



Mitigating the Effects of Greenhouse Gas Emissions and Migrating to Sustainable Energy Systems in Nigeria

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Abstract Electricity supply in Nigeria is a serious challenge. This has led to self-generation of power by households, governmental institutions and private businesses. The small and medium-sized generators burn fossil fuels that emit greenhouse gases in no small measure. Most of the licensed power stations in Nigeria (more than 80%) also burn fossil fuels which contribute immensely to these emissions, apart from the ones by the use of these fuels for transportation. This study appraised the emission of the GHG by these sources with a view of suggesting possible ways of mitigating the effects of these emissions. An explorative research method was employed to obtain information from already published statistical data. Deforestation and energy generation was discovered as major culprits in the emission processes which account for 38.2% and 32.6% respectively. Wastes contributed 14% and Agriculture 13%, Industrial Processes 1%. Afforestation (planting of more trees) and transiting to renewables as way of generating power will drastically reduce the emission of GHG and their effects on human health and the environment. A short and long term plans to ban the importation of small generators which burn fossil fuels is also proposed as a way of mitigating the effects of GHG emissions in Nigeria.

Keywords Fossil fuels, Greenhouse gases, Carbon dioxide, Renewable energy

1. Introduction

Adequate power supply is an unavoidable pre-requisite for a nation's development [14]. Electrical energy supply in the country on the other hand is a problem because there is a serious dis-equilibrium between electricity demand and supply in Nigeria. In 2015, the average electrical power supply was about 3.1 GW which was estimated to be about a third of the country's minimum demand. Nigeria is adjudged to be the most underpowered country in the world with power consumption 80% below expectations. These numerous challenges have led to self-generation of power nearing 14 GW [1]. The trend of electricity supply in the country vis-à-vis its indispensability has led to the continued heavy dependence on small scale fossil fuel powered generators in Nigeria by government institutions, businesses and households for electricity supply. Nigeria leads Africa as a generator importer and one of the highest importers worldwide with a total annual import figure put at \$112million (17.9 billion naira). Small scale businesses and households spends an average of \$21.8 billion (3.5 trillion naira) annually to power their generators with diesel and petrol. Nigeria's importer spent 243.6 million dollars on generator imports in 2016 and this is projected to reach 694 million dollars in 2022 [5] & [9]. It is said that generators are too many in Nigeria and the bill to ban small generator imports passed through the second reading in the lower legislative house in Nigeria on 11 March, 2020. The urgent need to generate more electricity and the resultant large reserves and availability of oil and natural gas has led to the increased use of fossil fuels for power generation as most of licensed power stations have favored the installation of gas turbine generators [10]. A reason adjudged for heavy dependence on gas-fired power



generating station is the reduced construction time of gas turbines generators and due to less on-site installations as compared with other types of conventional generating plants like the coal-fired plants [4]. Heavy dependence on oil evidenced when a face-value analysis of the country generating licenses show that 88% of the total generating licenses are for gas-fired power stations, another 4% for coal-fired generation and only 8% for the generation from renewable energy sources comprising mainly of hydropower [4]. This heavy reliance on fossil fuel powered generators in addition to the ones used for transportation constitutes a major threat to the nation's climate change and the world at large. There is a direct correlation between the use of generators and climate change because these generators burn fossil fuels. Most of the power generating stations in Nigeria are thermal sets which also burn fossil fuels. This obviously leads to the release of a lot of green-house gases and pollutants which are undesirable in the atmosphere.

2. Nigeria's Use of Fossil Fuels for Power Generation

2.1 What are fossil fuels?

Fossil fuels are fuels that are formed in the earth from dead plants and animals. They include coal, oil and natural gas. They are generally hydrocarbons. As a result of their high calorific values, they usually burnt to release power. They are primary source of energy and they are finite in nature. Since they are usually obtained naturally from the earth crust, they contain a lot of impurities which may or may not be totally done away with during the mining and refining processes.

When fossil fuels are burnt, they emit a lot of greenhouse gases (GHG). A greenhouse gas absorbs and emits radial energy within the thermal infrared region resulting in a greenhouse effect, a natural process that warms the earth's surface. The primary GHG in the atmosphere include water vapor oxide of carbon, oxides of Nitrogen, methane and ozone. The burning of fossil fuels as energy source had been adjudged to be the leading cause of global warming and atmospheric pollution. The effect of GHG emissions have severe implications which are borne at local, regional, national and global levels.

2.2 Nigeria's Continued Dependence on Fossil Fuels

From the literature reviewed, it has been revealed that in Nigeria, there is heavy dependence on fossil fuels not only for transportation needs but also for electricity generation. The whole world is now deploying in search cleaner and sustainable energy as a result of the consequences of conventional power generation methods. Even though the Nigerian Renewable Energy Master Plan supports harnessing the use of renewable energy sources for electrical power generation, the efforts channeled towards increased electricity generation has not favored the development of renewable energy technologies much. The US energy information administration reported in 2012 that Nigeria depends heavily fossil fuels for electrical power generation. This can be seen as illustrated figure 1 that the trend is on the increase. As a result of the availability of oil and natural gas which are often flared, the Nigerian government policy favored the installation of gas turbines which can utilize this abundant natural gas for electricity generation. Less installation period, quick start and stop features and less ancillary installations are other factors that favored the use of gas turbines in order to urgently meet her electricity needs but this is not without its attendant dire consequences. This scenario has only resulted in a shift from developing clean energy technologies [11]. The US energy information administration reported that in 2012 alone Nigeria consumed 35,000 tons of coal as illustrated in figure 2. There are two main types of power plants in Nigeria. They are (i) the hydroelectric power plants and (ii) the fossil- fueled power plants. The fossil fueled thermal power plants are either coal-fired plant types or the gas-fired plant types. The list of the current 32 power plants, the fuel types and their capacities are shown in table 1.



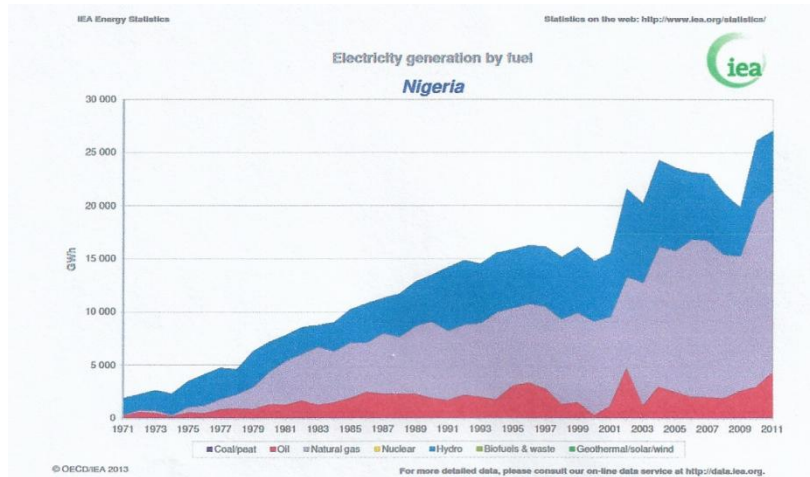


Figure 1: Nigeria’s Electricity Generation by Fuels [12]

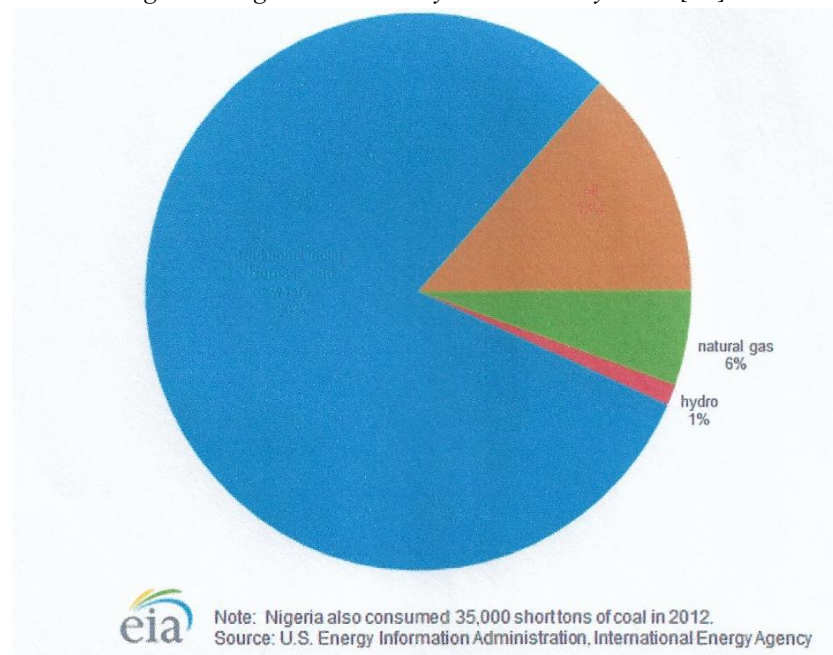


Figure 2: Nigeria’s Consumption of Coal in 2012 [12]

Table 1: List of Power Stations in Nigeria, Fuel Types and Capacities [7]

S. No.	Name	Type	Capacity
1	Kainji Power Station, Niger state	Hydro	800 MW
2	Jebba Power Station, Niger State	Hydro	540 MW
3	Kano Power Station, Kano State	Hydro	100 MW
4	Shiroro Power Station, Niger State	Hydro	600 MW
5	Dadin Kowa Power Station, Gombe State	Hydro	40 MW
6	Azura Power Station, Edo State	Gas turbine	450 MW
7	Itobe Power Station, Kogi State	Circulating Fluidized bed technology	1,200 MW
8	Sapele Power Station, Delta State (NIPP)	Simple cycle gas turbine	450 MW
9	Sapele Power Station,	Gas-fired steam turbine	1,020 MW
10	Transcorp Ughelli Power Station, Delta State	Simple cycle gas turbine	900 MW
11	Ibom Power Station, Ikot Abasi, Akwa Ibom	Combined cycle gas turbine	191 MW
12	Omotosho Power Station (1), Ondo state	Simple cycle gas turbine	336 MW
13	Omotosho Power station (2), Ondo state	Simple cycle gas turbine	450 MW
14	Omoku Power Station (1), Rivers State	Simple cycle gas turbine	150 MW

15	Omoku Power Station (2), Rivers State	Simple cycle gas turbine	225 MW
16	Olorunsogo Power Station (1), Oyo State	Simple cycle gas turbine	336 MW
17	Olorunsogo Power Station (2), Oyo state	Combined cycle gas turbine	675 MW
18	Okpai Power Station, Delta State	Combined cycle gas turbine	480 MW
19	Kulenda Power Plant, Kaduna State	Thermal gas	215 MW
20	Egbema Power Station, Imo State	Simple cycle gas turbine	338 MW
21	Egbin Power Station, Lagos State	Gas fired steam turbine	1,320 MW
22	Geregu Power Station (1), Kogi State	Simple cycle gas turbine	414 MW
23	Geregu Power Station (2), Kogi State	Simple cycle gas turbine	434 MW
24	Ibom Power Station, Akwa Ibom	Simple cycle gas turbine	190 MW
25	Ihovbor Power Station, Edo State	Simple cycle gas turbine	450 MW
26	AES BARGE Power Station	Simple cycle gas turbine	270 MW
27	Aba Power Station, Aba	Simple cycle gas turbine	140 MW
28	Afam Power Station (iv-v), Rivers State	Combined cycle gas turbine	726 MW
29	Afam Power Station (vi), Rivers State	Combined cycle gas turbine	624 MW
30	Alaoji Power Station (NIPP), Abia State	Combined cycle gas turbine	1,074 MW
31	Calabar Power Station (NIPP), Cross Rivers State	Simple cycle gas turbine	561 MW

This list of the available power stations in the country indicates that 86.92% of the plants are powered by fossil fuels while 13.08% of the plants are from the renewable energy source (hydro). Only the Itoke Power Station employed the clean coal technology (the fluidized bed) which represent 6.4% of the available Power Stations.

2.3 The Jeopardy and The Hidden Costs of Fossil Fuels

The real costs of fossil fuels (coal, oil and natural gas) cannot be determined by the pump prize or the market prize of these fuels. They are usually less obvious but their impacts can be very devastating. A few of the hidden costs often referred to as externalities such as air pollution and land degradation may be easily seen while others that are not easily seen may wield serious impacts on human health and the environment. Some life threatening sickness such as asthma, cancer as well rise in the sea level have been linked to the effects of GHG emissions. A few of these externalities include global warming and climate change, atmospheric pollution, acidic rain, water and land pollution and thermal pollution.

Global warming and climate change

Global warming also referred to as climate change is a long term rise in the average temperature of the earth's climate structure. The major cause of the trending global warming has been attributed to the effect of greenhouse effect arising from carbon dioxide emission that result from human activities. Other major culprits in this regards include water vapor, methane, nitrous oxide and chlorofluorocarbons (CFCs). The presence of these gases in the atmosphere contribute immensely to the depletion of the ozone layer. Scientist have predicted that if the current trend of emission continues the globe may become warmer in the next century resulting in serious ecological impacts such as the rise in sea level leading to the inundation of dry lands, river deltas and populated areas. Extreme weather conditions are predicted and agricultural land and activities may suffer as a result.

Atmospheric pollution

The burning of fossil fuels as energy source have been attributed to the emission of harmful substances (pollutants) which are harmful to human health and the environment. A few of such substances include Sulphur dioxide (SO₂), Nitrogen dioxide (NO₂) and particulate matters. The burning of coal results in the emission of SO₂ and particulate matters. SO₂ emission can make worse ailments such as asthma, nasal congestion and pulmonary inflammation. Particulate matters emission can also result in chronic bronchitis as well as aggravate asthma conditions. Emission of NO₂ which is a byproduct of fossil fuel combustion may contribute to the formation of smog. This can also aggravate respiratory conditions such as asthma and bronchitis.



Acidic rain, water and land pollution

An acidic rain is a rainfall or precipitation whose pH is less than 5.6. Sulphur Oxides and Nitrogen Oxides are produced in the combustion process of fossil fuels. These two substances are the important constituents of acidic rainfall. These gases chemically combine with water vapor in the cloud as can be observed in equation (i) – (v), to form Sulphur acid and nitric acid. When rain falls, these become part of the rain and snow. As these acids accumulate, rivers and lakes may become too acidic for plant and animal habitation. Acidic rain can have serious devastating effects on vegetation, buildings and marbles structures.



Thermal Pollution

Most power generation plants, are either coal-fired or gas-fired. Great amount of heat energy is usually generated most of which are released into the cooling tower as waste heat. In steam power plant where the heat is released into rivers or lakes, the aquatic ecosystem is usually upset. When much of this heat is released into the chimneys, it makes the atmosphere uncomfortable [13].

3. Greenhouse Gas Emission in Nigeria

The World Resource Institute Climate Analysis Indicators Tools (WRI CAIT) reported that in 2014, Nigeria's GHG emissions were primarily due to deforestation and energy generation. The emissions arising due to land use change and forestry (deforestation) accounted for 38.2% of the country's total emission while energy generation accounted for 32.6% of the total. Wastes contributed 14%, agriculture 13% and industrial processes 1%. From this parameters, it can be deduced the GHG emission in Nigeria is majorly as a result of deforestation and energy generation.

Nigeria's GHG emission number as at 2014 is 492.44MtCO₂e which is 1.01% of the world's 48,892 MtCO₂e. Nigeria's GDP growth during this period is 245% which is faster than the emission growth of 25%, yet this growth is 1.6 times the world's average as can be seen in figure 4. Deforestation is a major issue in Nigeria. As a result of population growth (85% growth from (1990 – 2014) there is a growing demand for land use for settlement, development and other purposes. Fuel wood extraction and mining purposes are other factor responsible for deforestation. Nigeria's annual deforestation rate according to WRI CAIT is estimated at 4% from 2005 – 2010. Nigeria, however has a plan to strategize, monitor and develop an action plan to stem the tide of deforestation [17].

Nigeria's GHG emissions by the energy sector increased by 32% from 1990 – 2014 due to the combustion of fossil fuels. Nigeria is the second largest exporter of crude oil in Africa and its production of natural gas is expected to double by 2030. As a result of insufficient infrastructure, a very large portion of gas is flared, although this has reduced by 50% over the last decade. Nigeria still remain the world's fifth largest gas flaring nation, even though the country is currently developing project to reduce or eliminate GHG emission from gas flaring by 2080 [17]. Nigeria's Biennial Update Report submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2018 also shows that in 2015 Agriculture, forestry and other land use were major the cause of GHG emissions leading by 66.9% and closely followed by energy which accounted for 28.2% of the total, Waste (3%) and industrial processes (1.9%). These can be seen in figure 3 below: the WRI CAIT data also revealed that Nigeria's GHG emissions increased by 25% (98.22 Mt CO₂ e) from 1990 to 2014. The average annual change in total emissions was 1% as can be seen in the figure 4 below. Nigeria, however have resolved to unconditionally reduce GHG emission by 20% by 2030. To achieve this goal, she has targeted providing 13 GW of electricity to rural communities; ending of gas flaring by 2030; reduction of GHG emission by 45% by 2030, conditioned upon the receipt of support from international communities. [17]. Some effects of GHG emission already being experienced in Nigeria include adverse weather conditions, loss of farmlands flooding and inexplicable health condition by medical practitioners.



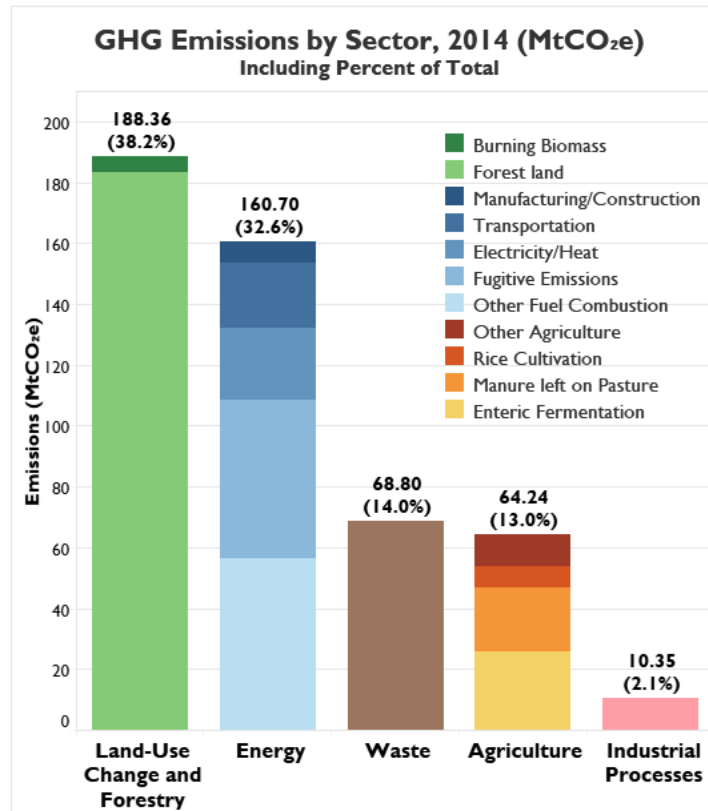


Figure 3: GHG Emission by Sector in Nigeria (2014) [17]

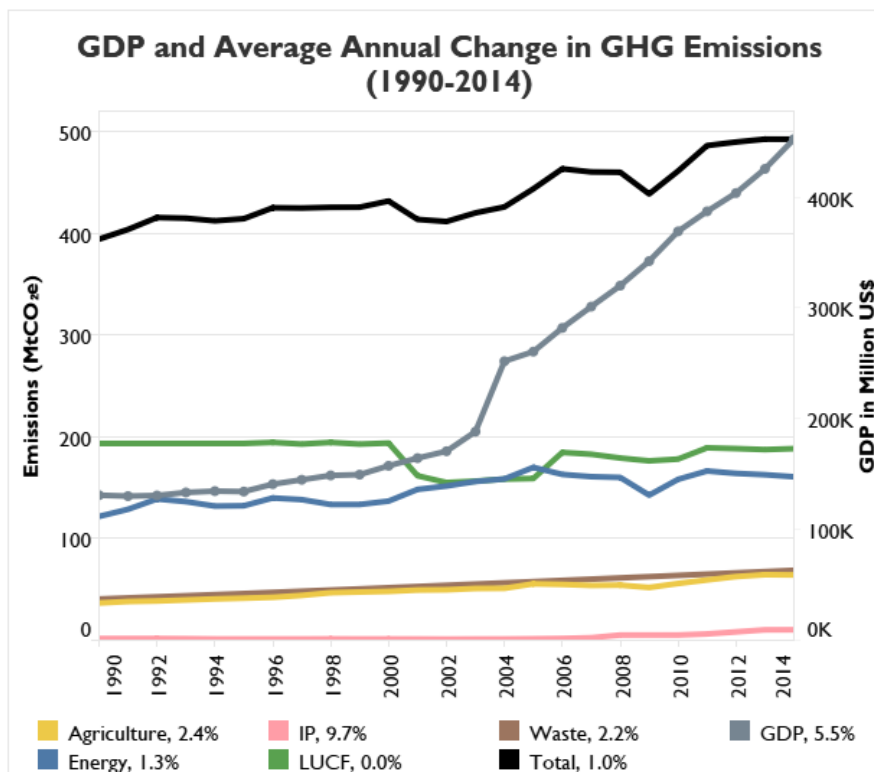


Figure 4: GDP and Annual Change in GHG Emission (1990-2014) [17]

4. Developing Sustainable Energy Systems

The sure way to mitigate GHG emissions and transform to sustainable energy systems is to adopt measures that will reduce the release of these emissions as well as develop sustainable clean energy technologies that are capable of supplying energy and power without interruption.

Sustainable energy is energy that meets the need of the present generations without compromising the ability of future generations to meet their own needs. Sustainable energy is about finding clean renewable sources of energy which are infinite in nature. According to the World Commission on Environment and Development [18], the importance of sustainability in energy is:

- (i) The ability to preserve its use
- (ii) The contribution of energy in living standard of the people and in economic development and;
- (iii) The significant impact that energy systems and processes have had and continue to have on the environment [18].

Sustainable energy has proved to be an important tool, be it from whatever source, in all countries, developed and developing for their sustainable development [16]. Energy sustainability is a major concern and topic all over the world. Energy sustainability involves the sustainable use of energy in the overall energy system which includes processes and technologies for harnessing of energy resources, their conversion to useful energy forms energy transport and storage and the utilization of energy to provide energy service like lighting in homes, offices, streets and cooking [10]. Sustainability energy is aimed at providing affordable, accessible and reliable energy services that meet the economic social and environmental needs within the overall developmental context of the society for which the services are intended while recognizing equitable distribution in meeting those needs. [12]. Where sustainable development is lacking in the energy sector of any nation, this will result in energy poverty whereby the citizenry of the country will lack power to meet their basic needs such as lighting and cooking and this may also lead to the collapse of the industrial sector.

To develop sustainable energy sector therefore, the energy policy has to be considered in the light of energy policy and demand in the world and other constraints such as environmental pollution control requirements, trained manpower and so on. It should be directed towards:

- (a) Reduction in energy consumption especially in industrialized countries.
- (b) Energy conservation in all sectors of economy.
- (c) Full integration of renewable energy sources into global energy supplies system [2].

Renewable energy technologies are emerging as a fast- growing alternative to conventional energy sources which have contributed adversely to climate change. [16].

There is a significant potential for power generation from renewable energy sources in Nigeria. Nigerian Renewable energy reserves is revealed as follows; Large hydropower (11,250mw), small hydropower (≤ 30 mw) (3,500mw) solar radiation (3.5 – 7.0kwh/m²/day), Wind (2-4m/s at 10m height); Biomass (fuel wood – 11million hectares of forest and woodland; municipal wastes – 30 million tonnes/year; Animal waste – 245 million assorted animals in 2001; Energy crops and Agric Residue – 72 million hectares of Agric Land) [8].

Owing to the fact that the national grid covers only 40% of the country's populace [3]. This implies 60% of the entire populace of about 180 million are in the dark without electricity supply, electricity generation through renewable energy sources promotion should be one of the priorities of the Nigerian Government. Electricity generation through renewable energy sources can offer a number of benefits for Nigeria, especially taking into account the high potential for biomass and the opportunities it can offer to rural development. Solar energy can rescue urban dwellers as well as time of emergency and provide succor from the National grid which is bedeviled by frequent collapse due to lack of development. Renewable Energy Systems are non-depletable and non-polluting. Renewable electricity generation can therefore complement the large thermal power plants and hydro power plant currently in use in Nigeria.

5. Conclusion

1. There should be a clear climate change policy in the country.
2. Nigeria should clearly spell out her emission control strategies and regulations and enforce it. For instance, Relevant government agencies should ensure that motor vehicles pass emission control tests



before they are certified road worthy. Industrial sites and their equipment should also pass the emission test before they are allowed to operate.

3. Urban development program in Nigeria should include provisions for tree planting in streets and residential areas in order to reduce the effects of GHG emissions.
4. Developing renewable energy technologies and deploying renewable energy sources for power generation can mitigate carbon emissions which is a major contributor to climate change. This will consequently transform the conventional unsustainable power generation mode to a clean and sustainable energy systems.
5. Research and development in the renewable energy sector is at the embryonic stage in Nigeria. There is need to intensify effort in the development of Renewable Energy technologies (RETs)
6. There should be a short term plan and a long term plan to outlaw the use of small generators in Nigeria.
7. Just like India who have achieved a feat in electrifying the New Delhi airport through the use of renewable energy for 24 hours a day, Nigeria should target the electrification of rural communities, schools, hospitals, financial institutions etc, as a way of reducing dependence on small and medium sized generators that burn fossil fuels,

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