Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 01, January-2023

Electrical Power Improvement; the Situation and Way-Forward Through Renewable Energy Implementation

Owolabi I. Moses
Department of Electrical and Electronics Engineering
Federal Polytechnic Nekede
Owerri, Nigeria

***Abstract*—This paper centers on the review of the electricity power system improvement in Nigeria, the present situation which was analyzed based on the recorded generation statistics and the way forward. Electricity has been identified as the prime mover of national development. However national grid had suffered from a lot of problems which include insufficient and inefficient power generation facilities, inadequately maintained long transmission lines and distribution facilities, and outdated metering system used by its customers. From the review it was confirmed that the major problem in Nigerian electricity supply is mainly in power generation which has failed to generate up to the level of electricity that can meet the demands of the consumers. The inadequate generation of power has always been attributed to the pipeline vandalism, insufficient supply of raw materials, corruption etc. However, from the review and the statistics it was concluded that the main limitation of the generation sector of the power grid is the poor facilities and limited generation sources. Therefore, it was concluded that for the national development to attain success in Nigeria, the electricity generation sources must be increased by including renewable energy sources especially solar, wind and biomass in order to increase the power generation level that can serve the consumers adequately and attract investors to facilitate the growth needed for development.**

Keywords*— *Solar Energy, Renewable Energy, Power Generation, Power Transmission, Power Supply

I. INTRODUCTION

Electrical power system has become the backbone for national development because the success of other factors of national growth depend on it. The national electrical power system is majorly divided into three: generation, transmission and distribution. The generation stations generate low voltages which are transformed to higher voltages for transmission. The transmission stations transmit three main levels of high voltages which include 330KV, 132KV and 66KV (in a special case). The transmission stations also step down the high voltages to 33KV which is fed to the distribution stations. The distribution stations distribute 33KV and 11KV and they are also in charge of the 240Vand 415V.

Many generation plants are being built and the transmission lines are being expanded in order to meet up with the tremendous increase in the demand of the electrical power at the consumer end. Due to the high rate of increase in the load, resulting to complexity in the system, the line faults and losses in the transformation and power transportation processes, there is significant level of power instability observed at the various stations and also at the consumer end. The transmission stations have been trying to apply available and cheap means to reduce power instability problems especially the power loss. One of the methods applied to reduce losses is the transmission of more of 330KV than the 132KV and 66KV. This is because the high voltage is cheaper to operate as it suffers lesser loss than the lower voltages. However, this method is dangerous to the human body due to the high level of radiation and it is not effective in terms of power conservation. Secondly, it will be very expensive to convert the already laid 132KV lines into a multi-tower line which can carry the 132KV and 330KV lines on same pole or tower. This method was introduced because the transmission and distribution stations presently have no effective means of power stabilization and loss compensation. The only compensation techniques existing in some transmission stations are the tap-changing and reactors techniques which are applied when a low voltage fault or high voltage fault occurs respectively. But these techniques have been overwhelmed by the complexity and faults of the recent day electrical power development. Hence, the national power system is currently suffering from regular power instability.

Vincent and Yusuf (2014) stated that the electricity situation in Nigeria can be described as epileptic with no sign in view of improvement. This epileptic power situation affects the manufacturing, service and residential sectors of the economy which in turn affects the country's economic growth. Even with the recent reforms in the power sector, more than half of the country's population still lack access to electricity. The epileptic condition of the power sector can be attributed to the inadequate and inefficient power plants, poor transmission and distribution facilities, and outdated metering system used by electricity consumers.

Most developing countries such as Nigeria is blessed with an abundant amount of fossil fuel and renewable energy resources, however, Nigeria is battling with an acute epileptic power situation and there has not been any good effort put towards utilizing the abundant fossil fuel and other renewable energy resources to bring a lasting solution to the electric power issue. Nigeria's poor energy situation results from the national grid network with problems ranging from inefficient power plants which are few in numbers to lack of renewables

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 01, January-2023

to support peak load, physical deterioration of the long transmission lines to distribution facilities which are inadequately maintained, lack of communication facilities, illegal electricity connections and outdated meters used by the consumers (Sambo, 2009) However, this paper presents the elements of power deregulation, the situation in Nigeria and suggest the way out.

II. THE 330KV NETWORK

In Nigeria, electricity power supply is mainly categorized or divided into three, namely, generation, transmission and distribution. The power stations in Nigeria are mainly hydro and thermal plants managed by Independent Power Project (IPP) and Generation Company (GENCO) private participating partners (Adepoju et al., 2017). According to Adepoju et al., (2017) the Nigerian national grid is an interconnection of 9,454.8km length of 330kV transmission lines with nine power stations as shown in figure 1. These generating stations are sometimes connected to load centers through very long, fragile and radial transmission lines, which are prone to frequent system collapse (Onohaebi and Apeeh, 2007). The grid interconnects these power stations with twenty eight buses and fifty two transmission lines of either dual or single circuit lines and has four control centers (one national control centre at Oshogbo and three supplementary control centers at Benin, Shiroro and Egbin (Eseosa and Ogujor, 2012).

The maximum transmission capacity of Nigerian transmission system is about 4,000 MW and it is technically weak, therefore very sensitive to major disturbances (Adepoju et al., 2017). The challenge of this major disturbances have been in existence for a very long time with some identified problems such as its wheeling capacity that is far below the required national needs, the technologies used generally deliver very poor voltage stability and profiles. There is also regular vandalization of the lines, associated with low level of surveillance and security on all electrical infrastructures with inadequate required fund to regulate, update, modernize, maintain and expand the network (Senbajo and Coker, 2013; Bada, 2012).

In (Eseosa and Ogujor, 2012) the total active and reactive power loss was found to be 0.0629pu and 0.0958pu respectively. According to them, the total power loss recorded in the national grid is too much and beyond the allowable level. Moreover, it has been argued that most of the power losses in the power system are not accounted for, therefore, the power loss should be the major disturbance in the power system which can have great instability effect on the performance of the system.

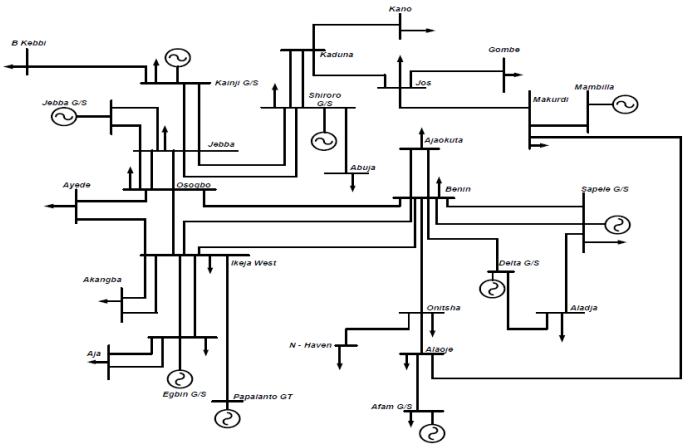

Figure 1: 28-bus Nigerian Power System Networks (Ademola, 2016; Adepoju et al., 2017)

III. REVIEW OF THE POWER SITUATION IN NIGERIA

The poor electricity production in Nigeria is a major contributor to the poor economic and industrial development in the country. Nigeria is renowned to have the lowest electrification per capita in Africa. Where, electricity generation, transmission and distribution account for less than one percent (< 1%) of its GDP but fifty-four percent (54%) of the share of utilities (e.g. electricity and water supply) (Adeola, 2013). According to U.S Department of Energy (DOE/NE-0088), the electrification rate in Nigeria is estimated at forty one percent (41%), indicating that the demand far outweighs the supply. The Federal Government is deeply concerned about this problem and has made several concerted efforts to increase electricity production in Nigeria. The government has made it an objective to increase the current electrification rate from forty one percent, 41%, (5,500MW) to fifty percent, 50%, (8,000MW) by 2016. It has a target of increasing electricity production to 40,000MW by the year 2020 (Chiemeka and Chineke, 2009).

In 2001, the National Electric Power Policy (NEPP) was introduced to kick-off the power sector reform and this lead to several other reforms in the past years (KPMG Nigeria, 2013). The NEPP in 2001 created the roadmap for Nigeria's Power Sector Privatization, but due to government bureaucracy; the policy was not signed into law until 2005. This signed document was the Electric Power Sector Reform (EPSR) Act in 2005 which was expected to level the playing ground for potential investors and improve the wellbeing of its citizens. The EPSR Act led to the incorporation of the Power Holding Company of Nigeria from NEPA, which was later defunct and divided into sub-sectors (Koledoye et al, 2013).

The total installed capacity of the currently generating plants in Nigeria as discussed earlier is 0,396.0 MW, but the available Capacity is less than 6056 MW as at December 2013. Seven of the twenty-three generation stations are over 20 years old and the average daily power generation is lower than the peak forecast for the current existing infrastructure. Through the planned generation capacity projects for a

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 01, January-2023

brighter future, the current status of power generation in Nigeria presents challenges, such as inadequate generation availability, delayed maintenance of facilities, insufficient funding of power stations, obsolete equipment, tools, safety facilities and operational vehicles, obsolete communication equipment, lack of exploration to tap all sources of energy from the available resources and low staff morale (Sambo et al, 2003; Patrick et al, 2013).

The installed capacities of various power generation companies in Nigeria and the summary of a typical national daily operational report are shown in Figure 2. Table 1 shows the trends in power electrification rates per state in the country

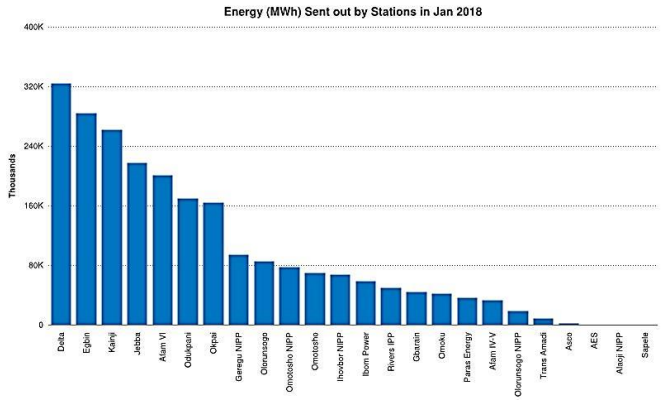

Figure 2: Summary of energy sent out to grid by each GenCo (National Electricity Regulatory Commission)

Table 1: The trends in power electrification rates per state in the country (Energypedia, 2021)

No.	State	No. of Households as of 1997 (*1)	% of Household with Electricity as of 1997 (*2)	No. of Households with Electricity as of 1997	Annual growth rate of consumers (%)	% of Household with Electricity			No. of Household with Electricity		
						2006	2010	2020	2006	2010	2020
1	Taraba	432,880	12	50,301	7.80	17	21	34	98,888	133,542	283,012
2	Jigawa	823,164	12	99,685	7.77	18	22	35	195,520	263,766	557,554
3	Zamfara	593,479	13	77,924	7.71	20	23	37	152,101	204,752	430,492
4	Sokoto	686,178	13	90,095	7.71	20	23	37	175,859	236,734	497,734
5	Kebbi	592,137	13	77,807	7.71	20	23	37	151,866	204,431	429,794
6	Katsina	1,074,392	14	145,902	7.69	20	24	38	284,184	382,194	801,663
7	Gombe	426,284	17	72,553	7.49	25	30	46	139,031	185,628	382,367
8	Bauchi	819,259	17	139,438	7.49	25	30	46	267,198	356,753	734,857
9	Benue	788,111	17	135,003	7.49	25	30	46	258,565	345,146	710,537
10	Yobe	400,682	19	75,729	7.39	27	32	50	143,826	191,270	390,098
11	Ebonyi	416,196	25	102,759	7.06	39	46	69	189,857	249,413	493,343
12	Enugu	608,334	25	150,198	7.06	39	46	69	277,505	364,554	721,096
13	Cross River	547,224	29	159,954	6.80	40	47	68	289,196	376,273	726,572
14	Nassarawa	345,773	31	108,607	6.68	43	49	71	194,326	251,669	480,372
15	Plateau	602,456	31	189,231	6.68	43	49	71	338,583	438,495	836,973
16	Kano	1,663,337	32	538,256	6.62	44	51	72	958,709	1,239,106	2,353,218
17	Borno	725,970	34	248,935	6.51	46	53	75	439,310	565,469	1,062,926
18	Adamawa	601,745	35	210,069	6.48	47	54	76	369,621	475,140	890,189
19	Akwa-Ibom	689,703	36	246,638	6.43	47	55	77	432,200	554,578	1,034,327
20	Niger	693,215	42	288,932	6.10	54	61	83	492,124	623,542	1,126,789
21	Kaduna	1,126,632	43	479,607	6.05	55	62	84	813,402	1,028,655	1,850,037
22	Kogi	614,828	50	309,996	5.60	62	70	90	506,218	629,499	1,085,526
23	Bayelsa	321,102	52	167,069	5.51	64	71	91	270,706	335,469	573,511
24	Rivers	912,575	52	474,813	5.51	64	71	91	769,348	953,408	1,629,926
25	Abia	547,888	52	287,587	5.48	53	58	75	464,946	575,611	981,623
26	Imo	711,551	61	433,833	5.00	72	78	96	673,132	818,258	1,333,107
27	Delta	741,568	62	462,294	4.92	73	79	96	712,530	863,590	1,396,589
28	Edo	621,770	63	388,855	4.91	73	79	96	598,757	725,382	1,171,814
29	Kwara	443,257	68	299,509	4.63	77	83	98	450,021	539,288	847,795
30	Osun	617,802	71	436,539	4.45	80	85	99	646,094	769,082	1,188,952
31	Abuja	106,397	71	75,436	4.44	80	85	99	111,517	132,676	204,841
32	Ogun	668,065	72	483,813	4.35	81	86	99	709,928	841,842	1,289,056
33	Ekiti	439,644	72	318,698	4.35	81	86	99	467,484	554,265	848,386
34	Ondo	643,968	72	466,812	4.35	81	86	99	684,748	811,860	1,242,673
35	Anambra	800,534	78	621,295	4.06	85	88	99	888,786	1,042,097	1,551,263
36	Oyo	988,395	78	771,541	4.03	85	89	100	1,101,286	1,289,986	1,915,566
37	Lagos	1,638,903	96	1,577,936	3.00	96	96	97	2,058,848	2,317,252	3,114,193
	Total Nigeria	25,475,400	44	11,263,648	6.04	53	58	75	17,776,220	21,870,672	37,168,770

(Remarks)
(*1) No. of Households as of 1997 was extraporated based on the result of 1991 Census.
(*2) % of Household with Electricity as of 1997 was quoted from the result of General Household Survey 1997/98.
Average number of persons per household 4.13
Annual growth rate of consumers (Highest) 7.80 %
Annual growth rate of consumers (Lowest) 3.00 %

3.1 The Power Supply Issues

In 2008, as a result of recorded high economic growth and demographic pressure as estimated, the Energy Commission of Nigeria (ECN) together with the International Atomic Energy Agency (IAEA) projected an electrical power demand of 15,730 MW for 2010 and 119,200 MW for the year 2030 under the reference scenario (7% yearly economic growth) (Sambo, 2008). Other electrical power authorities such as the defunct Power Holding Company of Nigeria (PHCN) (PHCN, 2009) or World Alliance for Decentralized Energy (WADE) etc., have also developed scenarios (WADE, 2009). The results of these studies vary widely, but they all concluded that the current gap between supply and demand is already very high in the ration of one is to three (i.e., 1:3) and that, it will become more entrenched under a 'business as usual' scenario (Energypedia, 2021).

3.2 The Challenges of Power Generation

Consequently, the significant gap between demand and supply of electricity, has led to recurrent power shortcuts as reviewed. Therefore, the heavy reliance on gas, limited technical/technological know-how, lack of energy efficiency practices and infrastructure maintenance, inadequate regulations and attacks on energy infrastructure contribute immensely to the challenges (Energypedia, 2021) the electrical power sector is currently facing. However, presently there is not implemented measure to address these stated issues.

IV. WAY-FORWARD

There is high need for significant improvement in the generation of the national grid system before there will be good result from the power restructuring in Nigeria. If renewable energy is added to the present energy supply, more than sixty thousand megawatts (60,000MW) or sixty Gigawatts (60GW) of power required to place Nigeria in the category of industrialized nation can be achieved without significant increase in environmental pollution. Therefore the key to the success of power restructuring and electricity supply in the Nigeria is the introduction and consolidation of the various renewable energy sources into the generation stage of the power supply.

Table 2 shows that, in addition to the current sources of electricity, the country is endowed with vast renewable energy wealth which the authorities also intend to utilize for power generation purposes.

Table 2: Potential renewable energy sources in Nigeria (ECN, 2014)

Energy Resources	Estimated Reserve
Large Hydropower	11,250 MW
Small Hydropower (<30 MW)	3500 MW
Fuel Wood	11 million hectares of forest and woodland
Municipal Waste	30 million tonnes/year
Animal Wastes	245 million assorted animals in 2001
Energy Crops and Agricultural Residue	72 million hectares of agricultural land
Solar Radiation	3.5-7.0 kW h/m2/day
Wind	2-4 m/s at 10 m height Wind speeds in Nigeria range from a low 1.4 to 3.0m/s in the Southern areas, except for coastal line and 4.0 to 5.1m/s in the North. The Plateau area particularly interesting.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 01, January-2023

From the review, it was found that a 10 MW pilot wind plant has been built in Katsina and it is awaiting commissioning. A major hydropower plant is currently under construction, the Zungeru 700 MW plant in Niger State. A number of smaller hydropower plants are also being planned such as Gurara (30 MW) or Kashimbilla (40 MW). The 3,050 MW Mambilla hydropower plant project is currently being reviewed. Furthermore, the Nigerian Electricity Regulatory Commission (NERC) has issued licenses for 8 solar projects totaling a capacity of 868 MW and a 100 MW wind park (Energypedia, 2021). In addition, it was also found that investors are increasingly enthusiastic about developing large solar plants in the country to help boost the power supply capacity.

However, despite the potential for renewable energy to contribute to solving national deficient grid infrastructure, there is currently no grid-based renewable energy electricity production at the moment (apart from large scale hydro), with the perception that renewables are a high-risk investment is still prevailing. It was found that fourteen solar PV companies signed power purchase agreements (PPAs) with the bulk electricity trader in 2016, with a combined capacity of 1 GW, however as at 2021 none of them have stated in full form as planned (Energypedia, 2021).

V. CONCLUSION

Electricity has been the backbone of national development, therefore efforts should be made to supply sufficient and reliable electrical power. However Nigerian electricity grid has been suffering from a lot of problems which include the insufficient and inefficient power generation facilities, inadequately maintained long transmission lines and distribution facilities, and outdated metering system used by its customers. From the review it was confirmed that the major problem in Nigerian electricity supply is on electric power generation which has failed to generate up to the level of power that can meet up to nor sustain the demands of the consumers. The generation problem has always been attributed to the pipeline vandalism, insufficient supply of raw materials, corruption etc. However, from the review and the statistics it was concluded that the main limitation of the generation sector of the power grid is the poor facilities and limited generation sources. Therefore, it was concluded that for the national desired development to attain success in Nigeria, the electricity generation sources must be increased by including renewable energy sources especially solar, wind and biomass in order to increase the power generation level that can serve the consumers adequately and attract investors to facilitate the growth needed for development.

REFERENCES

[1] Ademola, A.G., (2016). Evaluation and Mitigation of Technical Losses on Power Lines: A Case Study of Nigeria 330-KV Network
[2] Adeola, A. F., (2003). Electric infrastructure failures in Nigeria: a survey-based anallysis of the costs and adjustment responses, Elsevier, Energy Policy 31: pp 1519-1530.
[3] Adepoju, G. A., Sanusi, M. A. and Tijani, M. A., (2017), Application Of SSSC to the 330KV Nigerian Transmission Network for Voltage Control, Nigerian Journal of Technology (NIJOTECH), Vol. 36, No. 4, pp. 1258 – 1264
[4] Bada, A. S. A., (2012), Transmission Evacuation and Constraint, at National Power Sector Retreat Abuja, Nigeria
[5] Chiemeka, I. and Chineke, T., (2009). Evaluating the global solar energy potential at Uturu, Nigeria, International Journal of Physical Sciences,Vol. 4(3): pp 115-119.
[6] ECN, (2014), Energy Commission of Nigeria, Draft National Energy Master Plan [2014]
[7] Energypedia, (2021), Nigeria Energy Situation, Retrieved from: https://energypedia.info/wiki/Nigeria_Energy_Situation
[8] Eseosa O. and Ogujor E. A., (2012). Determination of Bus Voltages, Power Losses and Flows in the Nigerian 330KV Integrated Power System, International Journal of Advances in Engineering & Technology, Volume 4, No. 1, pp. 94-97
[9] Koledoye, T.O., Abdul-Ganiyu, J.A. and Phillips, D.A. (2013). The Current and Future Challenges of Electricity Market in Nigeria in the Face of Deregulation Process. *African Journal of Engineering Research*, 1, 33-39.
[10] Onohaebi, O. and Apeeh S. T., (2007). Voltage Instability in Electrical Network, A Case Study of the Nigerian 330 kV Transmission Grid, Journal of Engineering and Applied Sciences, Volume 8, No. 2, pp. 865-874.
[11] Patrick, O., Tolulolope, O. and Sunny, O. (2013). Smart Grid Technology and Its Possible Applications to the Nigeria 330 kV Power System, *Smart Grid & Renewable Energy*, 4, 391
[12] PHCN, (2009), Power Holding Company of Nigeria – Project Management Unit, January 2009, National Load Demand System – National Energy Development Project – Draft final report Volume 1 – National Demand Load Forecast, Tractebel Engineering Suez and Omega Systems
[13] Sambo A. S., (2008), Matching Electricity Supply with Demand in Nigeria, Fourth Quarter, International Association for Energy Economic, p. 33
[14] Sambo, A.S., Garba, B., Zarma, I.H. and Gaji, M.M. (2003). Electricity Generation and the Present Challenges in the Nigerian Power Sector. *Energy Resources Review*, 4, 7-10
[15] Senbajo A. A., and Coker J. O., (2013). An Overview of Integrated Power Supply System Solution to Nigerian's Electricity Problem, Journal of Applied and Natural Science, Volume 5, No. 1, pp. 268-273
[16] Vincent E.N., and Yusuf S.D., (2014). Integrating Renewable Energy and Smart Grid Technology into the Nigerian Electricity Grid System, Smart Grid and Renewable Energy, Scientific Research
[17] WADE, (2009), World Alliance for Decentralized Energy, Christian Aid and International Centre for Energy, Environment and Development, August 2009, More for less: How decentralized energy can deliver cleaner, cheaper, and more efficient energy in Nigeria