are vital to sustainable socio-economic advancement of any nation. Presently in Nigeria, there are six (6) Renewable Energy Centres having the responsibilities of research into various aspects of renewable energy but they are under-performing (Energy Commission of Nigeria, 2014). It is important that these centres are given adequate attention with regards to key issues such as energy development and utilization. This can be done by initiating and promoting energy related research and development programmes and these programmes must be result oriented and market driven (Organisation of African States, 2015).

Lack of Manpower Development and Training: There is inadequacy in capacity building in the energy sector of the nation's economy. Compared to the population of the country, there are insufficient energy related courses in most tertiary institutions (Energy Commission of Nigeria, 2014). Capacity building is lacking in the following areas viz: training of manpower to install, operate and maintain renewable energy technologies; development of manufacturing capabilities; development of critical mass of scientists, engineers, and economists to design an effective and functional institutional framework. It has become necessary to develop the human capacity needed to meet the manpower requirement of the renewable energy sector of the nation (Efurumibe, 2013).

The Lack of a Legal Framework: There is no law but policies governing renewable energy in Nigeria.

To achieve adequate energy supply where renewable energies play a major role, the creation of an appropriate legal framework is necessary. The lack of a law on renewable energy could affect contractual obligations, property rights, transfer of technology, and fair competitive bidding processes for potential domestic and international investments. A law can ensure certainty and compliance, giving investors a degree of confidence in the government.

5. Conclusion

Energy is imperative for any nation's development and improvement thus for Nigeria to develop they require a relentless increment in the measure of energy they create yearly. However, Nigeria needs to investigate its sustainable power source assets and make great utilization of it in order to upgrade monetary development and furthermore increment in the future of its natives and occupants. As fossil fuel age is expected to span only 1000 years of human civilization (1700-2700) according to Khitoliya (2004); considering the ever-increasing population and fuel consumption rates, and increase in petroleum product prices; the energy starvation is been felt by every developed and less developed country; renewable energy sources remain an alternative energy sources. Switching to renewable energy resources in Nigeria will not only led to positive contributions to rural development, lower health cost, energy independence and climate change mitigation, but will increase the energy capacity and availability in Nigeria; thus, bridging the energy gaps in the rural areas.

Worthy of note is that, renewable energy sources (wind, solar heat, waves, etc) cannot be stored in original natural form, rather converted continuously to electrical form, transmitted, distributed and utilized without long-term intermediate storage, making it available in large quantity and free of cost. Hence, consumption of renewable should be maximised to enhance productivity in the country and save future generation from inherited negative actions laid down by the predecessors. The wide vision behind vitality arrangement must be to meet energy requests dependably with energy which is spotless and moderate, and this must be done in an earth practical way utilizing diverse energizes and types of vitality, regular and non-customary, and in addition new and rising sources to guarantee supplies constantly. It is basic for Nigeria to have a steady energy approach, together with persistent quest for energy proficiency and protection, amplifying coal generation and enhancing the rail and port framework and in addition improvement of elective foundation for coal transportation, for example, waterfront waterways on the grounds that coal, being the least expensive type of vitality, will be the banner carrier of Nigeria's vitality needs. Policymakers should therefore undertake a comprehensive approach to energy decarbonization that aims to rapidly replace fossil fuels with zero-carbon energy resources while improving the economic and social welfare of communities around the globe. Thus far, Governments, senior political figures, policymakers, businesses, CEOs, development partners i.e. non-governmental organizations (Olalekan et al., 2019; Raimi et al., 2019), and others will need to engage in a policy dialogue identifying opportunities and best practices for developing and investing in Africa's energy markets and develop smart and adaptive strategies to ensure a socially just, yet rapid,

energy transition for innovation and investment to rectify the lack of energy in the region. To date, however, most policies focused on energy decarbonization which have failed to take a system-based approach (James et al., 2014). Although there are now several studies and analyses that demonstrate how energy systems could achieve rapid decarbonization (Mark et al., 2015) very few governments have developed comprehensive strategies to change their energy systems (Miller & Jones, 2018).

As a roadmap for the future, key recommendations to help governments, companies and others to seize this chance to enable clean energy to fulfill its long-term potential include.

a) Implement the National Policy on Renewable Energy and Support Research & Development (R&D) to bring down costs. Alongside cost reductions from economies of scale, R&D is crucial to lower costs and improve performance.

b) There should be successful implementation of the country's Renewable Energy Master Plan (REMP) of 2006. This will explore renewable energy in quantities and at prices to promote equitable sustainable growth in the country. By installing enough wind, solar PV, solar thermal and hydroelectricity nationwide.

c) Engage internationally and track progress. Enhanced international co-operation is needed across the board but especially on standards, sharing of good practices and cross border infrastructure. Hydrogen production and other alternative power supply use need to be monitored and reported on a regular basis to keep track of progress towards long-term goals.

d) Develop and implement energy efficiency programmes in different sectors of the economy, as well as public and private buildings and Eliminate unnecessary regulatory barriers and harmonise standards.

e) There should be enabling environment, economically attractive to encourage ready market for renewable energy by re-investing the annual fuel subsidy of 1.4trillion naira gained from the country's fuel subsidy removal to boost renewable energy sector.

f) Promote adaptation of the cleaner production concept in all energy production and consumption activities.

g) Focus on four key opportunities to further increase momentum over the next decade. By building on current policies, infrastructure and skills, these mutually supportive opportunities can help to scale up infrastructure development, enhance investor confidence and lower costs:

- Make the most of existing industrial ports to turn them into hubs for lower-cost, lower-carbon hydrogen and other alternative power supply.
- Use existing gas infrastructure to spur new clean hydrogen supplies and other alternative power supply.
- Support transport fleets, freight and corridors to make fuel-cell vehicles more competitive.
- Establish the first shipping routes to kick-start the international hydrogen trade and other alternative power supply.

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