

A Comprehensive Review of Nigeria Electric Power Transmission Issues and Rural Electrification Challenges

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Abstract: *This paper examines the Nigeria electric power transmission network, rural electrification scheme, issues and challenges. The electric power transmission network and rural electrification scheme were reviewed to identify their areas of strength and shortcomings in the Nigeria power sector. The paper then further proposes the way forward to optimize the Nigeria electric transmission network and rural electrification scheme.*

Keywords: *Transmission Network, Rural Electrification Scheme, Challenges, Issues, Current State of Infrastructure, Nigeria.*

I. INTRODUCTION

The Nigeria Complex transmission network and distribution system supply the vast needs of electrical power to their citizenry. Due to the tremendous power requirement, we must constantly be concerned with efficient operation of our power transmission network and the associated systems [1]. Power being an essential commodity, because it drives the economy of a nation and the reliability sustains her developmental growth. There is a correlation between the standard of living and the available power supply in a nation.

The Nigeria power supply is dated back to 1896 when electricity was first produced in Lagos, fifteen years after its introduction in England [2]. The total capacity of power generation was 60KW, in other words, the maximum power demand in 1896 was less than 60KW [3]. In 1946 the Nigerian government electricity undertaking was established under the jurisdiction of public works department (PWD) to take over the responsibility of electricity supply in Lagos state [3]. In 1959, the Electricity Corporation of Nigeria (ECN) was formed as a central body; other bodies like Nigerian Electricity Supply Company (NESCO) and Niger Dams Authority (NDA) were also formed. The NDA was established by act of parliament to produce

electricity and sell to ECN which they distribute and sell at utility voltages. In April 1972, the operations of ECN and NDA (Niger Dams Authority) were merged in a new organization known as the National Electricity Power Authority (NEPA) [3].

The Nigeria rural electrification actually started in 1981 with the introduction of the National Rural Electrification Program (NREP) which was being executed by the then National Electricity Power Authority (NEPA) on behalf of the federal government of Nigeria. The aim of NREP was to connect the headquarters of all the 774 Local Government Areas (LGAs) to the national grid system [4]. The NREP succeeded in connecting 600 of the LGAs to the national grid [4]. However, local network distribution within the LGAs connected has not expand beyond the LGAs headquarters and its immediate environs, to other villages and rural communities due to rural electrification challenges [4].

Since inception of NEPA, the authority expands annually in order to meet the ever-increasing power demand [5]. Unfortunately, the majority of Nigerians have no access to electricity and the supply to those that have access is not regular. It is this backdrop that federal government have embarked on aggressive power sector reforms with the intention of resuscitating NEPA and making it more efficient, effective and responsive to the yawning of the teeming populace [3].

Before the unbundling of the Nigeria power sector, the transmission system of Nigeria is controlled solely by the then NEPA which was later changed to PHCN. After the unbundling of the Nigeria power sector, we now have three companies: Generation Companies (Genco), Transmission Company (Transco) and Distribution Companies (Disco).

The Transmission system of Nigeria (Transco) which is called the Transmission Company of Nigeria (TCN) is a successor company of the then Power Holding Company of Nigeria (PHCN), following the unbundling of the power sector, and is currently being managed by a management contractor, Manitoba Hydro International (Canada) which is responsible for revamping TCN to achieve and provide stable transmission of power without system failure [6].

The Nigeria transmission lines require constant balance of power supply, demand and transmission capacity. The transmission system is operated for two primary objectives:

1. Reliability of the physical system
2. The economy of the system

Thus, from an operational perspective, it is transmission system operators who are responsible for achieving an efficient, economic and reliable power supply. Currently, the length of Nigeria electricity transmission system is made up of about 5,528.8 km of 330kV lines and 6,801.49 km of 132kV lines [6]. The transmission network operators majorly focus on system planning, administration and discipline. But with the above mentioned, there are various issues and challenges facing the Nigeria transmission network and rural electrification scheme today.

This paper is organized as follows: section ii Nigeria power transmission network and issues, section iii current state of Nigeria transmission network infrastructure, section iv Nigeria rural electrification scheme and challenges, section v the way forward and section vi conclusion.

II. NIGERIA POWER TRANSMISSION NETWORK AND ISSUES

The Nigeria transmission network is made up of about 5,528.8km of 330kV and 6,801.49km of 132kV transmission lines with 986.5km of 330kV and 705.3km of 132kV lines under construction [6 & 7]. Despite the aforementioned, there are different issues facing the Nigeria power transmission network today, the complexity of the Nigeria Grid Structure (NGS) arises from the fact that the Nigeria transmission lines span a lengthy distance to evacuate the power generated from generation points to consumers.

This section of the paper evaluates the issues facing the Transmission network of Nigeria (TCN) today in two major ways:

1. TECHNICAL ISSUES

The effect of technical issue on the Nigeria transmission system has far negative impact which has hampered the efficiency of evacuating power generated in Nigeria. They increase both the cost of production of energy as well as delivery cost in the system. Some of the major technical issues are highlighted as follows:

(a) **Long Transmission Lines:** The Nigeria transmission network is characterized with very lengthy transmission lines and feeders which make voltage control difficult. The Nigeria Grid Structure is geographically widespread and some of these lines include: Kainji - Birnin Kebbi (310km), Jebba - Shirro (244km), Oshogbo - Ikeja West (235km), Jos - Gombe (265km) [8]. The lengthy transmission network of Nigeria has reduce the maximum power transfer capability on the lines thereby reducing the margin between the planned power transfer and the maximum limit at which the lines is susceptible to transient and dynamic instability, and the restoration of power supply to the National Grid after major system disturbances is often delayed because of the necessity to ensure that adequate reactors are in the circuit and enough units have been synchronized to compensate the reactive Mvars generated by the lengthy transmission lines before switching [8].

(b) **Few Mesh Network:** One of the determinates of a power system's reliability index is the available numbers of alternate routes of power flow from a power station of the grid to another [8]. The structure of the Nigeria National Grid System is weak due to the existence of several single lengthy radial transmission lines with very few meshes or duplicated lines, thus constituting a single risk [8].

(c) **Line Losses:** Basically, losses in electrical transmission lines can be identified as losses caused by the internal factors. These are the I^2R losses that are inherent in all conductors because of the finite resistance of the conductors. In alternating current transmission lines, the line losses are higher due to skin effect. These losses occur as a result of current flow through the resistive materials (conductors) and the magnetizing energy in the lines of transformers [9]. Transmission line losses are one of the major technical issues faced by the transmission company of Nigeria (TCN). According to Anumaka [9], he said the transmission and distribution losses of Nigeria power sector have a large proportion-whopping of 40%. The lengthy distance covered by Nigeria transmission lines also attribute to this high losses witness in the transmission network today.

(d) **Dielectric Losses:** These are losses that result from the heating effect of the dielectric material between the conductors. The heat produced is dissipated in the surrounding medium thereby making system to heat up and increase losses in the system [8].

(e) **Induction and Radiation Losses:** These losses are produced by the electromagnetic fields surrounding the transmission line conductor links another line or metallic objects where by current is induced in the object. As a result, power is dissipated in the object and losses occur [8].

(f) **Transformer Losses:** The largest technical issue in the power transmission system in Nigeria is the transformer losses which contribute to the inefficiency of the power transmission. The transformer losses are of two types. These include the winding losses (due to internal impedance of the transformer coils) and core losses.

(g) **Lightning:** This is the second transmission technical major issue faced by Transmission Company of Nigeria (TCN). The transmission lines are built with a grounded shield wire placed along the top of the pole, above the conductors. Typically, the shield wire is bonded to ground at each transmission structure. This protects the transmission line from lightning but adequate lightning arrestor fixed on the line will arrest the ugly incident of lightning strike.

(h) **Fallen Lines:** The transmission line falls as a result of been hit by vehicle which are not fixed or repair on time, this can cause high downtime period in the system thereby affecting the system reliability and availability of power to Nigerians.

(i) **Inadequate Spare Parts:** The unavailability of spare parts, poor technical staff and training program affect maintenance of transmission lines. These are necessary for the efficient performance of workers and the system.

(j) **Lack of Modern Technology:** There is serious lack of required modern technology for communication and monitoring in the system. The absence of modern technology is also one of the major issues faced by the Nigeria power transmission system. This has reduced the system to analogue stage where reliability is highly hindered.

(k) **Overloading of Transformer:** The Nigeria transmission transformers deployed are overloaded due to under rating or failure to upgrade the existing power transmission transformers during expansion of loads which resulted to load shedding in the system.

(l) **Ferrant Effect:** This effect is cause as a result of longer or medium transmission line. The Long lines have considerable capacitance and hence

draws leading current from the generating sending-end when unloaded. This make the receiving – end voltage experience under no-load condition which is found to be greater than the sending – end voltage. The use of reactor is one possible solution to this ugly occurrence [8].

(m) **Corona Effect:** This is another technical issue facing the transmission system and is caused by local ionization of the air around the conductors of high voltage lines. In order to minimize corona, we must reduce the electric field (V/M) around the conductors, either by increasing their diameter or by arranging them in set of two, three or more bundled conductors per phase. This effect has hampered the efficient performance of the power transmission system as well [8].

2. NON- TECHNICAL ISSUES

The impact of non-technical issue on transmission lines has far negative effects as well. They increase both the cost of production of energy as well as delivery cost as earlier mentioned. Therefore, more cost for energy production due to non-technical issue in the transmission system. The major non-technical issues are highlighted as follows:

(a) **Vandalisation:** This is a societal problem that has been increasing the cost of transmission of electric power by billions of naira [8]. It is man - made and can only be reversed by the people who engaged in it. The items like tower member, bolts and nuts, sky wire, counter pose wire, conductors, lightning arrestors, spindles and insulators are not spared by the vandals. According to the oxford advance learners Dictionary, vandalisation is defined as “willful destruction or damage of public property.” Vandals according to the same dictionary are “persons who willfully destroy or damage works of art, public and private property, beauties of nature,” including electric utility installation and facilities [8]. Vandalisation of utility facilities is a crime worse than arm robbery [8]. The arm robbers target individuals while the vandals of electric transmission lines are on the entire nation. Another reason why we are convinced that vandalisation is worse than arm robbery is that most hospitals rely heavily on the power transmission for babies at birth, and to operate their medical equipment. Imagine that such hospitals are treating various patients, ranging from delivery of babies to various kinds of surgical operations, when these vandals strike most of the hospitals will come out with their patients dead [8].

(b) **Loss of Man-Hour:** The loss of man-hour resulted because the man-hour that would have been used in improving the transmission system is now be directed towards restoring the vandalized power transmission equipment or facilities [8].

(c) **Loss of Revenue:** This is one issue faced by the power transmission system as a result of technical and non-technical issue. The high losses in the power transmission line, if translated to money, high revenue is being wasted and the vandalized transmission facilities in the power transmission system lead to black - out in some part of the Nation [8]. As long the electric power transmission is non functional, there will be no revenue for the power transmission company. Any vandalized power transmission facilities is thrown out of operation. Thus, no revenue will be generated from the affected power transmission session of the Nation.

(d) **Loss of Funds:** Each time vandals strike on electric power transmission line facilities, additional fund is wasted on restoring such transmission installations. The wasted funds in some cases would have been channeled to other project such as transmission system improvement, reinforcement, and rehabilitation of broken poles and conductors [8].

(e) **Lack of Funds:** The transmission system of Nigeria before now is solely funded by the federal government of Nigeria with little or no assistance from anyone else, as it were before the unbundling of the power sector. Therefore, because there is inadequate funding from the sole source (Federal government of Nigeria), the power transmission company are unable to extend their services to some rural and urban sections of this country which has hindered the industrialization of this Nation as it where today, hence, the on-going building of transmission line such as [7]:

- i. 986.5km of 33kV lines under construction
- ii. 705.3km of 132kV line under construction

III. CURRENT STATE OF NIGERIA TRANSMISSION NETWORK INFRASTRUCTURE

The current state of transmission infrastructure can be itemized as follows [7]:

- i. Transmission capacity less than 6000MW
- ii. High non-technical loss
- iii. Low infrastructure coverage less than 40% of the country.

- iv. Low per capita of generation is less than 25W

The existing transmission infrastructure of Nigeria transmission system can be highlighted in Table 1 as follows:

Table 1: Existing Transmission Network Infrastructure

S/N o.	Description of Parameters	Rating/Numbers of Equipment
1	Transformation Capacity of 330/132kV	7,044MVA
2	Transformation Capacity of 132/33kV	9,852MVA
3	Numbers of 330kV Substations	28
4	Numbers of 132kV Substations	119
5	Numbers of 330kV Circuits	60
6	Numbers of 132kV Circuits	153
7	330kV Transmission Line Length	5,528.8km
8	132kV Transmission Line Length	6,801.49km
9	Number of National Control Centre	1
10	Number of Supplementary National Control Centre	1
11	Numbers of Regional Control Centre	2

Source: Modified [4].

1. ONGOING TRANSMISSION INFRASTRUCTURE [7]:

- i. 986.5km of 330kV lines are under construction
- ii. 705.3km of 132kV lines under construction
- iii. 1,350MVA capacity of 330/132kV transformer are presently being installed in new substations
- iv. Over loaded transmission stations are constantly being reinforced with additional capacity.
- v. 3,000MVA capacity of 132/33kV transformers is currently being installed in new substations.

The National Integrated power project has also contributed to the development of the transmission system of Nigeria has been highlighted below [7]:

2. ONGOING NIPP PROJECT

- i. They has increase 330kV capacity by 5,590MVA
- ii. They has also increase 132kV capacity by 3,313MVA
- iii. They increase 330kV transmission line length by 2,194km.
- iv. They also increase the 132kV transmission line length by 809km
- v. They also increase the system by 10 new 330kV substations
- vi. 7 new 132kV substations.
- vii. The expansion/reinforcement of 32 existing 330kV and 132kV substations.

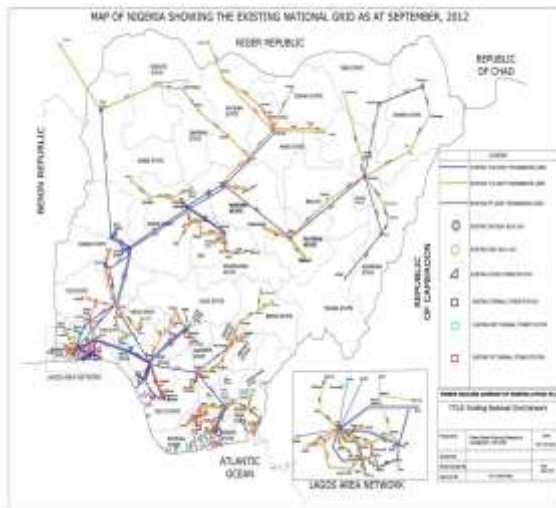


Figure 1: Map of Nigeria Showing Existing National Grid, 2012, Source: [4].

IV. NIGERIA RURAL ELECTRIFICATION SCHEME AND CHALLENGES

Rural electrification challenge is global, especially in the developing countries like ours. The problems of rural electrification in Nigeria is acute and peculiar because the country has not been able to provide adequate supply to the connected populace let alone the rural areas of the country, and also, it has not be able to extend its service of transmission of power to all nook and cranny of the connected area of the country. This is due to various challenges that the electricity transmission company of Nigeria face with rural communities and financial obstacles.

The Rural Electrification Agency (REA) was established by section 88(1) of the Electric Power

Sector Reform Act (EPSRA) 2005. Its mandate includes [5]:

- a) Promote Rural Electrification in Nigeria
- b) Co-ordinate Rural Electrification Programmers in Nigeria
- c) Administer the Rural Electrification Fund (REF) to promote , support and through public and private sector participation

Since the inception of Nigeria Rural Electrification Scheme in 1981, their primary objective has been to increase electricity access to rural areas or communities of the 36 states of the country. The strategy deploy then by the Nigeria Rural Electrification Scheme was to extend the Nigeria National Grid System (NNGS) to provide electricity to Local Government Headquarters. Meanwhile, this has resulted in greater access to electricity by Local Governments and fortunate consumers in the immediate vicinity, rural households have not seen much improvement in the availability of service [9]. In fact, today it is estimated that only about 20% of rural households have access to electricity as shown in Table 2, less than when the Nigeria Rural Electrification Scheme (NRES) commenced in 1981.

The growth in demand for electricity has outpaced supply and population growth, this has driven the rate of new household formation higher than the rate of new connections. Consequently, rural households still rely on fuel-wood, candle and expensive, unhealthy and unsustainable sources of energy to light - up their environment as shown in Table 2 below [5].

Table 2: Type of Main Lighting Fuel by Regular Households in Percentage

Areas	Total Firewood Used	Grass	Kerosene	Electricity	Gas	Battery	Candles	Other Means
Urban	4.1	0.4	32.8	57.2	0.2	3.6	0.4	1.2
Rural	13.1	0.7	41.3	20.0	0.1	19.6	0.9	4.2
NGA	9.6	0.6	38.0	34.7	0.1	13.3	0.7	3.0

Source: Modified [4].

The bar chart clearly show the rate at which the rural areas and households in Nigeria still rely heavily on other means to light up their environment despite the Nigeria Rural Electrification Scheme established since 1981. The rate of consumption of fuel- wood, candle, battery,

electricity and other means of energy by rural households in Nigeria is still on the high side till now despite the establishment RES. The graph below show the rate of consumption of other means of lighting up rural houses in Nigeria, figure 2 show four means in rural, urban and NGA. While, figure 3 show eight means of lighting rural and urban houses in Nigeria.

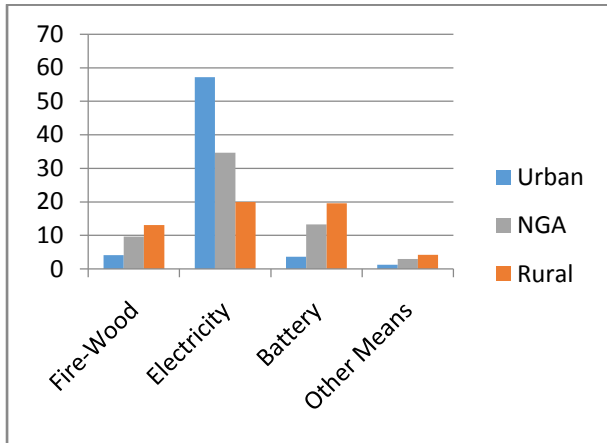


Figure 2: Means of Lighting up Rural Households in Nigeria.

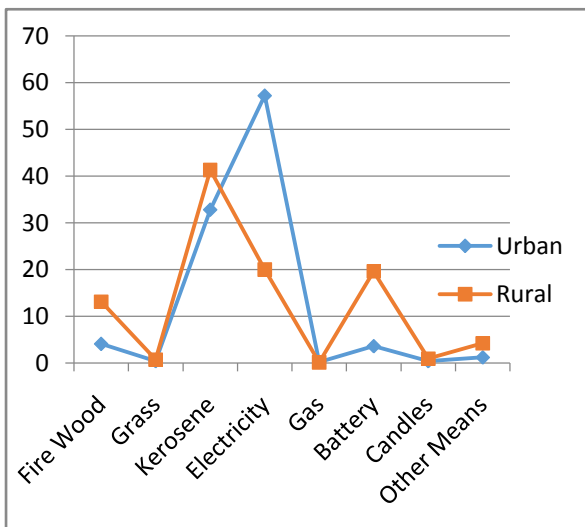


Figure 3: Means of Lighting up Urban and Rural Households in Nigeria.

Figure 3 above clearly shown why the migration from the rural to urban area in Nigeria is very high today. It also shown that urban area consumption of gas and electricity is higher as a means of lighting up houses in Nigeria with about 0.2% and 57.2% respectively, while the rural areas has high consumption in firewood, grass, kerosene, battery, candle and other means ranging 13.1%, 0.7%, 41.3%, 19.6%, 0.9% and 4.2% respectively. With the above comparative analysis it is shown that the rural areas consume high

polluted means of lighting houses in Nigeria. This is as a result of the rural electrification scheme failure to meet the demand for electricity to the rural consumers in Nigeria and also the weakness of the Nigeria National Grid System to extend power supply to the rural areas of Nigeria especially Niger Delta Region. The Table 3 and Figure 4 below shown the rate of rural electrification in different zone of Nigeria.

Table 3: Percentage of Electricity Supply in Different Zone of Nigeria, 2010 Source: Modified [4].

Regions	PHCN	Rural Electrification	Private Generator	PHCN/Generator	Rural Electricity/Generator
North-Central	81.9	1.8	1.0	14.9	0.0
North-East	82.3	9.8	1.6	5.9	0.5
North-West	94.8	2.3	0.9	2.1	0.0
South-East	90.8	2.8	0.9	3.5	0.4
South-South	79.3	8.8	1.7	8.3	1.9
South-West	83.9	0.3	5.2	10.5	0.1

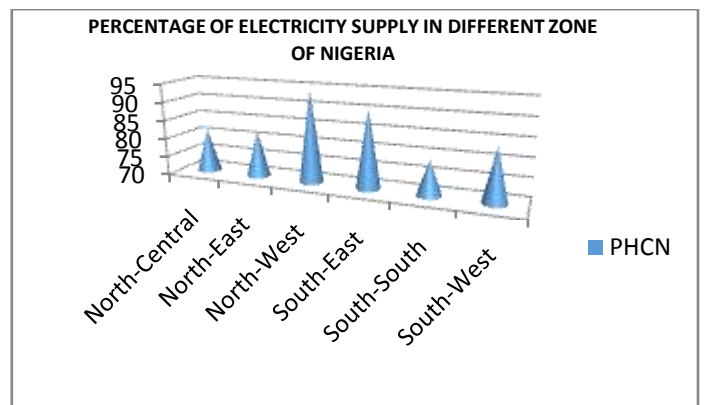


Figure 4: Percentage of Electricity Supply in Different Zone of Nigeria.

The Figure 4 above clearly shown the percentage of electricity supply by the then Power Holding Company of Nigeria (PHCN). From the bar chart, South-South have the lowest electricity supply of about 79.3% followed by North-Central, North-East, South-West of 81.9%, 82.3% and 83.9% respectively. The South-East and North-West have

the highest electricity supply by the then PHCN of about 90.8% and 94.8% respectively. The lower electricity supply in the South-South is due to the following factors itemized below.

The percentage of rural electrification in different zone of Nigeria can be clearly display in Pie chart as shown below.

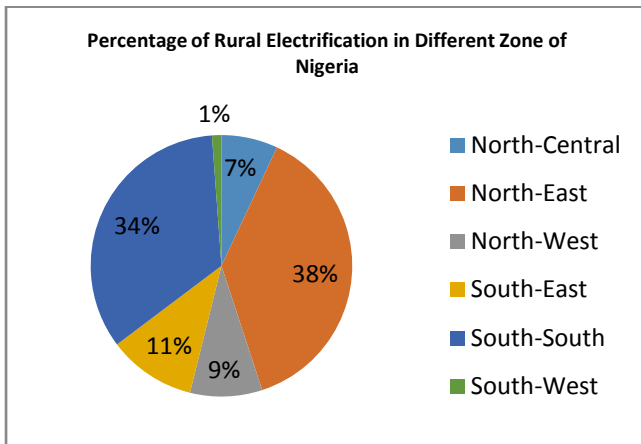


Figure 5: Rural Electrification in Different Zone of Nigeria

The Pie Chart clearly shown that the South-East zone has the highest percentage of rural electrification of 38%, follow by the South-South zone of 34%, South-East of 11%, North-West of 9%, North-Central of 7% and South-west of 1% in Nigeria Rural Electrification Scheme.

The Rural Electrification Scheme is aimed at promoting the welfare of the rural communities and also to improve the economic status of the people in the rural areas [10]. In addition, the rural electrification also helps for industrialization of the rural areas and thereby leading to the development of the country and civilization of her citizens. The challenges of the rural electrification scheme in Nigeria today are enormous, ranging from technical, non-technical to political challenges. Some of the common challenges faced by the Rural Electrification Scheme in Nigeria are highlighted below as follows:

a. **Topography of the Niger Delta Region:**

The geographical position of the Niger Delta Region has posed various challenges to rural electrification transmission which is due to the swamping nature of the region. The region is bound by rivers, estuaries, creeks, and stagnant swamps etc., that pose problems to rural electrification in terms of settlements accessibility of roads, good available means of transport etc. [10]. The climatic conditions and the flooding nature of the region are

major factors militating against the rapid growth of rural electrification of Nigeria. The lack of industrial customers, low load forecast, the terrain and swamping nature has necessitated a very long distance from the grid with huge cost of installation, maintenance and operation. These are the key factors that hamper the rural electrification transmission.

b. **Inadequate Funding:** The rural electrification scheme has been poorly funded by the federal government of Nigeria. This because the federal government is the solely organ that fund the system before the unbundling of the power sector with little or no-assistance from non-governmental bodies. The monopoly of the power sector by the defunct NEPA and provision of funds by government alone did not help the drive for rural electrification [4]. This has actually hindered the rural electrification scheme in Nigeria

c. **Militancy:** The militancy that exist in the rural areas of Nigeria has pose allot of challenges to the growth of rural electrification in Nigeria, like the Niger Delta Militants which called themselves freedom fighters started many years ago with the Niger Delta agitation for a fairer distribution of oil revenue. The activities of this groups which later turn to political and selfish gain with unrest in the Niger Delta Region which make many industries to closed down and relocate. This unrest has cause high hindrance to the rural electrification scheme in Nigeria.

d. **Policy Somersault:** The Nigeria power sector has suffers from policy somersault because of one administration after another identifies the sector as key to economic growth and development of the nation but in trying to address this, they will continue with entirely new policies instead of them continuing with that of the previous administration [6]. This failure of policy continuity has posed a lot of hindrance to the rural electrification growth and development.

e. **Poor Technical Staff:** The rural electrification scheme of Nigeria has faced a lot of poor technical staff in terms of recruitment, capacity building and training program. Most of the staff are not properly trained and the training program set up by the federal government is frowned by situation in the power sector industries. Staff are selected on the basis of “who you know” and connections with the man at the hem of affairs.

This situation has necessitated poor performance of the staff and the growth of the rural electrification. This has also caused low staff morale and lack of regular training.

f. **Data Inadequacy:** There is no adequate data for correct estimation of the rural customers for planning. This greatly accounts for the uneven allocation and distribution of rural electrification system to the rural region [6]. This has actually affected the decision making of the rural electrification scheme to maximize their efficiency and output.

g. **Political Issues:** Due to the dynamic nature and geopolitical division of Nigeria, government of the day tends to favour his or her geopolitical zone with policies and funds distribution. This has led to constant policing changing in the system with uneven distribution of resources. The rural electrification schemes face these policies changing constantly which hindered the rural electrification process in Nigeria.

h. **Corruption:** The level of corruption in the Nigeria governmental system has pose serious challenge to the success of government on power project in the rural communities of Nigeria. In other words the Rural Electrification Scheme of Nigeria has serious drawback due to high level of corruption on the government official. Most projects are awarded close to election period just to get votes of Nigerians or for the purpose of electioneering campaign during election. According to Elusakin, et al., [11], say that the 2006/2007 rural electrification project corruption saga is still fresh where about 1,946 projects were neglected.

The Nigeria transmission network issues and Rural Electrification Scheme challenges can be summarized as follows [7]:

- i. Radial lines with no redundancies
- ii. Obsolete substation equipment
- iii. Overloaded transmission lines and substations
- iv. Inadequate coverage of infrastructure
- v. Limited funds for developments projects
- vi. High technical and non-technical losses
- vii. Limited training opportunity
- viii. Community issue during project execution
- ix. Swamping nature of most rural areas
- x. Inadequate maintenance procedure for infrastructure

- xi. Political issues
- xii. Corruption
- xiii. Militancy
- xiv. Boko Haram

V. THE WAY FORWARD

- **Expansion of the Existing Network:** The current transmission network cannot evacuate total power that would be generated if all the NIPPs and IPPs project fully come on stream. Therefore, there is need to expand the present transmission network to meet these challenges.
- **Introduction of more Loops:** The radial, fragile and long transmission lines must be re-structured to introduce more rings or meshes into the network.
- **Grid Extension:** Extension of the Nigeria National Grid System to serve additional rural communities in the 36 states of the federation will be one of the best options to solve the rural electrification challenges in Nigeria. The extension should be done with consultation with the Nigeria Transmission Company and Distribution Companies of Nigeria [7].
- **Reduction of Power Losses:** The enormous power losses associated with the transmission network must be vigorously tackled. Deploying FACTS and other compensating devices instead of the present sluggish and mechanically controlled devices on the transmission network would go a long way in addressing this problem as highlighted in this paper.
- **Provision of Mini-Grid Systems:** In the remote areas of the rural communities where the national grid cannot be extend to; the mini-grid system will be effective and efficient option to electrify the rural communities. The Nigeria government should adopt the mini-grid system to reach the rural communities with difficult terrain.
- **Contingency Analysis Study:** The power sector operators must also take into cognizance the unstable nature of the network and conduct Contingency analysis study to strengthen the network to withstand contingencies and improve transmission capability thus minimizing outages.
- **Upgrading of Transformers:** Overloading transformers should be upgraded especially during expansion of load.
- **Renewable Energy:** With the presence of renewable energy sources such as wind, biomass, and solar, the Nigeria government should embark on off-grid electrification project and this could

solve the problems of rural electrification challenges if properly harnessed.

VI. CONCLUSION

It is important that the power Transmission Company of Nigeria addresses the current problems in the management and operation of transmission system. Since the major issues itemized above are now widely understood, the power transmission company should move beyond conflicts over power reform and address the current transmission issues facing the Nigeria power sector today. There is need to continue making steady progress and through collaboration process in resolving the more pressing and serious issues affecting the efficiency and growth of the transmission network as quick as possible. A body should be set-up that monitors the progress of the transmission company so that we can achieve better characteristics of a well functioning power transmission network. The Nigeria transmission network is very weak due to ageing network and few routes available to evacuate power generated. Hence, upgrading the network and the training of staff with current technology is a veritable tool to the development of the transmission network in Nigeria today.

The low population density, low consumption and difficult terrain are causes of the challenges of rural electrification scheme in Nigeria today [10]. Therefore, the rural region of Nigeria suffers for electricity or power supply from the power sector in Nigeria. Consequently, no small or medium scale industries are attracted to the rural areas, which is the cause of urban migration in Nigeria today. The provision of electricity in the rural areas should be encouraged by all government administrations and communities' leader. The lengthy distance of the transmission network result to greater electricity losses that require more expensive customer support

and equipment maintenance, but the rural customers are poor with very low income. It could be seen that even if a tariff system is introduced, the rural electrification scheme will need a highly subsidized government support or some agency to properly deliver the required services. Hence, the rural electrification is not attractive and cannot attract competitors. Due to the terrain, and the challenges of transporting power to the rural areas [10], if off-grid services based is properly studied and implemented in these areas, it will increase and improve the availability of electricity to the rural areas of Nigeria with extremely bad topography.

REFERENCES

- [1] **D. R. Patrick and S. W. Fardo**, " *Electrical Distribution Systems*," *Second Edition*, The Fairmont Press, Inc., 2009, Pg. 1
- [2] **Niger Power Review**: *Development of the Electricity Industry in Nigeria (1960 – 1985)*, 1985 Pg. 1 – 6.
- [3] **O. I. Okoro and E. Chikuni**, " *Power Sector Reforms in Nigeria: Opportunities and Challenges*," *Journal of Energy in Southern Africa*, Vol.18, No. 3, August 2007, Pg. 52 -53.
- [4] **S.M. Ohiare**, " *Financing Rural Energy Projects in Developing Countries: A Case Study of Nigeria*," *PhD Thesis*, July, 2014. Pg. 29, 46
- [5] Rural Electrification Agency, " *New National Rural Electrification Implementation Strategy and Plan*," August, 2014
- [6] **U.P. Onochie, H.O. Egware and T.O. Eyakwanor**, " *The Nigeria Electric Power sector (opportunities and challenges)*," *Journal of Multidisciplinary Engineering science and Technology (JMEST)*, Vol: 2, Issue 4, April 2015.
- [7] **H.S. Labo**, " *Current Status and Future outlook of the Transmission Network*," *Investors' Forum for the privatization of PHCN Successor Companies*, 18 -19 January, 2010.
- [8] **J.C. Ekeh**, " *Electric Power principles*" *Amfitop Books a subsidiary of Amfitop Nigeria limited*, first edition, 2003, Pg. 213 – 223.
- [9] **M.C. Anumaka**, " *Analysis of Technical losses in Electrical Power System (Nigerian 330KV Network as a case study)*," *International Journal of Research and Review in applied Science* Vol. 12, Issue 2, 2012. pg. 320.
- [10] **J.T. Afa**, " *Problem of Rural Electrification in Bayelsa State*," *American Journal of scientific and Industrial Research*, 2013, 412: 214.
- [11] **J.E. Elusaki, O. O. Ajide and J.C. Diji**, " *Challenges of Sustaining off-grid Power Generation in Nigeria rural communities*," *African Journal of Engineering Research*," Vol. 2(2), Pg.55 , July, 2014.