British Journal of Business and Management Research
Vol.1, No.1, pp.16-27, March 2014
Published by British Research Institute UK (www.gbjournals.org)

REVIEW OF ENERGY AVAILABILITY, DEVELOPMENT AND USAGE IN NIGERIA

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INTRODUCTION

The available energy resources in Nigerian energy economy are crude oil and natural gas, tar sand (bitumen), nuclear (see table 1) and renewable energy resources such as: hydro, fuel-wood, solar, wind, biomass and geothermal. Nigeria is highly blessed with abundant natural resources. However, since the late 1960's the economy has been dependent on the exploitation of oil to meet the country's developmental expenditures. In 1990 oil revenue alone accounted for over 90% exports. Approximate 80% of total government revenues with a contribution of about 30% to GDP. The dominant source of commercial energy is thus oil, accounting for over 70% since the early 1970's. Up to early 1960's coal production was significant and dominant the commercial energy supply. It was also the predominant source of energy for rail transportation and electricity generation. However, partly due to fuel substitution of oil and gas, coal production and utilization has dropped so low in 1990. Coal's share in total commercial energy consumption was less than 1%. Currently, fuel-wood account for over 50% of the overall energy consumption in the country and is the dominant source of energy in the domestic sector.

The renewable energy resources available in Nigeria and their uses are briefly discussed below:

Solar Energy

Solar energy has a substantial growth potential for meeting energy needs in Nigeria especially in the rural areas where a large percentage of the population have denied access to energy supply. Presently the natural solar energy unconverted to any form is used for dying most especially for agricultural products. One may expect a wide use of this solar energy for at least partial supply of domestic for small scattered consumers basically in small house areas.

Studies have that typically the overall efficiency of conversion of solar energy to useful high-grade heat or electricity is low, about 5%. But this notwithstanding solar energy can still be conveniently used in Nigeria for water heating, domestic and industrial use of (solar heating) distillation of water from salt or pond water (solar stills), plant growing stimulation (greenhouse), cereal grain crop dying driving heat engines for water pumping or power generation, driving thermal refrigeration machines for all conditioning, food and drug preservation (solar cooling) (Coiante and Barra 1992).

Photovoltaic

Photovoltaic is a highly flexible utility, cost effective, clean and renewable. It provides high grade energy (i.e electricity: which can be used most power consuming applications) with equal efficiency on almost every scale. A simple approach to many low power DC electrical needs is to have-powered devices which can be recharged from a central solar charger.

Before the first international oil crisis of 1973, PV cells had only space application. Consequent to this technology potential for terrestrial application were developed. Today PV applications involving grid connections (without storage) configuration ha become the reference model because it has appeared at the most feasible technical and economic solution.

Photovoltaic can be in telecommunication projects, pipeline cathodic protection systems, home lighting power for refrigerators, air conditioners, water pumping (i.e. solar pumping system), navigation stations, remote power supply systems. A few large-scale PV generator projects tied to grid or stand-alone systems are underway. Photovoltaic is also applied in remote electrical power.

Photovoltaic systems are becoming a more significant source of power. Small-scale systems are being home lighting powering remote facilities such as communications and lighting, and for providing power in developing countries. The cost of PV have dropped to the point that utilities (or their consumers) can better afford to install PV systems with where the alternative would be a long extension (one mile or more) from and existing distribution line.

Biomass and Biogas

As a result of the geographical formation of Nigeria ranging from the swamps through the tropical rain forest to the savannas, energy of biological systems (woods and wastes) are abundant. Biomass and its associated gas (biogas) can provide a significant and environmentally beneficial source of renewable energy resources for today and the future in Nigeria.

The biomass sources available in Nigeria has not been estimated but 1973 figures put the biomass resources availability at about $9.1x10^{12}$ MJ. These include products, industry waste, and by-product materials solid waste (MSW) and forest products, industry waste and materials produced purposely for energy use such as trees. With the estimate, biomass and bio-fuels represents perhaps the largest commercial energy source among the renewable energy resources in Nigeria. The major factors that determine resource potential of biomass are amount and type of land available and average biomass yields both of which can be varied to a reasonable advantage provided that aggressive replenishment strategies are evolved and implemented (Seriki and Adegbulugbe ,1992).

Liquefaction of biomass for use of transportation fuel is expected to be the largest single potential use of renewable energy. Significant progress is being realized in research in several areas. Today the production of liquid fuels from biomass primarily via fermentation of corn constituents to provide ethanol entails the use of high cost raw materials. The advanced technologies will utilize lower-cost materials (wood or other cellulosic materials) as feed stocks. The most impressive biomass is based on the principle of pyrolysis in which organic matter is decomposed through heating. This leads to the formation of gases: N_2, H_2, CO_2, and CH_4, in different proportion depending on the temperature, pressure and air supply. These gases are then used under suitable conditions to produce methanol, methane and other hydrocarbons. The process has been successful with urban refuse, wood, wheat, straw and other biological matter (Akujor, 1988). Biomass is also most extensively used as fuel in the direct combustion in boilers to raise steam. Large scale biomass based-turbine or electricity generation is at commercial stage in Nigeria today and it is expected to be competitive with many central power plants for adequate biomass feed stocks at reasonable prices (Esan, 1993).

Geothermal Energy

Geothermal energy is the heat energy available in the rocks hot water, and steam in the earth's sub-surface. It is conveniently defined as heat of the earth. Its resources are defined as concentrations of sub-surface heat that can be extracted and use economically. The thermal energy of the outer portion of the earth that can be reached by drilling (about 10km) is a result of radioactive decay in crustal rocks and the flow of heat from core and mantle (Renner and Reed, 1993). Geothermal energy is commonly divided into four categories; hydro thermal resources, geo-pressure-geothermal, hot dry rock and magma.

Geothermal resources have been utilized by mankind for centuries as a source of heat for cooking and bathing in Nigeria, if properly harnessed, it could be used to heat buildings, pasteurize milk raise fish, dry onions plus many other uses. Unlike the fossil fuels, this energy source does not produce emission.

Wind Energy

A large amount of power is contained in the movement of air in the form of wind. Potentials of wind as a source of energy in Nigeria abound in several parts of the country. Relative little research and investments have made part of harnessing utilization of wind energy either to generate electricity or to operate mechanical devices but researchers have identified improvement in blade airfoil design which will improve efficiency, allowing greater output from better wind sites and also making lower intensity wind resources economical to develop. In addition, improvements in gear and bearing mechanisms, blade materials and support structure are expected to reduce cost and increase reliability. The lower limit of the wind energy potential in Nigeria is about $53W/M^2$, which is equivalent to 1.5×10^{15} MJ or 4.1×10^{11} MW per annum for the whole country, (Bath 1993, Odukwe et al, 1988).

Hydro Energy

The electricity generation mix in Nigeria is dominated mainly by hydro and gas fired plants. Presently, hydro is the second largest energy source for electricity generation in the country, contributing about 37 percent in the total installed electricity generation capacity. The first hydroelectric power station in the country is at Kainji on the river Niger. This has a hydropower capacity of 836MW with provisions for expansion to 1156MW. The second hydro power station on the Niger at Jebba has an estimated capacity of 540MW. Potential sites have been identified on the same river at Lokoja (1870MW) and Onitsha (750MW). The rivers Kaduna, Benue and Cross River have potentials sites at Shiroro, Markurdi and Ikom respectively; the estimated combined capacity being 4650MW. Recent estimates indicate a total of about 233MW on the rivers in the Mambilla Plateau region. Thus the overall hydropower resources potentially exploitable in Nigeria amount to over 11,000MW, with a corresponding annual average energy capacity of more than 40,800Wh (Esan, 1993)

Table 1: Summary of Estimated Renewable Energy Resources in Nigeria

Resource	Unit	Reserve
1. Hydro	MW	11000
2. Solar	MW	2.5×10^5
3. Biomass	MW	2.5×10^5
4. Wind	MW	4.1×10^{11}
5. Geothermal	MW	Not yet quantified

Power and Energy Development in Nigeria

From the various available energy resources in Nigeria that the actual energy development in Nigeria is summarily presented as below in consonance with the Energy Commission of Nigeria presentations, (Sambo, 2007).

(a) Energy Resource

Table 2: Fossils and Nuclear Energy Type Resources

	Reserves				**Domestic**
S/No	Resource Type	Natural Units	Energy Units	Production (Btoe*)	**Utilization (Natural Units)**
1	Crude oil	35 billion barrels	4.76	2.5milllion bls/day	450,000 barrels/day
2	Natural Gas	187 Trillion SCF	4.32	6Billion SC/day	3.4 billion CF/day
3	Coal and Lignite	2.175 billion tonnes	1.92	(insigni-ficant)	(insignificant)
4	Tar Sands	31 billion barrels of equivalent	4.22	-	-
5	Nuclear Element	Not yet qualified	-	-	-

Source: Energy Commission of Nigeria

Table 3: Renewable Energy and Development in Nigeria

S/N	Resource Types	11,250MW Rese rves	0.8 (over 38 yr)	1938 MW (167.4)	Domestic Utilization
1	Large Hydropower	(Natural Units)	energy Units (Bote*)	production MWh /day	(natural units)
2	Small Hydropower	3,500 MW	0.25 (over 38 years)	30 MW (2.6 millions MWh /day)	2.6 million MWh /day
3	Solar Radiation	3.5 - 7.0 KWh/m^2 / day (485.1 million MWh /day using 0.1% Nigeria land area)	15.0 (38 years and 0.1% Nigeria land area)	Excess of 240 KWp of solar PV or 0.01 million MWh/day	Excess of 0.01 million MWph/day of solar PV
4	Win	(2-4) m/s at 10m height	8.14 (4m/s@70m height, Φ20m windmill, 0.1% land area of Nigeria over 38 years)		
5	Biomass: Fuel wood / Animal waste	11 million hectares of forest and woodland	Excess of 1.2M Tons./day	0.120 million tones/day 0.781 million tonnes of waste/day	0.120 million tonnes/day Not available
6	Energy Drops and Agric Residue	72 hectare of Agric. Land		0.256 million tones of assorted crops/day	Not available

Source: Energy commission of Nigeria

(b) Sustainable Energy Development

Triple Es

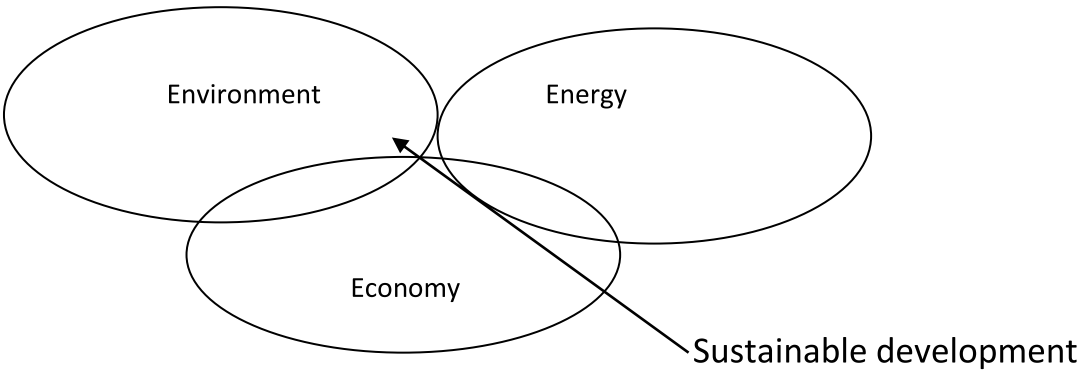

Figure 1: Energy Development and Sustainability in Nigeria

British Journal of Business and Management Research
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(c) (i) Economic Outlook

Nigeria's economy prior to 1999 was operated on the basis of a mixed-economy. As from 1999, however, the mode changed to a private sector economy. Economic and social reforms are now being implemented in the country.

Table 4: GDP Growth

Item	**1999**	**2001**	**2003**	**2005**
GDP Growth	2.8	4.6	10.2	6.2

Source: CBN Annual Reports, 1999 – 2005.

Table 5: Sectors Contribution to GDP in Nigeria

S/N	**Sector**	**1999**	**2001**	**2003**	**2005**
1	Agriculture	40.6	42.3	41.01	41.21
2	Petroleum	11.14	26.04	26.53	24.33
3	Mining and Quarrying	0.32	0.52	0.25	0.27
4	Manufacturing	5.85	3.52	3.57	3.79
5	Building and Construction	2.07	1.41	12.99	12.9
6	Whole and Retail Trade	11.74	12.76	12.99	12.9
7	Service	28.18	13.7	14.7	15.23

Source: CBN Annual Reports, 1999 and 2005

Energy Consumption

Table 6: Per Capita Energy Consumption

Year	**Energy Consumed (Million toe)**	**Population (million)**	**Per capita Energy Consumption (toe/capita)**
1999	233.585	111.8	2.09
2001	376.873	118.8	3.17
2003	408.891	126.2	3.24
2004	397.901	129.9	3.06

Source: CBN Annual Reports, 1999 and 2005

Table 7: Per Capita Electricity Consumption

Year	Energy Consumed (Mil toe)	Population (million)	Per capita Energy Consumed (toe/capita)
1999	8,576.30	118	76.7
2001	8,893.80	118.8	74.9
2003	13,311.00	126.2	105.5
2004	15,999.80	129.9	123.2

Source: CBN Annual Reports, 1999 and 2005

Table 8: Energy Consumption by Type (2000 – 2004)

Type	Average % of Total (2000 – 2004)
Coal	0.002 (Insignificant)
Hydro Power	5
Natural Gas	53
Petroleum Products	42

Table 9: Contribution of Energy to the Nigeria Economy

Year	2000	2001	2002	2003	2004	Remark
% contribution to Federation Accts	73%	63%	69%	75%	79%	Major contributor
% contribution to GDP@ 1990 constant Basic Prices	32.50%	32.70%	29.08%	33.40%	32.60%	2nd to Agric. Sector
% contribution to Export Earnings	98%	99%	95%	97%	96%	Major contributor

Table 10: Total Energy Demand Based on 10% GDP Growth Rate (Mtoe)

Item	2005	2010	2015	2020	2025	2030	Av. Growth rate %
Industry	8.08	12.59	26.03	39.47	92.34	145.21	16.2
Transport	11.70	13.48	16.59	19.70	26.53	33.36	4.7
Household	18.82	22.42	28.01	33.60	33.94	34.27	2.6
Service	6.43	8.38	12.14	15.89	26.95	38.00	8.7
Total	45.01	56.87	82.77	108.66	179.75	250.84	8.3

Source: Energy Commission of Nigeria (2006)

Table 11: Electricity Demand

Scenario	Demand (MW)				
	2010	**2015**	**2020**	**2025**	**2030**
Reference (7%)	15,730	28,360	50,820	77,450	119,200
High Reference (10%)	15,950	30,210	58,180	107,220	192,000
Optimistic (11.5%)	16,000	31,240	70,760	137,370	250,000

Source: Energy Commission of Nigeria (2006)

Table 12: Projected Country Demand for Fuel Petroleum Products

(Millions litres)

Year	PMS		DPK		AGO	
2005	9,826	9,826	2,167	2,167	2,329	2,329
2010	12,060	13,877	2,737	2,990	5,224	6,012
2015	16,973	22,424	3,421	4,194	7,365	7,753
2020	33,529	36,194	4,397	6,132	10,370	15,765
2025	33,529	58,376	5,765	9,274	14,600	25,459
2030	47,070	94,099	7,678	14,317	20,518	41,071

Source: Energy Commission of Nigeria (2006)

Institutional Framework

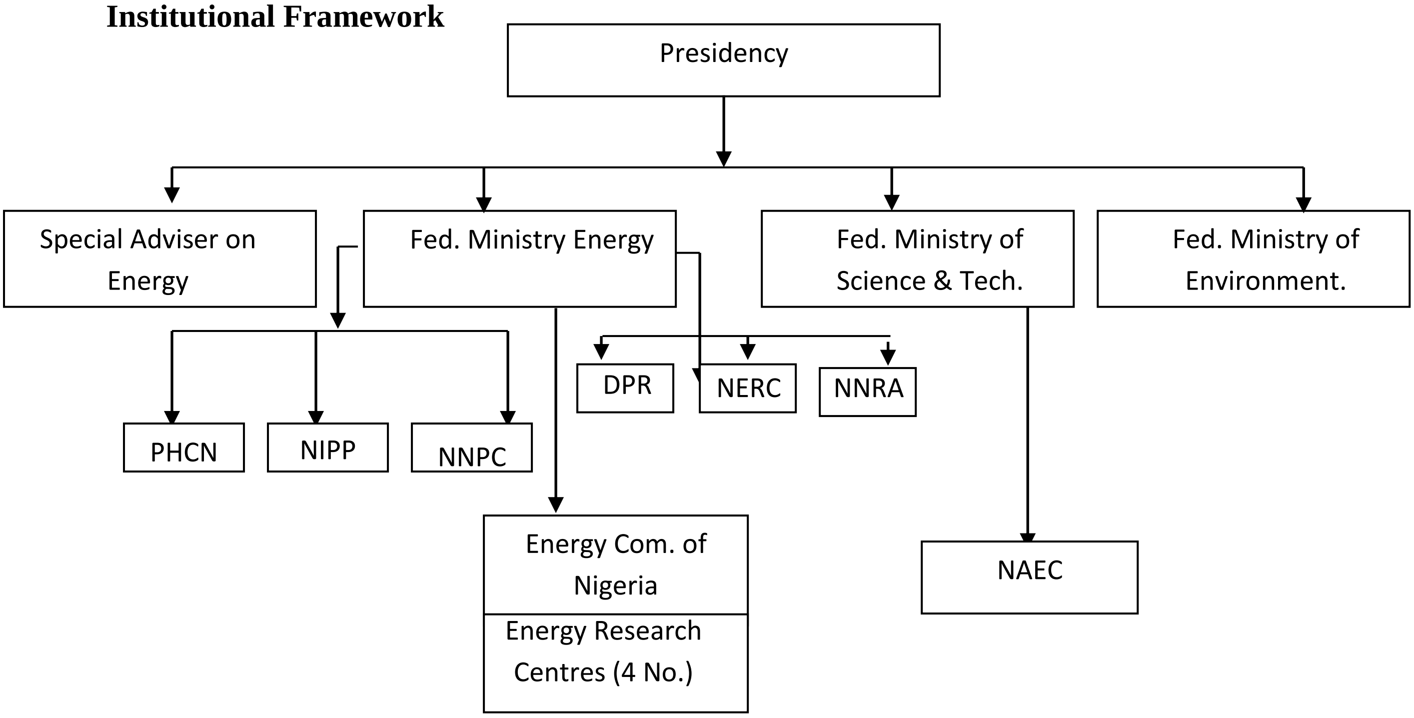

Figure 2: Institutional Framework

(c) Physical Infrastructure

(i) Refineries

Institutional Framework

Table 13: Refineries in Nigeria with Installed Capacities

Refinery	Year Commissioned	Capacity (barrels/day)				
		1965	1971	1978	1988	2000
PH Refinery I	1956	35,000	60,000	60,000		60,000
P/H Refinery II	1988	-	-	15,000		150,000
Warri	1978	-	100,000	125,000		125,000
Kaduna	1980	-	100,000	110,000		110,000
		35,000	60,000	260,000	445,000	445,000

(ii) Pipeline and Depots

Table 14: National Fuel Products Storage Capacity [m^3] ($1m^3$ = 1000 litres)

	PMS	DPK	AGO	ATK
WRPC	99.200	87,000	97,000	-
KRPC	135.00	65,000	97,000	-
PHRC	145,550	93,000	141,000	-
PPMC Depot	651,000	257,000	467,900	63,500
Marketer @ Apapa	40,000	17,300	23,300	11,500
Total	1,070,199	519,000	826,300	75,000

(iii) Power Stations

Table 15: Pre – 1999 Stations

S/N	STATION	CAPACITY
1	Kainji hydro	760 MW
2	Jebba hydro	578 MW
3	Shiroro hydro	600 MW
4	Egbin Thermal	1320 MW
5	Sapele thermal	1020 MW
6	Iora thermal	60 MW
7	Delta thermal	912 MW
8	Afam thermal	711 MW
9	Oji thermal	30 MW
10	NESCO	30 MW
		6021 MW

Post 1999 Power Station

Table 16: National Integrated Power Project (NIPP)

S/N	STATION	CAPACITY
1	Gbarain, Bayelsa	225
2	Ihuobor, Edo	451
3	Omoku, Rivers	230
4	Sapele, Delta	451
5	Egbema, Imo	338
6	Calabar, Cross Rivers	561
7	Ikot Abasi, Akwa Ibom	300
8	Ibom Power	188
		2,744 MW

Independent Power Producers (IPPs)

Table 17: Installed Capacities in Nigeria

S/N	STATION	CAPACITY
1	Geregu, Kogi	414MW
2	Omotosho, Ondo	335 MW
3	Papalanto, Ogun	335 MW
4	Aaoji, Abia	346 MW
5	AES, Lagos	270 MW
6	Geometric, Aba	140 MW
7	Agip JV, Agura, Agura,	480 MW
8	Igbin, Lagos	750 MW
9	Total Fina, Obite, Rivers	500 MW
10	Exxon Mobil Bonny, Rivers	500 MW
		4070 MW

(iv) Grid Network

Table 18: Transmission Capacity Improvement

Item	1999 Value	Addition Planned
330KV lines	4,800	2,194 km
132kv sub-station	6,100 km	809km
330/132kv sub-station	5,618 MVA	5,590MVA
132/33 KV sub-station	6,230 MVA	3,313 MVA

CHALLENGES

- Uncertain in continuity of energy policies due to absence of an energy policy law.
- Unfriendly community relations, which often descript gas and oil supplies to power plant and refinery projects
- Weak indigenous private sector, which is slowing down of the energy sector,
- Poverty and weak ability to pay for economic energy tariffs and prices
- Corruption as an impediment to development
- Institutionalization of the National Energy Policy (NEP) and its master plans through Act(s) of the national assembly so as to facilitate reasonable continuity in energy policy.
- Intensification of transparent privatization of the energy sector
- Appropriately arresting the unfriendly community relations o as to enable uninterrupted supply of energy services
- Strengthening of the private sector through provision of adequate incentive and development funds.
- Adequate funding of the energy sector reforms to arrest unfriendly labour relations matters.
- Strengthening of bilateral and regional cooperation to facilitate hydropower and other energy resources development.
- Intensification of R&D into problems of exploitation, generation, transmission and distribution of energy.
- Diversification of the use of primary energy resources to include solar, wind, small hydropower and biomass especially in the rural and peri-urban areas.

REFERENCES

Akujor, C.E (1988), Energy Technology, Onitsha: Summer Educational Publisher Nigeria Limited, 112 – 118.

Bath. T.D (1993), Proceedings of the 205 American Chemical Society National Meeting Held at Denver Colorado. March 28-April 2, 33(1) 263

Cheng Leong G. and Adeleke B.O (1978) Physical and Human Geography Ibadan Oxford University Press 35

Coiane D. and Barra. I (1992), “Can Photovoltaics Become an Effective Energy Options? Solar Energy Materials and Solar Cells Edited by C.M Lampert 27, 80-89

Essan A.A (1993). NSE/ECN workshop 3.2.7

Ogbuagu J.O (1994), Energy Education-Implication in Nigeria. Nigerian Journal of Solar Energy, 12.137-144.

Odukwe A.O and Enibs S.O (1998), “Energy Resources and Reserves in Nigeria,” Solar and Wind Technology, 5 (33), 335-338.

Ojosu J.O (1989), Solar Radiation Maps of Nigeria. Nigerian Journal of Solar Energy 1989, 7.370-384.

Renner. J.I and Reed M.J (1993), “Geothermal Energy” 205 American Chemical Society National Meeting, Denver, Colorado, March 28-April 2, 33(1), 248

Sambo A. S.,(2007), ‘Achieving the Millenuim Development Goals (MDGS): The Implication for Energy Infrastructure in Nigeria,’Proceedings of COREN 16th Engineering Assembly,
pp 130 - 144

Seriki D. A and Adegbulugbe A. O. (ed.) (1992), Energy Issues in Nigeria: Today and Tomorrow. Conf. Proc of NNC of WEC 17-41

Umar I.H (1993), “Fundamental Principles and Goals of the Nigeria Energy Policy” presented at the Nigeria Society of Engineers and Energy Commission of Nigeria 3 days workshop Held at Lagos. August 10-12