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Electric Power Transmission Upgrade in Nigeria: The Present Status

Tebepah, E. A.[1], Amadi, H.N.[2], Igbogidi, O.N.[3]
[1,2,3]*Department of Electrical and Electronics Engineering,*
Rivers State University, Port-Harcourt, Nigeria.

ABSTRACT
Nigeria's electric power transmission system faces challenges, including outdated infrastructure, heavy reliance on fossil fuels, and environmental concerns. These issues lead to frequent power outages, unequal access to electricity, and technical limitations, highlighting the need for significant upgrades and policy reforms. This study seeks to examine the electric power transmission upgrade in Nigeria including its present status. The method employed in this study is a comprehensive review of past studies, scholarly articles, government reports, and documented data related to electric power transmission in Nigeria. The methodology involves a critical analysis of the historical progression, current infrastructure, and the factors contributing to the energy crisis. The study considers environmental aspects, technology utilization, and their implications for power transmission. Findings from this study reveal a persistent gap in Nigeria's electricity sector, with increasing capacity falling short of demand. Operational challenges, vandalism, and ageing infrastructure limit actual capacity. Transmission and distribution issues, including poor funding and high losses, impede efficient electricity delivery. Overloading strains the 330kV grid. The historical evolution traces the sector's growth and recent reforms. Upgrade initiatives, from refurbishment to a proposed 750kV super grid and renewable energy integration, aim to address multifaceted challenges in the sector.

KEYWORDS: *Nigeria, electric power transmission, energy infrastructure, power outages, upgrades, policy reforms, energy crisis.*

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I. INTRODUCTION

Nigeria has frequently been challenged by issues involving the transmission of electricity. As arguably the most populated nation in the continent of Africa, Nigeria faces difficulties caused by both its rapidly expanding industrial sector and its ever-growing population, which put a constant strain on the nation's electrical infrastructure (Aliyu & Amadu, 2017). Any nation's ability to grow socioeconomically quickly and sustainably depends on having access to quality infrastructure services, particularly electricity (Amadi, 2015). Several serious problems exist with Nigeria's present electric power transmission infrastructure all of which lead to inefficiencies, frequent blackouts, and negative economic effects (Fabiyi *et al.*, 2016; Ayamolowo *et al.*, 2019). Over 200 collapses of Nigeria's national energy infrastructure have occurred in the last nine years, often resulting in protracted blackouts (Ekeng et al., 2024).

The challenges faced by the Nigerian Power Sector are multifaceted and deeply rooted, persisting over the years with underlying causes that demand comprehensive analysis. Inadequate funding stands out as a pervasive issue, consistently highlighted across studies (Remteng *et al.*, 2021). The primary cause of this financial constraint lies in the dependency on the Federal government as the sole source of funding. The centralised funding structure results in insufficient resources to support the necessary infrastructure upgrades, maintenance, and expansion projects, hindering the sector's overall development.

Outdated and deteriorating infrastructure in transmission substations is a recurring challenge, posing significant hurdles to efficient power transmission (Remteng *et al.*, 2021). The causes of this challenge are twofold: first, there is a historical lack of investment and attention to infrastructure maintenance. Second, the absence of a proactive strategy to modernise and upgrade ageing equipment contributes to the persistence of outdated infrastructure challenges. The failure to address these causes systematically has led to a continual decline in the overall health of the power infrastructure.

The strained relationship between the Federal Government and key stakeholders, including international oil companies and Independent Power Producers (IPP), emerges as another critical challenge (Remteng *et al.*, 2021). The causes of this issue can be traced to a lack of effective communication, collaboration, and shared vision between these entities. Poor coordination and alignment of interests hinder the development and implementation of coherent policies, impeding the sector's progress.

Metering challenges, such as the substantial metering gap identified in various studies, have their roots in a combination of technological and operational factors (Remteng *et al.*, 2021). The slow adoption of advanced metering technologies, coupled with insufficient infrastructure to support widespread metering, contributes to the existing gaps. Additionally, operational challenges, such as inadequate training for personnel responsible for metering, further exacerbate the issue. Vandalism of power infrastructure remains a prevalent challenge, with causes rooted in socio-economic factors and inadequate security measures. Economic hardships, coupled with a lack of surveillance and security on electrical infrastructure, create an environment conducive to vandalism. The absence of effective deterrents and preventive measures allows this problem to persist.

This research is important largely because it will give a thorough evaluation of Nigeria's electric power transmission infrastructure, providing essential information to stakeholders in the energy sector and policymakers. Sustainable energy regulations, resource allocation and technological prioritization may all be influenced by examining the historical development of power transmission. To increase capacity and dependability, the research will also guide for improving infrastructure and assisting government agencies, utilities and engineers in making well-informed decisions. Additionally, this study will advance our understanding of Nigeria's infrastructure, energy, and sustainable development. Finally, it is globally relevant, providing valuable insight for nations attempting to enhance their power transmission networks and confronting similar energy difficulties.

The main objective of this study is to investigate the current state of Nigeria's electric power transmission upgrade. Specifically, this work seeks to:

i. Provide a comprehensive review of the current status of electric power transmission in Nigeria, highlighting existing challenges and limitations in the transmission infrastructure.
ii. Analyze the historical evolution of electric power transmission in Nigeria, focusing on major developments, upgrades, and policy interventions that have shaped the present state of the transmission network.
iii. Assess the existing recent initiatives and investments aimed at upgrading the electric power transmission system in Nigeria and improving its capacity, efficiency and reliability.

1.1. THE TRANSMISSION FACILITIES IN NIGERIA

The transmission networks in Nigeria consist of two types of lines: 132kV and 330kV. The 132kV lines comprise the nation's local networks, while the 330kV lines comprise the nation's trunk system. The Niger Delta, which produces gas and oil in the southern part of the nation, is home to 70% of all producing facilities. The country's north, however, lacks any electricity sources at all. Extreme voltage dips occur in the central and northern regions as a result of the lengthy distances required for electricity transmission from the south to the north. The transmission lines that connect the Niger Delta in the south to Lagos, the greatest demand centre, are the main electricity arteries. Figure 1. shows the structure of the Nigerian transmission system.

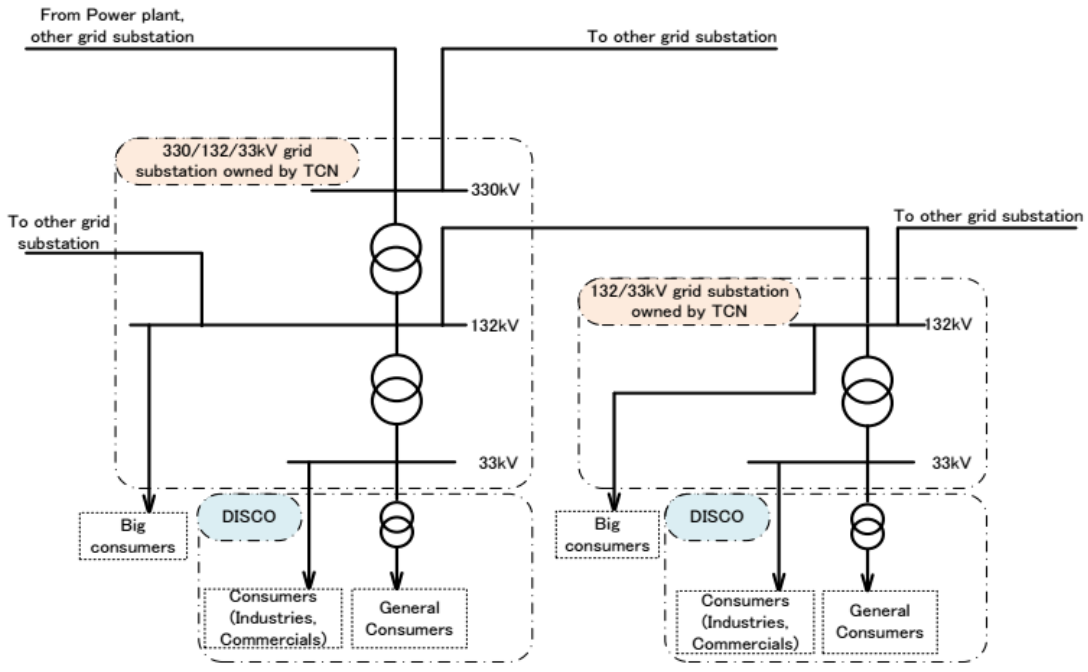

Figure 1. Structure of Transmission System (Japan International Cooperation Agency, 2020)

But at the moment, these transmission links are constrained, making it impossible to fully utilise the production capacity in the south. Furthermore, the way Nigeria's power systems are set up, transmission lines radiate out from the main power plants and substations, reducing the number of diversion routes available in case of equipment failure and lowering system dependability. Furthermore, as was already noted, a significant rise in generating equipment capacity is anticipated in the upcoming years. It is imperative to fortify the transmission infrastructure as the producing capacity is outpacing the transmission capacity. This is one of the key improvements needed for Nigeria's power system to become a single, highly dependable, and efficient power supply system.

II. METHOD

The method employed in this study is a comprehensive review of past studies, scholarly articles, government reports, and documented data related to electric power transmission in Nigeria. The methodology involves a critical analysis of the historical progression, current infrastructure, and the factors contributing to the energy crisis. The study considers environmental aspects, technology utilization, and their implications for power transmission.

A thematic synthesis approach is utilized for this study. Recurring themes, patterns, and trends across the literature, similarities and differences are noted from the findings of existing literature.

III. RESULTS AND DISCUSSION

3.1 The Current State of Electric Power Transmission in Nigeria

There is a present electricity crisis affecting both urban and rural regions in Nigeria due to a variety of problems associated with the transmission of electric power. The primary transmission network (Nigeria's 330kV) is made up of ten generating stations (plants) as shown in Figure 2. First and foremost, only 40% of Nigerians are linked to the national grid, and even those who are linked frequently experience power outages, this highlights the country's severe electricity issue (Aliyu, Dada, & Adam, 2015). The electrical grid is primarily dependent on massive hydropower plants and finite hydrocarbon supplies, which increases carbon emissions and makes it more susceptible to changes in the price of oil and political unrest.

Petroleum accounts for more than 80% of the nation's primary energy use, according to Akorede *et al.* (2017). The depletion of limited petroleum resources and adverse environmental effects are two major problems raised by this strong reliance on petroleum for local use. The environment of the entire country suffers as a result of the excessive usage of fossil fuels for energy production. Furthermore, access to power is particularly difficult in rural areas, which compounds the differences between urban and rural areas (Uzoma et al., 2021).

Nigeria, on the other hand, has an abundance of fossil and renewable energy resources. Data gathered from several sources indicate that the nation has significant energy reserves. Nigeria possesses substantial deposits of natural gas, coal, crude oil, and renewable energy sources including biomass, solar, wind, and hydropower. Nigeria is endowed with, for example, over 187 Trillion Standard Cubic Feet (SCF) of natural gas, 36.22 Billion barrels of crude oil, and 2.374 Billion tonnes of coal and lignite. In addition, the country also had 3,500 MW of undeveloped small hydropower and 11,250 MW of undeveloped big hydropower assets. Nigeria boasts vast agricultural and wooded areas, as well as the ability to produce biogas from animal waste (Akorede *et al.*, 2017).

Nigeria is faced with a continuing energy crisis despite having an abundance of energy resources since its supply cannot keep up with the increasing demand. Home activities are the main source of the nation's energy consumption; cooking accounts for around 91% of household energy consumption, with lighting coming in second at 6% and using electrical appliances at 3%. An analysis by the Central Bank of Nigeria (CBN) shows how strongly these processes depend on fossil fuels, with petroleum accounting for more than 80% of the commercial primary energy used. Akorede *et al.* (2017) highlighted the inconsistency by pointing out that a significant proportion of Nigeria's population roughly 58% does not have access to power, which is mostly produced by the nation's enormous petroleum resources. Moreover, Nigeria is among of the lowest per capita energy consumption rates in the world, which is indicative of the low levels of energy production and consumption in the nation and its strong correlation with pervasive poverty. Given the strong association between energy consumption and economic growth, Nigeria's relatively low per capita power consumption poses a serious obstacle to both economic progress and general well-being (Akorede *et al.*, 2017).

Nigeria is home to multiple hydroelectric power facilities, making it one of the most important sources of renewable energy in the nation. These include the 1,900 MW total installed capacity of Kainji, Jebba, and Shiroro power plants. However, these plants operate below their installed capacity due to a lack of proper maintenance and seasonal fluctuations in water levels in the hydropower reservoirs, leading to a reduction in power output (Olatomiwa *et al.,* 2015; Uzoma *et al.,* 2021). Despite this, Nigeria possesses a large amount of unrealized hydropower potential in several areas, with a capacity of around 12,190 MW. Diversifying energy sources and using new technology are two strategies being used to overcome this challenge. Sustainable

development depends on the availability of decentralised, dependable, and efficient energy sources that accurately reflect the true economic cost of energy products. Small hydropower station construction is an opportunity to support rural electrification initiatives. To expand the Zungeru power plant and produce around 700 MW of energy, the Federal Government of Nigeria recently signed a major deal with a Chinese business (Akorede *et al.*, 2017). Although Nigeria has abundant renewable energy resources, such as biomass, solar, wind, and hydropower, these resources are still underutilised. One important way to address the present electricity issue is to fully use renewable energy sources.

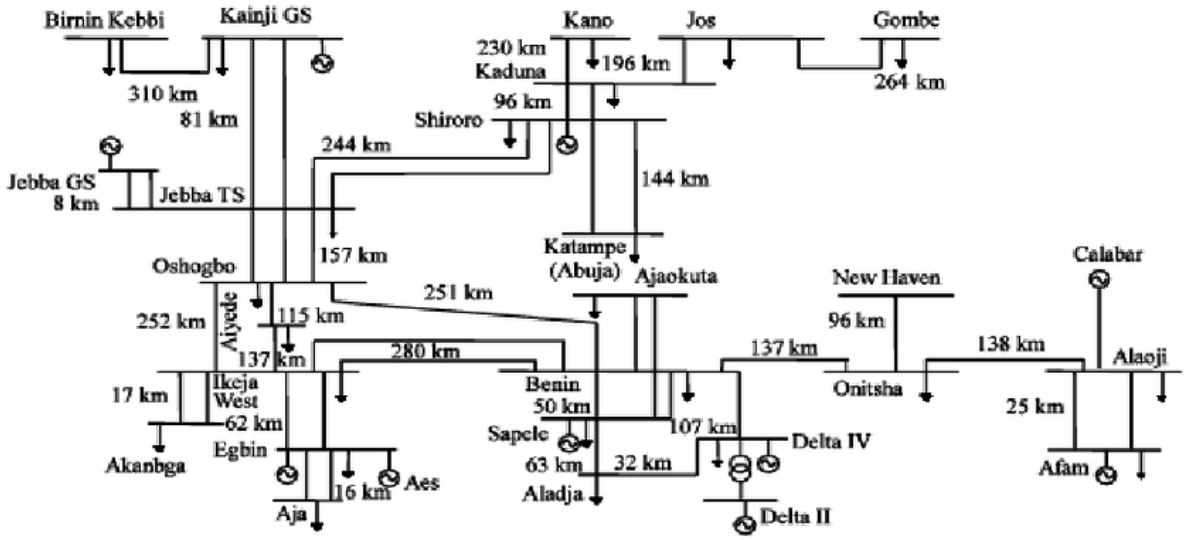

Figure 2: One Line Diagram of the Nigeria 330kV Transmission Grid (Okakwu & Ogujor, 2017)

3.2 Current Status of the Upgrade

The study highlights various strategies and plans to enhance electric power transmission in Nigeria. Oleka *et al.* (2016) emphasize strategies such as installing new transmission lines, reconductoring, converting to double circuits, voltage upgrades, reactive power compensation, and phase shifting. Other studies, including Addeh (2022), mention the need to expand and modernize the transmission infrastructure as seen in Figure 3. Figure 3 is the proposed upgrade of the 330kV network to 750kV with possible integration of distributed generation.

The Nigeria Transmission Expansion Project Phase 1 (NTEP 1) is a notable plan outlined in Study Nine. This project, a component of the Transmission Rehabilitation and Expansion Programme (TREP), focuses on rehabilitating and upgrading transmission substations and lines to increase the power transmission network. Furthermore, initiatives by Siemens, as part of the Presidential Power Initiative (PPI), and ongoing projects by the Transmission Company of Nigeria (TCN) (Ugbodaga, 2021; African Energy Portal, 2021) signify a commitment to large-scale upgrades.

Despite these plans, the current state reflects a mix of progress and challenges. The Federal Government's initiation of a new electricity substation construction project is a step toward increasing capacity (Addeh, 2022). TCN, with World Bank support, is actively involved in projects like NETAP, aiming to improve the national grid's efficiency (Jeremiah, 2021).

The Nigeria Transmission Expansion Project Phase 1 (NTEP 1), as part of TREP, aims to enhance grid wheeling capacity, and a loan of USD 210 million from the African Development Bank supports this project (Study Nine). Siemens has committed to upgrading transmission substations as part of the PPI (Ugbodaga, 2021).

However, the transition from plans to implementation is challenged by factors such as bureaucratic delays, funding issues, and technical complexities. While there are initiatives, the scale and speed of execution may not fully meet the growing demand and urgency outlined in the studies.

Challenges in implementing these strategies include financial constraints, infrastructural deficits, and an inefficient market structure (Onyekwena *et al.*, 2017). Additionally, the undiversified energy source base poses a challenge to electrification efforts in Nigeria.

Jeremiah (2022) highlights challenges in Lagos, where despite alternative power supply initiatives, a significant percentage of households remain off-grid. The overall power sector struggles with an insufficient capacity of 13,000 Megawatts, emphasizing the limitations in meeting the demand.

Infrastructure projects approved by the Federal Executive Council, such as the transmission substation in Adamawa, face challenges like vandalization of power lines (Premium Times, 2022). However, the proposed transmission grid for upgrading the existing 330kV network is shown in Figure 3.

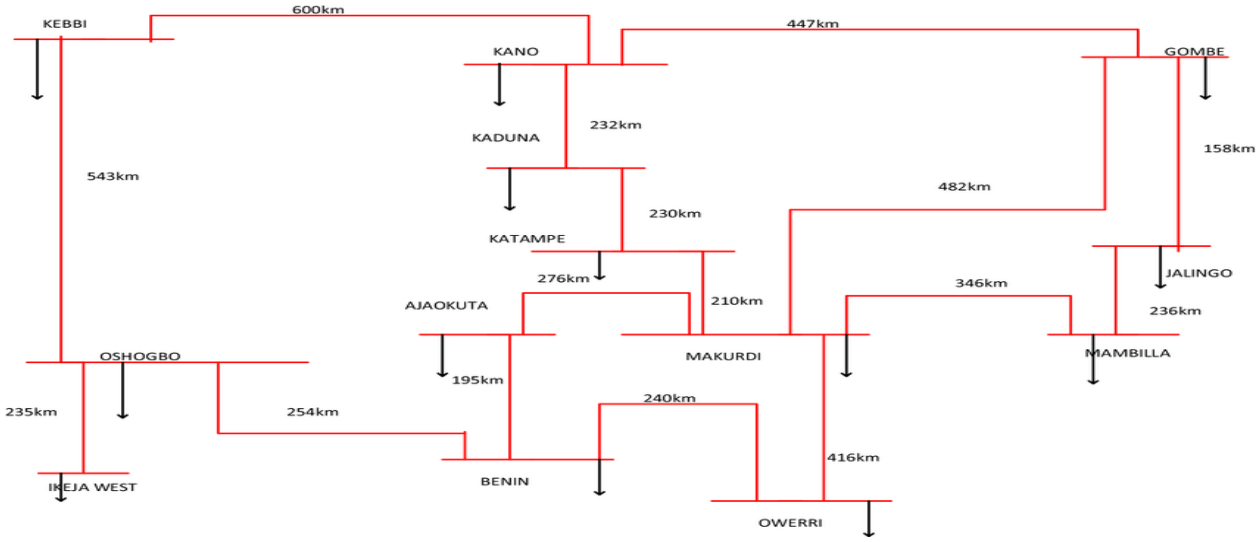

Figure 3: Single Line Diagram of the Proposed Upgraded 750kV Nigerian Transmission Grid (Abdulkareem *et al*., 2021)

IV. CONCLUSION

This review of Nigeria's current power status reveals a substantial gap between the installed capacity and the actual power available for consumption. Despite a consistent increase in electrical power generation, challenges such as operational constraints, vandalism, and ageing infrastructure significantly limit the effective capacity to meet demand. Despite significant turning points like privatisation and foreign partnerships, major developments are still lacking, highlighting Nigeria's complex path towards a more dependable and effective electric power transmission system. The transmission system faces hurdles like poor funding, inadequate coverage, outdated technologies, and regular vandalisation, contributing to inefficiencies in power delivery. Additionally, the distribution sector grapples with high losses, both commercial and technical, resulting in only a quarter of generated electricity reaching end-users.

The upgrade of the Nigeria Power Transmission System is an ongoing exercise with various initiatives aimed at increasing transmission capacity, including the completion of the National Mass Metering Program's first phase and the implementation of the Metre Assets Provider regulations to finance metre deployment and enhance transmission capacity. Furthermore, the government of Nigeria is funding several initiatives to increase generation using hydrostatic power plants, including those at Mambilla, Zungeru, Gurara, Lokoja, Makurdi, and other locations. New transformers have been installed at substations as part of recent improvements to improve bulk power availability for distribution firms. Two examples of these transformers are the 150MVA transformer at the New Haven Substation in Enugu and the 60MVA transformer at the Ojo Transmission Substation. The objective of these enhancements is to augment the dependability and capability of Nigeria's electricity transmission infrastructure [The International Trade Administration, U.S. Department of Commerce (2023)][Kemp (2023)][The Punch Newspapers (2024)].

The implementation of upgrade strategies, such as installing new transmission lines, voltage upgrades, and reactive power compensation (Oleka *et al.*, 2016), contributes to enhanced grid capacity and reliability. Upgrading transmission lines and infrastructure projects, as outlined in ongoing efforts by TCN and Siemens, aims to address bottlenecks and improve overall grid efficiency (Addeh, 2022; Jeremiah, 2021; Ugbodaga, 2023; Premium Times, 2022). The introduction of alternative power generation options, such as embedded generation (EG), presents cost-effective solutions. EG, involving onsite power production close to the point of use, is suggested to save up to 30% of the cost of delivered electricity by avoiding transmission and distribution costs. This introduces financial benefits for both consumers and the power sector.

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