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Power Generation In Nigeria: The Past, Present And The Future

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Abstract

The goal of power sector in Nigeria is to efficiently and reliably transmit electrical power to all parts of the country which are made up of thirty-six states of the federation and the federal capital territory. The constituents of electrical power system are the generation, transmission, distribution and the utilization of electrical energy. There is gross power imbalance between the generation and the required power demand which has culminated into a defective economy in the last three decades. This paper therefore examines the power imbalance between the generation and power demand by the consumers and therefore stresses the need to harness the opportunity of renewable energy generation close to the gap between the power generation and power demand. This will help in transmitting and distributing efficient, effective, reliable power to consumers and improve both human and capital development. The availability of renewable energy sources such as sun, wind and small hydro power will be explored for the future of power generation in the country to fill in the gap between power generation and demand in Nigeria.

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Introduction

Electrical energy is produced from energy available in various forms in nature such as the sun, the wind, water, fuel and nuclear energy [1]. The conversion of energy available in different forms in nature into electrical energy is called generation of electrical energy. Electrical energy is manufactured commodity such as clothing, furniture or tools. Electrical energy is produced from the forms of energy available in nature. Electrical energy must be produced and transmitted to the point of use at the instant it is demanded. This process takes a fraction of a second [1]. The production of electrical energy by special plants is called power plants [1]. Electricity is often generated at a power plant through electromechanical generators which is driven by heat engines fueled by combustion or nuclear fission but also by other means such as the kinetic energy of flowing water and wind [2]. Other energy sources include solar photovoltaic

and geothermal power [3].

Power generation and supply is one of the key indicators of economic prosperity for a country. It is crucial and unavoidably necessary for both human existence and a nation's development [4]. The per capital consumption of different countries as established by IEA energy statistics shows that united states of America has a population of 250million with generation capacity of 813,000MW with per capital consumption of 3.2kW. Cuba has a population of 10.54million, generation capacity of 4,000MW with per capital consumption of 0.38kW. United Kingdom has a population of 57.5million, 76,000MW of generation capacity and1.1kW per capital consumption. Iraq has a population of 23.6million, generation capacity of 10,000MW with per capital consumption of 0.42kW. South Africa has a population of 44.3million, generation capacity of 45,000MW with per capital consumption of 1.02kW while Nigeria has a population of 140million with generation capacity of ≤4,000MW and per capital consumption of 0.03kW [5].

Overview of Electricity Situation in Nigeria

Nigeria started electricity generation and supply during the colonial rule [6]. Electricity supply in Nigeria dates back to 1886. In 1951, the Electricity Corporation of Nigeria was established [7], when two (2) small generating sets were installed to serve the then colony of Lagos [8]. In 1929, Nigeria Electricity Supply Company (NESCO) was setup as electricity utility company operating a hydroelectric power station near Jos, Plateau State [9]. The electricity corporation of Nigeria (ECN) was established by an Act of Parliament in 1951 and in 1962, the Niger Dams Authority (NDA) was also established for the development of Hydro Electric Power [10]. The first 132KV was built in 1962 to link Ijora power station (Lagos) to Ibadan power station. There was a numerical increase in electricity infrastructure and this has changed the nomenclature and operations of the regulating agencies [11]. The NDA was mandated to develop the hydro-power sub-sector which was later merged with the ECN in 1972 [12]. While the country was searching for stable electricity supply, National Electric Power Authority, National Electricity Regulatory Commission and Power Holding Company of Nigeria and presently Distribution companies were set up at certain periods in the last four decades [13, 14]. In 1990s, facilities for power generation did not receive any expansion despite the increase in population of the consumers [15]. In 1999, the installed capacity of 5,906MW could only supply 1,750MW of electricity to a population of 120 million people. By year 2000, power generation has decreased to 1,500MW representing 25.3 percent of the installed capacity. The total installed capacity of generators was 6,200MW which has a constituent of two hydro and four thermal power plants [15]. In order to address the retrogression experienced in the power sector, NEPA was restructured and renamed Power Holding Company of Nigeria (PHCN) by the Electric Power Sector Reform Bill signed into law in 2005 [14].The reform allowed private companies to participate in the generation, and distribution of electricity while transmission companies remains under government ownership [15]. There are 6 successor generating companies (GenCos), the Independent Power Producers (IPP) and the National Integrated Power Project (NIPP) which make up the power generation sector till date. Government is making serious efforts to repair broken down power stations and to construct new ones. Efforts are in top gear to provide electricity for a population of over 139 million people in the year 2005. In 2013, the total installed capacity was 6,953MW while available capacity was 4,598MW. The actual average generation was 3,800MW. The World Bank noted that Nigeria had a total installed capacity of 8,457MW in 2014 with generation from hydroelectric sources reported at 17.59% of the total installed capacity. In early September 2016, the peak power generation was 4,285.90 MW by the Nigerian Electricity System Operator [15].

Current Situation of Power Generation in Nigeria

The total installed capacity of the currently generating plants is 7,876 MW, which has available capacity of less than 4,000MW as at December 2009. Seven of the fourteen generation stations are over 20 years old and the average daily power generation is below 2,700MW which is below the peak load forecast of 8,900MW for the existing infrastructure. This led the country to experiences massive load shedding [14, 16]. The challenges of the future of power generation due to its present states are:

- Inadequacy in generation availability;
- Insufficient and delayed maintenance of facilities;
- Obsolete facilities.
- Inadequacy in communication equipment
- Staff morale [17-20].

The types of power plants operating in Nigeria are hydro-electric and thermal power plants. [20]. The Nigeria power mix is dominated by the thermal power plant with 81% of a total installed capacity of 8457.6MW in early 2014. Electricity

production through hydroelectric sources is only 17.59% in same year according to the World Bank indicators for development. The two types of fossil fuel / thermal power plants in Nigeria are: (i) coal-fired and (ii) natural gas-fired [20].

Ownership of Power Generating Stations

The power plants are classified based on ownership, as either:

- Fully owned by the Federal Government of Nigeria (FGN) and plans are on the way to privatize these power plants [5, 20].
- Niger Delta Power Holding Company (NDPHC). This is owned by the three tiers of government in Nigeria. They are parts of National Integrated Power Project (NIPP) [14, 20].

S/N	PLANT (A)	PLANT TYPE	LOCATION STATE (B)	AGE (YEARS) (C)	INSTALLED UNITS	INSTALLED CAPACITY (MW)	UNITS AVAILABLE	% IN-STALLED UNITS (D)
1	Egbin	Thermal	Lagos	22	6	1320	4	66.6
2	Egbin AES	Thermal	Lagos	6	9	270	9	100
3	Sapele	Thermal	Delta	25-29	10	1020	1	10
4	Okapi	Thermal	Cross River	2	3	480	2	66.6
5	Afam	Thermal	Rivers	25	20	702	3	15
6	Delta	Thermal	Delta	17	18	840	12	66.7
7	Omoku	Thermal	Rivers	2	6	150	4	66.7
8	Ajaokuta	Thermal	Kogi	Na	2	110	2	100
9	Geregu	Thermal	Kogi	1	3	414	3	100
10	Omotosho	Thermal	Ondo	New	8	335	2	50
11	Olorunsogo/ Papalanto	Thermal	Ogun	New	8	335	2	25
	SUB-TOTAL		(THERMAL)		93	5976	44	47.3
12	Kainji	Hydro	Niger	38-40	8	760	6	75
13	Jebba	Hydro	Niger	24	6	540	6	100
14	Shiroro	Hydro	Niger	22	4	600	2	50
	SUB-TOTAL		(HYDRO)		18	1900	14	77.78
	GRAND TOTAL				111	7876	58	52.3
SUMMARY		% Thermal			84	76	76	90.5
		% Hydro			16	24	24	

[Source: https://naira metrics.com [9].

Table 1: Existing Power Generation Capacity In Nigeria.

S/N	POWER STATION	TYPE	STATE	CAPACITY (MW)	STATUS
1	Egbin	Thermal	Lagos	1320.00	Existing
2	Afam	Thermal	Rivers	969.60	Existing
3	Sapele	Thermal	Delta	1020.00	Existing
4	Ijora	Thermal	Lagos	40.00	Existing
5	Kainji	Hydro	Niger	760.00	Existing
6	Jebba	Hydro	Niger	578.40	Existing
7	Shiroro	Hydro	Niger	600.00	Existing
8	Delta	Thermal	Delta	912.00	Existing
9	Orji	Coal	Rivers	20.00	Existing
10	Geregu	Thermal	Kogi	414.00	Ongoing
11	Omotosho	Thermal	Ondo	335.00	Ongoing
12	Papalanto	Thermal	Ogun	335.00	Ongoing
13	Alaoji	Thermal	Abia	504.00	Ongoing
14	Omoku	Thermal	Rivers	230.00	New IPP
15	Rain/Ube	Thermal	Bayelsa	225.00	New IPP
16	Sapele	Thermal	Delta	451.00	New IPP
17	Eyaen	Thermal	Edo	451.00	New IPP
18	Egbema	Thermal	Imo	338.00	New IPP
19	Caliber	Thermal	Cross River	561.00	New IPP
20	Mambilla	Hydro	Taraba	2600.00	New
21	Zungeru	Hydro	Niger	950.00	New
22	AES	Thermal	Lagos	300.00	Commissioned IPP
23	AGIP Okpai	Thermal	Delta	480.00	Commissioned IPP

24	Omoku	Thermal	Rivers	150.00	Approved IPP
25	Obajana	Thermal	Kogi	350.00	Approved IPP
26	Ibom Power	Thermal	AkwaIbom	188.00	Approved IPP
27	Ethiope Energy Ltd			2800.00	Approved Licenses IPP
28	Farm Electric Supply Ltd			150.00	Approved Licenses IPP
29	ICS Power			624.00	Approved Licenses IPP
30	Supertek Ltd			1000.00	Approved Licenses IPP
31	Mabon Ltd			39.00	Approved Licenses IPP
32	Geometric Ltd			140.00	Approved Licenses IPP
33	Aba Power Ltd			0.00	Licensed Distributor
34	Westcom Tech & Energy Service Ltd			1000.00	LicenseGranted IPP
35	Lotus & Bresson Nig Ltd			60.00	License Granted IPP
36	Anita Energy Ltd			136.00	License Granted IPP
37	First Independent Power Co Ltd			95.00	License Granted IPP
38	First Independent Power Co Ltd			150.00	License Granted IPP
39	Hudson Power Station Ltd			200.00	License Granted IPP
40	Ibafo Power Station Ltd			640.00	License Granted IPP
41	Shell Distribution Coy Ltd			100.00	License Granted IPP
42	Agbara Shoeline Power Co Ltd			180.00	License Granted IPP
43	Index thermal power Ltd			1800.00	License Granted IPP
	Total			24,106.00	

[Source: Https://Naira Metrics.Com [9].

Table 2: Planned Total Present And Future Electricity Generation Infrastructure In Nigeria.

Present Condition of Power Transmission in Nigeria

- Funding by the FGN cannot meet the requirement [7].
- It low coverage of nook and cranny of the country [7]
- It's wheeling capacity is only 4000MW which cannot meet the demand of consumers [7].
- Some sections of the grid are out dated with inadequate redundancies as opposed to the required mesh arrangement;
- The Federal government lack the required fund to expand, update, modernize and maintain the network;
- There is regular vandalization of the lines, associated with low level of surveillance and security on all electrical infrastructure;
- The technologies used generally deliver very poor voltage stability and profiles;
- There is a high prevalence of inadequate working tools and vehicles for operating and maintaining the network;
- There is a serious lack of required modern technologies for communication and monitoring;
- The transformers deployed are overloaded in most service areas;
- In adequate of spare-parts for urgent maintenance; and poor technical staff recruitment, capacity building and training programme.

Distribution & Marketing

In most locations in Nigeria, the distribution network is poor, the voltage profile is poor and the billing is inaccurate. As the department, which inter-faces with the public, the need to ensure adequate network coverage and provision of quality power supply in addition to efficient marketing and customer service delivery cannot be over emphasize. In summary some of the major problems identified are:

- Funding by the FGN cannot meet the requirement [7].
- It low coverage of nook and cranny of the country [7]
- It's wheeling capacity is only 4000MW which cannot meet the demand of consumers [7].
- Some sections of the grid are out dated with inadequate redundancies as opposed to the required mesh arrangement;
- The Federal government lack the required fund to regular expand, update, modernize and maintain the network;
- There is regular vandalization of the lines, associated with low level of surveillance and security on all electrical infrastructure;
- The technologies used generally deliver very poor voltage stability and profiles;
- There is a high prevalence of in-adequate working tools and vehicles for operating and maintaining the network. There is a serious lack of required modern technologies for communication and monitoring;

The future of Efficient Power generation in Nigeria

The future of Efficient Power generation is determined by setting up a mathematical model that can determine the required power demand. A population data is collected. The per capita demand is estimated as shown below:

From the above statements:

The per capita demand= (power requirements by an area)/(population of the area)

$$The\ per\ capita\ demand = \frac{\text{power requirements by an area}}{\text{population of the area}} \quad (1)$$

National population commission stated that Nigeria has a population of 140million in 2016. Ajeiigbe 2010 noted that the per capita demand of fully urbanized state like Ibadan is 0.094KW.

Power demand/requirement = Population×per capita
= 140,000,000 X 0.094
= 13160000W
= 13,160MW.

The present power generation is 4,000MW.

Future power = Estimated power generation – Present power generator (2)
= 13,160MW – 4,000MW
= 9,160MW.

The future of generation requires energy mix of solar power, wind turbines and other renewable energy of 9,160MW.

Nigeria is endowed with natural resources which are aim at developing the country. The need for alternative energy resources to drive the nation economy cannot be over-emphasized. The incessant power failure has grossly affected the economy, seriously slowing down development in rural and sub-rural settlement. A robust solution must be found to end the crises. Alternative energy source has the potential of solving power problem in Nigeria as well as providing safer and cleaner environment [21].

From the energy outlook of Nigeria, it is very clear that the energy demand is very high and is increasing geometrically while the supply remains inadequate, insecure, and irregular and is decreasing with time; the mix has hitherto been

dominated by fossil resources which are fast being depleted apart from being environmentally non-friendly. The energy supply mix must thus be diversified through installing an appropriate infrastructure and creating full awareness to promote and develop the abundant renewable energy resources present in the country as well as to enhance the security of supply. There is clear evidence that Nigeria is blessed with abundant resources of fossil fuels as well as renewable energy resources. The major challenge is an inefficient usage [22]. Nigeria recorded an increase of 1,811.3MW in power generation in January 2019 as the transmission company of Nigeria (TCN) transmitted 127,157.7MW as against 125,346.4MW in December 2018 [23]. To provide adequate power to ensure that Nigeria is among the industrialized nations, three critical activities must be effectively achieved [14].

- Adequate power must be generated;
- The power must effectively be transmitted to all parts of the country; and
- Efficient power distribution tom consumers.

Overall efficiency and thermal efficiency of omotoso power plant was analysed and the average overall efficiency was 29.12 % and minimum value was 28.69% in 2008 and 29.70% maximum in 2012. These values are in deviance with expected values of 30%-35%. The thermal efficiency is averaged at 28.39%, 27.95% minimum in 2008 and 28.96% maximum in 2012 [14]. The future of an efficient power generation in Nigeria is renewable energy. Renewable energy is the energy source of the future for sustainable development. Nigeria is blessed with various sources of renewable energy that is available because of the location of the country. The available wind energy in Nigeria at Dan-Jama village sokoto is 0.75KW/h and is functioning. Solar energy in Nigeria with total solar radiation variation of between 12.6 MJ/m2 /day in coastal regions to 25.2 MJ/m2 / day and average sunshine of 6 hours per day. Solar energy has been utilized in Nigeria in various forms: namely, solar PV for rural electrification, solar cooker, solar crop dryer, solar manure dryer, solar water pump, solar water heaters, solar chick brooders etc. Notable solar projects in Nigeria include: street lighting in Ado Ekiti, Ekiti State, 7.2kW Kwalkwalawa Village Electrification, Sokoto State and 1.87 kW Iheakpu-Awka Village Electrification/TV Viewing, Enugu State among others [24, 25].

For hydro energy, the country has high precipitation and the rivers are characterised by high water discharges during the rainy season and very low discharges during the dry season with the exception of the river Niger which has a reliable and stable flow throughout the year. Hydropower of Nigeria is put at 30690 GMh /yr in 1980 and 5250 GWh was generated from the hydro power stations in 1997. Biomass energy is made up of water lettuce, dung, cassava leaves, processing waste, urban refuse, solid waste, agricultural residues and sewage as good substrates for biogas production while sorghum, maize and sugar cane are identified as very good substrates for bio fuel production [26].

Discussion

Table 1 shows the existing power generation capacity in Nigeria. Egbin thermal station has been installed for more than 22 years. The percentage units installed/ installed unit is 66.6%. Egbin AES operates optimally at 100% in 6 years. Sapele has been in operation for close to 30 years and its percentage functionality is just 10%. Ajaokuta and Geregu operate at 100% and their year of installation is only one year. Afam is 25 years and operates at 15%. Omotoso is new and it operates at 50%. The year of operation of Okapi, Delta and Omoka thermal stations are clearly indicated in Table 1. It is pertinent to note that the mean analysis of the thermal stations in respect of functionality is 47.3%. For hydro power station, kanji is about 40 years, Jebba is only 24 years while shiroro is 22 years and their percentage available unit/ installed units are 75%, 100%, and 50% respectively.

Table 2 shows planned total electricity generation infrastructures in Nigeria. The total power generation capacity is 24,106MW which is greater than the required power demand of consumers in Nigeria. Egbin thermal station has a capacity of 1320MW while Sapele thermal station is second on the log with 1020MW. Mambilla hydro station has a generating capacity of 2,600MW; Ethiope energy limited has a generating capacity of 1000MW. Westcom Tech energy services Ltd, Agbara shoe line power co. ltd and Index thermal power ltd have 1000MW, 1800MW and 1800MW respectively. The estimated power required to fill the gap between power generation and power demand through injection of renewable energy is estimated as 9160 MW as analysed by equations (1) and (2).

Conclusion

The paper has reviewed the past and present as well as the future of electrical power generation in Nigeria. The requirement for the future power generation was estimated to be 9160MW which will set Nigeria on track for full development and prosperity. This is achievable through

injection of energy of solar PV, wind turbines and other renewable energy sources.

Recommendation

Proper adequate planning of the energy sector from generation to the state of utilization requires optimum attentions. There is need to urgently inject renewable energy into the grid to bridge the gap.

Adequate funding through budgeting and support from World Bank and IMF will go a long way.

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