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The attached educational project, by ONUWA CHUKWUMA EKWUEME, JR., entitled THE ELECTRIC POWER DISTRIBUTION SYSTEM OF NIGERIA: HOW TO IMPROVE ELECTRICITY DISTRIBUTION, when completed, is to be submitted to the Graduate Faculty of the University of Wisconsin- Platteville in partial fulfillment of the requirements for the (MASTER OF SCIENCE IN INTEGRATED SUPPLY CHAIN MANAGEMENT) degree.

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THE ELECTRIC POWER DISTRIBUTION SYSTEM OF NIGERIA: HOW TO IMPROVE ELECTRICTY DISTRIBUTION

A Paper

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A. ABSTRACT

To understand the electricity supply industry, one must understand how electricity's physical characteristics work as a commodity. The electricity supply chain industry can be conveniently divided into energy sourcing, power generation, high voltage transmission, low voltage distribution, metering and supply. Central to almost all aspects of electricity are the issue of storage. Although most commodities can absorb production and demand variations by delivering to stock and withdrawing from stock, this cannot be done for electricity. While we shall see that there are various methods that amount to storage, in this instance we can assume that electricity must be consumed as it is produced. The purpose of this paper is to get a full comprehension of how supply chain management plays a critical role in the electricity supply industry of Nigeria. I'm looking to answer the following questions from this research:

1. Does the Electric Supply Industry have a substantial impact on Nigeria's industrial development?
2. What impact does the electricity capacity utilization have on Nigeria's industrial output?
3. How can the Electric Supply Industry in Nigeria improve in finding solution to the electricity supply?

B. INTRODUCTION

An electric power distribution system is the final stage in the delivery of electric power. Electricity travels from the transmission system to individual consumers. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2 kV and 35 kV with the use of transformers. Primary distribution lines carry

this medium voltage power to distribution transformers located near the customer's location. Distribution transformers then lower the voltage to the utilization voltage of household appliances. This usually feeds several customers through secondary distribution lines at this voltage. Service drops connect commercial and residential customers to the secondary distribution lines through. Customers that demand a much larger amount of power may be connected directly to the primary distribution level or the sub transmission level.

The electric power market is full of deregulations that have made electric energy more like a commodity that is bought in bulk from one market location and sold in another and from one country to another. These deregulations, coupled with increase in energy demand due to increasing population and economic activities, have in some cases resulted in over utilization of the transmission system as some of the transmission lines are stressed beyond their design limits.

The increase in demand on the transmission system has made some of them to be loaded more than their power transfer capacities and this has in some places reduced the quality of power delivered and in some other cases, resulted in cascading overloads with consequent power outages [1]. Because of these, researchers are working around the clock to devise means of extending the power transfer capacities of the transmission lines while maintaining the quality of power delivered through them. Technically, the limitation on power transfer capacity on a transmission line can always be removed by addition of new transmission capacity, but the economic, political and environmental considerations in building of new transmission facilities have made this option not always desirable [2]. Meanwhile, an important aspect of the contract terms for these inter regional and international power purchases is that the transmission system be adequate for the power evacuation [3,4].

Currently, in Nigeria, the previously government-owned power generation and distribution companies have been privatized. It is expected that this privatization will result in better management of these utility companies resulting in increased generation and more efficient power distribution and revenue collection [5]. It is a fact that the success of the privatized system still depends on the effectiveness of the transmission system.

The electric power sector is one of the most important sectors to national development. The power sector is critical to the developmental reform of any country. To discuss the electric power sector in Nigeria in a realistic way, an assessment of its development since independence is necessary in this study. This work seeks to evaluate the strength of the Nigerian electric power grid on industrial development in Nigeria, as well as ways to enhance the performances of the transmission lines in the grid with the aim of achieving better utilization of the available transmission assets.

C. LITERATURE REVIEW

i. EARLY DEVELOPMENT OF THE ELECTRICTY SUPPLY INDUSTRY

Providers of electricity can be normally grouped in the category of utilities. They are in the same category with providers of services such as clean water, waste water removal, gas and telecommunication. Electricity establishment is regarded as a basic utility that is noticeable in the most developed economy only after failure. In countries that are in development stages, the delivery of electricity remains a fundamental aspiration and development indicator.

The electricity industry dates back post the industrial revolution. While electricity was known by the ancient Greeks in the form of static electricity, it was not until the second electrical

revolution of the 1880's that power for lighting and motors was used to any degree, while still over a quarter of the world's population did not have access to electricity.

The early development of the Electric Supply Industry was driven by discovery and private enterprise. Although experimental usage grew during the 19th century, it was the growth of public incandescent lighting using power stations as a source that marks the beginning of the Electric Supply Industry. The results were an increase in the development to standardize electricity.

ii. THE LIFECYCLE OF ELECTRIC POWER

There are five essential stages in the lifecycle of electric power. Those stages are:

(i) Energy Sourcing

(ii) Power Generation

(iii) Network Transportation

(iv) Supply Management

(v) Consumption

Energy Sourcing – When it comes to energy sourcing, a natural asset under common ownership must be exploited to create electricity. This source might be underground (e.g. nuclear or fossil fuel), renewably harvested (e.g. energy crops), or arriving naturally (e.g. wind and water). There may be several activities involved when it comes to energy sourcing after initial gathering. Those activities may include processing and refining, and then delivery to the power station. When it comes to the extraction of natural resources, the political economics have been worked out over the last five thousand years, with the fundamental answer in the late 20th century following the same fundamental political philosophy that is driving the Electric Supply Industry. This is the

ideology of free markets versus the state running stewardship of national assets. There is limited opposition to a natural asset being extracted by foreign companies, and then exported, if there is sufficient national benefit along the way in the form of royalties, taxes, infrastructure, employment and development. However, there is acknowledgement that national attitudes may change when these resources become insufficient in the country of ownership.

Power generation – Power generation is the process by which an on-site energy supply is converted to electricity and delivered into the electricity transportation infrastructure or directly to a 'host' load. Delivering into the infrastructure does require a high degree of control of the electrical product. To generate power, requires not only a source of energy, but fair physical and economic access to the full energy source infrastructure. This infrastructure may include pipeline or rail, road, and ports. Similarly, the generator requires fair physical and economic access to the consuming customer.

Transportation – To transmit and distribute power requires extensive and intrusive access requirement to the physical equipment of towers, transmission and distribution lines, transformers and other equipment. The building of power lines and their presence may have a substantial attractiveness impact in terms of the disruption of views. This may require property rights that would be quite impossible without the support of local and national governments. Transportation is a natural monopoly and therefore is subject to regulated prices.

Supply management/Consumption – Consumers require all the upstream activities. Those activities include generation and transportation. For this to occur, electricity is delivered to most

consumers as a bundled retail product. Consumers pay a price to the suppliers for the delivered product, and the suppliers arrange everything else.

There are an additional four essential activities that can be considered as part of the supply chain, since every megawatt (MW) of electricity that passes through the network passes through them. Those activities include:

System operation – System operation is the electrical management of the system, particularly in the short term (less than one day). Since there is a need for production and demand to match perfectly and continuously, in the short term there is no time for multilateral interactions, and a single system operator must coordinate.

Market trading/Market operation – In the more mature markets, electricity is traded several times from the first producer sale to ultimate consumer delivery.

Market operation involves the commercial arrangements for energy and capacity trading between participants and the system operator, and coordination of such commercial arrangements between participants.

Metering – While cost is incurred at all points of the supply chain, there is only one source of revenue – the consumer. To pay for electricity, the consumer must have a definitive price and amount to pay for. The meter is clearly the source of information, but in practice the

processes are highly complicated. Hence we regard metering as an important and distinct part of the supply chain.

Disposal and environmental impact – This can variously be regarded as the last stage of the life cycle of electricity, a by-product of electricity production, or an input factor. As the impact is predominantly incurred in the generation sector, it is rendered unavoidable by the act of consumption.

iii. DEVELOPMENT, STRUCTURE, COORDINATION, LEGISLATION OF THE ELECTRIC SUPPLY INDUSTRY

The structural development of the Electric Supply Industry could respond to the technological capabilities and the sources of funds, and the legislature, in kind, responded to the structural development. There is a variety of organizational forms of ownership, operation and control. This is a direct result of the technical complexity of the industry and the variety of physical and socio-economic tradition and contexts in which it resides. Electricity in developed countries is regarded as a necessary utility that cannot reasonably be withheld and which must be provided at an affordable price to all consumers. The delivery to all customers including the poor, remote, and rural, is called universal service.

In the late 19th century, in which electricity supply could be said to have become an industry, the economic model in the industrial nations for new infrastructure development such as railways and canals was a mixture of private and municipal development, with a series of laws and rulings that first increased the standardization and coordination and then increased the degree of public ownership and control where national interests dictated that it should do. Then, as much as now,

the organizational structure of the Electric Supply Industry was strongly shaped by the prevailing political paradigm [6].

Soon after the attempts to standardize electricity, came attempts to regulate the electricity industry. For example, in 1898 Samuel Insull in the USA who tried to impose regulation over 'debilitating competition' and New York and Wisconsin initiated state regulation of utilities in 1907, while England took a more liberal view and allowed a 'rabble of small inefficient electrical undertakings with which parliament had unwisely saddled the country' [6].

It was in the early days when electricity usage was largely for municipal installations such as lighthouses and street lighting. During this time, the product sold was actual light, rather than electricity. The provision of the service used a tax and the municipality contracted directly with the utilities with names such as 'Illinois power and light'. This raised debt and equity from private investors. The earliest installations were a matter of civic pride. It was with the quick arrival of new utilities providing light and power and light to an increasing number of buildings, that it was realized that there is a need for greater coordination. Legislation was set up to systematize the procedure for setting up public supplies. National grids began being set up by statute. For example, in the UK, in the 1926 Electricity (Supply) Act, the General Electricity Board was created and the National Grid began development and construction. Between 1920 and 1950, most houses in Europe and America became connected to the networks [6].

D. LOCATION IN THE SUPPLY CHAIN

The supply chain sector, also called the retail sector in competitive markets, does not produce or deliver energy but purchases it from generators, pays the networks for transportation, pays

various other charges (such as metering and levies) and charges the consumers. With the presence of the supply sector, this means that the generation, transmission and distribution sectors can concentrate on core business. Supply sectors can vary in nature. For example, they can be driven by brand and outsource the billing and energy management, or driven by need to find a route to market for generated power. Three key activities for suppliers are:

i. Customer relationship – brand, inbound call center management, outbound call center management, cross selling, energy services.

ii. Risk management – wholesale energy, network costs, environmental costs, credit management.

iii. Physical and data process – Metering, information management, connections, service delivery.

A. ELECTRICTY DISTRIBUTION

The Electric Supply Industry utilizes a distribution system with a very inactive role in energy management. This system also plays a passive role in the design of the Electric Supply Industry in general. In terms of billing the customer, the high cost of losses, high extent and low accessibility of physical infrastructure means that the costs are comparable with that of generation for the residential sector. If commercial losses of electricity are included, then distribution costs can exceed generation costs.

The distribution sector picks up the energy from the grid and delivers it to virtually all electricity consumers. The asset and customer base is highly distributed and the tasks and challenges to the distribution system are different to that of the grid. History and changing practice means that the definition of distribution varies. The widest definition is for

distribution to include all Electric Supply Industry activities downstream of the transmission grid except for that part of the distributed generation sector that is privately owned. The narrowest definition is from transmission exit at low voltage up to, but not including, the electrical infrastructure at the site of consumption.

When it comes to the customers receiving electrical service, particularly in relation to connections, metering and disconnections, this indicates that there is a close relationship between distribution and supply. Ownership is often common or vertically incorporated. The Electric Supply Industry conditions distribution to be unbundled from supply.

B. METERING

Metering has an undeservedly low profile in the Electric Supply Industry. When the standard unbundling designation is put into consideration, it is not usually regarded as a sector. Instead, metering is commonly viewed as part of the distribution sector. However, when it pertains to the physical properties of metering and the data management arising from the meter reading, those features account for a total cost that commonly exceeds the cost of transmission and is comparable with the costs of distribution and of power generation. However, it is important to stress the emphasis of the role of metering in the most durable solution for the increasing issues of sustainability and the environment, the solution of simply consuming less. When undertaking detailed analysis of industry solutions, in the short and long term, in developed and developing countries, it turns out that metering is commonly at the heart of the problem, and on the critical path. The problem is commonly that when the solution is described at a high enough level to get onto a small number of pages, or to a non-technical audience, that metering somehow drops out of the dialogue.

Over the long term, demand reduction is a major or most significant element in solving energy and environmental issues. For this to occur, the meter must play a key role in the 'consumer experience' of electricity, since electricity is so invisible. The reason that metering is so critical is that the meter is the key interaction point between consumer and the market. Only through physical technology, information technology, and highly efficient business process in the supply sector can this interaction point be managed to manage energy demand.

E. HISTORY AND CURRENT STATE OF THE POWER SECTOR IN NIGERIA

A. HISTORY OF ELECTRICITY IN NIGERIA

Electricity supply in Nigeria dates to 1896 when two small generating sets were installed to serve the then Colony of Lagos. The total capacity of the generators used then was 60KW. In other words, the maximum demand in 1896 was less than 60 kW. The Nigeria Electricity Supply Company (NESCO) commenced operations as an electric utility company in Nigeria in 1929 with the construction of a hydroelectric power station at Kurra, near Jos. By an Act of Parliament in 1951, the Electricity Corporation of Nigeria (ECN) was established, and in 1962, the Niger Dams Authority (NDA) was also established for the development of Hydro Electric Power. However, a merger of the two was made in 1972 to form the National Electric Power Authority (NEPA), which because of unbundling and the power reform process, was renamed Power holding Company of Nigeria (PHCN) in 2005[6].

However, there was another body known as the Niger Dams Authority (NDA), which was established by an act of parliament. The Authority was responsible for the construction and maintenance of dams and other works on the River Niger and elsewhere, generating electricity

by means of water power, improving navigation and promoting fish brines and irrigation [7]. The electricity produced by NDA was sold to ECN for distribution and sales at utility voltages.

The Nigerian power sector is controlled by state-owned Power Holding Company of Nigeria (PHCN), formerly known as the National Electric Power Authority (NEPA). In March 2005, President Olusegun Obasanjo signed the Power Sector Reform Bill into law, enabling private companies to participate in electricity generation, transmission, and distribution. The government has separated PHCN into eleven distribution firms, six generating companies, and a transmission company, all of which will be privatized soon [8].

On August 26, 2010, President Goodluck Jonathan launched a new Power Sector Roadmap. Per Nnaji [7], The Presidential Action Committee on Power (PACP) was created to remove "red-tape", achieve policy consistency and cut-through bureaucracy indecision making by key stakeholders in power and the Presidential Task Force on Power (PTFP) was created for day-to-day planning, developing and driving forward the Reform Plan for the Nigerian Power sector which was the Electric Power Sector Reform Act (EPSRA) enacted in 2005. This Act was to drive the reform processes as follows:

1. Transfer NEPA's assets to PHCN and subsequent unbundling into: A transmission company, TCN, 6 generating companies, GenCos, 11 distribution companies, DisCos
2. NELMCO to take over PHCN stranded assets and liabilities
3. Establish a bulk trader of power as a broker between power producers and DisCos
4. Establish an independent sector regulator: (Nigeria Electricity Regulatory Commission (NERC) charged with the responsibility of tariffs regulation and monitoring of the quality of services of the PHCN
5. Provide for a consumer assistance fund

6. Develop competitive electricity market
7. Licensing of IPPs and ring-fence distribution companies
8. Establish a rural electrification agency, (REA).

It was with the transition into the Presidency of Umaru Musa Yar'adua, where the privatization issue was suspended. The new President began development of a new strategy which included, setting an agenda of industrializing Nigeria by 2020. The conference was therefore one of the highest and administrative governing structures that was considered to offer achievable solutions to the power supply problems to achieve this priority goal of the Nigerian government. Unfortunately, he was unable to accomplish his agenda before his death.

Per Niger Power Review [10], its stated that in April 1972, the operation of ECN and NDA were merged in a new organization known as the National Electric Power Authority (NEPA). Since ECN was mainly responsible for distribution and sales and the NDA created to build and run generating stations and transmission lines, the primary reasons for merging the organizations were:

1. It would result in the vesting of the production and the distribution of electricity power supply throughout the country in one organization which would assume responsibility for the financial obligations.
2. The integration of the ECN and NDA should result in the more effective utilization of the human, financial and other resources available to the electricity supply industry throughout the country.

Okoro & Madueme's research states [11], since the inception of NEPA, the authority expands annually to meet the ever-increasing demand. Unfortunately, majority of Nigerians have

no access to electricity and the supply to those provided is not regular. It is against this backdrop that the federal government 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. NEPA because of unbundling and the power reform process was renamed Power Holding Company of Nigeria (PHCN) in 2005.

In Nigeria, the electricity division has been plagued by a plethora of problems for many years. These problems included low generation capacity, poor distribution, decaying facilities and many others. Prior to reform, many countries have largely one state owned utility carrying out all the activities in that sector. When considering all the efforts towards sustainability of power in Nigeria, from ECN to NEPA down to PHCN, many complications continued against realizing the goal. Those problems include unfinished targets of power generation, insufficient equipment, inferior methods of transmission, poor zoning of distribution, low voltage supply, unauthorized connection and disconnection, corruption in the management, vandalizing of equipment and inefficient distribution planning. With the existence of these obstacles, there remains the challenge in accomplishing the aim of sufficient power supply in Nigeria.

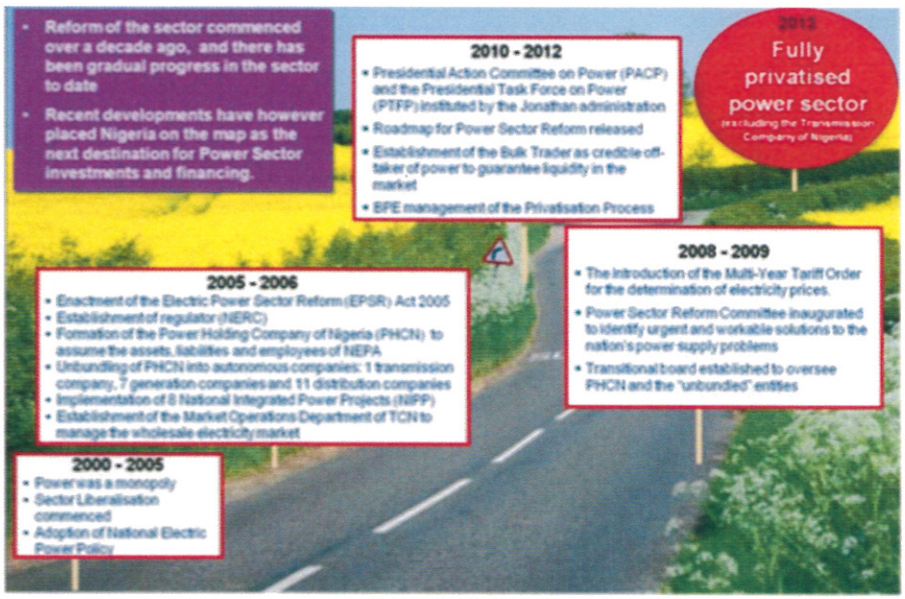
The first utility company established in Nigeria is known as the Nigerian Electricity Supply Company, was established in Nigeria back in 1929. Nevertheless, electricity generation in Nigeria had started over 30 years before the formation of the first utility in 1896. In 1946, the Nigerian government electricity commission was established under the jurisdiction of the public works department (PWD) to take over the responsibility of electricity supply in Lagos State. The Electricity Corporation of Nigeria (ECN) was established in 1951, while the first 132KV line was constructed in 1962, linking Ijora Power Station to Ibadan Power Station.

Notwithstanding the various efforts of the State-owned utility to manage the sector to

provide electricity, it became apparent by the late 1990s that the electricity system in Nigeria was failing to meet Nigeria's power needs. Therefore, the National Electric Power Policy of 2001 kicked off the power sector reform in Nigeria. This lead to several other reforms over the last decade.

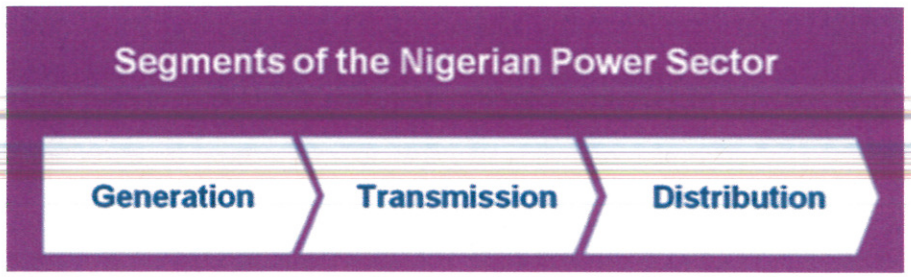
To improve the power sector, the Nigerian government has started long-term structural reforms focused on privatizing legacy power assets and instituting regulatory reform. Still, these reforms have proved insufficient and more must be done to address the challenges in the sector. These challenges include sub-optimal utilization of generation plants, inadequate transmission infrastructure and high distribution losses.

Since the arrival of the democratic government in Nigeria, there have been significant developments in the reform of the power sector. The Evolution of the Nigerian Power Sector is as depicted below:



Privatization of the power sector in Nigeria is believed to be one of the boldest privatization initiatives in the global power sector over the last decade, with transaction costs of about N3.0bn.

Over the past decade, Nigeria has could complete the privatization process. Nigeria retains the ownership of the transmission assets with the generation and distribution sectors fully privatized. The Nigerian Power Sector is made up of 3 major sub-sectors as depicted below:



B. CURRENT STATE OF ELECTRICITY IN NIGERIA

In accordance with the Electricity Power Sector Reform Act 2005, the privatization of PHCN was finally established in 2013. PHCN was subsequently unbundled into a transmission company, TCN, 6 generating companies, Gen-Cos, and 11 distribution companies, Dis-Cos.

The operating environment is such that the Dis-COs can purchase power from Gen-COs of their choice while Gen-COs can optimize production cost and hence make competitive offers for sale of power. The Trans-CO on the other hand is an independent power Operator (IPO), as well as, an energy carrier with the responsibility of ensuring bilateral contracts exist between Dis-COs and Gen-COs with additional responsibility of issuing operational guidelines for efficiency of the system [12].

F. STRUCTURE, DEREGULATION AND LIBERALIZATION OF THE ELECTRICITY INDUSTRY

Per NPSG [9], the structure of the Nigerian Power Sector is made up of 3 major subsectors as depicted below:

i. GENERATION, TRANSMISSION, DISTRIBUTION

1. GENERATION

There are currently 23 grid-connected generating plants in operation in the Nigerian Electricity Supply Industry (NESI) with a total installed capacity of 10,396.0 MW and available capacity of 6,056 MW. Most generation is thermal based, with an installed capacity of 8,457.6 MW (81% of the total) and an available capacity of 4,996 MW (83% of the total). Hydropower from three major plants accounts for 1,938.4 MW of total installed capacity (and an available capacity of 1,060 MW).

a. Independent Power Producers (IPPs)

Independent Power Producers are power plants owned and managed by the private sector. While there were Independent Power Producers (IPPs) existing in Nigeria prior to the privatization process, the Nigerian Electricity Regulatory Commission (NERC) has recently issued about 70 licenses to Independent Power Producers to improve the power situation in the country. The existing IPPs include Shell – Afam VI (642MW), Agip – Okpai (480MW) and AES Barges (270MW).

b. National Integrated Power Projects (NIPP)

The National Integrated Power Project (NIPP) is an important part of Nigeria's efforts to fight the power shortages in the country. In 2004, it was considered as a fast-track public sector

funded initiative to add significant new generation capacity to Nigeria's electricity supply system along with the electricity transmission and distribution and natural gas supply infrastructure required to deliver the additional capacity to consumers throughout the country. There were 10 National Integrated Power Projects (NIPPs), with combined capacity of 5,455 MW, scheduled for completion (for ongoing projects) and privatization in 2014. The NIPPs are:

S/N	NIPPs	Capacity (MW)	Expected completion date as at September 2013
1	Alaoji Generation Company Nigeria Limited	1,131	June 2014
2	Benin Generation Company Limited	508	December 2013
3	Calabar Generation Company Limited	634	June 2014
4	Egbema Generation Company Limited	381	June 2014
5	Gbarain Generation Company Limited	254	June 2014
6	Geregu Generation Company Limited	506	May 2013
7	Ogorode Generation Company Limited	508	All units commissioned
8	Olorunsogo Generation Company Limited	754	All units commissioned
9	Omoku Generation Company Limited	265	June 2014
10	Omotosho Generation Company Limited	513	All units commissioned

Source: Niger Delta Power Holding Company Limited, Transaction Review Conference, Completion Status of NDPHC Generation Companies

Nigeria set aside N50 billion in escrow accounts in 3 Nigerian Banks to serve as a defense for losses that the GENCOS may suffer during power transmission. Drawdowns are only possible where the stipulated conditions are met. The Nigerian Bulk Electricity Trading Plc (NBET) has managed the accounts.

2. TRANSMISSION

Nigeria maintains the ownership of the transmission assets. Manitoba Hydro International (Canada) is responsible for restoring TCN to achieve and provide stable transmission of power without system failure. Currently, the transmission capacity of the Nigerian Electricity Transmission system is made up of about 5,523.8 km of 330 KV lines and 6,801.49 km of 132

KV lines [9]. However, the generation and distribution sectors were fully privatized and owned by private individuals.

The TCN is made up of two major departments: System Operator and Market Operator. The Market Operations (MO) is a department under TCN charged with the responsibility of administering the wholesale electricity market, promoting efficiency and where possible, competition. The system operator is focused on system planning, administration and grid discipline. Furthermore, one of the major areas of focus of Manitoba Hydro International is to reorganize TCN and ensure that the Market Operator and the System Operator become autonomous.

Furthermore, one of the major areas of focus of Manitoba Hydro International is to reorganize TCN and ensure that the Market Operator and the System Operator become autonomous.

The responsibilities of the System Operator include [14]:

I. Implementing and enforcing Grid Code, and draft/implementation of operating procedures as may be required for the proper functioning of the System Operator Controlled Grid
II. System planning
III. Implementing and supervising open access to the System Operator Controlled Grid;
IV. Providing demand forecasts
V. Planning operation and maintenance outages
VI. Undertaking dispatch and generation scheduling

VII. Scheduling energy allocated to each load participant if available generation is not sufficient to satisfy all loads

VIII. Ensuring reliability and availability of Ancillary Services

IX. Undertaking real time operation and SCADA/EMS system

X. Administering system constraints (congestion), emergencies and system partial or total recovery

XI. Coordinating regional Interconnectors.

3. DISTRIBUTION

In the earlier days of distributing electricity, direct current (DC) generators were connected at loads at the same voltage. The generation, transmission and loads had to be set at the same voltage because there was no way of changing DC voltage levels. Low DC voltages were used because that was a practical voltage for incandescent lamps, which were the primary electrical loads then.

The adoption of alternating current (AC) for electricity generation was the drastic change that altered electronic generation. Power transformers were installed at power stations. These transformers could be used to raise the voltage from the generators, and transformers at local substations reduced it to supply loads. The increase of voltage reduced the current in the transmission and distribution lines. This also reduced the size of conductors and distribution losses. The result was a more economical way to distribute power over long distances.

A distribution network usually consists of two types: radial network and interconnected network. A radial network leaves the station and passes through the network area with no normal connection to any other supply. This is a standard of long rural lines with isolated load areas. An interconnected network has multiple connections to other points of supply. These points of

connection are generally open but allow a variety of arrangements by the operating utility by closing and opening switches. Operation of these switches can be controlled remotely from a control center or by a lineman. The advantage of the interconnected model is that in the event of a fault or required maintenance, a small area of network can be isolated and the remainder kept on supply.

Generated power cannot all be consumed at the generating stations and its immediate environment. Therefore, it must be distributed at suitable voltage to points and consumers. Distribution involves primary and secondary transformation of high voltage to the standard channel and low voltage by the appropriate transforming equipment.

CONCLUSION

Research Question #1: Does the Electric Supply Industry have a substantial impact on Nigeria's industrial development?

When it comes to the country of Nigeria, energy issues are a top priority in terms of developmental agenda by the Government. This is mostly encouraged by the acknowledgement that without energy, most expansion objectives, which include industrial development growth, cannot be achieved. The policy makers of Nigeria will need to tackle various issues in the energy sector, including access to electricity by much of the Nigerian population.

Over the last twenty years, the gap between energy supply and demand in Nigeria has been growing and it has been forecasted that the gap will continue to grow, and the living condition of the population will suffer in energy poverty. This will seriously slow down the socioeconomic development of Nigeria.

There is a need for proper implementation of the power sector objectives. Administering these objectives promote the efficient and sustainable supply of energy to the population. Not only will this promote efficiency and growth in the power sector, this will also aid in industrial development and economic growth. This will also encourage private sector participation and investment in The Electricity Supply Industry of Nigeria.

Privatization of the electricity sector brings about competition. This also allows management of privatized companies to have the full freedom to realize their optimal capabilities. For any company to take a lead over the other, its products must be second to none. Such a high quality of products could only be achieved through research. With a developing power sector, other sources of renewable energy such as wind, solar and biomass are expected to be explored.

Research Question #2: What impact does the electricity capacity utilization have on Nigeria's industrial output?

Nigeria is endowed with an abundance of energy resources to meet its present and future development requirements. Due to the importance and relevance of energy in industrialization to economic growth and industrial development, Nigeria has put in place various policies, incentives and institutions to push industrial development. Power generation in Nigeria is estimated to be 6,000 megawatts, with actual availability capacity of 2,000 megawatts over the past couple of years.

The current installed capacity of grid electricity is about 6000MW, of which about 67 percent is thermal and the balance is hydro-based. Between 1990 and 2000, there were no new

power plants built. During that same period, Nigeria witnessed substantial government under-funding of the utility for both capital projects and routine maintenance operations. Generating plant availability is low and the demand – supply gap is crippling.

In this current state, the number of Nigerians without access to electricity services will continue to increase over time. The chronic shortage of available generating capacity has negatively affected the industrial and manufacturing sectors. With self-generation widespread in the industrial, commercial and domestic sub-sectors, the electrical energy demand in Nigeria currently estimated at 10,000 MW is not known. Nigeria is starting comprehensive reforms to address the electricity situation in the country.

Research Question #3: How can the Electric Supply Industry in Nigeria improve in finding solution to the electricity supply?

Since the last two decades, Nigeria has been facing an extreme electricity shortage. This deficiency is multi-faceted, with causes that are financial, structural, and sociopolitical, none of which are mutually exclusive. Nigeria's power sector has high energy losses from generation to billing, a low collection rate and low access to electricity by the population. There is insufficient cash generation because of these inefficiencies and the power sector is consequently reliant on fuel subsidies and funding of capital projects by the government [15].

Improving the power sector for electricity supply, the Federal Government of Nigeria should ensure level playing fields for the independent power producers and other genuine investors in the power business. Also, consumers of energy should be provided with a good education on the most efficient use of energy. Other measures that should be taken in resolving

the power crisis in Nigeria includes the provision of community and military security to prevent vandalism of oil, gas and electrical equipment and lines, there is need for efficient pricing of electricity so that the price of electricity will not be lower than the average production cost. This will encourage private partnership participation. Privatization of the electricity sector brings about competition and allows management of privatized companies' full freedom to realize their optimum potentials.

Alternative source of energy to produce electricity must be prioritized, since there is too much of a reliance of fossil fuel and thermal. Other renewable energy source like solar, wind, and biomass can be used to produce electricity, both for urban and rural electrification. Although Nigeria is the most populous country and the nation that has the second largest economy in Africa, it is still suffering from energy poverty. This is because of ineffective institutional framework, inappropriate policies, and uneven distribution of power supply in various parts of the country.

RECOMMENDATIONS

For Nigeria to improve the industrialization process and efficiency in production and distribution of goods and services, this should not be left alone for the government in the development of industries. The country will need to embrace and encourage the growth of the Electric Supply Industry to be on the same level with developed countries that have embraced industrial development and the power sector as the cornerstone of their economic development.

To be a top contender in the world economy, Nigeria will need to comprise ways to meet their energy needs and to embrace better choices of energy consumption. Nigeria must continue

to invest in technology, to develop the technologies that would allow them to conserve more energy and be better inhabitants of their environment. An effort must be made to remove causes of inefficiency and ineffectiveness; this will require growth with equity and can be achieved in the following ways:

Poor Maintenance Planning: No adequate schedule to maintain the aging plant grids, which are quite not up to date with service performance for the production, transmission and distribution of electricity.

Solution: An essential part of a good maintenance strategy is to have good record keeping and effective supplies management policy. Its main function is to give basic information about the time purchase, condition and life cycle of all the plants/equipment etc. by way of proper decision and actions since maintenance schedules recommended by manufacturers are often inadequate for our public utilities into considering the socio-economic factors. The availability of spare parts, either by contract or direct supply, is most essential aspect of the maintenance strategy. A good number of maintenance cannot succeed unless they are backed up with effective spare parts providing policies.

Spare part for maintenance of public facilities in Nigeria is got either by contract or direct supply. The availability of spare parts is the most essential aspect of maintenance strategy. A good number of maintenance activities in the Nigeria public sector cannot succeed unless they are being supported with effective spare parts provisioning policies. The level of success achieved is borne out of availability of spare parts needed to make necessary repairs, be it major or minor repairs.

Insufficient Funding: The Federal Government of Nigeria has failed to realize the need to inject sufficient fund for the course of power generation in Nigeria, because of this, generating power has become a big and major problem for the power sector. Siphoning financial allocation to the sector by it personnel is also a major problem, which need to be address as soon as possible.

Solution: Since Nigeria's independence, the Federal Government has remained the major financier of power supply in Nigeria. This might have followed a political history of the country since independence, where the Military Governments that controlled the administration, established the concept of developing the power sector as the sole responsibility of the Federal Government. Additionally, under the military traditions, the Military Head of State ((Federal government) had always directly appointed the State Governors and had dictated resource allocations to the States from the Federation Accounts and literally also controlled the implementation of most capital projects executed in the States. This scenario under a democratic system of Government as currently practiced in Nigeria is not feasible. A deliberate and proactive strategy is required to ensure that all tiers of Government fully participate in this National Priority sector. It is therefore suggested that, in view of the vision for power to be provided on a sustained stable basis to the entire nation, all tiers of Government, like the strategy deployed on the provision of roads/highways network that we currently operate in the country. The concept being proposed is that, in view of the large investment required for the development of the Generation, Transmission and Distribution networks, States and Local Government should contribute a certain percentage of the total cost like the concept on road-network where all tiers of Government participate in development, maintenance and repairs.

Poor Electricity Pricing: Considering Nigeria is one of the poorest countries in the world, the price of electricity in Nigeria is quite unaffordable for majority of the population, and electricity pricing is just too high for the masses.

Solution: The government should also consider deregulating the electricity market so that the free market determines the price of electricity. The accumulation of investors into Nigeria's electric industry could substantially push the country's revenue and create jobs for many of its citizens simultaneously.

Electricity Industry Monopoly: Power Holding Company of Nigeria, has the sole responsibility of producing, transmitting and supplying electricity to the Nigeria masses. Because of this, there is limited chances for private investors to invest properly in the production of electricity in Nigeria, despite the clamor for private investor to boost the general performance of PHCN, it has continuously yield no positive response.

Solution: It is anticipated that the new private sector owners of the power companies will act quickly to enhance the low skill base inherited from the public-sector monopoly and to remedy the lack of effective maintenance going back decades. The entry of investors into the sector would improve power generation and distribution across the country and perhaps reduce Nigerians' reliance on private generators which cost three times as much as direct supply. The need to promote investment and private participation in the electric sector is critical in improving the sector. Private investors should be encouraged to invest due to the likelihood of high profits and the government can support this by creating policies to revamp the industry. Also, they can help by giving out incentives, such as tax holidays, to entice investors.

Lack of Energy Mix: Lack of various energy sources is a major problem in the energy sector of Nigeria, the availability of energy resources such as crude oil, which the power sector mainly focus on, resulted in no alternate use of other source of energy for electricity usage.

Solution: Renewables now have an increased energy efficiency and there has been a telling increase in the adoption of renewable energy in Nigeria. Every decision comes with a cost; even renewables have their own challenges – complaints against the use of farmlands as solar farms persist and the efficiency of renewable energy products are only two of those. Deciding to make renewable energy as one of the nation's major sources of power is no easy task. The country needs to purchase new equipment, which means that Nigeria needs to spend millions just to supply power to its citizens. The most important thing is to lay all the costs and benefits – including remote and immediate ones – on the table and then decide which we can afford, not only in terms of naira and kobo but also in terms of what we end up doing to the environment and the people affected.

Vandalism of Generation Facilities: Recent religious crisis in the northern part of Nigeria as resulted in the vandalism of energy facilities, ranging from breaking the power plant and destroying the regional office of the energy commission of Nigeria.

Solution: The government must enable security agencies with the tools and training to fight vandalism properly. Also, there should be strict penalties for defaulters because of the losses and excruciating pain they inflict on the masses due to poor power generation and its concomitant effects on economic activities.

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