Global Scientific JOURNALS

GSJ: Volume 11, Issue 4, April 2023, Online: ISSN 2320-9186
www.globalscientificjournal.com

AN ASSESSMENT OF ELECTRICITY PRODUCTION IN NIGERIA: CONSTRAINTS AND RECOMMENDATIONS

Chinweze, A.E.[a], Obinani, C.V.[b], Okunna C.C.[c], Okeke, J.C.[d], & Onye-Ndimele, M.O.[e]

[a,b,c,d] Department of Mechanical Engineering, Nnamdi Azikiwe University, PMB 5025, Awka, Anambra, Nigeria

[e] Department of Industrial Production Engineering, Nnamdi Azikiwe University, PMB 5025, Awka, Anambra, Nigeria

Corresponding Author Email: ae.chinweze@unizik.edu.ng

ABSTRACT

The rate of economic growth and industrialization of any nation depends on its ability to produce adequate quantity and quality of electric power and effectively distribute it to power homes and industries. The power generating stations have been discussed and the underperforming and non-functioning plants were identified. The paper dives into a detailed analysis of the factors affecting Nigeria's electricity generation and profers solutions to these problems.

Keywords: Power Plants, Gas Turbine, Electricity Generation, Nigeria

1.1 INTRODUCTION

Power generation is a process of generating electricity in a power plant, using primary energy sources such as coal: natural gas, hydro energy, nuclear, solar, or wind energy. Electricity is critical to any economy's growth. A power plant, in most situations, is made up of an electric generator. It could be a water wheel in a hydroelectric dam, a huge diesel engine, or a gas turbine spinning that generator. A steam turbine, on the other hand, is the most common item that spins the generator. Coal, oil, or natural gas could be used to generate steam. Alternatively, the steam might be generated by a nuclear reactor. Following the generation of electricity in a power plant, the generated electricity is transmitted and distributed to final users [1].

In this time of global market uncertainty, one thing is certain: the world requires energy in increasing quantities to promote economic and social progress and improve living standards, particularly in developing countries. However, supplying this energy around the world comes with a responsibility and commitment to sustainably develop and use our resources. We are dedicated to safeguarding both people and the environment while also contributing positively to the economy. Reliable and affordable energy enables the products and services that improve and extend life in developed countries like Canada. Computers, transportation, communications, cutting-edge medical equipment, and much more are all powered by energy. The demand for reliable and economical electricity is even more critical in emerging countries. It has the potential to enhance and perhaps save lives. Reliable energy promotes expanded industry, modern agriculture, increased trade, and enhanced transportation in these countries. These are the elements that enable people to rise above poverty and live better lives [2].

Nigeria is a country in the sub-Saharan region of West Africa. Nigeria is rich in several energy reserves which include crude oil, natural gas, solar, wind, coal etc. Fossil fuels are formed over millions of years through the conversion of remains of microorganisms living in the sea, into hydrocarbon by heat, pressure and catalytic action. The crude oil on fractional distillation and further processing give numerous products and by-products which include: petrol, diesel, kerosene, naphtha, fuel oil, and asphalt. Despite the abundant energy sources, the nation remains one of the lowest electricity consumption per capita in Africa.

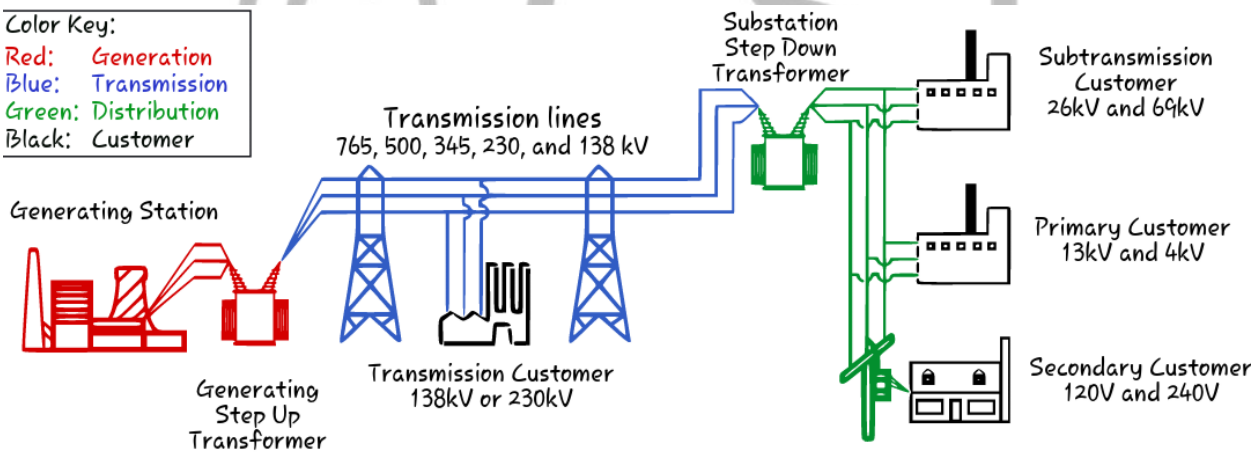

Fig 1: Diagram of an Electric Power System (Generation System in Red) [3]

1.1 OVERVIEW OF POWER GENERATION IN NIGERIA

In 1886, Lagos became the first city in Nigeria to use generators to generate 60 kilowatts of electricity [4]. Tin miners built a 2 MW plant on the Kwali River in 1923, and six years later, the Nigerian Electricity Supply Company, a private company in Jos, was formed to manage a hydroelectric plant at Kura to supply electricity to the mining industry. After that, United Africa

Company formed a private firm in Sapele to support the activities of the African Timber and Plywood Company [5]

Electric power generation was relatively modest between 1886 and 1945, with most of the power going to Lagos and other commercial centres like Jos and Enugu's mining industry. The colonial government established an electricity department inside the Public Works Department, which constructed generating sets in several cities to supply government reservation areas and commercial centres[6].

The Nigerian Legislative Council began efforts to integrate the energy business in 1950 when it passed a bill establishing the Nigerian Electricity Corporation, which was charged with creating and supplying electricity. PWD's energy sector activities as well as the generating sets of Native Authorities were taken over by ECN. The company was in charge of 46 megawatts of electricity in 1951. Between 1952 and 1960, the company built coal-fired turbines in Lagos' Oji and Ijora neighbourhoods and began developing basic designs for a transmission network to connect the power plants to other commercial areas. ECN constructed a 132 kV transmission line connecting Lagos to Ibadan through Shagamu in 1961, and the Western System was formed in 1965 when this line was extended to Oshogbo, Benin, and Ughelli [4].

In 1962, a statutory organization, the Niger Dams Authority (NDA) was formed to build and maintain dams along River Niger and Kaduna River, NDA went on to commission a 320MW hydropower plant at Kainji in 1969 with the power generated sold to ECN. In 1972 NDA and ECN merged to form the National Electric Power Authority (NEPA). NEPA was the major electricity firm in Nigeria until power sector reforms resulted in the creation of the Power Holding Company of Nigeria.

The Nigeria Power Sector Reform Bill was signed into law in March 2005, allowing private sector participation in electricity generation, transmission, and distribution [7]. As a result, Independent Power Producers (IPPs) emerged, with participation from foreign, local, and state governments in the generation of electricity, and they were required to sell the electricity they generated to PHCN. The Nigerian Energy Regulatory Commission (NERC) was established in November 2005 to supervise the PHCN's service quality and electricity tariff to ensure that its activities in the power sector run smoothly. By 2012, the IPP had supplied 25% of Nigeria's total electric power production, with the rest coming from PHCN [8].

On November 5, 2013, PHCN was privatised, with all of its assets and liabilities transferred to several private companies [9]. The power sector's generation, transmission, and distribution activities are currently dominated by the private sector, thanks to the sector's deregulation. The Federal Government of Nigeria, however, regulates the quality of service and tariffs through NERC.

1.2 POWER PLANTS IN NIGERIA

The table below shows the power plants in Nigeria, their types, capacity, years completed and operation status.

Table 1: List of power plants in Nigeria [10].

S/N	Thermal Power station	Community	Type	Capacity	Status	Year completed
1	Aba Power Station (IPP)	Aba Abia State	Simple cycle gas turbine	140 MW	Fully operational	2012
2	Azura Power Station (IPP)	Benin City	Simple cycle gas turbine	450 MW	Fully operational	2018
3	AES Barge (IPP)	Egbin	Simple cycle gas turbine	270 MW	Non-operational	2001
4	Afam IV-V Power Station (FGN)	Afam Rivers State	Simple cycle gas turbine	726 MW (Afam IV -6 x 75 MW (GT 13-18), Afam V -2 x 138 MW (GT 19-20))	Non-operational	1982 (Afam IV)- 2002 (Afam V)
5	Calabar Power Station (NIPP)	Calabar	Simple cycle gas turbine	561 MW	Non-operational	2014
6	Egbema Power Station (NIPP)	Imo State	Simple cycle gas turbine	338 MW	Non-operational	2012-2013
7	Omoku II Power Station (NIPP)	Omoku	Simple cycle gas turbine	225 MW (2 x 112.5 MW gas turbines)	Non-operational	Incomplete
8	Okpai Power Station (IPP)	Okpai	Combined cycle gas turbine	480 MW	Operational	2005

S/N	Thermal Power station	Community	Type	Capacity	Status	Year completed
9	Omoku Power Station (IPP)	Omoku	Simple cycle gas turbine	150 MW (6 x 25 MW gas turbines)	operational	2005
10	Ibom Power Plant (AKSG)	Ikot Abasi	Combined cycle gas turbine Ibom Power Plant presently consists of two GE Frame 6B and one Frame 9E turbine generator installed in a simple cycle configuration, using the conventional open cycle gas turbine (OCGT) technology. These three gas turbines are: GTG 1(Model PG 6551B), GTG 2(Model PG 6561B), and GTG3 (Model PG 9171E) combined to give an installed capacity of 191MW.	191MW	Operational Since 2009	2010→
11	Transcorp Ughelli Power Station (privatised) **known also as Delta power station.**	Ughelli, Delta State	Simple cycle gas turbine	900 MW	Partially Operational (465 MW)	1966-1990 Plant was built in 4 phases. I: 1966 (decommissioned), II: 1975 6 x 25 MW, III: 1978 6 x 25 MW, IV: 1990 6 x 100 MW
12	Ibom Power Station (IPP)	Ikot Abasi	Simple cycle gas turbine	190 MW	Partially operational (90 MW)	2009

S/N	Thermal Power station	Community	Type	Capacity	Status	Year completed
13	Sapele Power Station-Privatized	Sapele	Gas-fired steam turbine and Simple cycle gas turbine	1020 MW (Phase I: 1978-1980 6 x 120 MW Gas-fired steam turbines, phase II: 1981 4 x 75 MW gas turbines)	Partially operational (135 MW)	1978–1981
14	Egbin Thermal Power Station **(FGN but Privatized)**	Egbin	Gas-fired steam turbine	1320 MW (six 220-MW units)Egbin - Thermal Power Station in Egbin, Nigeria	Partially operational (1000 MW)	1985-1986
15	Afam VI Power Station (IPP)	Afam Rivers State	Combined cycle gas turbine	624 MW	Partially operational	2009(Gas turbines) 2010 (Steam turbines)
16	Alaoji Power Station (NIPP)	Abia state	Combined cycle gas turbine	1074 MW	Partially operational	2012-2015
17	Geregu I Power Station-Privatized	Geregu Kogi State	Simple cycle gas turbine	414 MW	Partially operational	2007

S/N	Thermal Power station	Community	Type	Capacity	Status	Year completed
18	Geregu II Power Station (NIPP)	Geregu Kogi State	Simple cycle gas turbine	434 MW	Partially operational	2012
19	Ihovbor Power Station (NIPP)	Benin City	Simple cycle gas turbine	450 MW	Partially operational	2012-2013
20	Olorunsogo Power Station	Olorunsogo	Simple cycle gas turbine	336 MW, (8 x 42 MW	Partially operational	2007
21	Olorunsogo II Power Station (NIPP)	Olorunsogo	Combined cycle gas turbine	675 MW NDPHC (4x112.5 MW and 2x112.5 MW steam turbines.) Working below capacity due to gas supply issues.	Partially operational	2012
22	Omotosho I Power Station (FGN-Privatized)	Omotosho	Simple cycle gas turbine	336 MW; (8 x 42 MW)	Partially operational	2005
23	Omotosho II Power Station (NIPP)	Omotosho	Simple cycle gas turbine	450 MW, (4x112.5 MW)	Partially operational	2012

S/N	Thermal Power station	Community	Type	Capacity	Status	Year completed
24	Sapele Power Station (NIPP)	Sapele	Simple cycle gas turbine	450 MW (4x112.5 MW)	Partially operational	2012

S/N	Hydroelectric station	Community	Type	Capacity (MW)	Year completed	Name of reservoir
25	Kainji Power Station	Kainji, Niger State	Reservoir	800	1968	Kainji Lake
26	Jebba Power Station	Jebba, Niger State	Reservoir	540	1985	Lake Jebba
26	Shiroro Power Station	Shiroro, Niger State	Reservoir	600	1990	Lake Shiroro
28	Zamfara Power Station	Zamfara State	Reservoir	100	2012	Gotowa Lake

1.3 NON – FUNCTIONAL POWER PLANTS IN NIGERIA

From table 1, more than 60% of the power plants in Nigeria are either not working or partially working (i.e. not operating at full capacity). This shows that the problems are myriad and multifaceted. From various research conducted on problems of power generation in Nigeria, factors affecting power generation in Nigeria are:

1. **Poor plant maintenance**

Preventive and corrective maintenance are the two basic forms of maintenance. Preventive maintenance can be done on a time or condition basis. The type of maintenance that is appropriate for various power plant equipment is determined by the equipment's criticality to the overall plant.

As a result, for the best plant performance at the lowest cost, an appropriate technique for each plant equipment must be used. However, most power plant stations in Nigeria adopt a corrective maintenance strategy, and in other situations, equipment maintenance is not even done. As a result, the output of electricity generation is poor.

2. Inadequate funding

Funds for power equipment infrastructure maintenance, upgrades and expansion are inadequate which had been worsened by the dwindling global price of crude oil.

3. Pipeline vandalism

The pipeline that carries natural gas to the thermal power stations is frequently being vandalized by militants in response to the government's failure to give them employment and provide basic amenities for their communities. This results in frequent disruption of gas supply to thermal power stations and frequent shutdown of power generating plants.

4. Wrong location

Power stations in some cases are sited far away from energy sources due to nepotism and ethnicity. The effect is usually multifaceted ranging from extra cost in transporting materials and human resources to power plant sites to possibilities of vandalism of materials in transit [11].

5. Unskilled manpower

Inadequate skilled manpower with the expertise to maintain, upgrade and expand power generation systems.

6. Lack of energy mix

Nigeria had relied mainly on oil, gas and hydro as the energy source for power generation and has failed to explore other sources of energy such as solar, wave and tidal energy and biomass. These alternative sources can supplement existing sources for greater power output.

7. Inadequate staff training

Mainly due to insufficient funds or misplaced priority, staff are not exposed to state of the art technology through local and oversea training for optimal day-to-day running of power generation systems.

8. Aged or Obsolete equipment

Most of the power infrastructure has been built for several decades. For example, 36% of the plants are over 20 years, 48% are over 15 years old and 80% are over 10% years [12]. Hence a majority of the plant is in the wear and tear region and as such often breakdown.

9. Low staff morale

Staff morale is generally low due to poor remuneration

10. Seasonal drought

During the drought period which occurs in the dry season and from March to June, the water level is very low which affect negatively hydropower generation

11. Poor electricity pricing

Since the botched privatisation of the power sector, the majority of private investors have engaged in the unethical practice of issuing excessive invoices to electricity customers under the guise of anticipated billing. The estimated billing system had proven counterproductive because consumers were unable to pay the exorbitant bills owing to their low income and had resorted to bribing power distribution company employees to continue to have access to electricity. The costs should be reasonable to encourage consumers to pay so that enough money is available to maintain, repair, and expand power-producing facilities.

12. Lack of policy continuity

Instead of building on the good policies of the previous administration, the policies are jettisoned and new policies activated will eventually be discarded by another Government [13].

13. Inadequate gas supply

Due to the frequent shutdown of the gas plant and vandalism of gas pipelines by the militant group and other agitators coupled with daily flaring of gas by multinational oil companies, most thermal stations from the time do not get adequate gas supply to generate electricity.

14. Poor asset management

Privatization carried out by the Nigerian government was a charade. The assets were sold to themselves and their political associate. These investors do not have the technical and managerial skills to optimally manage power generation infrastructure for maximum power production.

15. Customers' indebtedness to power providers

Electricity consumers in some cases are not patriotic concerning their responsibility of paying for electricity consumed [11]. Individuals, local government, State and Federal government agencies owning power companies billions of Naira. The debt if paid would go a long way in ameliorating the power crisis in Nigeria.

16. High cost of operation

High cost of operation due to the following reasons (1) high cost of purchase of spare parts to carry out maintenance (2) High cost of hiring foreign expatriates as a result of the limited number of local experts.

17. Climate change

The effect of global warming which brought about climate change has negatively affected water levels at hydropower generation stations and invariably resulted in a reduction in power generation output [14].

18. Inadequate gas pipeline maintenance

The pipeline that transports natural gas to power thermal stations is not maintained as when due and this does result in frequent pipeline failure [15].

19. Unwholesome practice by staff

Some technical staff sabotage the system by deliberately allowing equipment to fail from time to time so that they can request funds and the bulk of the fund is diverted into personal use. Others procure substandard equipment to fix the plant system thereby making the system fail.

20. Absence of research & development

Research and development are absent especially as it concerns the best approach to adopt alternative sources of energy such as nuclear, solar and biomass to supplement existing energy sources for greater electric power production output [11].

21. The kidnapping of local & foreign experts

Both local and foreign experts are subjected to inhuman treatment by kidnappers who kidnap for ransom. These had resulted in some foreign experts resigning and relocating back to their countries and invariably a shortage of skilled manpower to optimally operate, maintain and expand power generation infrastructure in Nigeria.

22. Corruption

From the lower staff cadre to the management level corruption thrive. Meagre resource available for power infrastructure maintenance, upgrades and expansion is either embezzled or mismanaged by power generation managers [13].

1.4 RECOMMENDATIONS

The engine that drives industrialization is electric power, a stable electric power supply is the key to the industrialization and economic emancipation we long for. To achieve a stable electric power supply to power industries and homes the country must be able to generate enough electric power to meet its demand. However, to meet up with the power demand, the various challenges discussed in section 2.3 that had bedevilled the sector must be overcome. From literature, interviews with power experts and based on my opinion, the general solutions to the challenges bedevilling power generation in Nigeria are described as follows:

I. Energy mix

No nation in the world can satisfy its electric power demand by generating it from one or two sources. To meet up with the high demand for electric power and to achieve any set goal there is a need to utilise multiple sources of energy with a well-articulated electric power policy framework. The low power generation experienced in Nigeria since independence is mainly because the nation concentrated all its efforts on generating electric power from only two sources namely hydro and natural gas. Unfortunately, the two energy sources have been poorly harnessed and managed [16].

II. Structured maintenance methodology

In Nigeria, maintenance is still regarded as an unwanted cost-generating activity rather than one that will produce greater plant system safety, availability and reliability and invariably higher Company profitability and productivity. Until there is a complete change of attitude towards maintenance by government and power generation managers, the power crisis will be a crisis without an end [17].

For the nation to achieve her aim of generating adequate electric power to meet power demand, there is a need for a structured maintenance methodology for the maintenance of her power infrastructure which must entail the following: right attitude toward maintenance, adequate budgetary provision for maintenance, plant system equipment or component risk analysis system, maintenance strategy selection methodology, spare parts inventory programme and an instrument such as computerized maintenance management systems (CMMS) for data collection and analysis.

III. Adequate funding

Nigeria's current electric-power generation capacity of less than 6000 MW would have to expand to 160 GW by 2030 AD if it is to fulfil its goal of becoming one of the world's most industrialised nations [18]. The authors went on to say that with this level of electric power supply, per capita electricity consumption will rise from 144 KWH now to almost 5000 KWH by 2030. The 5000 KWH is only similar to the per capita electricity usage of several industrialised nations in 2003. The entire financial resource required to meet this goal is anticipated to be around US$ 262 billion, or around US$ 10 billion per year [18]. However, the dwindling oil revenue due to the global economic meltdown, coupled with a high level of corruption and mismanagement has increased the competition for public funds and has reduced the government's capacity to adequately meet the financial obligation of the power sector. Even when resources are made available the money will end up in the pocket of a few individuals and the end product is that the project will be abandoned or will not even be executed. If the problem of the electricity crisis must be resolved, adequate finance must be set aside for the operation, maintenance, upgrading and expansion of the power sector infrastructure. Nevertheless, due to the enormous financial resources involved Federal, state, and local governments of Nigeria must support the private investor financially by way of grants and waivers.

IV. Elimination or Minimisation of Corruption

Corruption in the power sector must be addressed if the country is to meet its goal of generating enough electricity to power households and industries. To achieve zero corruption in the sector, the government must ensure that cash gained from energy sales by power management is returned to the sector for resource maintenance, upgrade, and expansion. The government must also ensure that any power management who is determined to be unfit is investigated and prosecuted by the Economic Financial Crime Commission (EFCC). Furthermore, the fraudulent practice of electric power distributors/marketers invoicing consumers on an estimated basis must be strongly condemned, and the government must ensure that power consumers are furnished with electricity metres. This will reduce corruption perpetrated by the staff of power distributing companies and electric power consumers.

V. Elimination or reduction of gas pipelines and other related infrastructure vandalism.

The Niger Delta militants and other Agitators are responsible for pipeline and other infrastructure destruction, and to diminish or eradicate this activity, the Agitators must be persuaded to lay down their arms against the state. To accomplish this, people must be reintegrated into society by receiving formal education and then finding gainful employment [13]. Furthermore, the issue of providing basic amenities to the inhabitants of the Niger Delta and improving the environment must be a government priority.

VI. Proper Management of Existing Power Plants

Proper management of Power plants helps ensure safe and effective power generation operations, meet regulatory and compliance standards, extend the life of power generation assets, minimize investments in inventory, and ensure that staff training is up to date and their work morale is high. This goes a long way in improving the overall output of a plant.

1.8 CONCLUSION

Any country's ability to create sufficient quantities and quality of electric power and distribute it efficiently to power households and industries determines its rate of economic growth and industrialisation. Hence, for Nigeria to achieve its aim of becoming one of the most 20 developed economies in the world, the electric power crisis which has lingered for decades must be completely resolved. Despite the abundant energy sources such as coal, natural gas, solar, wind and tidal energy and biomass in Nigeria, the nation remains one of the lowest electricity consumption per capita in Africa. The reasons and solutions for the low power generation capacity had been discussed. The research will go a long way in assisting power generation Managers in ameliorating the electric power crisis in Nigeria and other countries with similar challenges.

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