

An Expository on Energy with Emphasis on the Viability of Renewable Energy Sources and Resources in Nigeria: Prospects, Challenges, and Recommendations.

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ABSTRACT

Nigeria as of today generates less than 4000MW of electricity but has the capability of increasing her generation through different renewable energy sources considering unharnessed potentials in the country. This write-up summarizes the renewable energy potentials in Nigeria, its present status and investment opportunities. Nigeria is endowed with so many resources both human and natural; the need to harness these resources in serving the human needs is paramount.

Renewable energy remains the cleanest, most reliable and inexhaustible energy type and Nigeria is blessed with almost all types of renewable energy resources. Some of the most readily available renewable energy resources are solar power, wind power, and small hydropower. For example, Nigeria had the potentials of over 277 dispersed small hydro sites capable of generating electric power of about 734.2MW out of which only 30MW has been harnessed in 2005, and the potential as at today is estimated to reach 3,500MW. This of course is good enough to attract any serious investors considering the overwhelming population of the country as well as the high demands of electricity in all the surrounding villages of the said potential small hydro sites. Although there are few challenges in the sector, but one important assertion is that, the profit margin in renewable energy in Nigeria cannot be overemphasized and investment in this sector will be highly rewarding.

(Keywords: renewable energy potential, solar power, wind power, small hydropower)

INTRODUCTION

Energy demand in the pre - industrial world was provided mostly by man and animal power and to a limited extent from the burning of wood for heating, cooking and smelting of metals. The discovery of abundant coal, and the concurrent technological advances in its use, pro-pelled the industrial revolution. The discovery of abundant coal, and the concurrent technological advances in its use, pro-pelled the industrial revolution. Steam engines, mechanized production and improved trans-portion, all fuelled directly by coal. The inter-war years saw the rise of oil exploration and use. Access to this critical fuel became a key issue during the Second World War.

Post-war industrial expansion and prosperity was increasingly driven by oil, as was the massive growth in private car use. More recently a new phase of economic growth has been underpinned to a great extent by natural gas. A substantial proportion of coal and gas production is used to generate electricity, which has been widely available now for over a century. Electricity is a premium form of energy due to its flexibility and ease of distribution. Demand worldwide is growing, driven by the explosion in consumer electronics, the associated industrial activity and the widening of access to consumers in the developing world.

The world demand for oil and gas is increasing significantly each year. The major part of this increase is currently taken up by India and China where industrialization and the demand for consumer products is escalating at an unprecedented pace. China alone accounted for roughly 40% of this increase. The IEA forecasts that by 2030 demand for energy will be some 60% more than it is now.

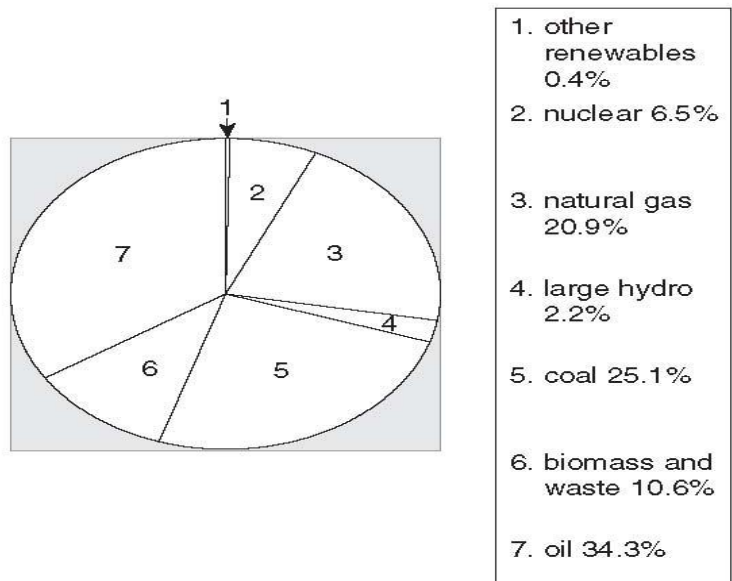


Figure 1: Percentage Contribution to World Primary Energy.

POWER AND ENERGY

Power and energy are two terms that are often misused. Energy can be thought of as the ability to do work, and it has units such as joules or Btu. Power, on the other hand, is the rate at which energy is generated or used, and therefore it has rate units such as joules/s or Btu/h.

In general, energy is the ability of a system to cause exterior impacts, for instance a force across a distance. Input or output of work changes the energy content of a body.

Energy exists in many different forms such as:

- 1) Mechanical energy
- 2) Potential energy
- 3) Kinetic energy
- 4) Thermal energy
- 5) Magnetic energy
- 6) Electrical energy
- 7) Radiation energy
- 8) Nuclear energy
- 9) Chemical energy.

Conversion of Energy Forms

A large number of energy conversion processes take place in nature. Man is capable of performing a number of additional energy conversion processes by means of various devices invented during the history of man.

Figure 2 shows the ways in which various types of energy can be converted into electricity (electrical energy).

Power stations convert primary energy sources such as coal, gas or uranium into useful electricity. Conventional power stations produce large amounts of waste heat, which is emitted into the environment. They convert only a fraction of the energy stored in coal, gas or uranium into electricity and the majority is 'lost'.

The efficiency, η , describes the conversion quality and is given by:

$$\text{efficiency } \eta = \frac{\text{profitable energy}}{\text{Expended energy}}$$

The average thermal power station around the world has an efficiency of around 34 per cent. Two thirds of the expended energy disappears as waste heat. This means that only one third remains as electricity.

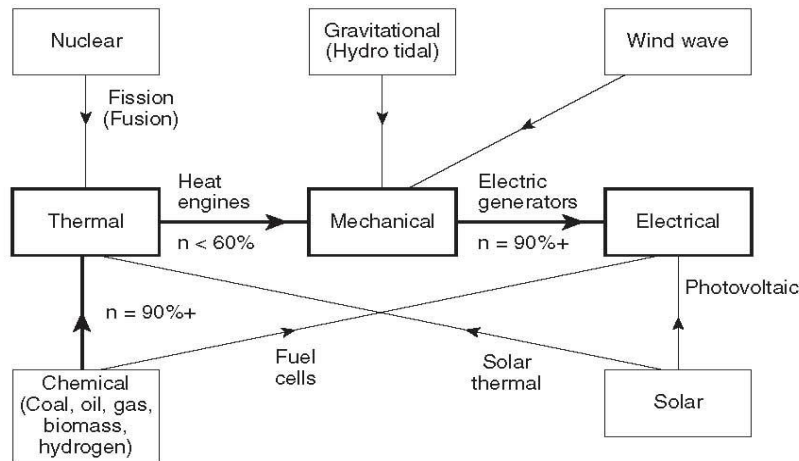


Figure 2: Conversion from a Variety of Energy Forms into Electricity.

Energy Terminologies

According to Max Planck, energy is defined as the ability of a system to cause external action. In this respect the following forms of energy are distinguished: mechanical energy (i.e., potential or kinetic energy), thermal, electric and chemical energy, nuclear energy and solar energy.

In practical energy appliances, the ability to perform work becomes visible by force, heat and light. In the world of energy technology, energy is often regarded as a commodity to be bought and sold in the market place. Energy is also viewed as a resource which provides the basis of life and wealth on our planet, but it is not unlimited. Energy may be regarded as a multiplying factor that greatly enhances man's ability to fashion resource materials into useful products and provide a wide variety of essential services

In the realm of Political and Social activity, energy is regarded as a strategic material and hence a factor in political confrontation.

A) Energy carrier - is a substance that could be used to produce useful energy, either directly or by one or several conversion processes.

Energy carriers are classified as:

- 1) Primary
- 2) Secondary energy carriers and

3) Final energy carriers.

1. *Primary energy carriers* -are substances which have not yet undergone any technical conversion (e.g., hard coal, lignite, crude oil, natural gas, forest wood, etc.)
2. *Secondary energy carriers* - are energy carriers that are produced from primary or other secondary energy carriers, either directly or by one or several technical conversion processes (e.g., gasoline, heating oil, rapeseed oil, electrical energy, etc.).
3. *Final energy carrier and final energy* - respectively are energy streams directly consumed by the final user (e.g. light fuel oil inside the oil tank of the house owner, wood chips in front of the combustion oven, district heating at the building substation). They are available for the conversion into useful energy. They result from secondary and possibly from primary energy carriers, or energies, minus conversion and distribution losses, self-consumption of the conversion system and non-energetic consumption.

B) Useful energy - refers to the energy available to the consumer after the last conversion step to satisfy the respective requirements or energy demands (e.g., space heating, food preparation, information, transportation).

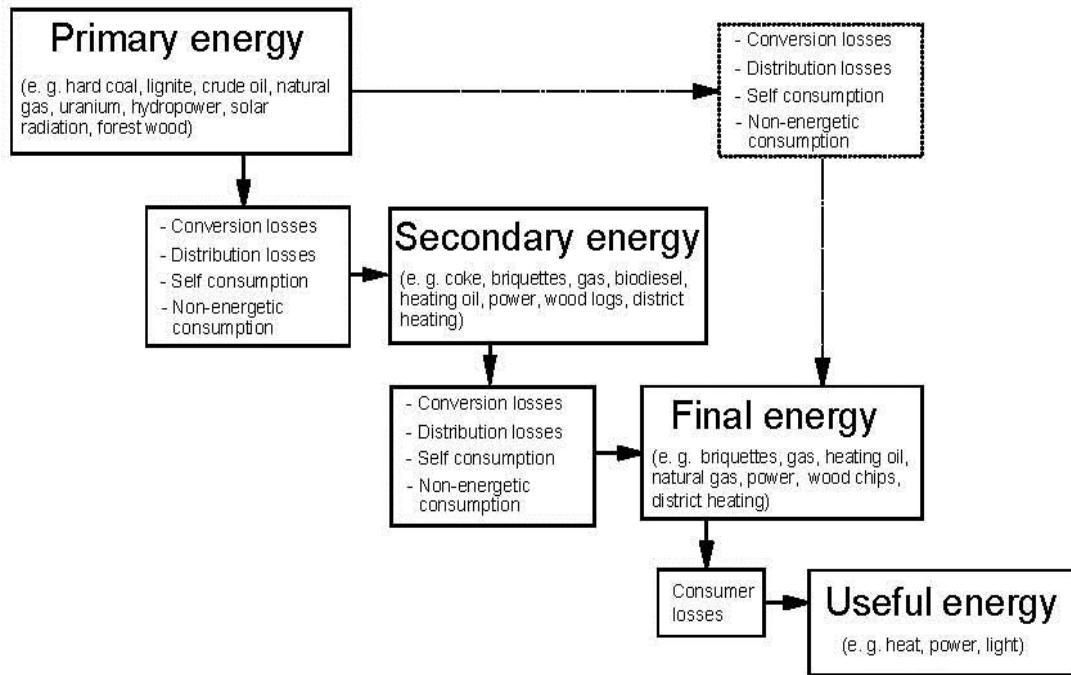


Figure 3: Energy Conversion Chain.

It is produced from final energy carrier or final energy, reduced by losses of this last conversion (e.g., losses due to heat dissipation by a light bulb to generate light, losses of wood chip fired stove to provide heat).

C) Fossil Energy Resources - are stocks of energy that have formed during ancient geologic ages by biologic and/or geologic processes.

- 1) Fossil biogenous energy resources - are stocks of energy carrier of biological origin (e.g., hard coal, natural gas and crude oil deposits, etc.)
- 2) Fossil mineral energy resources - are stocks of energy carrier of mineral origin or non-biological origin (e.g., energy contents of uranium deposits and resources to be used for nuclear fusion processes).

D) Recent resources - are energy resources that are currently generated, for instance, by biological processes. e.g., the energy

contents of biomass and the potential energy of a natural reservoir.

E) Energy sources - by contrast, provide energy streams over a long period of time; they are thus regarded as almost "inexhaustible" in terms of human (time) dimensions. But these energy flows are released by natural and technically uncontrollable processes from exhaustible fossil energy resources (like fusion process within the sun).

Even if such processes take place within very long time periods – and are thus unlimited in human (time) dimensions – they are nevertheless exhaustible (e.g. burn-out of the sun sometime in the future). All sources of energy may be grouped into two general categories:

1. Income Energy

This energy source actually includes all possible sources that provide energy to the earth from outer space e.g. electromagnetic, gravitational, and particle energy from stars, planets, and the moon as well as the potential energy of meteorites entering the earth's atmosphere.

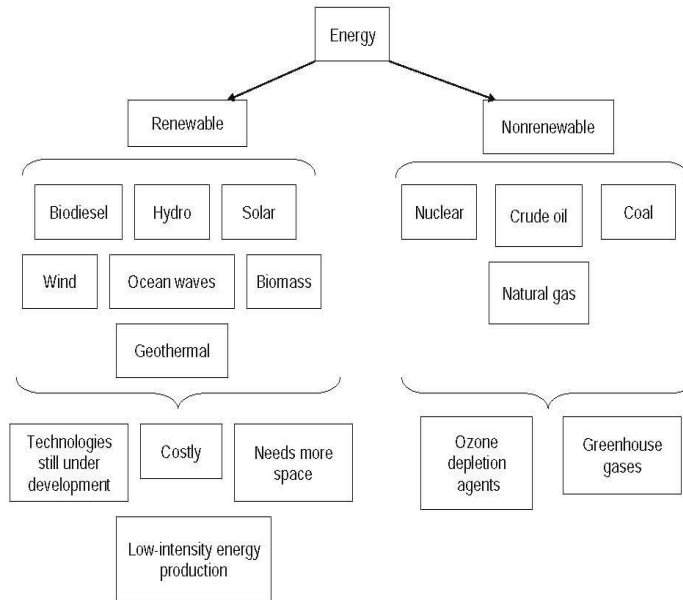


Figure 4: Various Forms of Energy - Renewable and Non-Renewable.

The only useful income energy sources are the electromagnetic energy from the Earth's sun, called direct solar energy, and the gravitational energy of the earth's moon which produces tidal flows.

2. Capital Energy

This is the energy that already exists on or within the earth. Capital energy sources include fossil fuels, geothermal energy and nuclear energy. Presently, the major source of the world's fuel energy is a capital energy source called fossil fuel.

F) Renewable energy - refers to primary energies that are regarded as in-exhaustible in terms of human (time) dimensions. They are continuously generated by the energy sources solar energy, geothermal energy and tidal energy. The energy produced within the sun is responsible for a multitude of other renewable energies (such as wind and hydropower) as well as renewable energy carriers (such as solid or liquid biofuels).

Energy Utilization Rate

Energy can be utilized but not consumed. It is a law of nature that energy is conserved. Instead of consuming it, we degrade or randomize energy.

All energy we use is degraded into heat and eventually radiated out into space.

The consumable is not energy; the consumable is the fact that energy has not yet been randomized. The degree of randomization of energy is measured by the entropy of the energy. Human use of energy, particularly capital energy, has accelerated over time due to an increase in the human population and the discovery of new technologies for utilizing energy.

This acceleration took on exponential proportions during the Industrial Revolution of the nineteenth and twentieth centuries.

In early times, man was totally non-technological, not even using fire. He used energy only as food, probably at a rate somewhat below the modern average of 2000 kilocalories per day, equivalent to 100W. Later, with the discovery of fire and an improved diet involving cooked foods, the energy utilization rate may have risen to some 300 W/capita.

In the primitive agricultural or Mesopotamia, around 4000 B.C., energy derived from animals was used for several purposes, especially for transportation and for pumping water in irrigation projects. Solar energy was employed for drying cereals and building materials such as bricks. Per

capita energy utilization may have been as high as 800 W.

There is a reasonable correlation between the total energy utilization rate of a country and its corresponding annual gross national product. One driving force behind the increasing worldwide per capita energy utilization was the low cost of oil before 1973 when the price of oil was substantially lower than what it is currently.

Technological innovation has resulted in more efficient use of energy. Examples of this include better insulation in houses and better mileage in cars. Alternate energy sources have, in a small measure, alleviated the demand on fossil fuels. Such is the case of using ethanol from sugar cane for the propulsion of automobiles.

NIGERIA ENERGY RESOURCE ENDOWMENT

Nigeria is richly blessed with primary energy resources. The country is endowed with the world's tenth largest reserves of crude oil currently

estimated to be about 36 billion barrels (about 4.896 billion tonnes of oil equivalent (toe)) in 2006. The country has also been described as more of a natural gas island than oil with an estimated endowment at about 166 trillion standard cubic feet (5,210 billion cubic meters). This includes associated and non-associated reserves, placing Nigeria among the top ten countries with the largest gas reserves in the World.

Other significant primary energy resource endowment in Nigeria include:

Tar sands – ~ 31 billion barrels oil equivalent (4.216 billion toe);

Coal and Lignite – estimated to be ~ 2.7 billion tonnes (1.882 billion toe);

Large Hydropower Potentials ~ 10,000 MW;

Small Hydropower Potentials, provisionally estimated to be ~ 734 MW.

Table 1: Nigeria's Energy Resources

| Resource Type | Reserves | Reserves (BTOE) ⁽¹⁾ |
|-------------------------|-------------------------------------|--------------------------------|
| Crude Oil | 36.0 billion barrels | 4.896 |
| Natural Gas | 166 Trillion SCF ⁽²⁾ | 4.465 |
| Coal & Lignite | 2.7 billion tonnes | 1.882 |
| Tar Sands | 31 billion barrel of Oil equivalent | 4.216 |
| Sub-Total Fossil | | 15.459 |
| Hydropower, Large Scale | 10,000 MW | |
| Hydropower, Small Scale | 734 MW | |
| Fuelwood | 13,071,464 Hectares ⁽³⁾ | |
| Animal Waste | 61 million tonnes/yr | |
| Crop Residue | 8.3 million tonnes/yr | |
| Solar Radiation | 3.5 – 7.0 KWh/m ² -day | |
| Wind | 2 – 4 m/s (annual average) | |

RENEWABLE ENERGY SOURCES IN NIGERIA

Society in general has become aware about the conservation of resources and protection of environment. The awareness has come after a great loss to the environment in the form of global warming, acid rain and ozone depletion etc. The environmental degradation cannot be dealt with in isolation. It has close relation with energy obviously the clean energy, green energy.

In Nigeria and all over the world, more and more people are using renewable energy:

- As it is a very good way of safeguarding our environment
- They are less harmful than other kinds of energy sources such as coal, oil and gas (fossil fuels)
- Fossil fuels are limited in nature and they produce harmful greenhouse gases resulting in global warming
- They also produce oxides of nitrogen and sulfur that cause acid rain and various diseases

Nigeria is blessed with a variety of RE resources ranging from wind, solar, hydro to biomass. These resources are well distributed throughout the country. The technologies for harnessing some of these resources have been developed or domesticated.

The viability of RE Technologies as option for meeting small isolated energy supply needs, have been proven. A number of R& D works on new and renewable energy sources are in progress in the nation's renewable energy research centers. There's a small but growing RE market.

The Energy Commission of Nigeria has a few technology-driven pilot projects on:

- Solar PVs,
- Two wind power demonstration projects located in Sokoto,
- A small hydro plant that has been operating in Jos for several years

Vast opportunities for small hydro remain untouched. Recently several state governments have embarked on solar projects for rural water supply, residential lighting and lighting of clinics, schools and community centers.

Table 2: Renewable Sources of Energy Available in Nigeria.

| Resource | Reserve Estimate | Comments |
|-------------------|--|--|
| Small Scale Hydro | 734.2 MW | In the 7 River Basins |
| Solar | 3.5 – 7.0 kWh/m ² -day | High: 39.4 btoe in 0.1% of area; Crude – 4.3 btoe. Annual averaging increasing from South to North |
| Fuel wood | 13,071,464 ha (forest and woodland) [1981] | 15.4% of Area; Depl. At 350,000 ha/yr |
| Animal Waste | Usage: 61x10 ⁶ ton/yr | Estimate |
| Crop Residue | Usage: 83x10 ⁶ ton/yr | Estimate |

A. Solar Energy

Sun is the prime source of energy. Sun daily spreads an enormous amount of energy; out of which our mother earth receives a very small fraction. Even that small fraction is so much that is sufficient to meet all our demands.

The energy that is directly received through the solar radiation can be classified as

- Solar Photovoltaic
- Solar Thermal

1. Solar Photovoltaic

The photovoltaic cells are used to turn sunlight directly into electricity. They were originally developed for use in space program and have powered nearly every man made satellite sent into the orbit.

These days many equipment are using solar energy in this way and so many buildings are being equipped with arrays of PV cells for meeting their electricity demand. Though the PV's efficiency is very low and the cost is high because of the problem of very high requirements of purity of material but, the PV method of solar energy conversion is very much

suitable for decentralized small uses like remote village electrification etc. The PV cells are modular in nature, having long effective life, with no moving parts and no pollution.

2. Solar thermal

This is another way of harnessing the solar energy. In this method sunray's heat energy is used either for air, water heating or for the production of electricity. In the latter case some parabolic dish concentrates the rays or other deflectors to some fluid like oil and this stored heat is converted to electricity by turbines.

In this method the sunrays are passed through some glass cover, which has the property of allowing sun's short wave radiation and entrapping the heat of long wave radiation.

Thus the temperature inside a collector can be increased to a very high level that can be used for heating air or water for conversion into electricity or solar cooking, solar drying, solar water heating or space heating for comfort in buildings.

Nigeria lies within a high sunshine belt and the country solar radiation is fairly well distributed. The annual average of total solar radiation varies

from about $12.6\text{MJ/m}^2\text{-day}$ in the coastal latitudes to about $25.2\text{MJ/m}^2\text{-day}$ in the far north.

The availability of the solar energy resource in Nigeria has fully indicated its viability for practical use. It has been confirmed that Nigeria receives 5.08×10^{12} kWh of energy per day from the sun. For example, if solar energy appliances with just 5% efficiency are used to cover only 1% of the country's surface area then 2.54×10^6 MWh of electrical energy can be obtained from solar energy. This amount of electrical energy is equivalent to 4.66 million barrels of oil per day.

Figure 5 shows some of the pilot projects on the application of Solar Energy in Nigeria.

A. Wind Energy

Since long time windmills are used to mill wheat and pump water. Modern windmills are called wind turbines. They transform the energy in the wind into mechanical power, which can then be used to produce electricity. Wind turbines can be used singly or in clusters called wind farms and are usually about 60 m high. For the economical harnessing of wind power a wind velocity of about 7 m/sec. is required which is the major limitation of this system.



Solar PV for Telecommunication
20km Kaduna-Abuja Road



Solar PV at Ilaje, Ondo State of Nigeria

- Solar PV installations is growing (\cong 1MW total dispersed installations country wide – water pumping, street lighting, vaccine refrigerators, community lighting.)



Solar PV mini-grid in a village in Sokoto, Sokoto State



Solar Street Lighting in Uyo, Cross River State



Solar Water Pumping for Students in Sokoto, Sokoto State



Solar PV at Itu.Mbuzo, Abia State

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Pilot Water Heater at UDUTH by SERC, Sokoto



2-tonne Solar Rice Dryer at Adarice Co. Enugu built by NCERD

- Solar water heaters and dryers are now being developed in our Research Centres. However, their use is not yet wide.

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Figure 5: Some Pilot Projects on the Application of Solar Energy in Nigeria.

Seasonal and locational variations in the energy received from the sun affect the strength and direction of the wind. Due to the varying topography and roughness of the country, large differences may exist within the same locality. Hence within a few kilometers, the wind speed may vary. The values range from a low 1.4 to 3.0m/s in the Southern areas and 4.0 to 5.12m/s in the extreme North. Peak wind speeds generally occur between April and August for most sites

Initial study has shown that total actual exploitable wind energy reserve at 10m height, may vary from 8 MWh/Yr in Yola to 51 MWh/Yr in the mountain areas of Jos Plateau and it is as high as 97 MWh/yr in Sokoto.



Figure 6: 5 kW Wind Power for Village Electrification, Sayya Gidan Gada, Sokoto State Built by SERC.

C. HYDROPOWER

Hydropower generation is a conventional renewable energy resource utilization method that is most environmental friendly but the problem of rehabilitation is typical. Hydropower is derived from the potential energy available from water due to the height difference between its storage level and the tail water to which it is discharged.

Power is generated by mechanical conversion of the energy into electricity through a turbine, at a usually high efficiency rate. Depending on the volume of water discharged and height of fall, hydropower can be large or small. Although there may not be an international consensus on the definition of small hydropower, an upper limit of 30MW can be considered for small hydropower.

Nigeria is endowed with abundant water resources. Hydropower is one of the major sources of base load electricity generation. Despite its high initial capital cost, hydropower provides one of the cheapest and cleanest sources of electricity. The country is well endowed with large rivers and some few natural falls which

are together responsible for the high hydropower potential.

Many dams were constructed and operated by the Government of Nigeria. Examples of these large hydropower dams are the Kainji(760MW), Jebba (640MW) and Shiroro power stations (600MW) which supply about 30% of the installed commercial electric power capacity.

The total technically exploitable large scale hydropower potential of the country is estimated at over 10,000MW, capable of producing 36,000GWh of electricity annually. Only about one-fifth of this potential had been developed. The small scale hydropower potential is estimated at 734MW. Current hydropower generation is about 14% of the nation's hydropower potential and represents about 30% of the total installed grid-connected electricity generation capacity.

Some existing Small hydropower stations are shown in Table 3. Also some potential SHP sites for development are shown in the Table 4.

| S/N | Location | State | Installed Capacity [kW] | Current Status |
|-----|---------------------|---------|-------------------------|---|
| 1 | Kwall Falls | Plateau | 6,000 | IPP (Operational) |
| 2 | Kurra Falls | Plateau | 19,000 | IPP (Operational) |
| 3 | Bakalori | Sokoto | 3,000 | Dam construction - Completed. Electro-mechanical equipment - Never installed. |
| 4 | Tiga | Kano | 6,000 | Dam construction - Completed. Electro-mechanical equipment - Never installed. |
| 5 | Ikere Gorge, Iseyin | Oyo | 6,000 | Dam construction - Completed. Electro-mechanical equipment - Never installed. |
| 6 | Oyan | Ogun | 9,000 | Dam construction - Completed. Electro-mechanical equipment - Never installed. |
| 7 | Waya Dam | Bauchi | 150 | Completed 2006 (Technical assistance from UNIDO) |

| | | | | |
|--------------|--------------------|--------|---------------|--|
| 8 | Ezioha-Mgbowo Dam | Enugu | 30 | completed 2006 (Technical assistance from UNIDO) |
| 9 | Challawa Gorge Dam | Kano | 7,000 | Dam construction - Completed. Electro-mechanical equipment - Never installed. |
| 10 | Gurara Dam | Niger | 30 | IPP – under construction |
| 11. | Tunga Dam | Taraba | 400 | Under construction – Electromechanical systems on site (Technical assistance from UNIDO) |
| Total | | | 56,610 | |

Table 3: Existing Small Hydropower Stations in Nigeria.

POTENTIAL SHP SITES FOR DEVELOPMENT

| S/NO. | RIVER BASIN/ STATE GOVT. | DAM SITE | TOWN | LGA | HEIGHT (m) | DISCHARGE m ³ /Sec. | STAGE |
|-------|-----------------------------|--------------------------|-------------|-------------|---------------|-----------------------------------|-----------------|
| 1. | KATSINA | JIBIA | JIBIA | JIBIA | 18.0 | 290-400 | Pre-Feasibility |
| 2. | " | FAJINA | AJIWA | | 12.5 | 400-500 | " |
| 3. | " | M/FASHI | M/FASHI | M/FASHI | 12.0 | 320-553 | " |
| 4. | " | MAIRUWA | FUNTUA | FUNTUA | 8.0 | 350-550 | " |
| 5. | " | GWAIGWAYE | FUNTUA | FUNTUA | 12.0 | 600-900 | " |
| 6. | " | ZOBE | DUTSINMA | | 19.8 | 600-900 | " |
| 7. | " | SABKE | MAPADUA | | 12.5 | 250-350 | " |
| 8. | OGUN-OSHUN | IDDO | IDDO | ORIADE | 15.0 | 2,699 | Investors Forum |
| 9. | " | SEPETERI | SEPETERI | SHAKI EAST | 14.23 | 1,984 | " |
| 10. | " | OKE-ADAN | | YEWA SOUTH | 16.0 | 2,245 | " |
| 11. | " | ERIN-IJESHA WATERFALL | ERIN-IJESHA | ORIADE | 230.0 | 0,910 | " |
| 12. | BENIN-OWENA | | UGONOBA | UHUNMWODE | 10.0 | 8.09 | " |
| 13. | " | OWENA | OWENA | BOLORUNDURO | 22.5 | 7.79 | " |
| 14. | " | ELE | ITAPAJI | IKOLE | 22.5 | 11.87 | " |
| 15. | UPPER-BENUE | JADA | JADA | | | | " |
| 16. | " | MONKIM | ZING | ZING | 18.0 | 3.71 | " |
| 17. | " | KIRI | NUMAN | | 22.0 | 6.0 | " |

Table 4: Potential Small Hydropower Sites.

D. ENERGY FROM BIOMASS

Trees and other vegetation convert the sun's energy directly into the useful biomass. The biomass can be converted into biogas or bio-liquid (bio-diesel) and used as a source of energy. Using the wood and other agriculture waste directly by burning is the most inefficient way of energy conversion.

By converting it into biogas at least 25% more energy can be obtained along with the benefit of useful natural organic manure.

Biomass is derived from the carbonaceous waste of various natural and human activities and is obtained from numerous sources including the

household waste, does not add CO₂ to the atmosphere because it absorbs the same amount of carbon in growing as it releases when consumed as a fuel.

Conversion of Biomass: Unlike other renewable energy systems that require costly advanced technology, biomass can generate electricity with the same equipment/ power plant that are burning fossil fuels at present.

In the biological conversion method biomass is converted into biogas by anaerobic decomposition method. The raw material may be cattle dung or the organic part of the municipal solid waste.

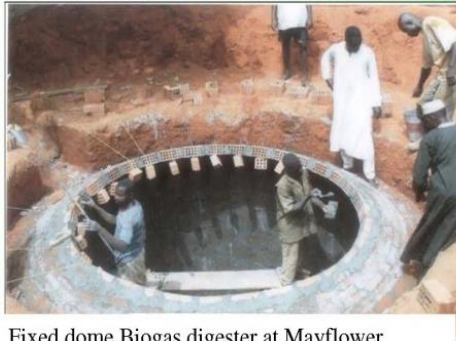
The biomass resources in Nigeria consist of;

- wood,
- forage grasses and shrubs,
- animal wastes arising from forestry, agricultural, municipal and industrial activities as well as aquatic biomass.

The primary way to utilize biomass is through direct combustion. The total land available in Nigeria for agriculture and under vegetation is a measure of biomass potential. Plant biomass can be used as fuel in:

- thermal power plants or converted to produce solid briquette, which can then be utilized as fuel for small scale industries.

- Biogas digesters of various designs are capable of sustaining household, industrial and institutional energy needs.
- Biofuels can also be derived from biomass and biowaste (e.g., manure, crop residue).
- These are used to produce power, heat, steam and fuel through a variety of processes.
- These fuels are used mainly to power vehicles and industrial machines and provide heating.
- Biofuel is renewable and its use has expanded throughout the globe with Brazil, US, France, Sweden and Germany emerging the leaders in biofuel development.



Fixed dome Biogas digester at Mayflower Secondary School, Ikenne, Ogun state



Figure 7: Sample of Household Biogas Digester – NCERD/.

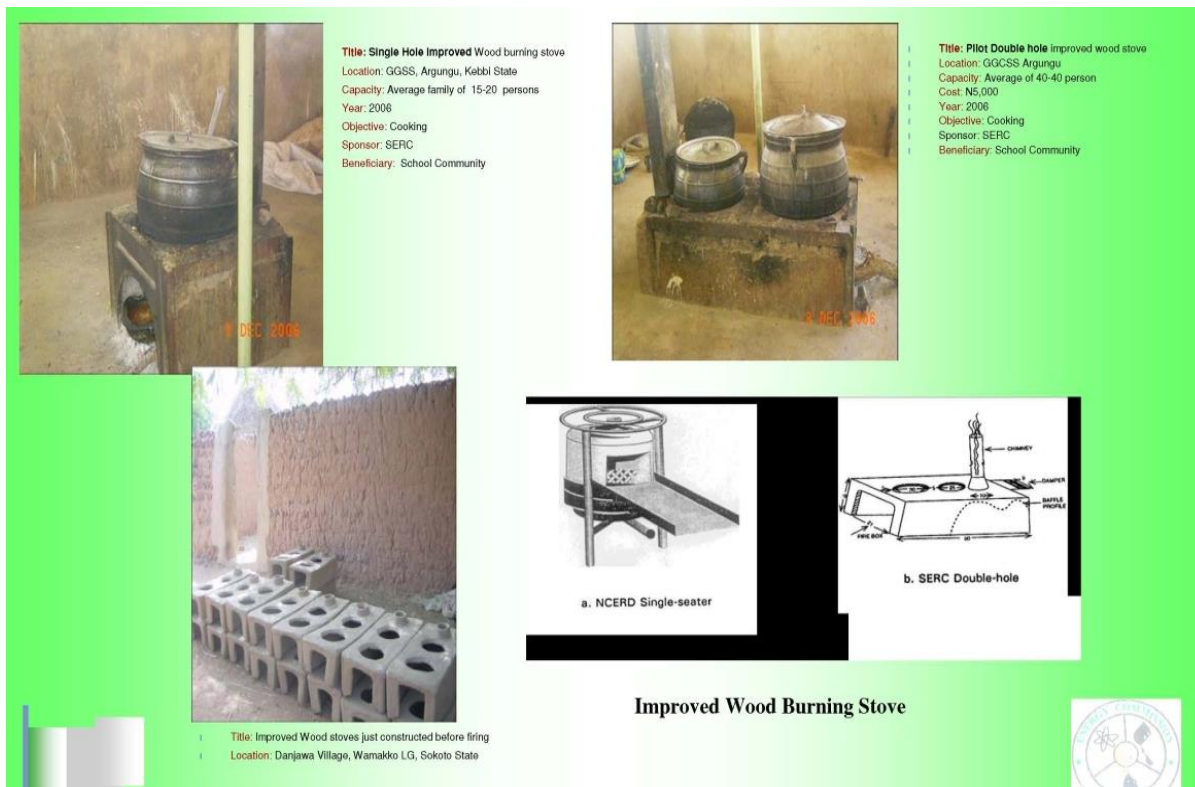


Figure 8: Improved Wood Burning Stoves.

KEY CHALLENGES FACING DEVELOPMENT OF RENEWABLE ENERGY SOURCES IN NIGERIA

Some of the key challenges facing the development of renewable energy sources in Nigeria include:

1. Policy, Legal and Regulatory Framework

The focus of national policy has consistently been on developing conventional energy sources for electric power generation. Subsidizing grid power has so far not encouraged investments in alternative energy solutions. This lack of a level playing field for all energy sources and technologies has constituted a formidable barrier to the growth of alternative electricity services

2. Non-existing Framework for Power Purchase Agreements (PPA)

Currently there is no PPA framework for renewable energy generation to the grid. A system of rational expectations between renewable electricity producers and the grid

operators are an imperative for the growth in grid-based renewables.

3. Institutional Framework

Unlike oil and gas, no agency has a clear mandate to oversee the development of renewable energy. The lack of a clear champion robs the sector of a driving force for its growth and development.

4. Affordability

Even though renewables have low operation and maintenance costs, most renewable energy technologies have high up-front capital cost compared to their conventional energy alternatives.

5. Capacity

Capacity building in four areas are most lacking, namely; training of manpower to install, operate and maintain RET, development of manufacturing capabilities, development of critical mass of scientists, engineers, and economists, and design and effective functioning of institutional framework.

6. Public Awareness

Awareness of the opportunities offered by renewable energies and their technologies is low among public and private sector stakeholders. This lack of information and awareness creates a market distortion that results in higher risk perception for potential renewable energy projects.

7. Poorly Developed Cross-sectoral Linkages

In Nigeria, renewable energy is inadequately linked to key drivers of the national economy such as the growth in small and medium enterprises, growing demand for water supply, developments in the telecommunication industry and the drive towards integrated rural development. Developing these cross-sectoral interfaces is crucial to expanding renewable energy opportunities.

8. Standards and quality control

A major constraint to the development of the renewable energy market in Nigeria is the poorly established standard and quality control of locally manufactured and imported technologies. Creating quality assurance is a precondition for building consumer confidence and in growing the market for renewable energy.

9. Inadequate resource assessment

The growth of the renewable power industry will depend to a large extent on the availability of a solid resource database. Reliable and up-to-date sources of data will assist investors in making decisions on renewable electricity.

10. Intermittency of resource availability

An underlying barrier affecting all renewable electricity resources is the intermittency of their availability. The challenge of energy storage and system management presents a major challenge and adds to the complexity and costs of renewable electricity.

POSSIBLE SOLUTIONS/RECOMMENDATIONS TO RENEWABLE SOURCES DEVELOPMENT IN NIGERIA

- 1) Immediate completion and approval of the National Energy Master Plan.
- 2) Institutionalization of the National Energy Policy and the National Energy Master Plan through an Act of the National Assembly for sustainability.

- 3) Establishment of a Renewable Energy Fund to serve as the instrument for the provision of financial incentives to local manufacturers, suppliers and users of RE electricity, especially with reference to the rural areas.
- 4) Provision of adequate fiscal incentives to local suppliers and manufacturers of RE electricity system components.
- 5) Sustenance of the energy sector reforms by successive governments.
- 6) Intensification of promotional and advocacy activities on RE electricity by the Energy Commission of Nigeria and all stakeholders.
- 7) Intensification of R and D into RE electricity technology to further bring down costs.
- 8) The enormous financial benefits now derived from the depletable fossil resources need to be partly invested in the development of RE electricity infrastructure in partnership with the private sector.
- 9) Establishment of regulatory framework for the RE electricity industry.
- 10) Development and sustenance of the RE resource database.

CONCLUSION AND INVESTMENT OPPURTUNITIES

According to the Nigeria Investment Promotion Council, NIPC (2011), Nigeria has a population of about 160 million people with over 2000 years of traditional culture and has one of the most modern life styles on the African continent. Nigeria is endowed with enormous natural resources, abundant mineral wealth, including massive crude oil and gas reserves, large deposits of solid minerals and abundant agricultural lands. Nigeria's pool of highly educated and skilled manpower is the biggest in Africa.

Skilled and trainable manpower at all levels with industrial experience abound are a major attraction for situating investments in Nigeria. The government privatization agenda is intended to cut down the cost of doing business in Nigeria and enhance the effectiveness of all public

enterprises as well as making the private sector to become the economy's engine of growth.

Renewable Energy can supply power for manufacturing, agricultural and household. The nation needs substantial scaling up of quantity and quality of energy services in view of the fact that the nation's energy demand is on the increase and the general power supply body – Power Holding Company of Nigeria (PHCN) has been unable to convene the growing electricity supply. Wider partaking in power production and supply is very vital if Nigeria is to meet up with its energy demand and achieve the required industrial and economic advancement.

For example, Nigeria is abound with potentials in small hydro power and has the capacity to generate as much as 3,500 MW of electricity which is more than enough to cater for its rural electrification needs, as well as the ICT power requirement and irrigation systems of all the surrounding villages, in over 248 small hydro sites cut across the six geopolitical zones of the country. There are few challenges in the sector. The overwhelming population and the widespread demands for energy in the nation make it possible to earn very high returns on investment and hence, the investment opportunities in the sector are motivating for any investor whether local or foreign.

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