American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-11, Issue-02, pp-47-61
www.ajer.org
Research Paper Open Access

Towards Attaining Energy Independence in Nigeria

ABU, N. and IBRAHIM, H.D.
Raw Materials Research and Development Council (RMRDC), Abuja

Abstract
Energy plays a vital role in the economic growth, progress and development, as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly. Nigeria does not generate enough energy to support the entire population of the country in spite of the fact that it is blessed with enormous natural resources. Over 80% of the current Nigerian primary energy consumption is met by petroleum. This overdependence on fossil fuels derived from petroleum for local consumption requirements had posed a very serious concern for the country. Various researches have shown that Nigeria is endowed with abundant energy resources which have not been properly harnessed to satisfy the nation's energy needs. Renewable resources such as biomass, solar, wind, hydropowerand biogas, etc are potential candidates to meet global energy requirements in a sustainable way. Hence, the urgent need to harness the renewable energy potentials in the country and to integrate these energy resources into Nigeria's energy system in order to have an effective, efficient, and reliable supply to her populace. This paper presents a criticalview of the available renewable energy resources in Nigeria and examines the current energy situations in the country that could be harnessed and developed for the attainment of energy independence and sustainable development.

Keywords; *Energy Independence, Alternative Energy, Energy Consumption, Sustainable Development.*

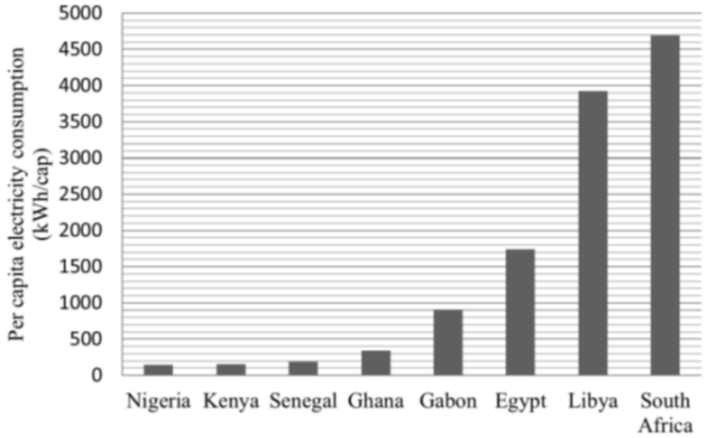
Date of Submission: 05-02-2022 Date of acceptance: 18-02-2022

I. INTRODUCTION

Energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly. The standard of living of a given country is directly related to the per capita energy consumption.

Energy supports the provision of basic needs such as cooked food, a comfortable living temperature, lighting, the use of appliances, piped water or sewerage, essential health care, educational aids, communication, and transport. Energy also fuels productive activities including agriculture, commerce, manufacturing, industry, and mining. Conversely, a lack of access to energy contributes to poverty and deprivation and can contribute to economic decline. Energy and poverty reduction are not only closely connected, but also with socioeconomic development, which involves productivity, income growth, education, and health [18]Nigeria is endowed with significant energy resources that includes fuel, large and small hydroelectric power resources, solar energy, biomass, biogas, wind, potential for utilization and development of geothermal and ocean energy, etc. However, it is yet to exploit these huge available energy potentials with less environmental and climatic impacts for its growth. Onthe contrary, the national energy supply is at present almost entirely dependent on fossil fuels and fuel wood [13]. Despite Nigeria's steady access to fossil based and renewable energy sources, its per capita electricity has been among one of the lowest in Africa, as shown in Fig. 1.

Fig. 1: Per capita electricity consumption of a few African countries.



As power demand studies have projected a medium- to longterm electricity demand of 30,000MW and 192,000MW respectively, there is need for substantial improvement in the energy production and supply sector if this demand is to be met [19].The current installed capacity of grid electricity is about 6000MW, of which about 67 percent is thermal and the balance is hydro-based [11]. Hence, the urgent need to optimally harness the renewable energy potentials available in Nigeria for the benefit of her citizens and Africa in general.

Non-conventional renewable energy is a key element in the overall strategy of the Federal Government of Nigeria in rapidly expanding access to electricity services in the country. Beyond large hydropower, the total contribution of renewable energy in Nigeria's electricity industry is about 35MW composed of 30MW small hydropower and about 5MW solar PV. This represents about 0.06% of total electricity generating capacity in the country [11].

Energy independence has been defined as "independence regarding energy resources, energy supply and/or energy generation by the energy industry of a nation". This therefore, refers to the ability of a country or region to meet all its energy needs without having to import primary or final energy from another country. Nigeria is far from being independent, given its present predicament.

Energy independence, as defined by President Richard Nixon(37th President of USA, 1969-1974) is "a situation in which domestic energy production is adequate to meet our own energy needs without depending on any foreign sources". By this, he simply meant that "Oil should become much less relevant to America's global affairs in terms of commodity trade",ensuring that the actions of foreign governments should not cause major disruptions in energy prices or supplies. This definition could be deduced to include the notion that the United States should reduce its reliance on Oil from unfriendly sources. In Nixon's case, the goal was to need no Oil from any foreign source, but to diversify suppliers that would provide USA with effective independence from unfriendly nations. This can effectively apply to Nigeria, given our vast resources potentials.

The energy crisis that has engulfed Nigeria for almost two decades today, has been enormous and has largely contributed to the incidence of poverty by paralyzing industrial and commercial activities in the country. The Council for Renewable Energy of Nigeria estimates that power outages has brought about a loss of 126 billion naira (US$ 984.38 million) annually in the last two decades [7].

Apart from the huge income loss, it has also resulted in health hazards due to the exposure to carbon emissions caused by constant use of 'backyard generators' in different households and business enterprises, unemployment, and high cost of living leading to a deterioration of living conditions. According to the Central Bank of Nigeria in 1985, it was estimated that Nigeria consumed 8,771,863 tonnes of Oil equivalent [17]. This is equal to about 180,000 barrels of Oil per day. Since then, Oil consumption in Nigeria has drastically increased. The effect of this increase on the economy relying solely on revenue from Oil is tremendous. Also, the Department for Petroleum Resources (NNPC, "Draft Nigerian biofuel policy and incentives,") reported that petroleum accounts for more than 78% of the total energy consumed in Nigeria.

Many indigenous researchers have looked into the availability of renewable energy resources in Nigeria with a view to establishing their viability towards enhancing the developmental trend in the country. In the present energy predicament as a nation, it is obvious that depending mainly on fossil fuel (petroleum) is not enough to meet the energy needs of the country. Since Nigeria is blessed with abundant renewable energy resources such as hydroelectric, solar, wind, tidal, and biomass, there is a need to harness these resources and chart a new energy future for Nigeria. There is every need to support the existing unreliable energy sector with a sustainable source of power supply. In this regard, the government has a responsibility to make renewable energy available and affordable to all.

CURRENT ENERGY SCENARIO IN NIGERIA

Nigeria is a rich country blessed with both fossil fuels such as crude oil, natural gas, coal, etc, and renewable energy resources like solar, wind, hydro and biomass, etc as presented in Table 1.

Table 1: Energy Resources in Nigeria

Resource		Reserves (natural units)	Production level (natural units)	Utilisation (natural units)
Crude oil		36.22 billion barrels	2.06 million bpd	445,000 bpd
Natural gas		187 trillion SCF	7.1 billion SCF/day	3.4 billion SCF/day
Coal and lignite		2.734 billion tonnes	insignificant	insignificant
Tar sands		31 billion barrels of oil equivalent	0	0
Large hydropower		11,250 MW	1,938 MW (167.4 million MWh/day)	167.4 million MWh/day
Small hydropower		3,500 MW	30 MW (2.6 million MWh/day)	2.6 million MWh/day
Solar radiation		3.5 – 7.0 kWh/m²/day	excess of 240 kWp of solar PV or 0.01 million MWh/day	excess of 0.01 million MWh/day solar PV
Wind		2 – 9 m/s at 10 m height	-	-
Biomass	Fuelwood	11 million hectres of forest and woodland	0.12 million tonnes/day	0.12 million tonnes/day
	Animal waste	245 million assorted animals in 2001	0.781 million tonnes of waste/day in 2001	not available
	Energy crops and agric. residues	72 million hectares of agric. land and all waste lands	excess of 0.256 million tonnes of assorted crops residues/ day in 1996	not available

Source; Constructed data obtained from the Nigerian National Petroleum Corporation, Renewable Energy Master plan and Ministry of Mines and Steel Development.

Nigeria holds 37,070,000,000 barrels of Oil Reserves, 187 trillion Standard Cubic Foot (SCF) of Natural Gas, 2.374 billion tonnes of Coal and Lignite of which virtually little has been tapped. The Nigeria's reserve for large hydropower is estimated at 11,250 MW and 3,500 MW for small hydropower. The identified hydroelectricity sites have an estimated capacity of about 14,250 MW. Nigeria has significant biomass resources to meet both traditional and modern energy uses, including electricity generation [14]. There has been a supply and demand gap as a result of the inadequate development and inefficient management of the energy sector in Nigeria. The supply of electricity, the country's most used energy resource, has been erratic [20]. The situation in the rural areas of the country is that most end users depend on fuel wood. Fuel wood is used by over 70% of Nigerians living in the rural areas. Nigeria consumes over 50 million tonnes of fuel wood annually, a rate which exceeds the replenishment rate through various afforestation programs. Based on estimates, cooking accounts for about 91% of household energy consumption, lighting uses up 6% and the remaining 3% goes to the use of basic electrical appliances such as television and pressing iron. Sourcing fuel wood for domestic and commercial uses is a major cause of desertification in the arid-zone states and erosion in the southern part of the country. Nigeria has a reserve of 11 million hectares of forest and woodland and 72 million hectares of agricultural land waste land. Based on the available statistics, Nigeria produces about 227,500 tonnes of fresh animal wastes daily. If fully utilized, this quantity is equivalent to 6.8 million cubic metres of biogas production every day.

Despite this abundance of energy resources in Nigeria, the country is currently facing energy crisis due to the country's gross inadequate energy supply that is incapable to meet the ever-growing demand. Essentially, the major energy-consuming activities in Nigerian households are cooking, lighting and use of electrical appliances.

To date, the national energy supply in Nigeria is entirely dominated by fossil fuels. Renewable energy resources are grossly underutilized in the country despite their availability in reasonable quantities.

Table 2; Projected Electricity supply by Fuel mix for 7% Growth

Scenario	2010 (MW)	2015 (MW)	2020 (MW)	2025 (MW)	2030 (MW)
Coal	0	2,393	6,515	9,305	15,815
Gas	13,555	23,617	37,733	56,086	85,585
Hydro	3,702	4,962	6,479	9,479	11,479
Small hydro	40	90	140	227	701
Nuclear	0	0	3,530	7,005	11,872
Solar	5	10	34	75	302
Wind	0	126	1,471	3,019	5,369
Total Supply	17,303	31,197	55,903	85,196	131,122

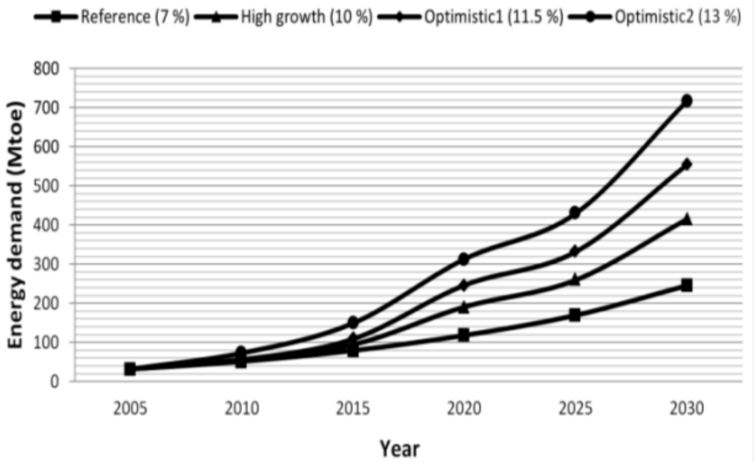
Source; Energy Commission of Nigeria, 2008.

From Table 2, obtained from Central Bank of Nigeria (CBN) report, shows the primary energy consumption by type. It is apparent from the table that while coal has a long period of neglected, petroleum has constituted over 80% of the commercial primary energy consumed in the country. However, it is paradoxical to say that in spite of Nigeria's rich Oil and Gas sector, 58% of the population do not have access to electricity which is a secondary form of energy fueled by the petroleum with which Nigeria is richly endowed.On most days, however, it is only able to dispatch around 4,000 MW, which is insufficient for a country of over 200 million people.

The Nigerian power sector experiences many broad challenges related to electricity policy enforcement, regulatory uncertainty, gas supply, transmission system constraints, and major power sector planning shortfalls that have kept the sector from reaching commercial viability.

According to the World Bank, Nigeria has the largest energy access deficit in the world. This is because 85 million Nigerians representing about 43% of the population do not have access to grid electricity, and lack of reliable power in the country has resulted in yearly economic losses estimated at $26.2 billion (₦10.1 trillion), which is equivalent to about two percent of Gross Domestic Product (GDP). That is to say access to reliable and affordable power is a catalyst for industrialization and productivity enhancement to make the economy globally competitive. Nigeria, as one of the largest economies on the continent, has substantial installed generation capacity of more than 13.5 GW, compared to the country's peak demand of 8.25 GW. Generation should be able to adequately address the national demand. Yet in 2019 the available capacity only amounted to 3.7 GW.

Fig.2. The energy demand projections for the four economic growth scenarios.

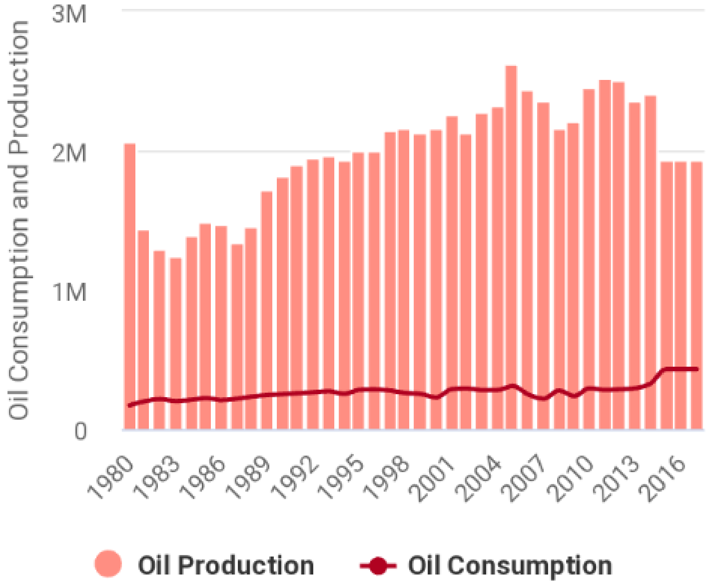


Source; CBN,

PETROLEUM AND NATURAL GAS RESOURCES

Nigeria holds 37,070,000,000 barrels of Oil Reserves, 10^{th} in rank in the world accounting for about 2.2% of world's total reserves of 1,650,585,140,000. Nigeria consumes 428, 000 barrels per day (B/D), 0.10 gallons of Oil barrels per capita every day, Produces 1,938,542.73 barrels per day of Oil and exports 85% of its production (1,654,739 barrels per day) as of 2016, Fig. 3, below.

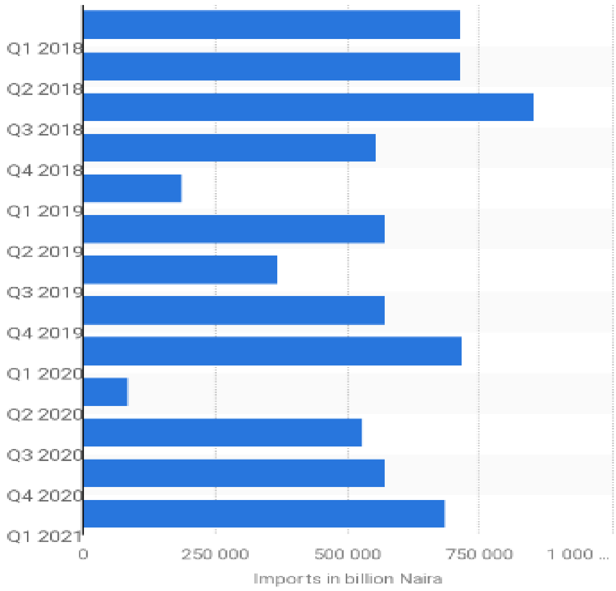
Fig. 3: Crude Oil Production in Nigeria (1980-2016) in Barrels per Day



Nigeria is also known to import massively petroleum products, despite the above figure, Fig. 3.

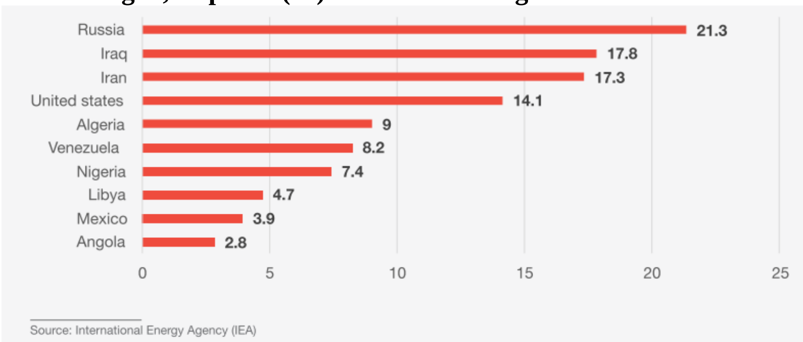
Up torecently, Nigeria's petrol import position, which is very massive, as presented in Fig. 4, which showsPetrol imported into Nigeria from 1st Quarter of 2018- 1st Quarter of 2021.

Fig. 4; Petrol import into Nigeria (1st Quarter of 2018- 1st Quarter of 2021)



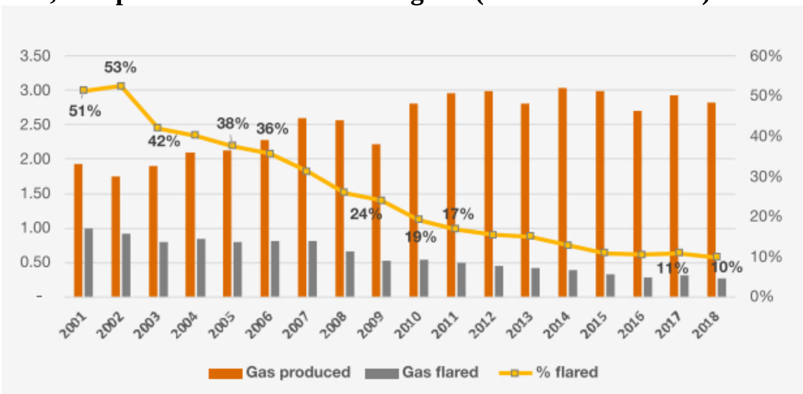
Nigeria has the largest proven gas reserves in Africa and the 8th largest in the world as of (2018) with 5,675 billion cubic meters(200.41 trillion cubic feet) of natural gas ,while the country's proven oil reserves is 36,972 million barrels or natural gas equivalent 9207.6 billion cubic feet) . This implies that Nigeria's gas reserves are over 900 times the country's total oil reserves.In terms of production, Nigeria produced 1.7 trillion cubic feet (49.2 billion meters) of natural gas (OPEC statistical bulletin, 2018) excluding gas flared or recycled.Daily gas production is very low, despite the large proven and unproven resources the country holds. It is estimated that Nigeria losses 28.8 billion (USD 94 million) annually, (National Environmental, Economic and Development Study for Climate Change in Nigeria). The percentage of gas flared in Nigeria has been reducing since 2002, and stood at 10% in 2018, in terms of volume flared, as depicted in Tables 3 and 4.
Globally, Nigeria is still in the top 10 gas-flaring countries, with 7.4 billion cubic feet in 2018, as captured in Fig. 5.

Fig. 5; Top Ten (10) Countries flaring Gas as of 2018



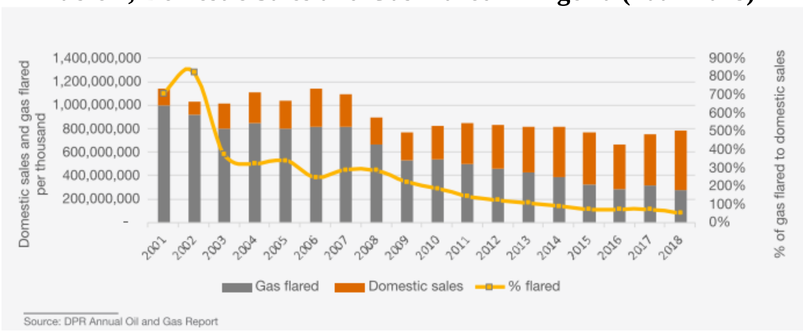
A good percentage of Nigeria's gas has not been adequately utilized, as presented in Table 3, below.

Table 3; Gas produced and flared in Nigeria (Trillion Cubic Feet) 2001-2018



Source; DPR annual Oil and Gas Report, 2020.

Table 4; Domestic Sales and Gas Flared in Nigeria (2001-2018)



Gas flared exceeded domestic sales from 2001 -2014. In 2014, significant revenue was lost, about 393 million scf gas was flared while 425 million scf was sold. This implied that the volume of gas flared was almost equal (94%) to the volume sold. By 2018,282 million scf was flared, relative to the domestic sales of 510 million scf. However,these showed that the proportion of gas sold is increasing, while the proportion that is having flared is reducing. This is an indication that gas flaring is being curtailed,with more energy beingharnessed for coordinated development, thereby enhancing our economic development.

The economic effect of gas flaring is quantified in terms of the lost amount of revenue that could have been generated from utilizing the volume of gas flared. Consequently, Nigeria lost ₦233 Billionfrom gas flaring in 2018, as shown in the Table 5, below.

This loss can be used to finance a lot of developmental projects and enhance the quantity of energy production in Nigeria.

Table5; Economic effect of gas flaring in Nigeria.

	Volume of gas flared per thousand scf	Average price of gas per thousand scf	Revenue lost in $	Revenue lost in Naira
2018	282,080,000	2.70	761,616,000	233,054,496,000
2017	324,192,401	2.70	875,320,000	267,847,920,000
2016	288,917,198	2.60	751,185,000	229,862,610,000
2015	330,933,000	2.40	794,240,000	243,037,440,000
2014	393,839,836	2.50	984,600,000	301,287,600,000

Source: DPR annual report, NNPC, PwC analysis

RENEWABLE ENERGY POTENTIALS IN NIGERIA

The potential of Renewable Energy Sources in Nigerian plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly [24]. Nigeria is blessed with a large amount of renewable energy resources [11].

Table 6; Target for Renewable Energy Contribution to Electricity Generation in Nigeria.

Resource	2010 (MW)	2015 (MW)	2030 (MW)
Large hydro	1,930	5,930	48,000
Small hydro	100	734	19,000
Solar PV	5	120	500
Solar Thermal	0	1	5
Biomass	0	100	800
Wind	1	20	40
Total RE	2,036	6,905	68,345
Total Energy Resources	16,000	30,000	192,000
Percentage of RE (%)	13	23	36

Source: Renewable Energy Master Plan for Nigeria, ECN 2005.

Renewable energy sources have contributed to Nigeria's energy mix in the last few centuriesnotwithstanding, in a largely primitive way. For example, fuel wood is the longest standing primary energy source for rural dwellers in Nigeria, just as for several other African countries. Similarly, large hydropower has contributed in no small measures as an energy source, providing about 32% of Nigeria's national electric grid supply.

Table 7; Capacity factor and Estimated Annual Energy output for some selected cities in Nigeria

Zone	City	Annual mean wind speed (m/s) at 10 m height	Annual wind speed (m/s) at 70 m height	Capacity Factor	Estimated Annual Energy (MWh)
South-West	Shaki	4.50[64, 67]	5.80	0.2264	1,983
	Iseyin	4.01[64, 67]	5.16	0.1715	1,502
	Lagos Mainland	4.61[67]	5.94	0.2387	2,091
	Lagos Island	4.69[67]	6.04	0.2477	2,170
	Ibadan	3.86[64, 67]	4.97	0.1547	1,355
	Ijebu-Ode	3.62[67]	4.66	0.1278	1,120
	Oshogbo	3.33[67]	4.29	0.0953	835
	Ondo*	1.77[67]	2.28	0.0000	0
	Benin	3.38[67]	4.35	0.1009	884
South-South	Port-Harcourt	3.30[67]	4.25	0.0920	806
	Calabar	4.60[67]	5.92	0.2376	2,082
	Ogoja	3.68[67]	4.74	0.1345	1,179
South-East	Enugu	5.73[65, 67]	7.38	0.3642	3,191
	Oweri	2.80[66]	3.61	0.0359	315
North-West	Yelwa	3.88[67]	5.00	0.1569	1,375
	Sokoto	7.21[65, 67]	9.29	0.5300	4,643
	Gusau	6.17[65, 67, 73, 75]	7.95	0.4135	3,622
	Kaduna	5.13[65, 67, 73, 75]	6.61	0.2970	2,602
	Kastina	7.45[73, 75, 76]	9.59	0.5569	4,879
	Zaria	6.08[76]	7.83	0.4034	3,534
	Kano	9.39[65, 67, 73, 75]	12.09	0.7743	6,783
North-Central	Ilorin	5.04[65, 67]	6.49	0.2869	2,513
	Bida*	2.46[67]	3.17	0.0000	0
	Mina	5.36[65, 67]	6.90	0.3228	2,827
	Abuja	3.77[67]	4.86	0.1446	1,267
	Lokoja	2.92[67]	3.76	0.0494	433
North-East	Bauchi	4.83 [73-75]	6.22	0.2634	2,307
	Potiskum	5.25[65, 67, 73]	6.76	0.3104	2,719
	Maiduguri	5.22[65, 67, 74]	6.72	0.3071	2,690
	Jos	9.47[65, 67]	12.20	0.7833	6,861
	Yola	4.16[74]	5.36	0.1883	1,650
Total					70,218

*cities where the annual wind speed is less than the cut-in speed of the chosen wind turbine

Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly. Nigeria is blessed with a large amount of renewable natural resources which when fully developed and utilized will lead to poverty reduction and sustainable development. In the present predicament as a nation, it is obvious that depending mainly on fossil fuel (petroleum and Natural gas) is not enough to meet the energy needs of the country. Hence, Nigeria being blessed with abundant renewable energy resources such as hydroelectric, solar, wind, tidal, and biomass, there is the need to harness these resources and chart a new energy future for Nigeria. In this regard, the development and utilization of this renewable energy should be given a high priority and the government has a responsibility to make renewable energy technologies available and affordable to all, thus;

Hydropower Energy Resources

Hydropower energy potential of Nigeria is high and it currently accounts for about 29% of the total electricity power supply in Nigeria. The first and large hydropower supply station in Nigeria is located in Kanji on the river Niger, in Niger State where it has an installed capacity of 836 MW and it also had provisions for more expansion to 1,156 MW. The second largest hydropower station is located in Jebba, Niger state with an installed capacity of 540 MW on river Shiroro. Ikom in Cross River state and Makurdi in Benue state, also contribute an estimated total capacity of about 4,650 MW, and the Mambila Plateau plant with an estimate of about 2,330MW.It has been reported that the total hydroelectric power potential of the country was estimated to be about 8,824 MW with an annual electricity generation potential in excess of 36,000 GW h. This consists of 8,000 MW of large hydropower technology, while the remaining 824 MW is from small-scale hydropower technology. Presently, 24% and 4% of both large and small hydropower potentials, respectively, in the country have been exploited.

At present, hydroelectricity contributes about 38.5% of the total grid electricity production in Nigeria. This contribution is mainly from the three large hydropower stations in Kainji (760MW), Jebba (578MW) and Shiroro (600MW) owned by Government, as well as the small hydropower station owned by NESCO (Nigerian Electricity Supply Company) in Jos, Plateau Statewith about 30MW capacity.

Apart from these, Nigeria has the potential to generate much more of electricity (estimated 15MW) from several other locations, Table 8. If these potentials are properly and adequately executed, Nigeria's energy system will be highly enhanced and we shall attain energy independence, easily.

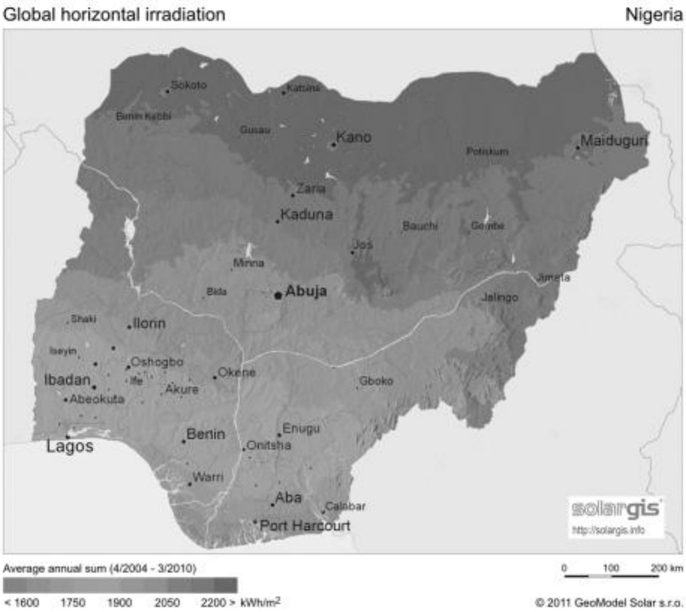
Table 8; Nigeria's hydropower potentially identified locations and their capacities

Location	River	State	Potential Capacity (MW)
Mambilla	Danga	Taraba	3,960
Lokoja	Niger	Kogi	1,950
Makurdi	Benue	Benue	1,060
Onitsha	Niger	Anambra	1,050
Ikom	Cross	Cross River	730
Zungeru I	Kaduna	Niger	500
Yola	Benue	Adamawa	360
Gurara	Gurara	Niger	300
Katsina Ala	Katsina Ala	Benue	260
Beli SE	Taraba	Kano	240
Donka	Niger	Adamawa	225
Afikpo	Cross	Ebonyi	180
Afikpo	Cross	Ebonyi	180
Garin Dali	Taraba	Taraba	135
Gembu	Dongo	Taraba	130
Karamti	Kam	Taraba	115
Sarkin-Danko	Suntai	Taraba	45
Kiri	Gongola	Adamawa	40
Oudi	Mada	Benue	40
Richa I	Mosari	Nassarawa	35
Gwaram	Jama'are	Adamawa	30
Ifon	Osse	Ondo	30
Kashimbila	Katsina Ala	Benue	30
Korubo	Gongola	Adama/Taraba	25
Kura II	Sanga	Kano	25
Richa II	Dafo	Kano	25
Mistakuku	Kurra	Plateau	20
Kura I	Sanga	Kano	15
Kafanchan	Kongum	Kaduna	5
Total			12,190

Solar Energy Resources

Nigeria is situated approximately between latitudes 4^0 North and 14^0 North, and longitudes 3^0East and 15^0 East, with a total landmass of 9.24 x 10 5 km2, and 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 and an annual average daily solar radiation of about 5.25 kW/m2 /day at the coastal area and 7.0 kW/m2 /day at the northern boundary [5].

Fig. 6; Nigeria Solar Irradiation Map



Consequently, Nigeria receives about 4.851 x 1012 kWh of incident solar energy per day or an average of 1.804 x 1015 kWh annually [6].

Table 9; Monthly averaged daily global irradiation (kwh/m2/day) in Nigeria (2001-2012)

Month	Sokoto		Maiduguri		Abuja		Ilorin		Ibadan		Enugu		P. Harcourt	
	H_h	H_{opt}	H_h	H_{opt}	H_h	H_{opt}	H_h	H_{opt}	H_h	H_{opt}	H_h	H_{opt}	H_h	H_{opt}
Jan	4.69	5.33	6.00	7.00	5.85	6.61	5.79	6.48	5.69	6.33	5.71	6.24	5.63	6.09
Feb	5.16	5.63	6.45	7.12	6.19	6.69	6.09	6.54	5.89	6.27	5.78	6.09	5.57	5.83
Mar	5.35	5.52	6.77	6.97	6.09	6.19	5.96	6.06	5.42	5.48	5.24	5.28	4.72	4.74
Apr	5.77	5.63	6.88	6.62	6.23	5.98	6.00	5.77	5.43	5.22	5.25	5.08	4.75	4.60
May	5.71	5.34	6.67	6.09	5.12	4.75	5.13	4.78	4.51	4.21	4.54	4.28	4.02	3.80
Jun	5.66	5.19	6.21	5.55	4.45	4.08	4.54	4.18	3.87	3.58	4.01	3.74	3.38	3.18
Jul	4.97	4.63	5.63	5.12	4.20	3.89	4.13	3.84	3.46	3.23	3.92	3.68	3.26	3.09
Aug	4.58	4.42	5.32	5.05	4.04	3.85	3.93	3.76	3.37	3.23	3.84	3.69	3.43	3.31
Sep	5.26	5.30	6.07	6.10	4.28	4.26	3.93	3.90	3.26	3.23	3.69	3.66	3.15	3.12
Oct	5.53	5.91	6.59	7.09	5.16	5.41	4.87	5.08	4.05	4.17	4.28	4.40	3.60	3.67
Nov	5.14	5.80	6.24	7.18	5.90	6.58	5.64	6.21	5.12	5.58	5.24	5.64	4.36	4.61
Dec	4.73	5.48	5.84	6.93	5.63	6.45	5.57	6.31	5.39	6.04	5.56	6.14	5.34	5.82
Average	5.21	5.34	6.22	6.40	5.26	5.39	5.13	5.23	4.61	4.71	4.75	4.82	4.26	4.31

*$H_h$is Irradiation on horizontal plane; *H_{opt} is Irradiation on optimally inclined plane

Source: PVGIS © European Communities, 2001-2012

This annual solar energy value is about 27 times the nation's total conventional energy resources in energy units and it is over 117,000 times the amount of electric power generated in the country [25].Onyebuchi [23] estimated the technical potential of solar energy in Nigeria with a 5% device conversion efficiency put at 15.0 × 1014 kJ of useful energy annually. This equates to about 258.62 million barrels of oil equivalent annually, which corresponds to the current national annual fossil fuel production in the country. This will also amount to about 4.2 × 105 GW/h of electricity production annually, which is about 26 times the recent annual electricity production of 16,000 GW/h in the country. In the work of Igwiro, 2010, in Oyedepo, 2012, heshowed that Nigeria receives abundant solar energy that can be usefully harnessed with an annual average daily solar radiation of about 5.25 kW h/m2 /day. This varies between 3.5 kW h/ m2 /day at the coastal areas and 7 kW h/m2 /day at the northern boundary. The average amount of sunshine hours all over the country is estimated to be about 6.5 h. This gives an average annual solar energy intensity of 1,934.5 kW h/m2 /year; thus, over the course of a year, an average of 6,372,613 PJ/year (approximately 1,770 TW h/year) of solar energy falls on the entire land area of Nigeria. This is about 120,000times the total annual average electrical energy generated by the Power Holding Company of Nigeria (PHCN).

With a 10% conservative conversion efficiency, the available solar energy resource is about 23 times the Energy Commission of Nigeria's (ECN) projection of the total final energy demand for Nigeria in the year 2030 (Oyedepo, 2012).

The efficiency of the solar system depends on the intensity of the sun. Higher current is generated when the solar panel is rotating than when it is stationary and placed at an inclined angle. Due to the movement of the earth relative to the sun, the direction or angle at which the rays reach the earth surface changes from sunrise to sunset and this greatly affects the intensity of radiation. Solar manual tracking is therefore usually introduced in order to move the panel in more than one direction, which involves human control in order to provide optimum solar energy at different time intervals.

Solar energy has been utilized in Nigeria in various forms (solar PV for rural electrification, solar cooker, solar crop dryer, solar manure dryer, solar water pump, solar water heaters, solar chick brooders etc). Currently, of all the solar installations in Nigeria, more than 80% are for water pumping, street lighting, vaccine refrigerators, and community lighting. Its domestic application is not yet pronounced because people are yet to be convincedabout its viability as an alternative to small size generators due to high capital cost.

Table 10; Estimated electricity generation from 1kwp PV module in selected cities in Nigeria

City	Latitude (North)	Longitude (East)	Optimal Inclination Angle (°)	Yearly Averaged daily radiation (kWh/m²/day)	Annual Electricity Generation (kWh)
Sokoto	13°3'25"	13°3'25"	0	5.21	1,426
			15	5.34	1,462
Maiduguri	11°49'59"	13°9'0"	0	6.22	1,703
			16	6.4	1,752
Abuja	9°4'0"	7°28'59"	0	5.26	1,440
			15	5.39	1,476
Ilorin	8°29'29"	4°32'40"	0	5.13	1,404
			14	5.23	1,432
Ibadan	7°23'47"	3°55'0"	0	4.61	1,262
			14	4.71	1,289
Enugu	6°27'9"	7°30'37"	0	4.75	1,300
			12	4.82	1,319
Port-Harcourt	4°47'5"	7°0'19"	0	4.26	1,166
			11	4.31	1,180
Total				71.64	19,611

Nigeria is known to be far behind in research on solar cell development and manufacturing. However, the National Agency for Science and Engineering Infrastructure (NASENI) took a giant step towards having Nigerian branded solar PV by establishing a solar assembly plant in Karshi, Abuja in the year 2011, but it is yet to start production. Efforts like this should be supported to ensure sustainability.

The researchers in the country should also embark on relevant research that will take the country to a level of locally producing accessories and components withthe intension to attain production of solar cells. Local manufacturing of solar PV will drastically bring down the cost of installation and promote availability and accessibility thereby promoting the adoption of solar energy as viable alternative source of energy in the country.

Wind Energy Resources

Wind speed in Nigeria ranges from 1.4-3.0m/s in the southern areas and 4.0-5.12m/s in the extreme north. Wind speeds are generally weak in the southern part of the country except for the coastal regions and offshore location. The technologies for harnessing wind energy have, over the years, been tried in the northern parts of the country, mainly for water pumping from open wells in many secondary schools of old Sokoto and Kano States as well as in Katsina, Bauchi and Plateau States. Other areas of “potential application” of wind energy conversion systems in Nigeria had been recently establishedfor the production in rural communities and for integration into the national energy grid.

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

Adekoya and Adewale (1992)had analyzed wind speed data of 30 stations in Nigeria, determining the annual mean wind speeds and power flux densities, which vary from 1.5 to 4.1 m/s to 5.7 to 22.5 W/m2, respectively. They carried out a 10-year wind data analysis from 1979 to 1988, considering the surface and upper winds as well as the maximum gusts. They performed a statistical analysis of the wind energy potential in Maiduguri, Borno State, using the Weibull distribution data for 10-year (1995 to 2004). A cost benefit analysis was also performed using the wind energy conversion systems for electric power generation and supply in the State. Each of these reports point to the fact that the nation is blessed with a vast opportunity for harvesting wind for electricity production, particularly at the core northern states, the mountainous parts of the central and eastern states, and also the offshore areas, where wind is abundantly available throughout the year. The issue then is for the country to look at ways of harnessing resources towards establishing wind farms in various regions and zones that have been identified as possessing abilities for the harvesting of wind energy.

Wind energy exploration in Nigeria has not been significant as most of the existing wind energy systems are abandoned due to inappropriate evaluation of its potentials, operations and management. Given the inadequate and epileptic power supply being experienced in the country, using wind energy conversion system to supplement the energy obtained from the serving hydropower and thermal power plants will be a wonderful initiative.However, given the huge initial investment capital, the government could encourage many individual users to adopt it by giving adequate incentives, such as feed-in tariff.

With the current deregulation of the power industry in Nigeria, the Council for Renewable Energy in Nigeria (CREN), whose responsibility, among others, is to coordinate renewable energy development and implementation plan for the country was created by the government could catch on these available potentials.

Biomass Energy Resources

Biomass is any organic material from plants and animals that store sunlight in the form of chemical energy. It is seen as one of the most important energy sources among the renewable energies in the near future. Generally, sources of biomass include virgin wood, energy crops and agricultural residues, industrial wastes, sawmill residues, etc.

Biomass fuels are overwhelmingly the most important energy source for rural households, agricultural production and rural industries particularly in developing countries. Modern biomass energy recycles organic waste from forestry and agriculture, like corn stokes, rice husks, wood waste and pressed sugarcane, or uses special, fast-growing ‘‘energy crops’’ such as willow and switch grass, as fuel. Based on the US International Energy Agency (IEA) report, 11% of the world’s energy, both heat and power, is currently derived from biomass. Depending on the type, when combusted, the chemical energy in biomass is released as heat that is used to produce steam which could in turn be used to either drive a turbine for electricity production or provide heat to industries and homes. Biogas and biofuel technologies are now widely used to convert organic biomass matters to gaseous and liquid states respectively.

There exists a huge potential for the successful deployment of biomass energy in Nigeria, most especially in the rural agricultural areas. Nigeria has a reserve of 11 million hectares of forest and woodland, 245 million assorted animals in 2001 and 28.2 million hectares of arable land, which is approximately equal to 30% of the total land. All these produce in excess of 1.2 million tonnes of biomass per day. [4]. In 1990 a total estimate of 1.2 PJ of biomass, consisting of animal and agricultural wastes, and wood residues, was made for Nigeria. Furthermore, research revealed in 2005 that bio-energy reserves/potential of Nigeria stood at 13 million hectares of fuel wood, 61 million tonnes per year of animal waste, and 83 million tonnes of crop residues [3].

The proportion of biomass used for energy purposes is 34% in total of biomass production in Nigeria. A fuel-wood supply deficit of about 22% and 28% was projected for 2008 and 2010 respectively. Biomass and waste make up 78% of total primary energy supply [9]. It is unlikely that all agricultural biomass harvest is used for heat. A significant amount of corn husks, paddy husks, shells, etc are left to decompose on the farms. In the absence of study data, a fair estimation would be 50%. However decreases in the availability of biomass in the country are likely due to the reduction in land area from sea level rise and flooding in the south, and droughts in the north.

Biomass in form of fuel-wood, coal, bamboo trunks and dead leaves are commonly useful sources of cooking fuel in the Niger Delta Area region of Nigeria. Of all these the most frequently used is fuelwood. This fuel-woods are usually logged from nearby bushes and forests or are collected as dead branches within the residential vicinities by the women and sometimes children and are used to generate energy for cooking.

There are technologies for making renewable energy from biomass (waste). This commercially available source of energy generation is based on biomass gasification. An example is the project embarked upon by the United Nations Industrial Development Organization (UNIDO) and Ebonyi state Government. The gas turbines are designed to use the husks from the mills to generate power that will contribute to the rapid development of the state.

Fig. 7; A biomass gas turbine project sited at Ikwo in Ebonyi State, Nigeria

This power generation converts woody biomass to electricity and heat. This technology is an extraordinary opportunity of a waste-to-wealth campaign converting easily available biomass into affordable, renewable, reliable energy in Nigeria.

Biogas Energy Resources

The development of biogas energy, which is considered as an important energy resource for the future, is a fitting option to solve global environmental and energy issues in a sustainable manner. Biogas is naturally produced when any organic matter including landfill sites, weeds, woods, grasses, leaves, fruits and vegetable solids wastes, wastewater treatments facilities, animal farm manure, algae, compost, sewage and agro-food sludge decomposes under anaerobic conditions. Biogas is comprised primarily of methane (50-70%) and carbon dioxide (25-45%) in approximately 3:2 ratio. Methane is the important component, as it is a highly flammable gas that can be utilized as fuel for cooking, lighting, water heaters and, if the sulphur is removed, it can be used to run biogasfuelled generators to produce electricity. One main advantage of biogas is the waste reduction potential. Biogas production by anaerobic digestion is popular for treating biodegradable waste because valuable fuel can be produced while destroying disease causing pathogens and reducing the volume of disposed waste products.

In Nigeria, identified feedstock substrate for an economically feasible biogas programme includes water lettuce, water hyacinth, dung, cassava leaves, urban refuse, solid (including industrial) waste, agricultural residues and sewage. It has been estimated that 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, 20 kg of Municipal Solid Wastes (MSW) per capita has been estimated to be generated in the country annually. Nigeria with a current population figure of about 200million, will generate about 2 x 1.77 million tonnes of MSW (about 3.54 million tonnes) annually. With increasing urbanization and industrialization, the annual MSW generated will continue to increase.

It has been recentlyestablished that the identified feedstock substrate for an economically feasible biogas program in Nigeria includes water lettuce, water hyacinth, dung, cassava leaves, urban refuse, solid (including industrial) waste, agricultural residues, and sewage. The authors are of the view that Nigeria produces about 227,500 tonnes of fresh animal wastes daily. Since 1 kg of fresh animal wastes produces about 0.03 m3 gas, then Nigeria could produce about 6.8 million m3 of biogas every day. In addition to all these 20 kg of municipal solid wastes per capital has been estimated to be generated in the country annually.

Researchers have devised ways to convert existing septic tanks into biogas generators with little more than plastic pipes, cement, gas valves and some digging. This retrofitted biogas generator is relatively cheap to build; requiring only low-tech materials such as plastic pipes, cement and sand. This concept can help solve Nigeria's sanitation issues, rather than attempt a wholesale overhaul of Nigeria's waste system, this approach makes use of the existing septic tank.

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.

Geothermal Energy Resources

The widespread occurrence of geothermal manifestations in Nigeria is significant because the wide applicability and relative ease of exploitation of geothermal energy is of vital importance to an industrializing nation like Nigeria. There are two known geothermal resource areas (KGRAs) in Nigeria: the Ikogosi Warm Springs of Ondo State and the Wikki Warm Springs of Bauchi State. These are hot-water springs from great depths through faults in the basement complex rocks of the area. Within sedimentary areas, high geothermal gradient trends are identified in the Lagos sub-basin, the Okitipupa ridge, the Auchi-Agbede area of the Benin flank/hinge line, and the Abakaliki anticlinorium. The deeper Cretaceous and Tertiary sequences of the Niger delta are geopressured geothermal horizons. In the Benue fold-belt, extending from the Abakaliki anticlinorium to the Keana anticline and the Zambuk ridge, several magmatic intrusions emplaced during the Late Cretaceous line the axis of the Benue trough. Positive Bouguer gravity anomalies also parallel this trough and are interpreted to indicate shallow mantle. Parts of this belt and the Ikom, the Jos plateau, Bauchi plateau, and the Adamawa areas, experienced Cenozoic volcanism and magmatism, resulting in issue outs of hot water springs.

Geothermal gradients indicate that steam would be encountered at a depth of about 6,000 ft (1,800 m) in the Lagos and Auchi-Agbede areas, and at about 4,250 ft (1,300 m) in the Abakaliki area. A combination of heat-flow measurements and analysis of existing aeromagnetic data would provide a basis for the determination of geothermal gradients in the undrilled resource areas and the determination of depths to Curie isogeotherms (about 570°C, 1,058°F) in the basement complex and the intrusive areas from thermal attenuation of the remnant magnetic field. The separate but preferably combined application of gravity analysis, electrical, refraction-seismic, electromagnetic, and telluric methods would help in the accurate delineation and evaluation of Nigeria's known and suspected geothermal resource areas for future detailed investigations and possible exploitation. These ultimately will add up to the National energy-mix, for efficient and sustainable resource utilization in Nigeria.

Ocean Energy Resources

Nigeria has about 850 Km long of coastline. Ocean Thermal Energy Conversion (OTEC) within about 25 degrees each side of the equator, the surface of an ocean in Nigeria is warmed and the depths are cold to the extent that there is a modest temperature differential. This can be a source of energy, using a low boiling point fluid such as ammonia, which, at normal atmospheric temperature, colder water can be pumped from the deep ocean to condense the ammonia and then let it warm up and expand to gas.

The resulting gas pressure can power a turbine to turn a generator. But the plant would have to be huge and anchored in the deep open ocean or on a ship, all subjects to storm and corrosion, and the amount of water which has to be moved is enormous as the efficiency is very low. How to store and transport the resulting electricity would also be a large issue. OTEC does not appear to have much potential as a significant energy source, but the end product is electricity. This energy resource is vastly available in Nigeria, if managed and harnessed.

Tidal Energy Resources

It takes a special configuration and a high tide of a coastline and a narrow estuary which can be dammed, to be a tidal power site of value. Damming estuaries would have considerable environmental impact, like their abundance in Nigeria. Areas in southern part of the country have, for a long time considered places for tidal power sites. Developing them would not have negative effect on the fisheries and other sea-related economic enterprises and will not disturb the habitats of millions of birds which use the areas as part of their migration routes. Tidal power is not a significant power source, but the end product is electricity.

CHALLENGES

It is often assumed that alternative energy will substitute for oil, gas ,coal, but integration of alternative energy into our current energy system will require enormous investment in both new equipment and new infrastructure, along with the resources consumption required for their manufactureat a time when capital to make such investments have become harder to secure.

This raises question of suitability of moving towards an alternative energy future on assumption that the structure of current large scale, centralized energy system would be maintained.

1) Many alternative energy have been successfully demonstrated at small scale, but demonstration scale does not provide an indication of potential for scale production because alternative energy relies on engineering and construction of equipment and manufacturing process for its production.

2) These technologies that have proved feasible today will likely have little impact into the 2030s.Because alternative energy today constitute only small scale fraction of total energy production, the volume of resources and energy demanded for its production has so far been easily accommodated. This will necessary be the case with large scale expansion.

3) Alternative energy production is reliant not only on range of resource inputs, but also on fossil fuel for mining of raw material, transport, manufacturing, construction, maintenance and decommissioning. Currently no alternative energy exist without fossil fuel input and no alternative energy process can reproduce itself, i.e., manufacture the equipment needed for its own production without the use of fossil fuel.

4) The modern focus on centralized production and distribution may be harder to maintain, since local condition will become increasingly important in determining the feasibility of alternative energy production.

WAY FORWARD

Despite their availability in reasonable quantities, renewable energy resources are grossly underutilized in Nigeria. In the light of this scenario, the following recommendations as way forward, are hereby proposed;

i. Research and Development centres and Technology Development institutions, like RMRDC, the Universities, Polytechnics, e.t.c. should be adequately strengthened to support the shift towards increased renewable energy utilization.

ii. Resource survey and assessment should be carried out to determine the total renewable energy potential in the various Geo-political zones of the country. And also identify local conditions and local priorities in various ecological zones.

iii. Human resource development, critical knowledge and know-how transfer should be in focus for renewable energy projects development, project management, monitoring, evaluation, implementation and actualization.

iv. Government should develop policies on Renewable energy efficiency and integrate them into current existing energy policies and develop appropriate drivers for the implementation of these energy efficient policies for the overall benefit of the populace.

v. Renewable energy related projects have a greater likelihood of success if implemented together with activities in these sectors to ensure sufficient demand for the energy services providers.

vi. To create awareness on renewable energy resources exploration and utilization in Nigeria at all levels.

vii. Demonstration projects on various renewable energy forms should be widely established so that the performance and efficiency with which services are delivered can be made known to consumers.

viii. Government at various levels should pay more attention to renewable energy projects by allocating more resources to it in their budget. Renewable energy funding/financing agency should be established and co-financed by the various tiers of Government.

ix. Entrepreneurship and managerial skills development training programmes and technical courses in renewable energy technologies (RET)s with a view of developing Energy Service Companies (ESCOs) providing services to rural areas need to be introduced to support the total integration of RETs in to the general energy system.

REFERENCES

[1]. Adekoya LO, Adewale AA (1992) Wind energy potential of Nigeria. Renewable Energy 2(1):35–39

[2]. Agbetuyi, A. F, Akinbulire, T.O, Abdulkareem, A., Awosope C.O.A, (2012) Wind Energy Potential in Nigeria, International Electrical Engineering Journal (IEEJ) Vol. 3 (2012) No. 1, pp. 595-601.

[3]. A.M. Agba, M. E. Ushie, F. I. Abam, M. S. Agba, and J. Okoro, "Developing the Biofuel Industry for Effective Rural Transformation," European Journal of Scientific Research, vol. 40, pp. 441-449, 2010.] .

[4]. A.S. Sambo, "The Place of Renewable Energy in the Nigerian Energy Sector" presented at the World Future Council Workshop on Renewable Energy Policies, Addis Ababa, Ethiopia, 2009.

[5]. Bala, E.J., Ojosu, J. O., and Umar, I. H., (2000) "Government Policies and Programmes on the Development of Solar PV Sub-sector in Nigeria" Nigeria Journal of Renewable Energy, 8(1&2):1-6. 19.

[6]. Chendo, M. A. C (2002). Factors Militating Against the Growth of the Solar-PV Industry in Nigeria and their Removal. Nigerian Journal of Renewable Energy Vol. 10, Nos. 1&2 pp. 151-158. 20

[7]. Council for Renewable Energy, Nigeria (CREN) (2009) Nigeria Electricity Crunch. www.renewablenigeria.org.

[8]. Department for Petroleum Resources [NNPC], "Draft Nigerian biofuel policy and incentives,"

[9]. Edirin. B. A., Nosa. A. O., A COMPREHENSIVE REVIEW OF BIOMASS RESOURCES AND BIOFUEL PRODUCTION POTENTIAL IN NIGERIA, Research Journal in Engineering and Applied Sciences 1(3) 149-155, Emerging Academy Resources (2012), ww.emergingresource.org

[10]. Fagbenle RO, Adenikinju A, Ibitoye FI, Yusuf AO, Alayande O (2006). Draft Final Report on Nigeria's Electricity Sector (Executive Report).

[11]. Federal Ministry of Power and Steel, Federal Republic of Nigeria, Renewable Electricity Action Program (REAP), International centre for Energy, Environment and Development, December 2006. www.iceednigeria.org.

[12]. Idris N .A, Lamin, H.S. Ladan, M.J. Yusuf, B.H Nigeria's Wind Energy Potentials: the Path to a Diversified Electricity Generation-Mix, International Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol.2, Issue.4, July-Aug. 2012 pp-2434-2437.

[13]. Ijeoma V. A., Renewable energy potentials in Nigeria, Conference Proceedings' Energy Future, The Role of Impact Assessment. 32nd Annual Meeting of the International Association for Impact Assessment (IAIA) 27 May- 1 June 2012, Centro de Congresso da Alfândega, Porto – Portugal.

[14]. Ighodaro CAU (2010) Co-Integration and Causality Relationship between Energy Consumption and Economic Growth: Further Empirical Evidence for Nigeria. Journal of Business Economics and Management 11(1):97–111.

[15]. Igbinovia, F.O (2018). AN OVERVIEW OF RENEWABLE ENERGY POTENTIALS IN NIGERIA: PROSPECTS, CHALLENGES AND THE WAY FORWARD. Department of Electrical Power Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Technicka 2, 166 27 Praha 6, Prague, Czech Republic. Uploaded on the 24th July 2018.

[16]. M. F. Akorede1, O., Ibrahim, S. A., Amuda, A. O. Otuoze, B. J. Olufeagba (2012). CURRENT STATUS AND OUTLOOK OF RENEWABLE ENERGY DEVELOPMENT IN NIGERIA. Nigerian Journal of Technology (NIJOTECH) Vol. 36, No. 1, January 2017, pp. 196 – 212.

[17]. M. F. Akorede, M. I. Mohd Rashid, M. H. Sulaiman, N. Mohamed, and S. Ab Ghani, "Appraising the viability of wind energy conversion system in the Peninsular Malaysia," Energy Conversion and Management, vol. 76, pp. 801-810, 2013

[18]. Nnaji C. et al (2010) In: Nnaji CE, Uzoma CC (eds) CIA World Factbook., Nigeria, http://www.cia.gov/library/publications/the-world-factbook/geos/ni. html.

[19]. Obioh I., Fagbenle R.O., (2009). Energy Systems: Vulnerability – Adaptation – Resilience (VAR). Hello International. www.heliointernational.org/VARNigeria.

[20]. Okafor ECN, Joe-Uzuegbu CKA (2010) Challenges to Development of Renewable Energy for Electric Power Sector in Nigeria. International Journal of Academic Research 2(2):211–216

[21]. Onyebuchi E.I. (1989) Alternative energy strategies for the developing world's domestic use: A case study of Nigerian household's final use patterns and preferences. The Energy Journal 10(3):121–138

[22]. Onyebuchi E.I. (1989) Alternative energy strategies for the developing world's domestic use: A case study of Nigerian household's final use patterns and preferences. The Energy Journal 10(3):121–138

[23]. Onyebuchi E.I. (1989) Alternative energy strategies for the developing world's domestic use: A case study of Nigerian household's final use patterns and preferences. The Energy Journal 10(3):121–138

[24]. Oyedepo, S.O. (2012). Energy and sustainable development in Nigeria: the way forward. Energy, Sustainability and Society 2012, 2:15 http://www.energsustainsoc.com/content/2/1/15

[25]. Osueke C. O., Ezugwu C.A.K. (2011) "Study of Nigeria Energy Resources and Its Consumption" International Journal of Scientific & Engineering Research, Volume 2 (12):121-130. 21