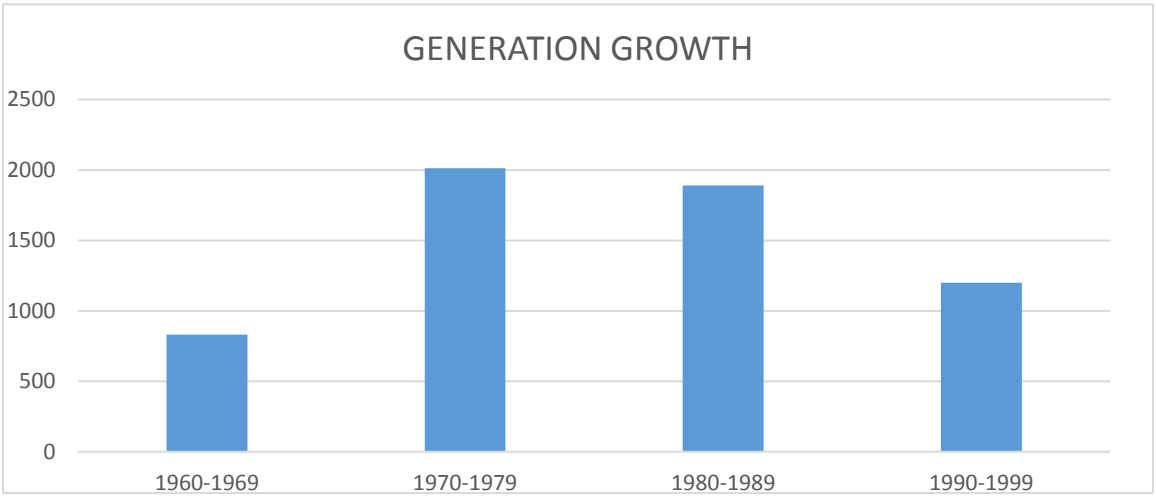

Fig. 1: Nigerian MW power growth since Independence

The agitation of the customers and the loss of some investors due to poor electricity supply prompted the government to hand over the affairs of the power system to private investors. The Nigerian power sector has been under the virtually integrated system with the state-owned Power Company under different names trusted with the sole responsibility of generation, transmission and distribution of power to the entire country from 1951 when Electricity Corporation of Nigeria (ECN) was established till 2013 when the sector was fully privatized. The 2005 Electric power sector reform bill gave way to the privatization of the then Power Holding Company of Nigeria (PHCN) through the Bureau for Public Enterprise. The framework of the reform are as follows [2];

• Unbundle the state-owned power entity into generation, transmission and distribution

• Provide for the transfer of assets, liabilities and staff of NEPA to PHCN and then to successor generation, transmission and distribution companies

• Create a competitive market for electricity services in Nigeria

• Set up an independent regulator

The unbundling of the power sector in Nigeria was successful which now comprises of six generating companies, one transmission company and eleven distribution companies. The power systems worldwide have undergone serious changes in the last twenty years [3]. Nigeria is in the final stage of this reforms and this is an important stage in this deregulation as it will give the consumers the much-needed options. Power sector reforms involves moving from vertically integrated monopoly at various levels of the sector to a competitive stage where buyers of

electricity enjoy having options of which sellers meets their demand. This involves government having limited or no control of the electricity market. The reform can be in the form of any of the following category; Single buyer where a single entity will be given access to buy electricity directly from the generating unit and then sell to distribution companies, Retail competition where customers have option of buying electricity from distribution companies of their choice or Wholesale competition where the distribution companies are given access to purchase power directly from generation unit and sell to customers. Attempts have been made by various researchers on the suggestions to improve power supply to the country post restructuring [4, 5]. However, these suggestions will be better appreciated when wholesome understanding of the limitations to the power sector restructuring in Nigerian are made. In this paper, the implementation of the models in deregulation of electricity in Nigeria will be assessed to find out the level of customers' satisfactions based on the international acceptable standard of electricity reforms.

2. The Nigerian Power structures

The structure of the Nigerian power system comprises of Generation, Transmission and the distribution. The first electricity company in Nigeria called Nigerian Electricity Supply Company was established in 1929 [1]. The Nigerian Electric Power Authority took charge of the Nigerian Power sector in the year 2000 and was in charge of the generation, transmission and distribution of electric power in Nigeria until different stages of reforms.

Generation

Power generation in Nigeria is mainly through thermal and hydro sources with the main source of fuel coming from fossil fuels. Gas accounts for majority of the generation capacity in Nigeria with the remainder being hydropower sources [2]. The Electricity Power Sector Reform (EPSR) Act of 2005 unbundled PHCN into six generating companies which are: Afam Power Plc, Sapele Power Plc, Egbin Power Plc, Ugheli Power Plc, Kainji Power Plant, Jebba Power Plant and Shiroro power Plc. Presently; the generation sub-sector includes 23 grid-connected generating plants. The sub-sector has a total installed capacity of 10,396 MW (with 6,056 MW; 58.25% available). The thermal based generating plants have an installed capacity of 8,457.6 MW (with 4,996 MW; 59.07% available) while the hydropower have 1,938.4 MW total installed capacity with 1,060 MW; 54.68% available. This total power comprises of the Independent Power Producers (IPPs), privatized Generating Companies (GenCos) and the generating stations under the National Integrated Power Project (NIPP) [1].

The Niger Delta Power Holding Company (NDPHC) is a public sector funded emergency intervention scheme which has the mandate to manage the NIPP which primarily involves the construction of identified critical infrastructure in the generation, transmission and distribution and natural gas supplies in the power sector value chain. The NDPHC is expected to add 10 new gas fired power plants which will add about 4,774 MW of power to the national grid. These power stations are shown in table 1. If Nigerian Power Reforms are implemented, Nigeria is expected to generate 40,000 MW by the year 2025.

Table 1: NIPP power stations

S/N	NAME	CAPACITY (MW)	STATE LOCATED
1	Alaoji	1,074	Abia
2	Benin (Ihovbor)	451	Edo
3	Calabar	563	Cross River
4	Egbema	338	Imo
5	Gbarain	225	Bayelsa
6	Geregu	434	Kogi
7	Omotosho	451	Ondo
8	Omoku	225	Rivers
9	Olorunsogo	335	Ogun
10	Sapele (Ogorode)	450	Delta

Transmission

The electricity transmission network is managed by the Transmission Company of Nigeria (TCN). It is among the 18 companies that were unbundled from PHCN in April 2004 [**1**]. The licensed activities of TCN include: electricity transmission, system operation and electricity trading. It provides vital transmission infrastructure between the Generating Companies and the Distribution Companies' feeder Substation. The transmission voltages available in the Nigerian power transmission network are 330kV and 132kV and are entirely radial. The theoretical transmission wheeling capacity of the network is 7,500MW over 20,000km of transmission lines. Presently, its transmission wheeling capacity (5,300MW) is greater than average operational generation capacity of 12,522MW but it is far below the total installed generation capacity of 12,522MW [6]. The Nigerian power transmission network is shown in Fig. 3. TCN has three operational departments: the Transmission Service Provider (TSP), the System Operations (SO) and the Market Operations. The TSP is responsible for the maintenance of the physical structures of the transmission grid and its expansion to new areas. The SO manages the flow of electricity throughout the Nigerian power system from generation to distribution. It is responsible for controlling grid frequency and voltage, allocating loads in times of insufficient generation, SCADA design, installation and maintenance, economic dispatch of generating units, procuring and managing ancillary services, enforcing grid code and operational procedures, coordinating all planned outages for the maintenance of system equipment and performing post fault analysis of all major disturbances. On the other hand, MO is responsible for: Implementing and administering the Nigerian Electricity Market Rules, Drafting and implementing the Market Procedures; Administration of the Commercial Metering System by ensuring that each trading point has adequate metering systems in place; Administration of the Market Settlement System; Administration of the Payment System and

commercial arrangement of the energy market, including Ancillary Services; Supervising Electricity Market Participants' compliance with and enforcing the Market Rules and the Grid Code. Periodic reporting on the implementation of the Market Rules and Capacity building of market of Participants on the Market Rules and Procedures and Trading Arrangements.

Fig. 2: The Nigerian Power transmission network [5]

Distribution

The distribution is the aspect of energy body closest to the people and that provides the only platform which the people express their level of satisfaction of power availability. The distribution companies make up 11 companies which were created from the unbundling of PHCN. The distribution companies are responsible for the distribution of the power generated by the GenCos to the final consumers. They are the ones who deal directly with the consumers of electricity in Nigeria. The distribution companies carry out such functions like supply of energy to the consumers, network maintenance and distribution of tariffs to customers, and enforcement of disconnection of customers owing bills. More than 80% of Nigerians pay electricity bills through estimation (where the Electricity distribution board determines what a customer will pay for the

month irrespective of the consumption). The complaints that characterized the customers appraisal level of the power supply in Nigeria before the reforms seems to be on the increase nearly a decade after privatization.

3. Demand and supply power scenario in Nigeria

Nigeria is the most populous country in Africa and seventh in the world. As at 2016, there are currently 23 grid-connected generating plants in operation in the Nigerian Electricity Supply Industry, with a total installed capacity of 10,396.0 MW and available capacity of 6,056 MW. The Nigerian power sector generation is predominantly based on fossil fuels. Most generation is thermal, with an installed capacity of 8,457.6 MW (81% of the total) and an available capacity of 4,996 MW (83% of the total). Hydropower from three major plants accounts for 1,938.4 MW of total installed capacity (and an available capacity of 1,060 MW) [7]. In Nigeria, the available capacity of the generating stations based on the source of fuel is shown in Fig. 2.

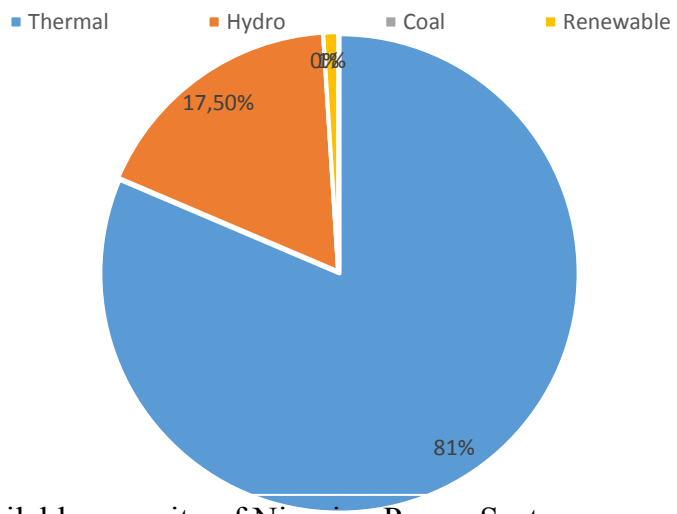

Fig. 3: Available capacity of Nigerian Power System

There is a very huge gap between generation and demand of power in Nigeria hence the need for alternative sources. Nigeria has large coal reserves in eastern and central regions but

unfortunately, Government interest in power generation from coal has been in the cold since the discovery of oil. The only coal fired plant to have existed in Nigeria, the Oji River Power Plant was established in 1933 and closed immediately after the civil war. The renewable energy resources are abundant in the country especially in the northern region where the average wind speed is approximately 6.0m/s [8] but unfortunately these are yet to be exploited in large scale.

Also, Nigeria has an estimated deposit of 17,459,215.2 million MJ/day of solar energy falling on the country's 923,768 km^2 land area (approximate range of 12.6 MJ/m^2/day in the coastal region to about 25.2 MJ/m^2/day in the far north) [9]. The Nigeria Renewable Energy Master Plan (REMP) is a policy being implemented by Nigeria's Federal Ministry of Environment that aims to increase the contribution of Renewable Energy to account for 10% of Nigerian total energy consumption by 2025. However, the reality on ground shows that the Ministry is still far from the desired target.

4. Reform of the Nigerian power market

The vertically integrated way of electricity market ceases to exist once reform and restructuring takes place. The first step to power system reform is establishing whether there is the need for reform. The decay in the available Power system infrastructure in Nigeria where Generation is far less than the power need of the consumers, a situation where the acclaimed revenues generated from energy sales is lower than the maintenance cost, government investment in power sector is dominated by internal politics and interest and so on, then the need for power system reform is inevitable. The reform was intended to address the following; ensure transparent and responsible management of available power, eliminate government's involvement in utility management, encourage private investment in generation to address inadequate supply, ensure level playing field for all investors, release government funds to finance core activities [10**]**. Nigeria has operated restructured Power systems before 1972 but government's interest in controlling the flow of cash and information led to its suspension and subsequent creation of Nigerian Electric Power Authority in 1972. Due to the increase in the country's population, investments and companies, and the need for more power supply, NEPA couldn't match the demand for power and this led to its unbundling first in 2005, from NEPA to Power Holding Company of Nigeria (PHCN) and finally in September 2013, PHCN ceased to exist and this led to the creation of the Nigerian Electricity Regulatory Commission (NERC) in the same year. This also paved way for private investors into the power system [11]. The mission of NERC is to promote and ensure an investor-friendly industry and efficient market structure to meet the needs of Nigeria for safe, adequate, reliable and affordable electricity. The NERC issues licences for new on and off-grid generation of power, as well as for distribution of electricity to end users. They also manage consumer complaints and such related issues on tariff. With the unbundling of the PHCN, it now has 18 companies as follows: six (6) generating companies, one (1) transmission company (i.e., Transmission Company of Nigeria-TCN), and eleven (11) distribution companies. The generating companies are AFAM, EGBIN, KAINJI, SAPELE, SHIRORO and UGHELLI.

There are also some new Independent Power Producers under the auspices of the Niger-Delta Power Holding Company (NDPHC) [10]. The 11 distribution companies are Abuja Electricity Distribution Company (AEDC), Benin Electricity Distribution Company (BEDC), Eko Electricity Distribution Company (EKEDC), Enugu Electricity Distribution Company (EEDC), Ibadan Electricity Distribution Company (IEDC), Ikeja Electricity Distribution Company (IKEDC), Jos Electricity Distribution Company (JEDC), Kaduna Electricity Distribution Company (KEDC), Kano Electricity Distribution Company (KNEDC), Port-Harcourt Electricity Distribution Company (PHEDC), Yola Electricity Distribution Company (YEDC). It is disheartening that those peculiarities in Nigerian power system operations before reforms are still obtainable at the moment, a typical example is where individuals/communities will procure transformer and still pay installation charges running millions to the distribution companies before it will be linked to the grid, the issue of estimated billing and long outage of power for days are still common with the distribution companies. In comparison with the way restructuring of power takes place, it is observed that Nigeria is far away from the real restructuring process. For instance, the supply of power generally hasn't improved since the restructuring and the level of customer complaints about metering and billing are still quite large. In the first quarter of 2020, a total of 204,506 consumer complaints were received by the NERC with only 188,749 complaints resolved. The NERC quarterly report shows that customer complaints centred on service interruption, voltage instability, load shedding, metering, estimated billing, disconnection, delayed connection, among others [12]. However, metering and billing accounted for about 42.96% of the total complaints received, while the remaining 57.04% of the complaints are related to load shedding, voltage fluctuations, interruption, Disconnection, connection delay, etc. In African ranking of the Electricity Regulatory index Report published by AFDB [13], Nigeria ranked 8th. This ranking which is based on Regulatory Governance Index (RGI), the Regulatory Substance Index (RSI) and the Regulatory Outcome Index (ROI) is a measure of how transparent the activities of the key regulatory authorities and their independence from Government interest.

5. Limitations of the Reform

With nearly a decade after the full privatization of the Nigerian Power sector, one of the challenges facing the country is the irregular supply of Power to the teaming populace. The Electricity reform process in the country focused more on ensuring financial independence of the generation and distribution while government controls the activities of the transmission structures. The power sector reforms succeeded in breaking the monopoly of a single entity controlling the affairs of the generation, transmission and distribution. This ensured that distribution facilities are closer to people which ensured that customers access to complaint points are easier. However, the following are the limitations of the restructured power sector in Nigeria:

- The reform has failed to improve the availability of supply as many local substations are still subjected to load shedding due to the greater demand than the ratings of the transformers in the streets and villages. The expectation of an improved electricity stability has rather worsened.

- Also, customers still stay long without supply when fault occurs along a major line even when complaints are made on time and sometimes, the customers have to pay for repairs done on their substations. This scenario characterized the era of NEPA and PHCN and as well continues even after privatization.

- More so, the option of buying electricity from different sellers are limited due to rigorous government policies. The expectation of Nigerians prior to privatization was that customers can decide on which distribution agents that can buy power but so far things have remained the same.

- Also access to the national grid has not changed and still remains at 54.5% [14] despite government investing huge amount of money to the sector [15].

- Transmission and distribution losses have not improved as it is still above the 8% target for Multi-Year Tariff Order (MYTO) of the NERC [16]. Accordingly, the difference between the generated power and the actual power sent to the DISCOs are on the high as depicted in Fig. 4.

- The tariff structure and policies have not changed either as the case of estimated billing still remains the major way of customer billing in the electricity sector. However, a regulatory body NERC was set up to address the issue of unsatisfactory state of the consumers but long delay in attending to customers' complaints and lack of transparency in their mode of operation have left consumers' doubt in their capabilities high.

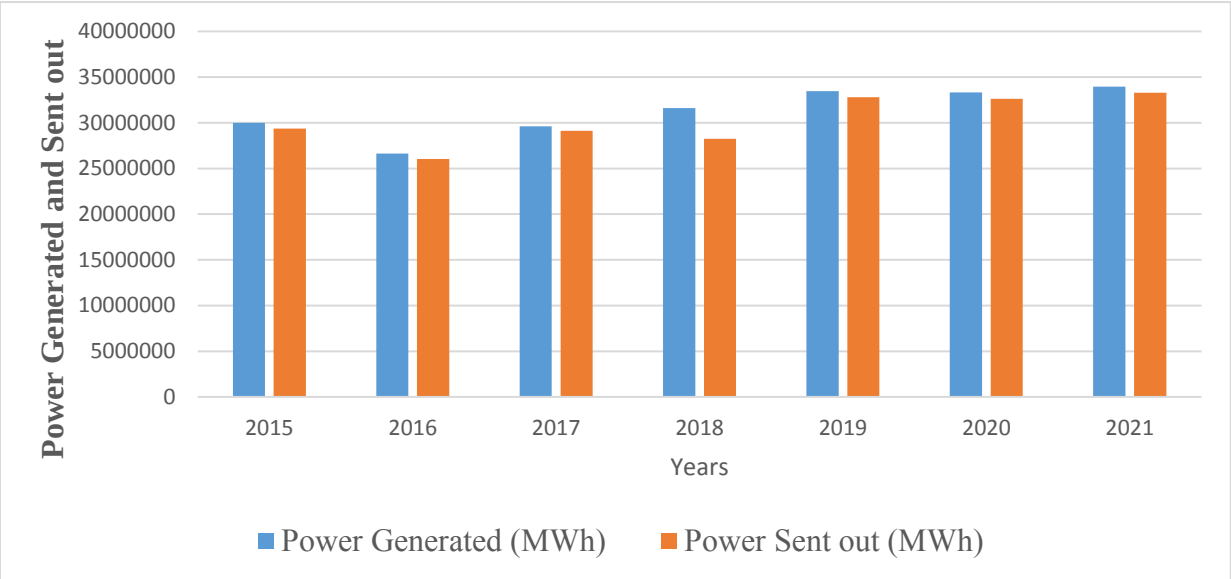

Fig. 4: Power generated and sent out

6. Conclusion

Power sector restructuring in Nigeria can be said to be still in a continuing process nearly a decade after its reform. The monopolistic structures of the different power system areas have been dismantled which is the beginning of the reform process. However, access to electricity have not improved since many villages still don't have access to the national grid. Also, the availability of electricity has not improved as many cities and villages still stay for days without power supply. However, there are over thirty (30) power stations either functional or under construction in Nigeria currently. These power stations invariably will improve the availability of power when completed.

In social terms, the cost of electricity in Nigeria is low when compared to other African countries [17], although the income levels especially the government workers are quite lower. The issue of billing which is a very important yardstick to assessing the power sector reform haven't improved either. The estimated billing approach which forms greater percentage of the billing strategy in the country scores the power sector restructuring low. In general, Nigerians haven't experienced any improvement in all aspect of power supply since the power system reforms. Most of the Government policies are stronger in the media than in reality with people on ground. There is an ongoing effort by the government to ensure that all connected customers are installed with pre-paid meters. This will ensure transparency in billing and will increase customers' satisfaction.

References

[1] Nigeria to improve electricity access and services to citizens, World Bank press release, available online at https://www.worldbank.org/en/news/press-release/2021/02/05/ Nigeria-to-improve-electricity-access-and-services-to-citizens.

[2] B. Onagoruwa, ''Nigerian Power Sector Reforms and Privatization'', Bureau of Public Enterprises, June 2011.

[3] L.L Lai, ''Power System Restructuring and Deregulation, John Wiley and Sons Ltd, New York, 2001.

[4] B. J. Adenle, F. Onaifo, O. A. Alashiri, K. G. Adekusibe and A. A. Adelakan, "Evaluation of electrical power outages: A restructuring approach in Nigeria", Proceedings of the 13th iSTEAMS Multidisciplinary Conference, University of Ghana, Legon, vol. 2, pp. 235-244, 2018.

[5] T.O Ajewole, W.A Oyekanmi, K.O Alawode, O.D Momoh, and M.O Omoigui, "A performance assessment of the distribution subsystem in the deregulated Nigerian power sector" 2019 IEEE PES/IAS Power Africa.

[6] Transmission - Nigerian Electricity Regulatory Commission available online at: https://nerc.gov.ng/index.php/contact/forum-offices.

[7] Nigerian Electricity Markets, NIPP transactions, available online at: https://www.nipptransactions.com/background/electricity-market/

[8] Lehmeyer (International) Consultants (2005). Report on Nigeria wind power mapping projects, Federal Ministry of Science and Technology, pp. 37-51, (Unpublished).

[9] S.O Olayinka, S.A Muyiwa, M.O Olanrewaju and O.F Richard, "Solar energy applications and development in Nigeria: Drivers and barriers'', Renewable and Sustainable Energy Reviews, Vol. 32, 2014, pp. 294–301.
[10] Overview of the Nigerian Power Sector Reform
[11] Onochie U.P, Egware H.O and Eyakwanor T.O, "The Nigeria Electric Power Sector (Opportunities and Challenges)", (2015).
[12] F. M. Dahunsi, O. R. Olakunle and A. O. Melodi, "Evolution of Electricity Metering Technologies in Nigeria", NIGERIAN JOURNAL OF TECHNOLOGICAL DEVELOPMENT, VOL. 18, NO.2, pp. 152-165, 2021.
[13] Electricity Regulatory index for Africa 2021 Report published by African Development Bank, https//www.afdb.org/en/documents/electricity-regulatory-index-africa-2021.
[14] "Nigeria to improve Electricity access and services to citizens", World Bank Press Release No: 2021/088/AFR, Feb., 2021, available online at www.worldbank.org.
[15] Premium Times. (2019, Sept. 26). Nigerian government spent N1.5 trillion on Power sector in two years [online]. Available: https://www.premiumtimesng.com
[16] "Key Performance Indicators for Transmission losses". Nigerian Electricity Regulatory Commission monthly report, available online at: https//nerc.gov.ng.
[17] V. Foster, "Zambia's Infrastructure: A Continental Perspective", The World Bank African Region Sustainable Development Department, March 2011.