

Enhancing Electric Power Generation in Nigeria Using Renewable Energy Mix

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ABSTRACT: *The electricity generation of Nigeria despite its abundant renewable and non-renewable energy resources has never been adequate from the installation of the first generating power plant up till this present moment. As it stands, the country's total installed capacity is 12,500 MW; out of which about 5,500 MW is available for onward transmission. This has greatly affected the daily activities of citizens and it might get worse as the country's population and demand for electricity increases. Owing to the necessity to save the ecosystem, improve the utilization of non-renewable energy sources, and most importantly, the need to have a consistent power supply, there is a need to turn to renewable energy resources as an alternative for meeting the electricity generation demand of the country. This paper therefore proposes renewable energy (wind, solar and Small Hydro) mix as a way to improve the electricity generation capacity of Nigeria. The analysis of the capacities of the proposed renewable energy mix studied shows that 26,298.8 MW of power can be added to the current generation. This will improve the standard of living of the country and also increase the socio-economic development, hence an increased energy security in Nigeria.*

KEYWORDS -Electricity generation, Renewable Energy, Energy Mix, Energy Security, Solar, small hydro

I. INTRODUCTION

In the world of today, availability of electricity is very crucial for a sustainable development in any economy. The inadequate electricity supply will no doubt restrict socio-economic activities, constrain economic development and negatively affect the quality and standard of living of a nation. Hence, electricity supply is an important factor for socio-economic development and economic growth of any nation in the world. Looking at the increase in population, quest for a better standard of living and rapid industrialization in Nigeria, the future demand of electricity is expected to double the current demand in the year 2040 [1] thereby triggering the need for increasing the generation capacity [2].

Nigeria is one of the countries in the world that are heavily endowed with the widest range of energy resources for the generation of electricity which include coal, natural gas, petroleum, solar, nuclear, hydro etc., yet the country's electric power generation remains relatively low with the current capacity being less than 5500 MW [3]; thus only 56.5% of the Nation's population have access to electricity as at 2018, despite its vital role in the economic growth and development as well as poverty eradication and security. The nation's poor electric power generation vis-a-vis supply crises are exemplified in persistent electricity blackouts and reliance on self-generated electricity by her citizens. These situations have worsened the socio-economic conditions which invaluably contribute to poverty and deprivation that results to the decline in economy, productivity, income growth, education and health, and has greatly hampered the provision of basic needs [4]. Moreover, since Nigeria is blessed with abundant renewable energy resources such as hydro, solar and wind, there is need to harness these resources and use them to chart a new future electricity mix for Nigeria [5]. In this regard, several

journals, conference papers, and other materials relating to the subject matter were reviewed for gathering appropriate information to develop a broader insight and comprehension for proper inference.

Moreover, it was seen from literatures that Nigeria has about 12,500 MW of installed generation capacity, of which about 5,500 MW is available for onward transmission. Meanwhile, the total electric power demand of the Nation was estimated to be 45 GW. To this end, there is absolutely need to source for alternative means of increasing the generation capacity. Thus, the renewable energy sources. This paper therefore aims at providing vital information that would assist Nigeria government and electricity utility operators in charting a new course for electric power generation for sustainable development.

II. ELECTRIC POWER GENERATION IN NIGERIA

The electric power generation in Nigeria can be traced back to 1898, when the first generating power plant with a total capacity of 60 kW was installed in Marina, Lagos. From then, the idea and plan to build and install different electric power stations kick-started in various part of the country and soon afterwards more Power Plants were installed [6]. During this period, the government of generation and supply of electricity was run by the public works Department and some Native authority; thus, it remained separate operational entities around various regions for several years. This eccentricity of electricity generation and supply was brought to an end in 1946 when the public works Department ceased to have control over the operation of the electricity generating plants and distribution system in the country. Consequently, the Nigerian Government Electricity undertaking was immediately established to take over the assets and liabilities of electric power generation and supply in Lagos. Four years later (1950), a central body - the Electricity Corporation of Nigeria (ECN) was established to take over all the various electricity generation outlets within the country[4].

More so, with the increase in demand for electricity, some projects were carried out in Ijora, Oji River, Kano and Ibadan power stations to improve availability and quality of electric power generation. In addition to further increase the electric power generation, the Nigeria government established Niger Dams Authority (NDA) with an act of parliament enacted in 1962 and saddled it with the responsibility of generating electric power using hydro. This led to the creation and completion of Kainji Dam in 1969 [7]. Furthermore, ECN and NDA was merged in 1972 to form a unified body known as National Electric Power Authority (NEPA)[8]. The network continued to grow under NEPA and the growth experienced by NEPA is reflected in the number of



generating stations built across the country – Fig. 1.

Figure 1: Key Power Stations in Nigeria **Source:** [8]

Despite the effective role of NEPA in the nation's socio-economic development and in steering the Nation into a greater industrial society, the problem of insufficient power generation to meet the consumer's demand of electric power persists. Hence, between 1978 and 1983, the Federal Government had sponsored two panels of enquiry to fashion out models of restructuring NEPA into an independent unit which was tailored towards privatizing it out of monolithic nature [9];[10]. The outcome of these panels of enquiry was the unbundling and privatization of the national power utility company into eighteen (18) companies – Table 1.

TABLE 1: Current Nigeria Generation, Transmission and Distribution Companies

Generating Companies	Transmission company	Distribution Companies
Egbin Electricity Generating Company (EEGC)		Abuja Electricity Distribution Company (AEDC)
Sapele Electricity Generating Company (SEGC)		Benin Electricity Distribution Company (BEDC)
Ughelli Electricity Generating Company (UEGC)		Eko Electricity Distribution Company (EKEDC)
Afam Electricity Generating Company (AEGC)	Transmission company of Nigeria (TCN)	Enugu Electricity Distribution Company (ENEDC)
Shiroro Electricity Generating Company (SEGC)		Ibadan Electricity Distribution Company (IBEDC)
Kainji Electricity Generating Company (KEGC)		Ikeja Electricity Distribution Company (IKEDEC)
		Jos Electricity Distribution Company (JEDC)
		Kaduna Electricity Distribution Company (KDEDCC)
		Kano Electricity Distribution Company (KNEDC)
		Port-Harcourt Electricity Distribution Company (PHEDC)
		Yola Electricity Distribution Company (YEDC)

Source:[11]

III. THE RENEWABLE ENERGY

Renewable energy is a clean energy derived from nature. Its advantages include but not limited to ability to be replenished, lowers reliance on foreign energy sources, has numerous health and environmental benefits, saves money and generates additional employment opportunities[12].Nigeria is endowed with abundant renewable energy resources; the ones having modern technologies that are currently being explored are solar energy, wind energy and small hydro. Research shows that in few years to come, renewable energy as a source of electric power generation will predominately rule the world [13]; [14]. This paper looks at the potentials in solar, wind and small hydro in Nigeria and use it to show how much electric power can be added to our national grid.

IV. POTENTIALS OF THE RENEWABLE ENERGY SOURCES

4.1 SOLAR ENERGY POTENTIALS

Solar energy, is one of the most promising renewable energy sources owing to its apparent limitless potential. Nigeria is endowed with an average daily sunshine of 5 hours at the coastal areas and 9 hours at the far north and an estimated average daily solar radiation of 5.5 kW/m²/day at the coastal areas and 7.0 kW/m²/day at the northern border. Figure 2 depicts the average sun hour's map of the country. Consequently, with an average solar radiation of 19.8 MJm⁻², an estimated average sunshine of 9 hours in the northern part, 6^{1/2} hours per day in the remaining part and an average flux 5.55 kWh per square meter, Nigeria is capable of generating up to 190.55TWh energy for a year, if only 1% of its landmass is covered with solar modules. This amount of power is over 300 times the current grid electricity consumption [15]; [16];[12].

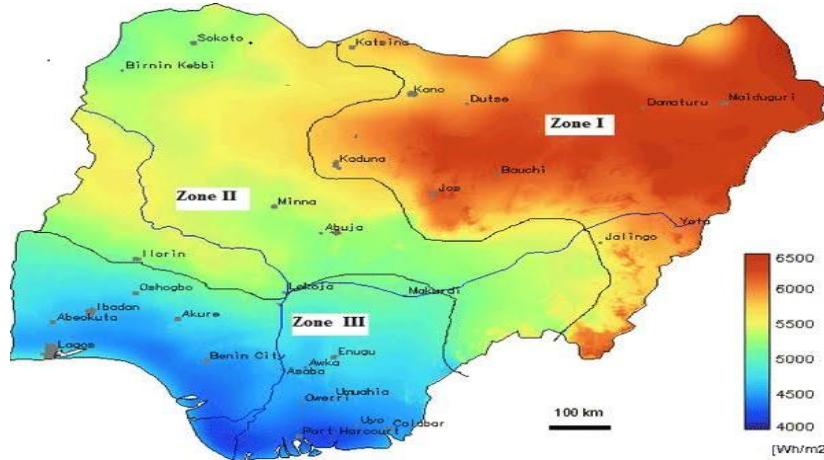


Figure 2: The average sun hour's map of Nigeria,
Source:[4].

4.2 WIND ENERGY POTENTIALS

Wind energy may be seen as a sustainable form of energy since the earth cannot run out of wind. Electricity may be derived from wind using wind turbines connected to an alternator. The recent development of wind technologies has made it a viable means of electricity generation[17]. In Nigeria, it is observed that wind energy is not commonly used as a means of generating electricity in Nigeria. However, owing to the vast wind speed in some areas within the country, its potentials can be utilized efficiently[18]. Table 2 shows the wind speed of some areas in the country; Figure 3 is a graphical representation of the data while Table 3 shows the estimated wind energy potentials and the potential generation capacity for some selected states in the Country.

Table 2: Wind speed at various measurement stations.

STATIONS	WIND SPEED (m/s)
Sokoto/ Badage	5.4
Jos Airport/ Kassa	5.2
Southern part of Jos	5.0
Funtua, Kano State	4.9
Maiduguri	4.7
Lekki beach, Lagos	4.7
Enugu/Nineth mile corner	4.6
Umudike, Abia State	5.4
Ibadan, Oyo State	2.9

Source: [19]

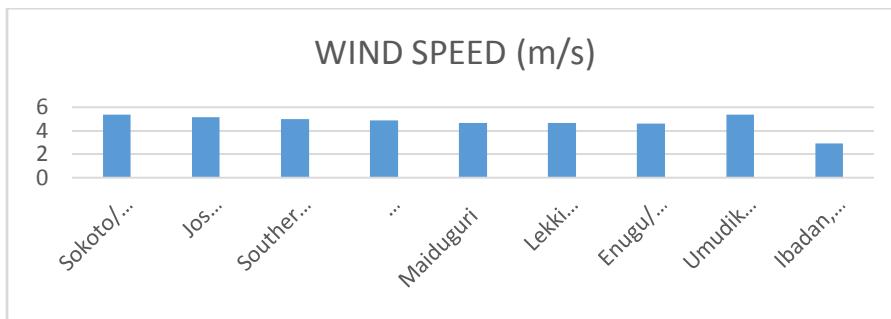


Figure 3: Graphical representation of some stations in Nigeria with their wind speed(m/s)

TABLE 3:Estimated wind Energy potentials for some states

Selected State	Area (km ²)	Wind Area (%)	Effective Wind Area (km ²)	1% Area (km ²)	Potential Capacity(MW)	Potential Generation (MWh/Yr)
Adamawa	37957	45	17080	170	854	2244
Bauchi	48197	50	24098	240	1204	3166
Borno	72767	100	72767	727	3638	9561
Gombe	17428	100	17428	174	871	2290
Jigawa	23415	100	23415	234	1170	3076
Kaduna	44217	60	26530	265	1326	3486
Kano	20389	90	18350	183	917	2411
Kastina	23822	100	23822	238	1191	3130
Kebbi	36320	25	9080	90	454	1193
Plateau	26539	90	23885	238	1194	3138
Sokoto	32146	90	28931	289	1446	3801
Taraba	59180	40	23672	236	1183	3110
Yobe	44880	100	44880	448	2244	5897
Zamfara	33667	80	26933	269	1346	3539
Total			3808	19043	50046	

Source: [20]

As seen from Table 3, the country will generate about **50.046 GWh** of Energy in a year. This will go a long way in improving the generation capacity of the country.

4.3 HYDRO ENERGY POTENTIALS

Hydropower rely on the potential energy of flowing water head. The water turbines which convert the potential energy of water heads are coupled to suitable generators which converts the mechanical power of the shaft to electricity. Hydro power is the most widely used form of renewable energy globally, accounting for about 20 percent of global electricity generation [21]. In Nigeria, hydro power has the biggest potential sources of electricity but these potentials remain largely untapped because of the country's preference for large dams [22]. To this end, the adoption of a new approach to hydroelectricity generation that involves the use of cost effective, easy to erect and ecological friendly small hydro power plants is not being looked into. Hydro power can be categorized according to the water flow in Nigeria as:

- Small hydro – $> 2 \text{ MW} \leq 10 \text{ MW}$
- Mini hydro – $\geq 100 \text{ KW} \leq 2 \text{ MW}$
- micro hydro – $\geq 5 \text{ KW} \leq 100 \text{ KW}$
- Pico hydro – $< 5 \text{ KW}$

To buttress this point, Table 4 depicts some of the small hydro potentials in some states in Nigeria.

TABLE 4:Small Hydro Potential Sites in Nigeria

S/N	State	Potential Sites	Cumulative Power Estimate (MW)
1	Adamawa	3	28.6
2	Akwa Ibom	13	300
3	Bauchi	20	42.6
4	Benue	19	69.2
5	Cross River	18	258.1
6	Delta	10	70.0
7	Ebonyi	5	1.4
8	Edo	5	3.8
9	Ekiti	6	1.3
10	Enugu	10	20.5
11	FCT	6	8.0
12	Gombe	2	35.1
13	Imo	71	90.8
14	Kaduna	19	59.2
15	Kano	28	46.2
16	Borno	28	20.8
17	Katsina	11	234.3
18	Kebbi	1	5.0
19	Kogi	2	1.1
20	kwara	12	38.8
21	Nassarawa	3	1.5
22	Niger	30	117.6
23	Ogun	13	15.6
24	Ondo	1	1.3
25	Osun	8	2.6
26	Oyo	3	1.1
27	Plateau	32	110.4
28	Sokoto	22	30.6
29	Taraba	9	134.7
30	Yobe	5	15.0
31	Zamfara	16	34.8
32	Gongola	38	162.7
TOTAL			1962.7

Source: [23]; [24]

V. RESULTS AND DISCUSSION

From the study, it is obvious that there is a countless prospect for power generation through the available renewable energy resources in wind, solar and small hydro. The exploitable renewable energy (wind, solar and hydro) potentials in Nigeria is shown in Table 5.

TABLE 5: The exploitable renewable energy potentials (Wind, Solar, Small hydro) in Nigeria.

S/N	Renewable Energy Sources	Potential Power Generation (MW)
1	Solar	5293.1
2	Wind	19043
3	Small Hydro	1962.7
TOTAL		26298.8

Following this estimation, a total of **26298.8 MW** can be conveniently generated in the country. Going by the current country's generation capacity, the energy mix outlook will increase the generation capacity by over 300%. Table 6 presents a comparison between the estimated country's energy demand, Current capacity from the existing generating Plant and the potential generation capacity using the renewable energy mix discussed while figure 4 further explains this using a pie chart.

TABLE 6: A comparison made between the estimated country's energy demand, Current capacity from the existing generating Plant and the potential generation capacity using the renewable energy mix discussed.

DESCRIPTION	GENERATION CAPACITY (MW)
Estimated country's energy demand	45000
Current capacity from the existing generating Plant	5500
Potential generation capacity from wind, solar and small hydro	26298.8

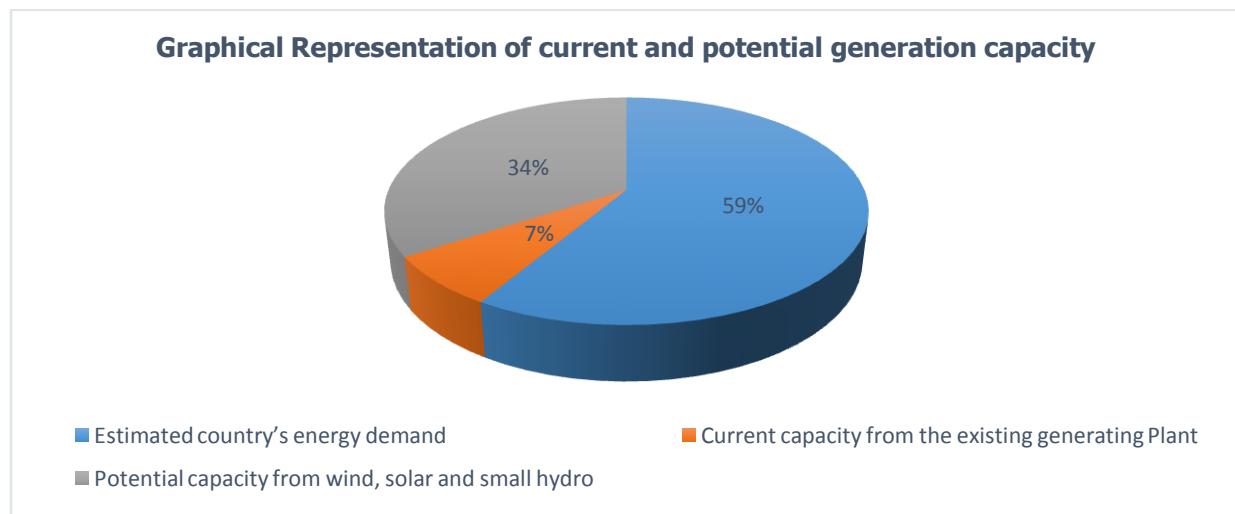


Figure 4: Graphical representation of the estimated country's demand, Current capacity and the potential generation capacity using renewable the energy sources discussed.

VI. CONCLUSION

From the energy outlook of Nigeria, it is evident that Nigeria is blessed with abundant resources of fossil fuels as well as renewable energy. Nevertheless, the nation does not generate enough electricity to support the entire population demand. As a result, there is a necessity to encourage the involvement of energy mix to improve grid electricity generation and also conserve the ecosystem [25]. It is seen that the day to day activities of man revolves around the availability of energy, hence there is a rapid need to turn to renewable energy sources as an alternative to the degrading power supply system in the Country. This will increase the standard of living of the citizens and also boost the Nation's GDP. More so, the government has to intensify further implementation of renewable energy efficiency programs in order to ensure the sustainability of electricity generation and economic development of the country.

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