The Role of Renewables in Nigeria's Energy Policy Mix

BY EMMANUEL OMONIYI FALOBI

Introduction

Nigeria is well endowed with abundant Renewable Energy (RE) technologies. Main RE technologies include, Small and Large Hydro, Nuclear Power, Solar PV, Wind, Geothermal and Biomass. The rapidly growing energy demand in the country is met principally through finite fossil fuel sources especially crude oil and natural gas. However, these have their attendant challenges of global warming through greenhouse gas (GHG) emissions and CO_2 pollutions. Nigeria's energy demand far outstrips current supply, and this has been the bane to industrial and economic development. Several government reforms have taken place in the past to address the energy challenges in Nigeria. The Power Holding Corporation of Nigeria (PHCN), a company responsible for power generation, transmission and generation was unbundled in 2010, into 18 different companies – 6 Generation Companies (GENCOS), 11 Distribution Companies (DISCOS) and 1 Transmission company, to improve energy efficiency and accessibility. This measure allowed for private participation, eliminating monopoly in the sector. Epileptic power generation and distribution over the years has negatively impacted economic growth and industrialization.

The national target of 40 GW by 2020 from the current level of 3,879MW could only be achieved and sustained with quick intervention from the country's huge untapped RE potentials. Nigeria's installed electricity capacity at year-end 2016 was 12.562GW comprising 15.42% large-hydro, 0.5% small-hydro and 84.1% fossil fuels. However, only 7.141GW of this was available. Due to inadequate grid capacity, an average of 3.879GW of this base figure became technically available within the year following constraints attributable to gas, water management, transmission, etc. Currently, electricity consumption is about 149kWhr/capita. According to IEA (2014), 93 million Nigerians are without electricity whilst the electrification rate stood at 45%, ranking Nigeria about the lowest in Africa. Government targets 75% by 2025 (Vision 20:2020 & FMP 2015 Rural Electrification Strategy and Plan).

Electricity Demand in Nigeria

Projections by International Researchers suggest an expected steady, sustained increased rate in electricity demand effective 2018 going forward (Figure 1). Expectedly, Off-grid supply should augment grid demand in meeting consumption in rural areas (Africa-EU RECP, 2016).

The 7% GDP Growth scenario of the RE Master Plan study conducted by Africa-EU RECP, (2016), gave electricity demand projections of 50,820MW, 77,450MW, and 119,200MW for 2020, 2025, and 2030 planning horizon, respectively.

Table 1 shows Nigeria's 25 grid-connected Power Generating Plants and their installed capacities. However, a number of these plants are unavailable for evacuation to the national grid because of the peculiarity of Nigeria's system – lack of maintenance and repair requirements, trip offs, faults and leakages. Most of these plants are fired by fossil (natural gas) thermal power (85%, i.e., 22 Gas Plants generating 10,632MW) whilst the remaining 15% are accounted for by 3 hydroelectric power plants – Jebba, Kainji and Shiroro Power Stations generating 1,930MW (Africa-EU RECP, 2016).

Emmanuel Omoniyi Falobi is a PhD Candidate in Renewable Energy Policy at the Center for Petroleum, Energy Economics & Law (CPEEL), University of Ibadan, Nigeria. He may be reached at: efalobi7707@stu.ui.edu.ng

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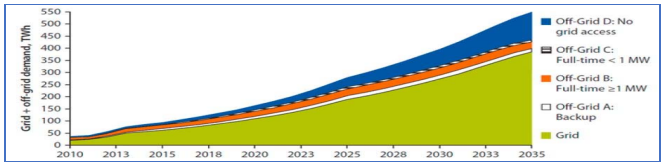

Figure 1: Projected Electricity Demand in Nigeria
Source: GIZ 2015 (FMP & PHCN Data and UN 2010 Rural/Urban Population Data (for Off-grid D Projections), RECP 2016

Energy Supply in Nigeria

According to the International Energy Agency (IEA, 2011), Nigeria's total primary energy supply (TPES), excluding electricity trade, was 118,325 Kilo

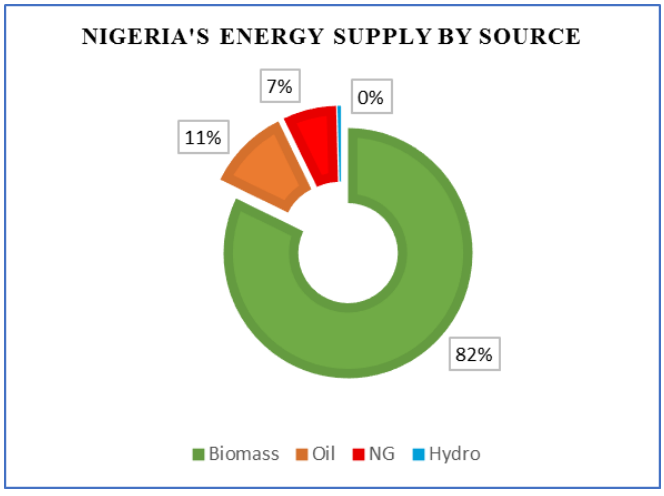

Figure 2: Nigeria's Total Primary Energy Supply by Source
Source: IEA, 2011, Author

Power Station	Fuel Type	Year Com-pleted	Installed Capacity (MW)	Average Available Capacity (MW)	Average Available Capacity (MW)
EGBIN	Gas	1985	1,320	941	539
AFAM VI	Gas	2009	685	587	455
OKPAI	Gas	2005	900	536	375
TRANSCORP UGHELLI	Gas	1990	480	463	374
JEBBA	Hydro	1986	570	431	262
OLORUNSOGO GAS	Gas	2007	335	277	189
IHOVBOR NIPP	Gas	2012	434	374	182
GEREGU NIPP	Gas	2012	450	328	179
KAINJI	Hydro	1968	760	444	173
OLORUNSOGO NIPP	Gas	2012	760	260	171
OMOTOSHO NIPP	Gas	2012	500	306	169
OMOTOSHO GAS	Gas	2005	335	280	163
SHIRORO	Hydro	1989	600	508	153
GEREGU GAS	Gas	2007	414	159	131
SAPELE NIPP	Gas	2012	450	184	111
IBOM POWER	Gas	2009	190	91	76
SAPELE	Gas	1978	504	219	69
ALAOJI NIPP	Gas	2015	720	158	67
ODUKPANI NIPP	Gas	2013	561	234	64
AFAM VI-V	Gas	1982	724	3	2
ASCO	Gas	?	294	270	-
OMOKU	Gas	2005	110	-	-
TRANS AMADI	Gas	?	150	-	-
AES GAS	Gas	2001	180	175	-
RIVERS IPP (Independent Power Producer)	Gas	2009	136	-	-
TOTAL			12,562	7,141	3,879

Table 1: Nigeria's Power Stations Situation (2016)
Source: Africa-EU RECP, 2016, Author's Update.

ton of oil equivalent (ktoe). In terms of energy demand, the residential sector accounted for the bulk of the energy consumed with a total final consumption of 116,457 ktoe. Biomass (including biofuels) and waste constituted (82.2%) and dominated TPES whilst RE sources accounted for just a little share of the energy supply with hydro power accounting for just a paltry 0.4%. (Figure 2).

Energy Consumption in Nigeria

Total Primary Energy Consumption (TPEC)

According to the U.S. Energy Information Administration (EIA, 2012) and IEA (2012), traditional solid biomass and waste dominated Nigeria's TPEC (Figure 3). Nigeria also consumed 35,00 short tons of coal in 2012.

Electricity Consumption by Sector

Data from IEA (2014) source, shows Nigeria's electricity consumption pattern (Figure 4). Here, the residential sector consumed 57% of the total energy demand.

In 2015, power supply averaged 3.1GW (Africa-EU, RECP, 2016) which was just about one-third of the minimum power demand in the country. Consequently, most consumers who could afford stand-by generators resorted to the use of generators to power their businesses and households to augment the intermittent power supply.

Energy Consumption by Economic Sector

Table 2 shows Energy Consumption by Economic Sectors. The residential

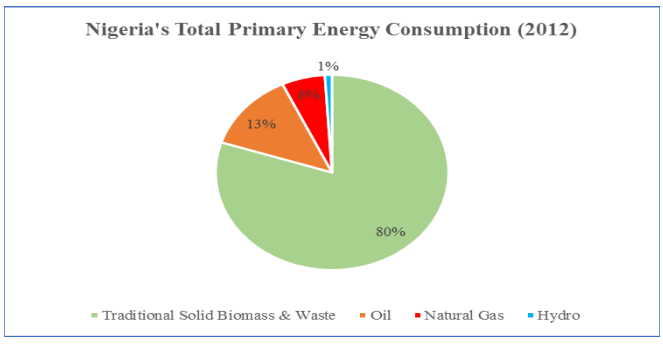

Figure 3: Nigeria's Total Primary Energy Consumption
Source: EIA, IEA, 2012

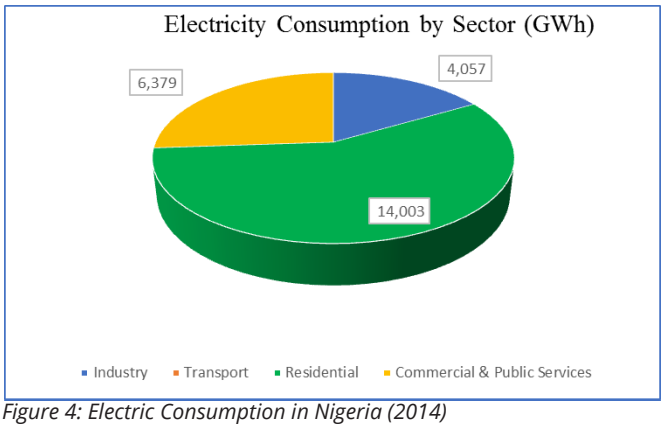

Figure 4: Electric Consumption in Nigeria (2014)
Source: IEA, 2014, Author

Economic Sector	Consumption (ktoe)
Residential	90,709
Industry	10,148
Transport	8,736
Commercial and Public Services	3,561
Non-specified	2,176
Non-Energy Use	1,123
Agriculture and Forestry	4
Fishery	0
T O T A L	116,457

Table 2: Nigeria's Energy Consumption by Economic Sectors
Source: IEA, 2011.

Sector accounted for the largest consumption with 90,709 kilo tons of oil equivalent.

RE Potentials in Nigeria

Agricultural Land Potential

Land is a key endowment to the development of

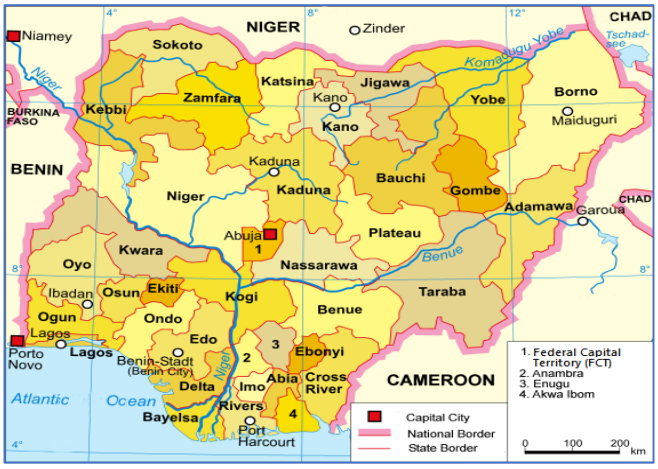

Figure 5: Map of Nigeria showing its vast Land Potential
Source: Wikipedia

RE in any nation. Nigeria has a total land mass of 92.4 million hectares (923,800 km^2 or 357,000 sq. miles). Land occupies 79.4 million hectares (86%) whilst the remaining 13 million hectares (14%) are water bodies. Hence, there is a huge land potential for cultivation and production of agricultural biomass without necessarily interfering with food security. The climatic and agro-ecological setting of the northern part of Nigeria is essentially arid and suitable for the cultivation of sweet sorghum, groundnut, millet, maize, sugarcane and jatropha; whilst in the southern rain forest belt, crops like, cassava, oil palm, and maize thrive readily. These crops are largely produced by small-scale farmers under relatively low labour costs[1] and are the key feedstock for first generation biofuels[2] production.

RE Potentials

RE potentials (Table 3) derive from the RE technologies including biofuels. Nigeria's RE Master Plan (REMP 2005, 2012 Revised) plans to increase on-grid renewable electricity supply from 13% of total electricity generation in 2015 to 23% in 2025 and to 36% by 2030. This would enable renewable electricity to account for 10% of Nigeria's total energy consumption by 2025 (ECN, Nov 2012; REMP 2012 Revised).

Government's Electric Power Sector Reform (2013) had set ambitious targets to increase installed hydroelectric power to 5.69GW, thermal to over 20GW and renewables to 1GW capacities by 2020. These targets aim at diversifying Nigeria's energy mix to reduce the age-long dependence on natural gas with its attendant environmental concerns.

Estimates of renewable electricity potential is presented in Table 4. Small- and Large-Hydro are

Energy Source	Estimated Potential (MW)	Percent Estimated (%)
Wind – On-Shore	1,600	1.70
Wind – Offshore	800	0.85
Solar PV Panels	7,000	7.45
Geothermal	500	0.53
Biomass	50	0.05
Small & Large Hydro	64,000	68.12
Nuclear Power	20,000	21.29
T O T A L	93,950	100

Table 4: Estimated Renewable Electricity Potential (MW)
Source: GIZ, 2015

Resource	Potential	Current Utilization and Further Remarks
Large Hydropower	11,250 MW	1,900 MW exploited
Small Hydropower	3,500 MW	64.2 MW exploited
Solar	4.0 kWh/m^2/day – 6.5 kWh/m^2/day	Significant potential for solar infrastructure – both for on-grid & off-grid use. Current estimates give 7,000MW from Solar PV Panels
Wind Onshore Wind Offshore Wind	2-4m/s @ 10m hub height mainland -1,600MW - 800MW	Electronic wind information system (WIS) available. Moderate wind potential in the country
Geothermal	500 MW	Requires Technology to fully harness this potential
Biomass (Non-fossil organic matter)	Municipal waste	18.5 million tonnes produced in 2005 and now estimated at 0.5kg/capita/day. 30 million tonnes/yr. in 2016
	Fuel wood	43.4 million tonnes/yr. fuel wood consumption. 11 million of forest & woodland
	Animal waste	245 million assorted animals in 2001
	Agricultural Residues	91.4 million tonnes/yr. produced. 72 million Ha of Agricultural land
	Energy crops	28.2 million hectares of arable land; 8.5% cultivated

Table 3: Summary of RE Potentials in Nigeria
Source: Energy Commission of Nigeria (ECN, 2014), Energy Implications of Vision 20:2020 and Beyond. Report No. ECN/EPA/2014/01

the prominent power source of renewable electricity accounting for about 68%.

RE Resources

Concerted efforts to harness Nigeria's vast untapped RE resources using appropriate technologies through its Agencies, the: Energy Commission of Nigeria (ECN), Nigerian National Petroleum Corporation (NNPC), Nigerian Electricity Regulatory Commission (NERC) and Petroleum Products Pricing and Regulatory Agency (PPPRA), are been driven by well-defined policies and all-encompassing reforms over the years.

Biomass Energy Resources

According to EIA, (2012E)[3], of the estimated 4.5 quadrillion British thermal unit (Btu) TPEC in Nigeria, traditional solid biomass and waste (fuel wood, charcoal, manure and crop residues) accounted for 80% and represents the use of biomass to meet off-grid heating and cooking needs, especially in rural areas. Fuel wood is largely found in the southern rain forest belt of Nigeria and serves as the main source of fuel for over 70% of the populace; thus, accounting for about 65% of TPEC in the country[4] and the negative effects of it has prompted government to discourage the use of fuel wood as an energy source. On December 12, 2012, the Lagos State Government, commissioned its "Waste-to-Energy Scheme" which aimed at generating about 50 MW of electricity from the various dump sites[5]. This typically is an example of the utilization of biomass for clean energy generation (converting municipal waste to clean energy).

Activity / Item	Timeline / Quantity		
	Short Term	Medium Term	Long term
1.Biomass Electricity (MW)	5	30	100
2.Improved Woodstoves (No.)	300,000	500,000	1,000,000
3.Biogas Digesters (No.)	500	6,000	8,000
4.Biomass Briquetting Machine (No.)	30	50	80
5.Biofuel (ML/day)*			
- Bio ethanol (B10)	5.3	9.7	24.2
- Biodiesel (B20)	2.0	3.4	11.7

Table 5: Biomass Programme and Government's Set Target
Source: ECN, (REMP 2005, 2012)

Biomass Targets and Timelines

Energy Commission of Nigeria conducted energy demand and supply studies under various growth scenarios using MAED and MESSAGE energy planning models of IAEA (ECN, NREEP, 2014). Table 5 shows the contribution of RE (biomass/biofuels) towards the realization of the set targets and timelines.

Hydroelectric Power Resources

Three main sources of hydro-power potentials and their installed capacities (totaling 1,930MW) in Nigeria are Kainji Dam (760MW), Jebba Dam (570MW), and, Shiroro Dam (600MW). A survey conducted in 1980 identified 277 sites across the country with potentials to generate 3,500MW of electricity (ECN, 2005). Large Hydro-Power promises an additional 11,250MW. In 2006, the Federal Ministry of Power and Steel came up with the possibility of additional 12,220MW from exploitable hydro sites in Nigeria (ECN, 2005).

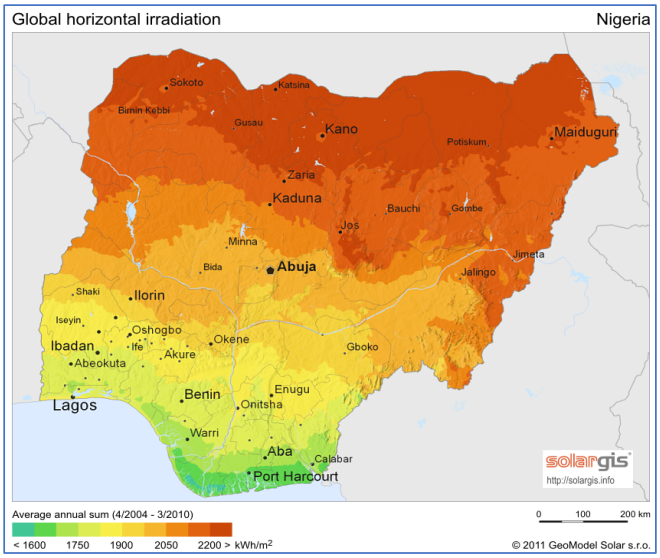

Figure 7: Global Horizontal Solar Irradiation in Nigeria
Source: SolarGIS, Africa-EU RECP, 2016.

Nuclear Power Resources

Nigeria has large deposits of uranium which can be tapped for nuclear power generation. With technological advancement, there are now fast breeder reactors that can conveniently generate up to 20GW of nuclear power on a sustainable basis.

Solar Resources

According to Africa-EU RECP, 2016, Nigeria's solar potential is enormous. With a well distributed solar radiation and average sunshine hour of about 6 hours per day, Nigeria's solar irradiation averages 19.8MJm^2/day. In Figure 7, Northern Nigeria has a higher concentration of solar radiation. The assumed potential for concentrated solar power and photovoltaic generation is estimated around 427,000MW.

Further investment in solar power projects in the country was witnessed in July 2016, when 14 Greenfield Independent PhotoVolataic (PV) Power Projects signed off their Power Purchase Agreements (PPAs) with the Nigerian Bulk Electricity Trading PLC (NBET), a wholly owned Federal Government entity, for a capacity generation of 1,125MW.

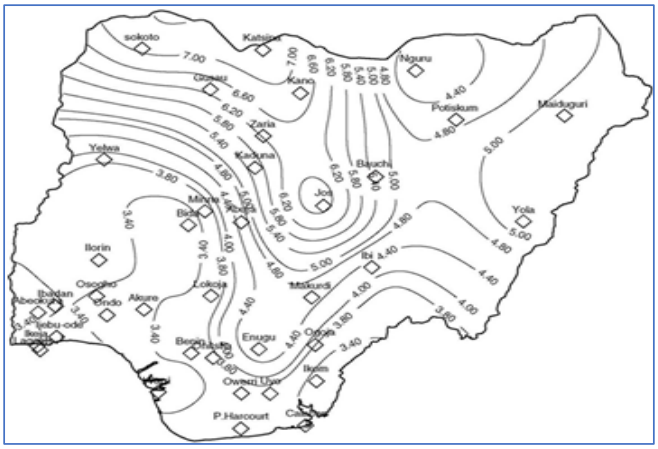

Figure 8: Wind Map of Nigeria (in m/s, determined from 40 year's measurements at 10m height.

Source: Nigeria Metrological Department, Oshodi, Lagos State. Nigeria (NIMET)

Wind Resources

Data obtained from the National Metrological Department, Ministry of Science and Technology reveals a record of an annual speed between 2m/s and 4m/s at the coastal area and heights of about 30m up north, respectively. This correlates well with the findings of Sambo (1987) who recorded annual speed ranges of 2.32m/s and 3.89m/s for Port Harcourt and Sokoto, respectively. Wind speeds of up to 5m/s have been recorded in some areas. These values are not sustainable for a meaningful investment on wind farms as the minimum speed to fully power a wind turbine is 6m/s (REMP, 2005).

Basin	Geothermal Gradient Range
Niger Delta	1.3 – 5.5°C/100m
Anambra	2.5 – 4.9°C/100m
Bida	2.0 – 2.5°C/100m
Borno	1.1 – 5.9°C/100m
Sokoto	0.9 – 7.6°C/100m

Table 5: Geothermal Gradient in Nigeria's Basins

Source: Avbovbo (1978)

Geothermal Resources

Potential for geothermal power generation is very high given the favorable records of geothermal gradient registered across the country. According to Avbovbo (1978), the earth's normal geothermal gradient ranges between 2 - 3°C/100m. Gradients above this range are considered good potential for geothermal power process. Table 5 summarizes what obtains in Nigeria's basins:

In addition, hot and warm springs are indicative of geothermal processes because of tectonic plate movement in the earth crust. The following are notable sites that have become tourist centers of attraction:

- Wikki Warm Springs, Yankari Game Reserve, Bauchi State – 32°C;
- Akiri Hot Spring in Benue State – 53.5°C;
- Ruwan Zafi at Lamurde in Adamawa State – 54°C; and
- Ikogosi Warm Springs in Ondo State. The warm spring has 70°C at source and 37°C at the confluence[6].

Given the right technology, these potentials, when harnessed have been projected to generate about 500MW of geothermal energy.

Thermal Resources

Nigeria's natural gas reserves are estimated at 192 trillion cubic feet (TCF). She currently ranks 9th in the world. Given this huge potential, about 90% of the installed plants are fired by gas thermal power.

RE Policies, Laws and Regulations

Relevant documents containing guiding policy statements for RE in Nigeria include:

RE Policy Guidelines (2006)

Sets out Federal Government's Vision, Policies and Objectives based on the constitution of each policy initiative. Renewables are to be developed on equitable and sustainable basis. This will facilitate the gradual transition from a fossil economy to a less carbon-intensive economy powered by natural gas and renewables. These guidelines include Policy documents on National Electric Power Policy (NEPP), Electric Power Sector Reform (EPSR), REMP, NREEP, Rural Electrification Agency (REA).

RE Master Plan (2005, 2012 Update)

Provides a roadmap for increasing the role of RE in achieving sustainable development (ECN; Nov 2012).

National RE and Energy Efficiency Policy (NREEP, 2015).

NREEP is a compendium of various other policies and strategies in one document. It calls for an

Milestone	Policy Initiative Milestone
2001	National Electric Power Policy (NEPP)–sets a target of 10% RE mix for all new connections by 2020
2003	National Energy Policy (NEP)
2005	Electric Power Sector Reform (EPSR) Act (2005)
2006	RE Master Plan (REMP)
2006	Rural Electrification Agency (REA) established
2010	International RE Agency (IRENA)
2012	REMP Revised
2013	RE Strategy Document
2015	National RE & Energy Efficiency Policy (NREEP)

Table 6: Key Policy Initiatives for RE Policy in Nigeria

Source: GIZ (2015), Africa-EU RECP 2016 and Compilation by the Author from various sources

Milestone	Targets
2015	300MW of Solar PV by 2015
	100MW of Small Hydropower (SHP)
2020	40MW of Wind Power
	30MW of Biomass-fired capacity
2025	4000MW of Solar PV
	760MW of SHP
	18% of electricity from RE sources
2030	20% of Solar PV by 2030

Table 7: Nigeria's RE Targets
Source: GIZ (2015).

RE Technology	Units	2013-2015	2016-2020	2021-2030
Large Hydro	MW	1,930	5,930	48,000
Small Hydro	MW	100	734	19,000
Solar PV	MW	5	120	500
Solar Thermal	MW	-	1	5
Biomass	MW	-	100	800
Wind	MW	1	20	40
Renewables	%	13	23	36

Table 8: RE Master Plan Targets
Sources: Area-net (http://area-net.org), Africa-EU RECP (2016). .africa-eu-renewables.org/market-information/nigeria/governmental-framework/

integrated RE & energy efficiency policy that will serve as a vehicle that limits future conflicts and promotes development of RE technologies in Nigeria (GIZ, 2015).

Policy Initiatives for RE Promotion

Table 6 presents a high-level summary of various initiatives for promoting renewables in Nigeria.

Table 7 summarizes RE Targets of the government.

RE Master Plan Targets are summarized in Table 8:

Conclusions

Diversifying Nigeria's energy mix beyond the current fossil fuel source has always been a major pre-occupation of government. Renewables are replenishable and cost-effective in providing ready solutions to energy issues. Several policies were developed in the past by government to support its efforts of proffering solutions through RE technologies to solve Nigeria's energy problems. Assuredly, renewables have vital roles to play in the energy equation of any nation that desires to run a low carbon economy and be green compliant, and Nigeria, a member of the Paris Accord, is no exception. The Power Sector Reform effort is laudable and will attract more investments. So also, the biofuel initiative to blend gasoline with ethanol by 10% (E10) will not only produce cleaner energy, safer environment, but also increase the country's energy security profile and encourage the use of biofuels for a healthier environment. New job opportunities especially in the rural areas will also emerge.

The government needs to pursue its energy agenda (especially the Power Sector Reforms) vigorously so that the country can be better for it. Power infrastructure is a sine qua non to any meaningful economic development and Nigeria is currently lagging in this critical area. Concerted effort is required to ensure uninterrupted supply of power for the nation's economic growth agenda. Government's vision of becoming one of the top 20 economies of the world by 2020 with a target of attaining 40GW of power is only realizable with dogged determination and unwavering effort by all stakeholders.

Footnotes

1 See http://www.fao.org/ag/agp/GPC/doc/Counprof/nigeria/nigeria.htm. Accessed on May 3, 2015.

2 First generation biofuels are derived from food crops sources, such as cassava, maize, wheat, sugarcane, sugar beet, sweet sorghum as feedstocks to produce typically, Ethanol and Biodiesel. Ethanol is used in petrol engines whilst Biodiesel which is produced from vegetable oils (jatropha, rapeseed, soya, oil palm) and used in diesel engines (SWAC/OECD, 2008).

3 http://www.eia.gov/countries/cab.cfm?fips=NI. Accessed last on May 14, 2015.

4 Sesan, Temilade , "Status of RE Policy and Implementation in Nigeria", 2008, Institute for Science and Society, Faculty of Social Sciences, Law and Education, University of Nottingham, United Kingdom.

5 https://www.vanguardngr.com/2012/12/lagos-generates-electricity-from-waste-lawma-boss/. Accessed last on December 05, 2015.

6 Wikipedia – Ikogosi Warm Springs.

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