

The Rigerian Society of Engineers

POSITION PAPER ON NATIONAL POWER SUPPLY

PRESENTED BY THE NSE NATIONAL POWER SUPPLY COMMITTEE

JANUARY 2021

EXECUTIVE SUMMARY

The role of power supply to the development of any nation cannot be over-emphasized as it is the bedrock for the country's overall development. The Nigerian Electricity Supply Industry has been going through some challenges for the past few decades now with current installed generation capacity of about 13,000 MW but only about 7,500 MW can be generated mainly due to various problems with the entire value chain ranging from inadequate supply of gas to the gas power plants, which constitute more than 75% of the existing power plants in the country, to revenue collections from end users. The power currently being distributed to consumers is only about 5,000 MW due to the existing limitations in the transmission and distribution infrastructure. Significant expansion of the generation and distribution systems in the country has not been realised despite the privatisation of the government-owned six generation and eleven distribution entities.

The "Power Committee" of the Nigerian Society of Engineers (herein referred to as the NSE) identified that there is the need to expand the energy mix for electricity generation from the current two sources of gas and hydro to other sources including coal, nuclear, solar, wind and biomass/biofuels so that the enhanced level of security of electricity supply can attract large number of investors into the industry. Only about 20% of the licences granted for the various power infrastructure have been developed essentially due to the lack of interest from investors and non-funding by the financial institutions who have consistently turned business plans down due to the current unattractive electricity tariffs.

It should be noted that the problem of epileptic power supply to industries and multinational corporations has resulted in the departure of many businesses out of Nigeria to neighbouring countries like Ghana, where power is more stable. The Nigerian Society of Engineers is now calling for the much-needed policies that will reposition the Nigeria's energy sector into attracting national and international investments and support.

On the demand and supply side, the Power Committee of the Nigerian Society of Engineers noted that current electricity demand estimates including future projections is already substantial and is increasing rapidly due to population and socio-economic growths. It is clear from its study that Nigeria is one of the most underpowered countries in the world, with actual consumption being 80% below expectations based on current population and income levels. A comparative study by the committee showed that peer countries consume far more electricity per capita than Nigeria. Ghana, for instance, consumes about twice as much electricity as Nigeria; Tunisia over ten times while South African consumes almost thirty times as much electricity as Nigeria. It should be noted that what is currently being supplied nationally for consumption of not more than 5,000MW is far below the actual demand that is around 28,300MW as at the end of 2020.

The Committee also reviewed power supply models of some developed and developing countries and noted that the main challenge for security of supply is not the availability of needed capacity as such, but the availability of flexibility that is needed to support the system and provide for a constant balance between supply and demand, in other words, the ability and capacity to generate enough electricity to meet demand, and, the ability and capacity to wheel the generated electricity to points of use.

The Power Committee of the NSE also reviewed the Siemens "Nigerian Electrification Roadmap", herein referred to as the "NER" document and commended the effort of the Federal Government in taking this positive step of partnering with Siemens in addressing the bottlenecks within the Nigerian Electricity Supply Industry. This Committee has examined the NER document and presented it thoughts as part of this position paper.

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1. INTRODUCTION

The Nigerian Electricity Supply Industry (NESI) has been under a series of challenges for the past three decades with complex and multi-faceted issues. Despite the unbundling of the sector in 2005 and its subsequent privatisation of in 2013, the problems never seem to be getting any better. Power is a strategic infrastructure and represents the most important requirement for moving the economy forward.

Due to the disturbing challenges in the power sector, the Nigerian Society of Engineers Presidential Adhoc Committee on National Power Supply was inaugurated by the President of the Society, Engr. Babagana Mohammed, FNSE, on 23rd July 2020. The main objective was to prepare a position paper on the Nigerian Electricity Supply Chain, with a view to identifying the issues and challenges within the sector and proffering solutions that will be adequate to address them.

The Committee inaugurated had the following composition:

1)	Engr. Prof. Abubakar S. Sambo, FNSE, OON	-	Chairman
2)	Engr. John Ayodele, FNSE	-	Member
3)	Engr. Paulinus N. Ogu, FNSE	-	Member
4)	Engr. Tunji Ariyomo, FNSE	-	Member
5)	Engr. Charles Okafor, MNSE	-	Member
6)	Engr. Mike Ezugwu, MNSE	-	Member
7)	Engr. Ibrahim Hashim Bakori, MNSE	-	Member
8)	Engr. Ahmad Ibrahim Kaitafi, MNSE	-	Member
9)	Engr. Joseph D. John, MNSE	-	Member
10)	Engr. M. B. Nasir, MNSE	-	Member
11)	Engr. T. Shekarau, MNSE	-	Member
12)	Engr. Dr. I. Musa, MNSE	-	Member
13)	Mr. Oluwalade Adewale, ANSE	-	Secretary

1.1. Terms of Reference

The Terms of Reference (TOR) of the Committee were given as follows:

- a) To carry out a holistic assessment of the state of power generation, transmission and distribution in the Country.
- b) To determine the national power demand and the supply gap.
- c) To identify the constraints hindering adequate power generation, transmission and distribution.
- d) To examine power supply models in some selected countries with adequate power supply and recommend workable models to the country.

- e) To proffer solutions to the identified power supply problems and state the responsibilities of NSE
- f) To examine Siemen's document and provide comments and recommendations.

1.2. Sub-committees

As a result of the constraints imposed by the COVID-19 pandemic the Power Committee worked by holding virtual meetings. The Committee, at its meeting on 6th August 2020 created sub-committees and assigned responsibilities to members. These responsibilities were later reviewed during another meeting held on 30th September 2020, following an update on its terms of reference. The sub-committees are as follows:

A) Sub-Committee A

Members:

- Engr. Charles Okafor Coordinator
- Engr. John Ayodele
- Engr. Ibrahim Hashim Bakori,
- Engr. Mike Ezugwu
- Engr. Joseph D. John
- Engr. Prof. A. S. Sambo

Terms of Reference:

- i) Carry out a holistic assessment of the state of power generation, transmission and distribution in the country.
- ii) Identify the constraints hindering adequate power generation, transmission and distribution.
- iii) Proffer solutions to the identified power supply problems and state the responsibilities of NSE

B) Sub-Committee B

Members:

- Engr. Tunji Ariyomo *Coordinator*
- Engr. Dr Idris Musa
- Engr. Prof. A. S. Sambo

Terms of Reference:

i) To determine the national power demand and the supply gap

C) Sub-Committee C

Members:

- Engr M B Nasir Coordinator
- Engr Timothy Shekarau

Terms of Reference:

- i) To examine power supply models in some selected countries with adequate power supply and recommend workable models to the country
- D) Subcommittee D

Members:

- Engr. Paulinus N. Ogu Coordinator
- Engr. Charles Okafor
- Engr. Ahmad Ibrahim Kaitafi

Terms of Reference:

i) To examine Semen's document and give comments and recommendations

1.3. Methodology

The sub-committees reviewed available relevant and extant literature and materials including but not limited to past reports and publications from NSE members, previous works from Energy Commission of Nigeria (ECN), Nigerian Electricity Regulatory Commission (NERC), the defunct Power Holding Company of Nigeria (PHCN) and information from members of the Committee working with Electricity Distribution Companies (DisCos). These provided the information which the sub-committees used.

Engr. Charles Okafor submitted the report of Sub-Committee A, while Engrs. M. B. Nasir, Tunji Ariyomo and Paulinus Ogu respectively submitted the reports of Sub-Committees B, C and D. The reports of the four Sub-Committees are attached herewith as Appendix A (one zip file for the four reports).

2. RESPONSES TO THE TERMS OF REFERENCES

2.1. Term of Reference #1:

To carry out a holistic assessment of the state of power generation, transmission and distribution in the Country.

RESPONSE:

Although Nigeria has been generating electricity in commercial quantities for over a century, the pace of electricity infrastructure development in the country is very slow and power supply remains highly inadequate. Following the liberalization of the nation's power sector by the Electricity Power Sector Reform Act of 2005 (EPSRA 2005) and subsequently unbundling of government's power utility into 18 business units, in 2013 two segments of the sector, generation and distribution, were privatized to resolve the challenges associated with the government's monopoly of the sector.

However, despite the privatisation power supply remains largely inadequate, unaffordable and unreliable in the country. Presently, about eighty million Nigerians (more than twice the population of Canada) are not connected to the national power grid. For those connected, power supply is a serious problem as approximately 90% of total power demanded is not supplied. With the current installed generation capacity of about 13,000 MW, average operational generation capacity is not more than 5,000 MW of which 7.4% is lost in transmission, and up to 27.7% load is rejected at distribution. This leaves Nigeria with less than 3,250 MW. Recently, power supply has peaked up to about 5,500 MW.

It should be noted that Nigeria's electricity demand was estimated at 24,380 MW in 2015. As a result, Nigerians self-generate a significant portion of their electricity with highly polluting off-grid alternatives and at a cost that is more than twice the cost of grid-based power. It should also be noted that power supply of about 5,000MW for a population of about 200 million Nigerians implies that the annual average electricity consumption per capita is about 219kWh. The International Energy Agency's figures for 2018 show that for the United States of America it was about 12,071kWh, the average for the World was 2,604kWh and for sub-Saharan Africa it was 500kWh. For Nigeria to be at the electricity consumption of sub-Saharan Africa the supply should be at about 11,500MW and for it to be at the World average figure the supply will have to be about 59,000MW.

Within the coming years, electricity demand is expected to rise significantly. Household electricity demand, which has the largest share, will rise due to growing urbanization (at a rate of 4.23% per annum) and population growth (estimated at 2.7% per annum, while global growth rate is 1.1%), at rates more than twice global averages. Industrial and commercial demands are also expected to increase as Nigeria slowly exit from the recent recession, with the projected gross domestic product rates trending between 4.50% and 7%. A GIZ study estimates electricity demand to rise to 45,490 MW by 2020 and by 213,122 MW by 2040. Although the results of electricity demand studies vary widely, they all conclude that the current gap between supply and demand is already very substantial and that, it will become more entrenched under a 'business as usual' scenario.

2.1.1. Current State of Power Network:

The current electricity generation installed capacity is about 13,000MW, while the total available generation capability is about 7,500MW. Average daily power dispatched to the grid and distributed to consumers is less than 5,000MW. It should be noted that some power stations are near the end of their expected service lifespans, and there seems to be no plans to decommission and replace them. Also, more than 75% of the generation capability are gas-based (thermal) and that puts the security

of supply at great risk especially when the hydro units have short supply of water in the dams. A fuel mix for electricity generation of only two sources, gas and hydro, is totally unacceptable.

As far back as 2007/2008, a gas master plan was rolled out by the NNPC. In the gas master plan, the country's gas needs, including for the power plants under the National Integrated Power Project (NIPP) were duly captured and identified. To a great extent, the issue of gas has been on the front end since the inception of the NIPP project in 2005. The main problem was that the country was not able to attract investors in the gas sector, yet FGN outside the Joint Ventures has not invested in gas development and transportation. In addition, the issue of the recurring vandalism of the nation's gas infrastructure needs to be addressed.

It is important to also note that the Nigerian power sector will require substantially more investment to achieve reliable 24/7 power supply. Industry operators estimate that the country will require as much as \$100 billion in investment over the next 20 years. The World Bank is financing a \$486 million International Development Association credit for the Nigerian Electricity Transmission Access Project (NETAP), part of the Transmission Rehabilitation and Expansion Program (TREP) is to support the rehabilitation and upgrade of Nigeria's electricity transmission substations and lines, to expand the power transmission network and allow distribution companies to improve supply to consumers.

The implication of this is that there is a bottleneck between the generators and the load (the various categories of electricity consumers), that is inhibiting the transfer of power from the grid to the loads, and causing the under-utilization of the available generation capacity, with the associated commercial issues. This bottleneck is within the transmission and distribution networks in the various regions and DisCos in the Country. For a seamless dispatch and distribution of power to sufficiently serve the end-consumers of electricity within the country, the resultant capacities of the individual infrastructure elements should be capable of supporting the load at the interface substations. Assessment and analysis of these individual transmission and distribution infrastructure if appropriately done will reveal the capacity gaps in the specific infrastructure elements.

2.1.2. Distribution System

There are presently eleven Electricity Distribution Companies (DisCos) within the Nigerian Electricity Industry. These 11 distribution companies are: Abuja, Benin, Eko, Enugu, Ibadan, Ikeja, Jos, Kaduna, Kano, Port Harcourt and Yola. The distribution grid operates mainly on 33kV and 11kV level, i.e. medium voltage (MV) and low voltage level (LV). It is obvious that the current distribution infrastructure, are completely inadequate and built with so many sub-standard practices. Most parts of the distribution infrastructure were built outside the NEPA/PHCN system, through

community efforts, local and state Government Rural Electrification Schemes (FGN and other agencies under rural electrification schemes) with distribution design philosophy completely distorted due to very poor planning including lack of urban system planning and development zoning. This is evident from the conversion of small residential buildings to multi- story high rise structures all with no municipal infrastructure. When one looks at the system, majority of the constructions are also below standard and not load or demand driven, rather, built as a result of political considerations. Distribution networks were added and extended under such schemes without recourse to whether the source substations and/or lines are overloaded or not. Even when such was noted, due to political pressure, PHCN was not in the position to reject such connections to the system.

The consequences are low voltage, voltage instability, insufficient capacity to cope with the load (since NEPA/PHCN was not part of the planning for such additional infrastructure), load shedding and general system instability resulting to very poor and difficult system control. Demand and supply, a necessary balance of which is required in system operation, became very erratic and indeterminable and often led to system collapses. Many of these distribution units of the present infrastructure are obsolete, having lost their technical characteristics, yet no funds were available for their replacement. The net effect was wire cuts and electrical accidents, many of which have been very fatal. Despite infrastructural deficiencies, various connections to new towns and development in cities and villages continued unabated, with the economic improvement in people's lives continuing to add more to their woes.

The distribution networks have also been under serious threats ranging from vandalism, thefts of cables and transformers, and draining of transformer oil, all resulting to loss of power or total blackout to the affected communities for periods of time. A technical due diligence of the distribution system was not made during the privatization process. The importance of that is that buyers bought "black boxes" without details of the contents. The net effect of that is that most of the new buyers were totally unaware of the conditions of the business units they bought and only started seeing the situation with them after take-over. In most cases most of the buyers were shocked at the enormity of the problems facing them and may take longer time than expected to get the infrastructure to a state that can be technically stable. It should be borne in mind that PHCN, since 2007 had not been investing heavily on operations, due to paucity of funds and the uncertain nature of the privatization exercise. The electricity sector union's agitation did not help matters either.

Many consumers on the estimated billing system were not fully captured in the billing cycle, while unmetered consumers and theft of electricity became the order of the day. Rather than pre-paid metering to be an asset, it rather led to nose-diving of the revenue due to unwholesome by-pass and in some cases, outright destruction of the meters. Furthermore, the metering system was placed in the hands of contractors, under the Revenue Cycle Management (RCM) which did not fully interface with the PHCN billing system. Furthermore, the old billing system was fraught with outdated billing software that was not updated because maintenance of the system was stopped with the privatization exercise, and the entire process was jeopardized.

It is apparently clear from analysis of the power value chain that the distribution sector management is the weakest link in the power management system and seriously needs urgent action to improve the performance of this sub-sector. As part of the necessary actions required to help bring about stable distribution of power, it is mandatory that review of the existing feeders be undertaken on the distribution network, particularly the 33KV and 11KV feeders. Feeder outage contributes to the under-utilization of the available generation in the country. Apart from contributing to the under-utilization of generation capacity, feeder outages can play other adverse roles in the electricity market, such as the distortion of the energy distribution equilibrium upon which the retail tariffs are based.

2.1.3. The Transmission Network

The transmission segment of the power value chain connects the generation companies to the distribution companies. The present transmission infrastructure was assessed and found to be inadequate of wheeling power above 5,600MW. This needs to be re-evaluated through load studies that should be carried out by an independent consultant in order to establish its present status. Modern power systems are controlled and operated in real time with a functioning Supervisory Control and Data Acquisition System (SCADA) for efficient operation, this is currently not the case with the Transmission Company of Nigeria's grid network which is currently being operated using the GSM protocol. The national grid is fully government owned. Manitoba Hydro International was brought in to manage the National Grid and reduce its aggregate technical and commercial losses in 2012. The contract with Manitoba ended in 2015 but was extended for another one year, which took the contract finally to the end 2016 and since then TCN has been operating as a government agency.

The transmission lines and generators are interconnected in a common grid, with a National Control Centre (NCC) at Oshogbo and a Supplementary National Control Centre (SNCC) at Shiroro. The National Grid operates at 330 kV and 132 kV voltage level (HV). In 2010, more than 12,300 km of transmission lines (5,523 km of 330 kV and 6,801 km of 132 kV) connecting thirty-two 330 kV and hundred and five 132 KV substations were operational while more than 24,000 km of distribution network were available. The transmission grid is currently characterised by poor voltage profile in

the network (especially in the north due to its radial nature) and is constrained by limited control infrastructure as previously mentioned. TCN has currently has an on-going Transmission Rehabilitation and Expansion Program (TRP) aimed at closing the 330kV Grid loop and mitigate the radial lapses. This program is majorly Donor-funded.

Overloaded transmission lines and high technical and non-technical losses are a regular feature. The ageing transmission system could not be built to meet the extensive power production especially with the introduction of the NIPP plants that initially concentrated on building power plants without due consideration for evacuation to the grid. Although efforts were made after realizing the issues to remedy the issue by designing new substation projects under the NIPP to complement the existing transmission infrastructure, challenges remain. The number of transmission projects both in NIPP as well as in the TCN should be critically reviewed. All projects, especially ongoing ones with obvious value addition to wheeling capacity or network flexibility enhancement, should be funded on fast-track basis. Any impediments to completion of these projects, including those related to contractor's ineptitude or recalcitrance, should be quickly cleared in line with the new dispensation.

2.2. Term of Reference #2:

To determine the national power demand and the supply gap

RESPONSE:

Electricity demand estimates and projections for Nigeria suggest that demand is already substantial and increasing rapidly due to population and socio-economic growths. It is useful to consider the following points:

- a) Nigeria is one of the most underpowered countries in the world, with actual consumption being 80% below expectations based on current population and income levels.
- b) Peer countries consume far more electricity per capita than Nigeria does currently. Ghana, for instance, consumes twice as much electricity as Nigeria. Tunisia consumes over ten times while South Africa consumes almost thirty times as much electricity as Nigeria.
- c) Self-generation in Nigeria is extremely prevalent; nearly 14GW capacity exists in small scale diesel and petrol generators, and nearly half of all electricity consumed is self- generated. This implies a huge unserved demand.
- d) Due to a population boom and a large gap in electrification, the World Bank report of 2019 projects electricity demand will have grown by a factor of over 5.0 between 2009 and 2020, and 16.8 by 2035.

A power demand and supply gap analysis were carried out as part of this report using extant literature on supply and demand and comparing peer nations in Africa with similar energy utilization characteristics. Current demand estimates and projections suggests that demand is already substantial and increasing rapidly due to growths in population and in the socio-economy. Findings show that Nigeria is one of the most underpowered countries in the world, with actual consumption being 80% below expectations based on current population and income levels. Peer countries like Ghana, for instance, consumes twice as much electricity per capita, while Tunisia consumes over ten times and South Africa almost thirty times as much electricity as Nigeria. Due to this very high demand and supply gap, the uneconomical self-generation option is now the other of the day for Nigerian, with self-generating capacity of nearly 14GW using small scale diesel and petrol generators.

A case study of ten African nations with the highest electricity access figures as percentage of population were identified whilst the mean value of their per capita consumption was used as part of the information to estimate a demand scenario for Nigeria together with some extant literatures of the Energy Commission of Nigerian (ECN). Extract from ECN's literature covers the works done by some technical experts, trained on the use of the International Atomic Energy Agency, IAEA modelling tools to compute Nigeria's energy demand and supply projections covering 2005-2030. Result of the modelling and analysis shows estimated "reference growth rate scenario", with a GDP growth rate of 7%, electricity demand for 2020 as 28.3GW, corresponding to 1288.6kWh/capita. Under the same scenario electricity demand was estimated at 58.2GW with corresponding consumption per capita of 2167.3kWh in 2030.

Based on the above and with a supply not more than 5,000 MW as at the end of 2020 it can be said that electricity demand and supply gap was of the order of 28,300 MW against 5,000 MW. It should be noted that electricity demand, like hospital services demand, water supply demand, university admission slots, amongst others, is ever increasing driven mainly by population growth and the citizens' ever-increasing socio-economic growth. This means that if adequate care is not taken to plan and execute roadmaps for expansion of supply along with its transmission and distribution infrastructure the gap between demand and actual supply will be widening.

2.3. Term of Reference #3:

To identify the constraints hindering adequate power generation, transmission and distribution.

RESPONSE:

The major constraints of the Nigerian Power Sector can be identified as:

- a) Infrastructure Constraints: There are a series of serious challenges of infrastructure across the entire electricity supply value chain in Nigeria ranging from weak fuel to power distribution chain, insufficient gas pipelines, highly restricted energy mix for electricity supply, obsolete generation plants and equipment, as well as inadequate and poorly maintained transmission and distribution networks. There is the problem of vandalism and theft of electricity infrastructure.
- b) Insufficient End-User Tariffs/Pricing: Due to rising supply cost (associated with inflation, currency devaluation, and unexpected infrastructure constraints) that have not been accompanied by timely adjustments to tariffs. The electricity tariffs, which are not cost-reflective, have restricted players of NESI to secure investment funds from financial institutions.
- c) Inability to Reduce Aggregate Technical, Commercial and Collection (ATC&C) Losses: The design of the power sector reform makes the viability of the distribution companies (DisCos) critical to the long-term sustainability of the sector. However, DisCos are unable to recover cash shortfall on account of the lack of investment in network rehabilitation and metering (partly due to low tariffs and inability to obtain loans from Nigerian banks due to unpaid debts).
- d) Sector's Cash Shortfalls: Total cash shortfall in the sector between 2015 and 2016 is estimated at \$1.3 billion. Out of which \$1.2 billion accounts for deficits caused by tariffs being lower than the cost of service delivery, and the remaining \$100 million caused by DisCos inability to reduce ATC&C losses.
- e) Debts, Electricity Theft, and Non-payment Culture of the Public: Especially government ministries, department and agencies who owe the industry an estimated \$72 million as at the end of 2016; contributing to the sector's cash shortfall.
- f) Grossly Inadequate Electricity Supply: Electricity supply ranging from 3,500 5,000 MW for the nation's current population of about 200 Million Nigerians and for the entire socioeconomy covering the industrial, services, household and transport sectors. At the same time the nation is well endowed with a rich variety of conventional and renewable energy resources all of which are convertible to electricity.
- g) Non-implementation of the Terms of Sale Agreements: Following the sale of the 6 generation and 11 distribution entities to the private sector the new owners have not complied with the major sales agreement of expanding their facilities in line with the terms of the sale agreements. Both the Generation and Distribution Companies mainly explain that their inability to expand their respective infrastructure is due the low-electricity tariffs that has been making their business plans un-attractive to the financial institutions.

- h) Major Electricity Distribution and Transmission Problems: Distribution Companies have been reported to be rejecting supplies of up to 2,000 MW from Generation Companies for distribution to consumers. There are also reports of Distribution Companies being unable to collect payments from consumers, non-payment of Generation Companies for electricity supplied and non-provision of metering facility to all customers of the Distribution Companies. The major problem of Transmission Company of Nigeria is lack of funds to strengthen and expand the National Grid.
- Estimated Billings: The non-provision of metering facility by the Distribution Companies to all consumers and the continued resort to estimated billings is a major public complaint on the Distribution Companies. The major complaint is that the Distribution Companies send the estimated bills whether electricity is supplied or not.
- j) Natural Gas Constraints: More than 75% of the nation's power plant capacities in the country are natural gas fired and their constant complain is that they do not get the quantity of gas they need. Additionally, the domestic natural gas infrastructure is weak, and the quality of gas is not always of the required purity for power generation.
- k) Inability of Licensees of NERC to Raise Funds: The majority of licensees of the Nigerian Electricity Regulatory Commission have difficulties in raising funds from financial institutions. They attribute the cause of their predicament on the unattractive business plans occasioned by the existing low electricity tariffs.
- Poor Demand Side Management: Recent studies showed that there are significant wastages in the supply and consumption of electricity in Nigeria. While the studies showed that energy savings of up to 40% can be attained from good demand side management it seems there is no clear policy for this.
- m) Vandalisation and Customer Indiscipline: Vandals often steal electricity cables, transformers and other items plunging the affected communities into darkness sometimes for several months.
- Non-alignment of policies and programs. This misalignment of vision, policies, and strategies in the power sector need to be addressed to ensure synergy and streamlining of various programs to achieved the desired impact in the power sector.

2.4. Term of Reference #4:

To examine power supply models in some selected countries with adequate power supply and recommend workable models to the country.

RESPONSE:

A review of the power supply models for some developed countries that include United Kingdom, United States of America and the European Union was carried out with a bid to finding out which model best suits the Nigerian electricity market. In arriving at what was deemed the best possible outcome from these models, the power committee noted a reoccurring pattern in the generation systems of these countries through a desk review of their grid reliability using various indices, rankings, datasets and previous power reports.

The United Kingdom

The electricity supply industry (ESI) in the United Kingdom is made up of generation, transmission, distribution and supply segment with 12 Regional Electricity Companies (RECs). Transmission is the responsibility of the National Grid Company (NGC), a company fully owned by the RECs. The electricity market is centralised with large power stations generating energy while the national suppliers buy and sell this energy and the whole system is balanced on a national scale.

The suppliers have various options for buying electricity, including a contract with a generator, through a trader over an energy exchange or within their own company if they are vertically integrated with the supplier being responsible for maintaining "balancing and settlement", which is about ensuring that electricity supply matches demand as closely as possible since electricity is generated, transported and used in real-time.

The United State of America

The electricity supply industry in the US is in no way different from that of the UK, other than having more players and trading arrangement varies more by regions due to the size of the country. In other words, how electricity is bought and sold varies by region of the country. While many cities are served by utilities owned by the municipalities and some rural areas are served by customer owned rural cooperatives, most electricity customers are served by utilities that are owned by investors.

These investor-owned electric utilities can be either regulated and operate as vertically integrated monopolies with oversight from state public utility commissions, or they can operate in deregulated markets where electric energy prices are set by the market with some federal oversight of wholesale market operations. These regulatory constructs determine how retail and wholesale electricity prices are set and how power plants are procured.

The European Union

Although generation patterns may vary slightly within the various states that made up the EU, the electricity supply industry within them is the same, and similar to that of the United Kingdom. Their electricity market consists of suppliers, consumers, transmission system operators (TSO), and distribution network operators (DSO). Regulators set rules and oversee the functioning of the market. Some generating companies can transmit and distribute to both wholesalers and consumers alike.

Recommendation

Analysis of these supply models indicates that the Nigerian Electricity Supply model did not differ much from the UK system. It should, however, be improved to approach the situation in the European Union member nations. This can come as a response to the call of the Senate for bills to amend any legal instrument that will strengthen the electricity industry in Nigeria.

2.5. Term of Reference #5:

To proffer solutions to the identified power supply problems and state the responsibilities of NSE.

RESPONSE:

i) <u>RECOMMENDED SOLUTIONS TO THE IDENTIFIED POWER SUPPLY PROBLEMS</u>

It's believed that significant improvement in the nation's electricity supply can be attained by implementing the following recommendations:

- a) Expansion of Generation, Transmission and Distribution Capacities: Electricity demand and supply projections have to be used to comprehensively plan the expansion of the generation, transmission and distribution of the electricity systems of the country. A special effort is needed in this regard because of the need for significant expansion of the power supply base given the fact that 5,000 MW is far too small for a nation that has a population of more than 200 Million citizens and which hopes to expand its source of revenue through large-scale agriculture, large scale mining and mineral processing, manufacturing, amongst others. A special purpose vehicle similar to the NIPP/NDPHC is required but this time the funding should come from development banks, development partners and some developed nations. As some power plants and associated transmission and distribution infrastructure are developed, they will be privatized or concessioned to the private sector and the proceeds will be deployed to develop next set of generation, transmission and distribution systems.
- b) Expansion of the Energy Mix for Electricity Supply: There is the absolute need to expand the energy mix for electricity supply from the current two sources of hydro and gas to seven of hydro, gas, coal, nuclear, solar wind and biomass/biofuels. With an expanded energy mix and

subsequent greatly increased electricity supply in line with the demand and supply projections use will have to be made of embedded plants as well as micro- and off-grid arrangements since the National Grid is weak and fragile.

- c) Review of Electricity Tariffs: As the power supply base increases in line with point a) above, the regulator should undertake a massive campaign to ensure the entire country acknowledges the improvement of electricity supply and thereafter the tariffs could be raised so that players in the industry can realise some margin with which they can secure investment funds from the financial institutions.
- d) Government should pay its share capital in the distribution companies: The Government should raise funds, possibly from the World Bank or the African Development Bank, to pay its 40% share capital in the Distribution Companies so that the they will have more funds to expand their networks and also to enable Government to be better represented in the corporate administration of the boards of the Distribution Companies in such a manner that when private groups appoint managing directors of DisCos the government will appoint the board chairmen and if there are ten board members the private groups will appoint six and the government will appoint four.
- e) Elimination of Estimated Billings: While NERC should go ahead and ensure that its new metering policy, the Meter Asset Provider Regulation, is fully implemented.
- f) Expansion of the Transmission Grid: There is need for the Government to fast-track the regionalization of the nation's National Grid and to concession it, transparently, in the respective regions so that the concessionaires can invest in line with the capabilities of their regions.
- g) Actualizing Licenses of NERC: In addition to review of electricity tariffs for raising the income profiles of the DisCos and GenCos, there is also the need for Government to hold investment summits to get the private sector to better understand the Nigerian terrain and get clearer picture of the economic potentials of the Nigerian electricity market.
- h) Entrenchment of Energy Efficiency and Conservation: There is need to entrench the culture of energy efficiency and conservation which if well done could reduce up to 40% of electricity demand. This will require the Government to implement the 2015 National Renewable Energy and Energy Efficiency Policy.
- i) Attract investment to the energy sector: The sector is in dire need of capital injection in other to make it more attractive to investors. Attracting investment would require audit into the power

asset inventory to determine priority investment needs across the value chain and funding to replace or repair assets. It is also necessary that long standing government liabilities are resolved followed by the creation of fiscal rules for all future payments to prevent debt buildup. The Transmission Company of Nigeria (TCN), budget performance should be duly reviewed and analysed followed by increase capital allocation for their operation.

- j) Solve barriers in the gas-to-power value chain: The numerous gas fields of Nigeria should be developed to ensure that all the gas power stations get the quantity and quality of gas they need. This can be achieved by lunching a federal coordination mechanism covering gas supplies, generation, transmission and distribution. This should be backed up by enforcing existing default penalties for non-payment along the value chain.
- k) Boost revenue collection to support DisCos viability: It is necessary that all existing tariff schedule be updated to synchronize the payment expectations in the Multi-Year Tariff Order (MYTO) and the financing plans of GenCos, TCN and DisCos. Also, comprehensive data analysis should be utilized to more effectively allocate available power to where there are demands. This would mean investing in new IT infrastructure for the DisCos to enable revenue collection, management and transparency. As part of the effort to boost revenue collection, an independent assessment of the power sector value chain should be conducted to ensure accurate estimation of costs for electricity delivery and tariff adjustments.
- Understand demand to guide prioritization: There should be a comprehensive energy demand study to determine customer profiles, as well as stranded capacity in load rejection to ensure data-driven planning and reduction in technical, commercial, and collections losses.
- m) Remodeling of the distribution system: This to ensure that DisCos do not lose money due to the lack of patronage. Some kind of minimum or maintenance payment should suffice. And this should be derived from the power sector securitization fund with NERC.

ii) <u>RESPONSIBILITIES OF NSE</u>

The role of the NSE in strengthening the Nigerian power sector should actually be extended to the entire energy sector and will be more advisory that will become more and more serious depending on how the Society asserts itself on the Government and to the major players of the sector. The Society should note that Presidential Order Number 5 is for planning and execution of projects, promotion of Nigerian content in contracts and in Science, Engineering and Technology. The Order directed Ministries, Departments and Agencies (MDAs) of government to engage indigenous professionals in the planning, design and execution of national security projects and maximize in-

country capacity in all contracts and transactions with science, engineering and technology components. It is now recommended that the NSE should, exact itself on these MDAs, with the possibilities of leading the different government energy/power parastatals instead of non-engineers.

The Society should also note that as a result of the Sustainable Development Goals (SDGs) of the United Nations (UN), which Nigeria has signed and ratified, the whole World is moving towards a clean energy pathway to avoid global climate change disaster and which for the power sector has made the UN to be actively promoting renewable energy and energy efficiency technologies. For the transport sector the SDGs have led to remarkable progress in the development of the unstoppable electric vehicles phenomenon which will definitely lead to a sizeable drop in the demand for Nigerian oil.

The NSE should do the following:

- Produce a brief out of this report and present same to the President and Commander-in-Chief or to the Vice-President in his capacity as the Chairman of the National Economic Council.
- 2) Prepare a list of engineering firms owned by members of the Society that can effectively participate in the activity's MDAs in line with the provisions of Presidential Order Number 5.
- Establish or review its committee on energy to be keeping in touch with global developments in electricity and transportation matters.
- 4) In view of the significance of energy to the Nigerian economy the NSE should institute an annual Energy Summit to be jointly organized by its Energy Committee and its Divisions that are involved in energy matters to be held in May or June and to focus on showcasing major energy projects executed by Nigerian Engineers.
- 5) Develop close working relationships with energy related Ministries, Departments and Agencies like Ministries of Power, Petroleum Resources, Mines and Steel Development, Water Resources, Energy Commission, Nigeria Atomic Energy Commission, Nigerian Electricity Regulatory Commission, National Automotive Design and Development Commission, amongst other.
- 6) Recommend the diversification of revenue other than from sale of oil and in particular on manufacturing, mechanised agriculture and agro-allied industries, mining and mineral processing and on tourism the success of which will depend on the availability of regular and reliable electricity.
- Request for participation in the corporate governance of engineering agencies at policy making bodies of government agencies.
- 8) Whenever engineering infrastructure are to be concessioned or privatized preference should be accorded to companies owned by Nigerian engineers.

 NSE should draw the attention of government on the need to appoint engineers as heads of energy related Ministries, Department and Agencies.

2.6. Term of Reference #6:

To examine Siemen's document and give comments and recommendations.

RESPONSE:

The committee identified the following areas of concerns and uncertainty after reviewing the Siemens "Nigerian Electrification Roadmap":

- Getting the Nigerian Society of Engineers involved at the level of membership of the Special Purpose Vehicle of the NER is a welcome development and it is a recognition that the Society is a key technical and advisory stakeholder in all engineering and technical projects in the country.
- 2) It was stated clearly in the NER that the May 2019 copy was a draft document. It is currently unknown if there is a finalized version with defined solutions, and agreements tailored towards target delivery for each phase. If there is, does this version have the expanded scope of work under the roadmap?
- 3) While we are uncertain of the current status of the development of the contractual relationship between the German and Nigerian governments on this subject, we have observed a number of the gaps in the document that need serious attention before finalization. Some of the critical gaps are:
 - a) The Siemens Roadmap appears to have treated the Nigerian Electricity Supply Industry (NESI) as the integrated monopoly it used to be before privatization, by intending to enter into a financial contract on behalf of the generation and distribution companies which are limited liability companies. The contract will be financed with public funds and the beneficiaries would be required at a point to pay back hence the full legal consent of the GenCos and DisCos may be needed for the success of the roadmap.
 - b) The success of the NER mostly depends on the revenue collection efficiency of the DisCos to service all the stakeholders and market players in the NESI. Unfortunately, the NER does not seem to have addressed this adequately.
 - c) The urgent increase in the last-mile deliverable investments involving 33kV and 11kV underground cables and switchgear would place huge financial demand on the DisCos as these are not covered in the financial proposals of the Contract.

- 5) Confirmation is required on how personnel (engineers, craftsmen and artisans) would be drawn unto this project. Siemens being the main technical coordinator of this roadmap, should lay out prequalification criteria for selection of local engineering procurement construction (EPC) partners.
- 6) For work of this magnitude, and as part of government's requirement to meet local content demand the provision made or allowed for patronizing local manufacturers of electrical equipment and materials should be stated. This should be highlighted in the contract and as part of meeting the Nigerian local content requirement.
- 7) It is noted that the list of projects to be executed as part of the distribution work programme during phase 2 is not fully comprehensive, as it is noted that while the Benin DISCO area has few projects, the report identified just one and Yola DisCo was omitted. It is expected that further study is required to identify what is to be done or needs to be carried out and to assist in detailed project scope development, as it seems many projects are left out.
- 8) There is the need for harmonising the projects by TCN under its Transmission Expansion and Rehabilitation programme and the list of projects as detailed on page 9 of the draft roadmap.
- 9) There is also the need to allow for supply of spares for equipment and materials for maintenance as part of the contract. Additionally, as the contract is single sourced, there must be guarantee for availability of spares for the life of the equipment to be installed say for 40years and possibility of interoperability thereafter.
- 10) The technical and security implications of proprietary equipment should be seriously addressed in the main contract as it is well known that the perennial failure of the SCADA/EMS programs of TCN in the past years had something to do with SIEMENS proprietary equipment.
- 11) Supply of vehicles such as Hiab and operations and maintenance vehicles fitted with communication gadgets for Disco should be considered.
- 12) It is recommended that construction of small hydro power stations to improve voltage profile, especially in the far north should be considered.
- 13) More than 80% of the nation's generation comes from gas. There is the need for massive investment in the rehabilitation and upgrading of the existing gas infrastructure for improved gas supply to power service delivery.

- 14) Although training is part of the contract, but training on power sector reform, electricity market development and operations, regulatory framework and ruling document are necessary but completely omitted.
- 15) The three phases of the projects in the NER should be packaged and implemented as scalable independent projects to be completed, evaluated and lessons drawn before proceeding to the next phase in order to avoid the pitfalls of the globally unprecedented privatization programme of the Nigerian power sector.
- 16) To enhance the system stability and protection of the entire network, the NER should implement Wide Area Protection System to mitigate the characteristic frequent system collapses of the Nigerian Power System.
- 17) Due to the amount of work to be carried out under a phased sequence, Siemens and the Nigerian government agree on how a "Special Purpose Delivery Vehicle Company" can be set up to coordinate and manage the entire project from start to finish.

3. CONCLUSION AND RECOMMENDATIONS

The socio-economic growth of the nation cannot fully materialise without any significant improvement in electricity supply. It is of crucial importance that energy planning, via use of energy modelling tools for projecting demand and supply, is taken very seriously. In this way energy plans of the nation can be mainstreamed into the overall national development plans. There is the need for the expansion of the energy mix from the current two sources of gas and hydro to also include coal, nuclear, solar, wind and biofuels. Due to current limitations of the transmission network, adoption of off-grid/mini-grid and embedded generation alternatives should be encouraged. In addition, the transmission grid network should be regionalised and concessioned transparently to the private sector after undertaking a thorough review and improving the sales agreements with which the generation and distribution entities that have been privatized.

There is need to take steps to facilitate the passage of the Petroleum Industry Bill into law to ensure, amongst others, the conclusion of exploration activities in highly potential inland basins outside the Niger Delta like the Benin Basin, Enugu Basin, Lake Chad Basin, Upper Benue Trough, Bida Basin and Sokoto Basin. This will eventually lead to the availability of more gas for the nation's gas power plants. Having ratified the United Nations Sustainable Development Goals there is the need for Nigeria to set the machinery in motion to ensure that by 2030 the SDGs are attained. Current efforts made toward enhancing the quality of power supply is slow-paced and insufficient, although, various multilaterals (through initiatives with the World Bank and Power Africa) agencies, the

Nigerian government and private sector are all making efforts to address these key challenges of the Nigerian Electricity Supply Industry (NESI).

For instance, the government has inaugurated several projects aimed at expanding thermal and hydro sources as well as extended two intervention facilities to GenCos and DisCos to ease their financial constraints. DisCos have also embarked upon mass metering of customers, as well as implemented maintenance and upgrades on their networks by installing new transformers and building dedicated lines to commercial and industrial customers over the past years to reduce these losses and enhance service delivery. However, the investments are marginal compared to existing deficits and targets. There is need for the government to fully pay its share capital in the DisCos and participate more effectively in their governance.

There is a significant gap between demand and supply of electricity in Nigeria. This is the principal cause of the ever-recurring power outages across the nation. The challenges faced by this sector are occasioned by the heavy reliance on gas, limited technical know-how, lack of energy efficiency practices, poor infrastructure maintenance culture, over centralization of management authorities, inadequate and poor regulations and energy infrastructure vandalisms. Renewable energy options offer the possibility of a decentralized, deep and broad access electricity supply through off-grid and grid-tied energy solutions, hence the need to increase access to renewable energy resources in the country's energy mix. Investments into new transmission and distribution technologies are also required to allow deep penetration of renewable energy technologies.

Strong consideration should be given to allowing various states to develop their "state controlled" local mini grids where they can generate and use and whenever possible, transmit to the national grid, for wheeling to states or area with more need.

4. APPRECIATION

We would like to use this opportunity to thank the Nigerian Society of Engineers for the confidence reposed on us by assigning this very important matter to us. We wish to confirm our preparedness to assist the Society in similar undertakings in the future.

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