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THE ROLE OF CLIMATE IN SUSTAINABLE ENERGY DEVELOPMENT IN NIGERIA

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ABSTRACT

The climate of the world is changing and evidence of its variability abounds. This includes steady increase in temperature, erratic precipitation patterns and increasing incidence of weather related disasters. These have consequences on water resources and energy development. This paper examines the role of climate on sustainable energy development in Nigeria with the specific objective of assessing the extent of climatic influence on energy development. The result of the study have shown that nearly all energy sources are directly or indirectly dependant or influenced by aspects of climate especially the renewable sources. Secondary data were used in the analysis and discussions. Conclusively, climate and its variability and change are identified to significantly influence energy development in a number of ways. Recommendations include continuous monitoring of changes in the climatic and energy variables to ensure sustainable energy development.

Keywords: climate, Temperature, Precipitation, Sustainable energy development

INTRODUCTION

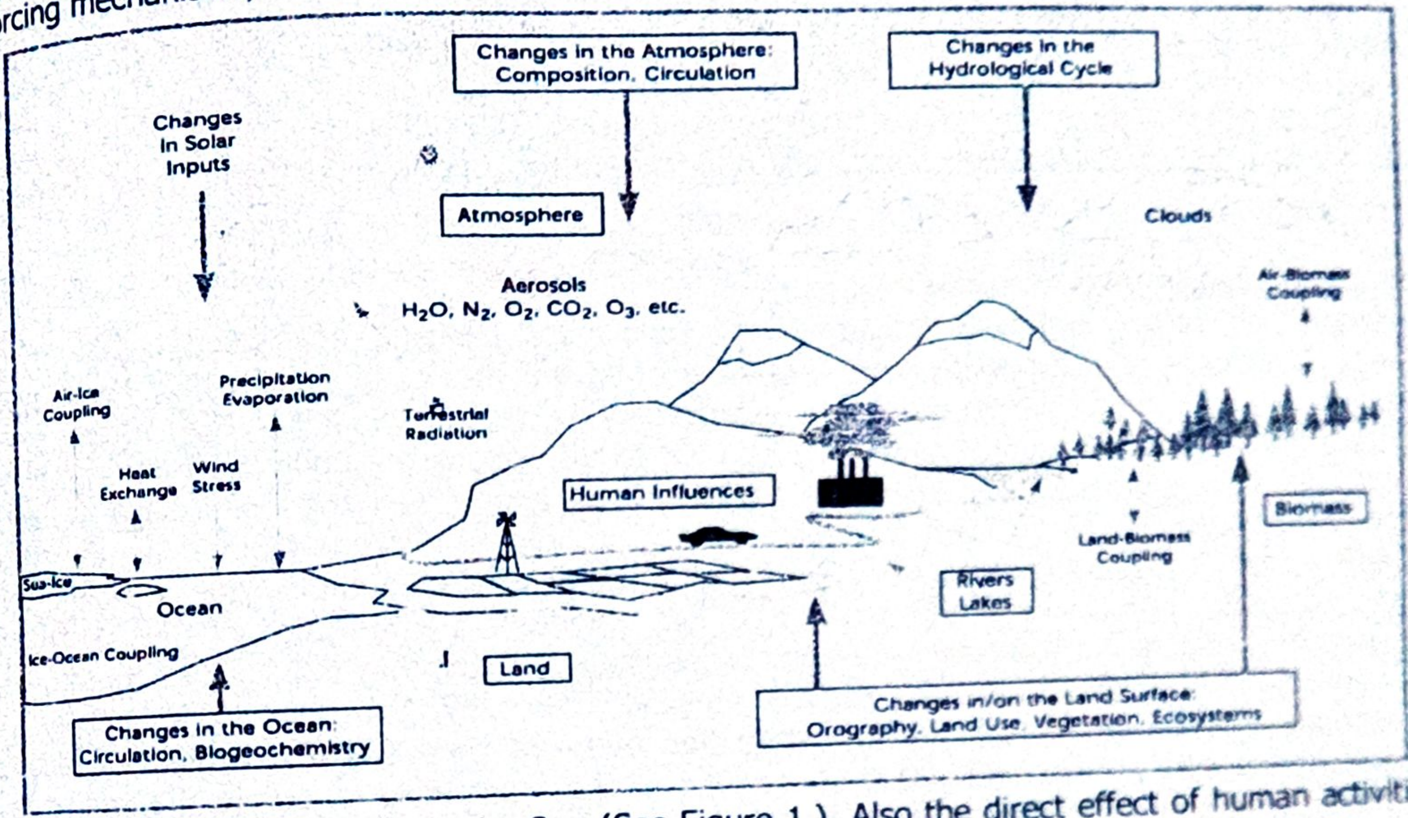
Weather and climate have a profound influence on life on Earth. They are part of the daily experience of human beings and are essential for health, food production, energy development and well-being. Many consider the prospect of human-induced climate change as a matter of concern. The IPCC (1996) presented scientific evidence that human activities may already be influencing the climate. If one wishes to understand, detect and eventually predict the human influence on climate, one need to understand the system that determines the climate of the Earth and of the processes that lead to climate change.

The weather, as we experience it, is the fluctuating state of the atmosphere around us, characterized by the temperature, wind, precipitation, clouds and other weather elements. This weather is the result of rapidly developing and decaying weather systems such as mid-latitude low and high pressure systems with their associated frontal zones, showers and tropical cyclones. Climate refers to the average weather in terms of the mean and its variability over a certain time-span and a certain area. Classical climatology provides a classification and description of the various climate regimes found on Earth. Climate varies from place to place, depending on latitude, distance to the sea, vegetation, presence or absence of mountains or other geographical factors. Climate varies also in time; from season to season, year to year, decade to decade or on much longer time-scales, such as the Ice Ages. Statistically significant variations of the mean state of the climate or of its variability, typically persisting for decades or longer, are referred to as "climate change".

Climate variations and change, caused by external forcing, may be partly predictable, particularly on the larger, continental and global, spatial scales. Because human activities, such as the emission of greenhouse gases or land-use change, do result in external forcing, it is believed that the large-scale aspects of human-induced climate change are also partly predictable. However the ability to actually do so is limited because we cannot accurately predict population change, economic change, technological development, and other relevant characteristics of future human activity. In practice, therefore, one has to rely on carefully constructed scenarios of human behaviour and determine climate projections on the basis of such scenarios.

The Climate System

The climate system is an interactive system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere, forced or influenced by various external forcing mechanisms,



the most important of which is the Sun (See Figure 1.). Also the direct effect of human activities on the climate system is considered an external forcing.

Figure 2.1: Schematic Overview of the Components of the Global Climate System
Source: Adapted from IPCC (1996).

The Concept of Energy and Energy Resources

Energy defined as the ability to do work comes in different forms; Heat (thermal), light (Radiant), motion (kinetic), Electrical, chemical, nuclear energy and gravitational. There are two types of energy – stored (potential) energy and working (kinetic) energy. For example, the food we eat contains energy and your body stores this until you use it via work or play. When we use electricity in our home, the electric power was probably generated by burning coal, by a nuclear reaction, or by a hydroelectric plant at a dam. Therefore, coals, nuclear and hydro are called energy sources. When you fill up a gas tank, the source might be petroleum or ethanol made by growing and processing corn.

Energy sources are divided into two groups – renewable (an energy source that can be easily replenished) and non-renewable (an energy source we are using up and cannot recreate). Renewable and non-renewable energy sources can be used to produce secondary energy sources including electricity and hydrogen. Renewal energy is energy generated from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). A non-renewable energy resource is a natural resource which cannot be produced, regrown, regenerated, or reused on a scale which can sustain its consumption rate. These resources often exist in a fixed amount, or are consumed much faster than nature can recreate them. fossil fuel

(such as coal, petroleum and natural gas) and nuclear power are examples. In contrast, resources such as timber (when harvested sustainably) or metals (which can be recycled) are considered renewable resources. They are fossil fuels like gas oil and coal.
Natural resources such as coal, petroleum, oil and natural gas take thousands of years to form naturally and cannot be replaced as fast as they are being consumed. Eventually natural resources will become too costly to harvest and humanity will need to find other sources of energy. At present, the main energy sources used by humans are non-renewable as they are cheap to produce. Abundant and economical energy is the life blood of modern civilizations. Coals, nuclear and hydro are used primarily to make electricity. Natural gas is widely used for heating. Biomass, which usually means wood or dried dung, is used for heating and cooking. The red sliver is wind and solar power, primarily. The red sliver may be small, but it is the future because wind and solar power are sustainable.

Climate and Energy Development
The impact of climate and weather on energy supply and demand have received increasing attention in recent years, especially since a number of severe winters in the northern hemisphere middle latitudes have highlighted mankind's vulnerability to climatic variability. Cold winters have increased the demand for energy and have also led to disruptions of supply. At the same time, interest has been growing with regard to future energy supply and the possibilities of using renewable sources of energy, especially solar energy, instead of nonrenewable, especially fossil fuel, resources. The renewable energy sources tend to be dependent upon climatic elements such as solar radiation, wind, rainfall and cloudiness. This emphasis is a reflection of the fact that a considerable proportion of the energy demand in industrialized countries is for space conditioning and this demand tends to be more climate sensitive than, say, the demand for energy for transportation. McKay and Allsopp (1980) state that over one-third of the energy consumed in industrialized North America and about 50 percent of that consumed in Europe (Denmark and Great Britain) is used to overcome the direct or indirect consequences of climate. To him climate dictates the potential supply of renewable energy sources.

It is suggested that **solar energy** systems are most promising between 35 °N and 35 °S. Significant hydropower and biomass production also occur in this zone. Ocean thermal energy is most obtainable in the tropical latitudes, wave energy in ice-free waters, and wind energy is readily available in most latitudes. There is a variety of technologies for the conversion of **solar energy**. These range from solar collectors on house roofs for space and water heating to solar power plants, with large arrays of mirrors concentrating solar energy to heat water and drive turbines to produce electricity. To some extent the type of solar energy conversion system installed in an area depends on the prevailing climate. Solar thermal electric conversion systems based on the `power tower' concept convert only direct solar radiation. Therefore, they are more suited to the dry desert climate regions, where the proportion of direct radiation is high, than to the cloudier middle latitudes, where the proportion of direct radiation is much smaller, especially in the winter months. The use of solar energy for domestic space and water heating depends on a number of climatic factors. Not only does the solar energy collection depend on climatic variables, but the heat losses in a house are also climatically sensitive. Information on microclimatic conditions (shading, sheltering, etc.) as well as on the macroclimate is necessary for the design of a solar-heated house.

The impact of climate on **wind energy** resources has also been considered. The distribution of wind energy varies markedly in space and time and knowledge of these distributions is necessary so that the selection and sitting of wind energy conversion systems can be effective. Hannele Holttinen (2006) listed the meteorological properties needed for wind energy conversion system studies as areas of smoothly accelerated or enhanced winds, locations of flow separation zones, mean hourly wind velocity distributions, characteristics of local turbulence and gusts, occurrences of extreme winds and calms, vertical profiles of wind velocity as a function of atmospheric stability, frequency of severe thunderstorms, lightning, hail, icing, tornados, or hurricanes, presence of salt spray or blowing dust.

Biomass is another renewable energy source that is influenced by climate. The overall prospects for the development of the use of biomass as a source of energy in Europe have been evaluated by Palz and Chartier (1980). They point out that the main climatic factors controlling plant growth in Europe are temperature and the length of the growing season, expressed as periods above 5 °C or numbers of frost-free days, and these factors rather than total solar energy received determine the units of productivity.

The impact of climate on **hydropower** supplies has been discussed by McKay and Allsopp (1980) on a quantitative basis. They point out that storage must be provided to overcome climatic variability. The resource potential is greatly diminished in drought and increased in wet periods.

Oil powers almost all machines that move and that makes oil uniquely versatile. Oil powered airplanes that carry 500 people across the widest oceans at nearly the speed of sound. Oil powered machines produce and transport food. In North America there are many more seats in oil powered vehicles than there are people. Oil powered machines are everywhere. Clearly, we live in the age of oil, but the age of oil is drawing to a close.

As a responsible world citizen we should start looking for alternate energy solutions like solar energy and wind energy. Employing these alternate power solutions is extremely feasible and cost-effective. You will not only cut down your power bills but also contribute to a better future of the world. In response to the petroleum crisis, the principles of green energy and sustainable living movements gain popularity. This has led to increasing interest in alternate power/fuel research such as fuel cell technology, liquid nitrogen economy, hydrogen fuel, methanol, biodiesel, solar energy, geothermal energy, tidal energy, wave power, and wind energy, and fusion power. To date, only hydroelectricity and nuclear power have been significant alternatives to fossil fuel..

Challenges of Renewable Energy use

A criticism of some renewable sources is their variable nature. But renewable power sources can actually be integrated into the grid system quite well.

Availability and Reliability. There is no shortage of solar-derived energy on Earth. Indeed the storages and flows of energy on the planet are very large relative to human needs. The ultimate source of energy is the sun. Its energy is found in all things, including fossil fuels. Plants depend on the sun to make food, animals eat the plants, and both ended up becoming the key ingredients for fossil fuels. Without the sun, nothing on this planet would exist. The sun also provides enough energy that can be stored for use long after the sun sets and even during extended cloudy periods. But making it available is much easier said than done. It would be cost prohibitive to make solar energy mainstream for major world consumption in the near future. The technology is pretty much ready for many business and consumer applications, but it would be way too expensive to replace the current energy infrastructure used for fossil fuel energy.

Because the wind blows during stormy conditions when the sun does not shine and the sun often shines on calm days with little wind, combining wind and solar can go a long way toward meeting demand, especially when geothermal provides a steady base and hydroelectric can be called on to fill in the gaps (Mark, 2009).

Aesthetics. Both solar and wind generating stations have been criticized from an aesthetic point of view. However, methods and opportunities exist to deploy these renewable technologies efficiently and unobtrusively: fixed solar collectors can double as noise barriers along highways, and extensive roadway, parking lot, and roof-top area is currently available; amorphous photovoltaic cells can also be used to tint windows and produce energy. Advocates of renewable energy also argue that current infrastructure is less aesthetically pleasing than alternatives, but sited further from the view of most critics.

Land area required. One environmental issue, particularly with biomass and biofuels, is the large amount of land required to harvest energy, which otherwise could be used for other purposes or left as undeveloped land. However, it should be pointed out that these fuels may reduce the need for harvesting non-renewable energy sources, such as vast strip-mined areas and Slag Mountains for coal, safety zones around nuclear plants, and hundreds of square kilometers being strip-mined for oil sands. These responses, however, do not account for the extremely high biodiversity and endemism of land used for ethanol crops, particularly sugar cane.

Longevity issues. Though a source of renewable energy may last for billions of years, renewable energy infrastructure, like hydroelectric dams, will not last forever, and must be removed and replaced at some point. Events like the shifting of riverbeds, or changing weather patterns could potentially alter or even halt the function of hydroelectric dams; lowering the amount of time they are available to generate electricity.

Some have claimed that geothermal being a renewable energy source depends on the rate of extraction being slow enough such that depletion does not occur. If depletion does occur, the temperature can regenerate if given a long period of non-use. It should be stressed that the geothermal resource is not strictly renewable in the same sense as the hydro resource. Radioactive elements in the Earth's crust continuously decay, replenishing the heat. The International Energy Agency classifies geothermal power as renewable.

Diversification. Although most of today's electricity comes from large, central-station power plants, new technologies offer a range of options for generating electricity nearer to where it is needed, saving on the cost of transmitting and distributing power and improving the overall efficiency and reliability of the system.

Energy use and Climate Change

While the Earth's climate has always changed naturally, for the first time human activity is now a major force affecting the process, with potentially drastic consequences. Huge volumes of fossil fuels in the form of gasoline, oil, coal and natural gas are used every day, releasing carbon dioxide. This, together with other emissions generated by human activity, such as methane and nitrous oxide, accentuate the natural 'greenhouse effect' that makes the Earth habitable. Carbon dioxide is the most important anthropogenic greenhouse gas, with annual emissions growing 80 per cent in 1970–2000 (IPCC, 1990).

Energy use and supply is of fundamental importance to society and with the possible exception of agriculture and forestry has made the greatest impact on the environment of any human activity – a result of the large scale and pervasive nature of energy related activities. Although energy and environmental concerns were originally local in the character; for example, problem associated with extraction, transport or noxious emissions – they have now widened to cover regional and global issues such as acid rain and the green house effect.

Climate and Energy Crisis in Nigeria

Nigeria is an energy resource rich country blessed with both fossil such as crude oil, natural gas, coal, and renewable energy resources like solar, wind, biomass, biogas, etc. Similarly, Nigeria is also human resource rich with a total population of 140 million by the 2006 population census, and an annual population growth rate of about 3 percent.

Resource	Reserve	Reserves (billion toe)
Fuel wood	43.3 Million tones	1.6645 (over 100 years)
Animal Wastes & Crop Resid	144 Million tones/Year	3.024 (over 100 years)
Small Scale Hydro Power	734.2 MW	0.143 (over 100 years)
Solar Radiation Wind	1.0 KW per m2 land area (pe	-
Wind	2.0 – 4.0 m/s	-

Nigeria's Energy Scene

The National energy supply is at present almost entirely dependent on fossil fuels and firewood (conventional energy sources) which are depleting fast. According to Chendo (2001) recent estimates indicated that the reserve for crude oil stood at about 23 billion barrels in 1998, natural Gas 4293 billion m3 at the beginning of 1999, made up of 53% associated gas and 47% non associated gas. Coal and lignite stood at 2.7billion tones, tar sands at 31 billion barrels of oil equivalent and large scale hydropower at 10,000MW.

Tables 1 and 2 show various conventional and non-conventional energy sources and their estimated reserves in Nigeria.

Table 1: Nigeria's Conventional Energy Resources

Resources	Reserve	Resources in Energy (billion toe)	% Total conventi Energy
Crude	23 billion barrels	3.128	21.0
Natural Gas	4293 billion m3	3.679	24.8
Coal & Lignit	2.7 billion tones	1.882	12.7
Tar Sands	31 billion barrels of oil equi	4.216	28.4
Hydropower	10, 000 MW	1.954 (100 years)	13.1
Total	**Conventional/Commerci Energy Resources**	**14.859**	**100%**

Source: (Chendo, 2001)

Note:

Toe = Tones of oil Equivalent

100m3 of Natural Gas = 0.857 toe

100 kWhr = (0.223 toe)

1 barrel of Oil = 0.136 tones of oil

1 Tonne of coal = 0.697

Table 2: Nigeria's Non Conventional Energy Resources

Source: Chendo,(2001)

Note:

1000 kWhr (primary energy) = 0.223 toe, 1 Tonne of Fuelwood = 0.38 toe

1 Tonne of Agric waste = 0.28 toe, 1 Tonne of Drug Cakes = 0-.21

Energy Supply Mix in Nigeria

The 1995 distribution of energy consumption (Figure 2), typifies the current energy supply mix in the country. It shows that of the total energy consumption, the share of natural gas was 5.22%, hydroelectricity took 3.05%, fuelwood had the lion share of 50.45% and petroleum products had 41.28% share. This further confirms the fact that presently, renewable-energy use in the country is split essentially between hydroelectricity and traditional fuel wood (Akinbami, 2001).

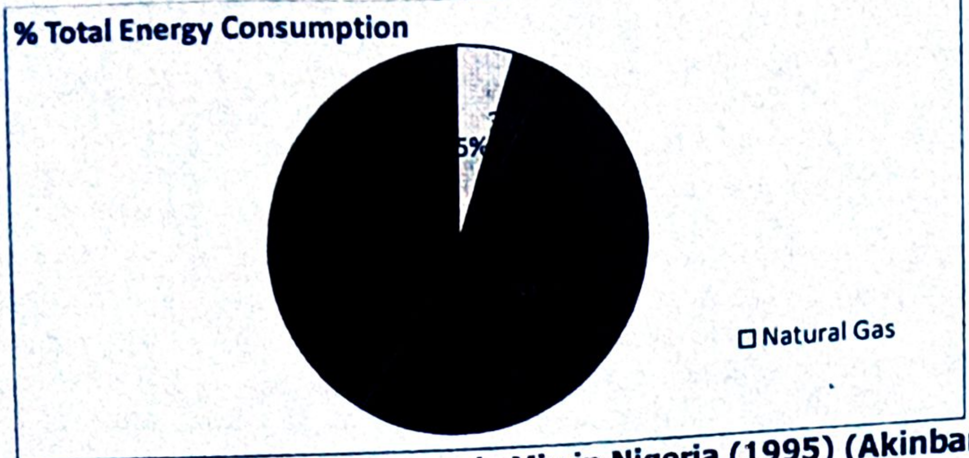


Figure 2: Typical Energy supply Mix in Nigeria (1995) (Akinbami, 2001)

Renewable Energy Potentials

Small Scaled Hydro Power

Aliyu and Elegba (1990) indicated that the country is, at least, reasonably endowed with large rivers and some few natural falls. The total technically exploitable hydropower potential based on the country's river system is conservatively estimated to be about 10,000 MW of which only 19% is currently being tapped or developed. Deserving more attention in Nigeria than hitherto, therefore, is the potential contribution of distributed small hydro schemes for dispersed energy needs of scattered rural communities (Aliyu and Elegba, 1990).

Table 3: Classification of various Hydro Schemes (Largely Applicable to Nigeria and other Developing countries)

Scale of Hydro Scheme	Capacity Range (MW)
Large	> 100
Medium	50 – 100
Intermediate	10 -50
Small	1 -10
Mini	0.5 – 1
Micro	< 0.5

Source: Aliyu and Elegba, (1990)

Wind Energy Potentials

Globally, Nigeria is located within low to moderate wind energy zone. Ojosu and Salawu (1989) carried out the most comprehensive nationwide study on wind energy availability and potential in Nigeria. The study uses Data on Wind speeds and directions for 22 Meteorological Stations from the Nigerian Meteorological office, Oshodi near Lagos. The meteorological data are based on the 3-hourly records of wind for periods ranging from 12 to 33 years (1951 – 1983)

The insolvents at 10 m heights are drawn and four different wind zones/regimes are identified. The wind energy potential for wind energy utilization in Nigeria is broadly appraised. Ojosu and Salawu, (1990) estimated the maximum energy obtainable from a 25m diameter wind turbine with an efficiency of 30% at 25m height to be about 97 MWh year-1 for Sokoto, a site in the high wind speed regions, 50 MWh year-1 for Kano, 25.7 MWh year-1 for Lagos and 24.5 MWh year-1 from Port Harcourt.

Solar Energy Resources in Nigeria

According to Bala et al (2000), Nigeria is endowed with an annual average daily sunshine of 6.25 hours, ranging between about 3.5 hours at the coastal areas and 9.0 hours at the far northern boundary. Similarly, it has an annual average daily solar radiation of about 5.25 $KW/m^2/day$, varying between about 3.5 kWm^2/day at the coastal area and 7.0$kW/m^2/day$ at the northern boundary.

Nigeria receives about 4.851x 1012 KWh of energy per day from the sun. This is equivalent to about 1.082 million tones of oil Equivalent (mtoe) per day, and is about 4 thousand times the current daily crude oil reduction, and about 13 thousand times that of natural gas daily production based on energy unit. This huge energy resource from the sun is available for about 26% only of the day. The country is also characterized with some cold and dusty atmosphere during the harmattan, in its northern part, for a period of about four months (November-February) annually. The dust has an attenuating effect on the solar radiation intensity (Bala, et al, 2001).

Based on the land area of 924,000 for the country and an average of 5.535 kWh/m^2/day, Nigeria has an average of 1.804 x 1015 kWh of incident solar energy annually. This annual solar energy insolation value is about 27 times the nation total conventional energy resources in energy units and is over 117,000 times the amount of electric power generated in the county in 1998 as depicted in Table 8 (Chendo, 2002.)

In other words, about 3.7% only of the national land area is needed to be utilized in order to annual collect from the sun an amount of energy equal to the nation's conventional energy reserve.

Biomass

The biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal as waste arising from forestry, agricultural, municipal and industrial activities, as well as, Aquatic biomass. The biomass resources of the nation have been estimated to be about 8 x 10^2 M.J. Plant biomass can be utilized as fuel for small-scale industries. It could also be fermented by anaerobic bacteria to produce a very versatile and cheap Fuel Gas i.e. biogas (Garba and Bashir, 2002).

Biogas Energy Resources

Akinbami et al (2001)'s assessment indicated that in Nigeria, identified feedstock substrate for an economically feasible biogas programme includes water lettuce, water hyacinth, dung, cassava leave, urban refuse, solid (including industrial waste, agricultural residues and sewage).

Tables 5 and 6 present the various agricultural and livestock resources and their associated residues as the potential substrates for biogas production in the country.

Akinbami et al (2001)'s views include the following; Nigeria produces about 227,500 tons of fresh animal wastes daily. Since 1 kilogram (kg) of fresh animal wastes produces about 0.03 m3 gas, then Nigeria can produce about 6.8 million m3 of biogas every day. In addition to all these, 20kg of municipal solid wastes (MSW) per capital has been estimated to be generated I the country annually. By the 1991 census figure of 88.5 million inhabitants, the total generated MSW will be at least 1.77 million tones every year. With increasing urbanization and industrialization, the annual MSW generated will continue to increase. Biogas production may therefore be a profitable means of reducing or even eliminating the menace and nuisance of urban wastes in many cities by recycling them.

Table 4: Agricultural Resources and residues in Nigeria for 1992

Resources	Production (10	Residue (10^3 tc	GJ
Industrial wood + fuel	214250	85700	80.5580
Wood + charcoal	-	-	-
Cereals	12403	16124	207540
Roots and tubers	41602	16641	106502
Sugarcane	-	-	3.097
Cotton	276	358.8	6.387
Coconut	135	175.5	2246
Coffee (Green)	3	3.9	50

Source: (Akinbami et al, 2001)

Table 5: Livestock Resources and Residues in Nigeria in 1992

Resources	Stock (10^3 head)	Residue (GJ)
Cattle	15, 700	32342
Sheep and Goats	37, 500	15375

Source: (Akinbami et al, 2001)

Presently, biogas is not in the national energy equation. However this not to say that already a few units of biogas digesters are not in use both in the urban and rural segments of the country for various activities.

Other Resources

Presently, the potentials of some the resources like geothermal, waves, tidal and ocean thermal gradients still remain unqualified (Garba and Bashir, 2002).

1. **National Policy Position on Renewable Energy Development**

Iloeje (2002) identified the key elements in the national policy position on the development and application of renewable energy and its technologies as follows:

- To develop, promote and hardness the Renewable Energy resources of the country and incorporate all viable ones the national energy mix
- To promote decentralized energy supply, especially in rural areas, based on RE resources
- To de-emphasize and discourage the use of wood as fuel
- To promote efficient methods in the use biomass energy resources
- To keep abreast of international developments in RE technologies and applications.

Barriers to Renewable Energy and Priorities for Action

The key barriers to Renewable Energy in Nigeria have been identified by Akinbami (2001). These are as follows:

i. Technological Incapability – With the exception of solar, thermal and biogas technologies, no other Renewable Energy Technologies (RET) has been developed in Nigeria. Most of the technologies have to be imported, thereby further escalating the already high investment cost;

ii. High cost of Energy Infrastructure – Small scale hydro power, central and residential solar PV technologies, etc have not penetrated the Nigeria's energy supply systems because of their relatively high investment costs. This barrier has also been found to be the major obstacle to widespread adoption of family- sized biogas digesters in the country.

iii. Financial Constraints – there is limited public funds available for the deployment of RETs. In the absence of any serious private sector involvement in the development and the dissemination of the technologies, this posed a serious barrier to the RETs;

iv. Low Level of Public Awareness – public awareness of renewable energy sources and technologies in Nigeria and their benefits, both economically and environmentally are generally low. Consequently, the public is not well-equipped to influence the government to begin to take more decisive initiatives in enhancing the development, application, dissemination and diffusion of renewable energy resources and technologies in the national energy market; and,

v. General absence of comprehensive national energy policy – Nigeria has never formulated a comprehensive energy policy; only sub-sectoral policies have formulated. Since such a policy is pivotal to using energy efficient and RETs, this has to large extent contributed to the lack of attention for the RETs.

Priorities for Action

i. That an energy policy which emphasis the development of renewable energy resources and technologies should immediately be put in place (note: Nigeria now has a published energy policy. The policy did emphasize the development Renewable Energy).

ii. Since the lack of access to affordable, clean and convenient energy is inextricably linked to poverty, it is recommended that a resource survey and assessment be carried out to determine the total renewable energy potential in the country as well as identify local conditions and local priorities in various ecological zones.

iii. The development of renewable energy services is linked to many other sectors such as agriculture, small scale industrial enterprises and poverty alleviation, it is recommended that, renewable energy related projects have a greater likelihood of success if implemented in tandem with activities in these sectors to ensure sufficient demand for the energy services providers.

iv. Recognizing that current flow of information on renewable energy technologies is inadequate, it is recommended that demonstration projects on various energy forms be Status of Renewable Energy in Nigeria established widely so that the performance and efficiency with which services are delivered can be sensitized.

v. In order to ensure an orderly development of renewable energy technologies and to assure quality of products, it is also recommended that a testing and standards laboratory for RETs similar to the one in South Africa be established in Nigeria.

vi. As RET applications in the developing countries are attracting increased interest and financial support from the donor community, it is recommended that the Government of Nigeria develop agreements, guarantees and financial instruments that specifically target RETs and stimulate market to attract investments. In this regard, development of market supporting framework will remain the primary conditions for the country's ability to attract foreign capital.

vii. In view of the vital importance of RETs to kick start rural industrialization and the need for harnessing and channeling multilateral and bilateral funds to that purpose, it is recommended that a renewable energy funding/financing agency like India's IREDA (Indian Renewable Energy Agency) be established.

viii. That activities such as entrepreneurship and managerial skills development training programmes and technical courses in RETs with a view of developing Energy Service Companies (ESCOs) providing services to rural areas be introduced.

ix. The need for capacity building both at institutional and personnel level for acquiring technical, organizational, and managerial skills required for increased development of renewable energy.

x. The concerned agencies to help commercialize proven indigenous renewable energy technologies and promote local production of RE equipments, devices and components through investment promotion strategies and fiscal incentives.

CONCLUSIONS

Climate effects on energy supply and demand will depend not only on climatic factors, but also on patterns of economic growth, land use, population growth and distribution, technological change and social and cultural trends that shape individual and institutional actions. No single solution can meet our society's future energy needs. The solution instead will come from a family of diverse energy technologies that share a common thread - they do not deplete our natural resources or destroy our environment. Energy and climate policies must plan for a world with a smaller carbon footprint, as well as for each nation's economic path. Scores of measures are under discussion, such as compensation for countries that forgo forest clearance, tax incentives for low-emission technologies, the use of nuclear power and the development of new energy sources.

Tackling the immense and multidimensional challenge of climate change demands extraordinary ingenuity and cooperation. A "climate-smart" world is possible in our time. Yet, as argued in World Development Report, 2010, effecting such a transformation requires us to **act now, act together, and act differently**. Whatever actions are taken, the IPCC says that all the scenarios for climate stabilisation indicate that 60–80 per cent of reductions in emissions will come from energy supply and use, and industrial processes, with energy efficiency playing a key role in many scenarios.

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