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NIGERIA ELECTRICITY INDUSTRY: ISSUES, CHALLENGES AND SOLUTIONS

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PREAMBLE

To God be all the glory. I am grateful to our Chancellor, Dr. David Oyedepo and the Management Team of this University led by our amiable VC, Professor C.K. Ayo for allowing me to deliver this public lecture today.

The topic of today's lecture concerns **Electricity** as it exists in Nigeria from the very beginning. The lecture will take us through the developmental stages of **Electricity infrastructure** in Nigeria from the beginning to what it is now.

We all know that the engine of life the world over, is the **uninterrupted electrical power supply**. We also know that there is a very strong link between the per capita consumption of electrical power and the state of physical advancement of a nation. This means that if the energy consumed per person in a nation is very high, more industries will be working, which leads to a strong nation. This is what every right thinking citizen of any nation will want but it is very sad to note that this is yet to be true in our country, Nigeria.

The above situation prompted me as a concerned Nigerian to want to discuss the circumstance of electricity as it pertains to Nigerian.

1. The History of Electrical Power Supply in Nigeria

1.1 Introduction

The history of electricity development in Nigeria can be traced back to the end of the 19th Century, when the first generating power plant was installed in Marina, Lagos, in 1898, fifteen years after its introduction in England. Its total capacity was 60kW. After the amalgamation of the Northern and Southern protectorates in 1914 to form modern Nigeria, other towns in the country started to develop electric power supply system on the individual scale.

The following major cities thus had a dose of electricity supply in the following order:

Port Harcourt 1928

Kaduna	1929
Enugu	1933
Maiduguri	1934
Yola	1937
Zaria	1938
Warri	1939
Calabar	1939

1.2 The Birth of Electricity Corporation of Nigeria (ECN)

The Government and NA owned systems remained separate operational entities for several years until 1946. In this year, the Public Works Department ceased to have control over the operation of the electricity generating plants and distribution system in the country. In the same vein, the Nigerian Government Electricity Undertaking (NGEU) was immediately established (as an arm of the Public Works Department) to take over the assets and liabilities of electricity supply in Lagos. Four years later, in 1950, a central body was established to take over all the various electricity supply outlets within the country. This body is referred to and addressed as the Electricity Corporation of Nigeria (ECN).Meanwhile, the Native Authorities (NAs) continued to manage their respective systems while Niger Dams Authority (NDA) was also inaugurated for the benefit of generating electricity through hydro power systems. As a result of this, the Colonial Government established the Electricity Corporation of Nigeria (ECN) under the ordinance no.15 of 1950.

The new body, i.e. ECN, officially took over all electricity supply activities in Nigeria in April 1951 by integrating all the Government-owned as well as native-owned generating plants and systems. This creditably improved the electric power supply in the country through grid connection of generation, transmission and distribution of electricity. Meanwhile, the sale of electrical energy was also done in such a way that the return on its investment had a common purse. This was later referred to as the vertically integrated utility (VIU).

With the increase in demand for electricity, some projects were carried out in Ijora, Oji River, Kano and Ibadan power stations to improve availability and quality of power delivery. Thus, the Ijora power station was commissioned in Feburary 1956 and it served satellite towns like Ikorodu, Shagamu, Ijebu-ode and other towns in the Ibadan-Ijebu provinces which provided the socio-economic transformation of these western states ahead of other parts of the country.

1.3 The Birth of Niger Dams Authority (NDA)

In 1962, an Act of Parliament established Niger Dams Authority (NDA) which was responsible for dam construction after discovering the innumerable benefits that would accrue from the Dam. This led to the construction of Kainji Dam in 1962 and was completed in 1968. The vast nature of the country grid power transmission system started operation in 1966 with the collaborative effort of the defunct ECN and NDA, which linked Lagos with Kainji. Kainji-Kaduna link was extended to Zaria and Kano. In the southern part, Oshogbo-Benin-Ughelli and Benin-Onitsha-Afam (Alaoji) links were constructed. Inspite of the great size of the country, the national grid now links the thirty-six state capitals and the Federal Capital Teritory Abuja.

1.4 The Birth of National Electricity Power Authority (NEPA)

On 1st of April 1972, ECN and NDA merged to form a unified body known as **National Electric Power Authority (NEPA)** with the actual merging taking place on the 6th of January 1973 when the first manager was appointed.

The network continued to grow under NEPA and between 1978 and 1983, the Federal Government had sponsored two panels of enquiry to fashion out models for restructuring NEPA into an independent unit or toward privatizing it out of monolithic nature. This led to the establishment of the electrification boards whose work is to take power supply to the rural areas and new cities.

1.5 The Birth of Power Holding Company of Nigeria (PHCN)

By 1999-2005 (The advent of democratic government), an act was enacted establishing PHCN, an Initial Holding Company (IHC), as a result of Government effort to revitalize power sector. This was an intended name for privatization which was meant to transfer assets and liabilities of NEPA to PHCN. It was officially commissioned on the 5th of May 2005 and was to carry out business of NEPA which is still on. In the same vein, the **National Integrated Power Projects (NIPP)** was inaugurated in 2004 to be able to catalyze and fast track the upgrading of adding more capacity to the current available electricity capacity in the country. This was basically a private iniative which is currently being supervised by the **Niger Delta Power Holding Company (NDPHC).**

1.6 The Unbundling of PHCN

The PHCN, as a Company, was unbundled into 18 companies as follows: **six (6) generating companies, one (1) transmission company (i.e. Transmission Company of Nigeria-TCN), and eleven (11) distribution companies. The generating companies are Egbin Electricity Generating Company (EEGC), Sapele, Ughelli, Afam, Shiroro and Kainji. There are also some new Independent Power Producers under the auspices of the Niger-Delta Power Holding Company (NDPHC). The 11 distribution companies are Abuja Electricity Distribution Company (AEDC), Benin Electricity Distribution Company (BEDC), Eko Electricity Distribution Company (EkEDC), Enugu Electricity Distribution Company (EnEDC), Ibadan Electricity Distribution Company (IbEDC), Ikeja Electricity Distribution Company (IkEDC), Jos Electricity Distribution Company (JEDC), Kaduna Electricity Distribution Company (KdEDC), Kano Electricity Distribution Company (KnEDC), Port-Harcourt Electricity Distribution Company (PHEDC), Yola Electricity Distribution Company (YEDC).** Currently, the Federal Government owns **100%** of the transmission company, while its hold on the generating companies is **20 per cent (with 80 per cent** of equity sold to private investors) and in the case of the distribution companies, eleven of them that have been sold, government only sold **60 per cent** and is still holding **40 per cent**. In other words; the transmission company of Nigeria (**TCN**) is **100 per cent** owned, generating companies (GENCOs) **20 per cent** owned by government and **80 per cent** private sector ownership. For DISCOs, **60 per cent** owned by private sector, **40 per cent** owned by government. The TCN is controlled by the government (nonetheless, the management of TCN is handled by the Canadian company, Manitoba Hydro Company). On the **30th of September 2013,** the Federal Government handed over certificates of ownership to prospective owners. Since then the generation and distribution of electricity have been transferred to the private investors. Meanwhile, a mid-term assistance from the Government is expected to take place later this year. On **Wednesday February 12, 2014,** the Nigerian Electricity Regulatory Commission at the meeting held with power generating and distributing companies in the country unanimously agreed that the Transition Electricity Market (TEM) idea should be left in the cooler for the meantime. The full import of this is that the electricity industry in the country is believed to currently operate in the transition regime.

2.0 THE BENEFITS OF THE UNBUNDLING PROCESS.

2.1 Impact of Uninterrupted Power Supply.

Electricity is the hub of both economic and techological development. The electricity industry in the developing countries has gone through quite a lot of metamorphosis in the recent past.

Electricity supply is a very sensitive issue with several political and economic sophistications in many countries which most of the time define the industry's effectiveness. Thus, it has continuously drawn great attention from both the industrialists and the political class. As a matter of fact, it has become a veritable avenue to gaining more votes during elections. This is just because if a politician can easily tackle issue of unavailability of electricity supply, then, such is considered a national hero. More important is the fact that every other sector of the economy depends on adequate supply of electricity.

2.2 The Birth of Electric Power Sector Reform (EPSR)

As discussed earlier on, due to lack of efficiency in the power sector in Nigeria, the Nigerian Electricity Supply Industry (NESI) was unbundled into eighteen companies comprising 6 generating companies (GENCOs), 1 transmission company (TRANSYSCO) and 11 distribution companies (DISCOs). The bill that brought about the transformation of the Power Holding Company of Nigeria (PHCN) from vertically integrated utility to this unbundled companies was signed into law in 2005. It was christened the **Electric Power Sector Reform (EPSR) Act 2005.** The intention of this metamorphosis is to ensure improved system reliability, but this is very difficult to achieve because of the poor system maintainability that has been the bane of the system for a very long time.

2.3 Effects of Faults on Electricity Supply.

The essence of the unbundling of the three segments of the electric power supply system is to bring about better maintainability and reliability of the system, each of the segments contributes to the ultimate provision of electricity at the load end. Thus, due to the distance between the generating station and the load point, the system is bound to be weak and vulnerable along this line which can easily engender failures at various points. The occurrence of this fault results [2] in

- deterioration of the system's reliability and availability of service.
- destruction of sensitive electrical industrial appliances.
- loss of revenue.
- security threats to the military intelligence.
- loss of life in hospitals when operation is in progress and when patients are on life support systems.
- national embarrassment.

It is important to categorize some of the faults that are mainly encountered in power system as follows[2]:

For generators:

- instability of exciters due to sudden load increase and armature reaction.
- complete loss of field which makes the synchronous generator to pull out of synchronism.

For transmission and distribution systems:

- deterioration of insulation (in the case of transformers).
- damage due to natural effects such as bird perching on the lines, felling of trees on the line or even other natural disasters like wind storm, etc.
- fault generated due to sudden switching or other disturbance in the system.
- collapse of insulation due to lightning strikes.

To reduce the frequency of occurrence of these faults (and some others not mentioned above), there are three major and essential factors that must be given priority in electric power sector. These are

- proper commissioning of the electrical plants before usage. In the process of preparing the system for commissioning, the engineers are expected to carry out preliminary tests on every aspect of the system operation which would afford them the opportunity to identify the specific parts that may fail later and prepare adequate remedies for such occurrence.
- appropriate operation of electrical plants as a means to prolong the life span of the equipment. Hence it is important to operate the electrical power equipment below their respective maximum rated current and rated running temperature rise. So, strict adherence to the operational rules of the equipment is very essential to guarantee a lasting operation of the equipment.
- regular maintenance of the equipment is also essential for a long life expectancy of the electric power equipment.

But interestingly, Nigeria's engineering facilities have been deficient in these areas because of several reasons that are going to be considered later in this Lecture

The Governements of many of these nations **such as India, China, Mexico and South America in general** have been trying to ensure that most of the investement in the industry is committed to the management of the private investors. This has led to the unbundling of the industry for the private sector to buy it up. This is believed to have an impact on the reliability of service. Hence, mostly this has led to a very wonderful performance in the industry.

2.4 The Appalling Maintenance Culture of Electricity Equipment in Nigeria

The issue of maintenance of electric power equipment is of paramount national interest. This is due to the colossal amount of money spent on replacing some of these power equipment if left without maintenance for several years of operation. It is appalling that the Nigerian electricity supply industry (NESI) lacks patronage from investors after more than 5 years of its unbundling advertisement for would-be investors[1,2,3,5]. This has a lot to do with the current state of most of the power equipment in the industry. And the status of equipment has quite a lot to do with its age and the degree of maintenance it has enjoyed.

Maintenance is defined [3] as the combination of all technical and administrative actions with the intention of retaining an equipment in (or restore it to) an operating state in order for it to perform its required functions. It can also be defined as any work undertaken in order to keep or restore a facility to any acceptable standard [1,3]. The challenges of maintenance engineering infrastructures reached a very embarrassing state that the **Nigerian Society of Engineers (NSE)** had to organize several seminars and workshops on the subject matter from time to time [2].

The privatization of the power sector has suffered a setback through the lack of good maintenance culture which has resulted in a number of situations whereby the industry has remained unviable to investors

[4].This is depicted by lack of maintenance that was witnessed in that sector in which there was little or no investment in the industry for a long time [1,4].

2.5 The General Concept of Maintenance as Perceived by NESI

There are two broad types of maintenance namely: preventive and corrective maintenance. The preventive maintenance includes condition monitoring and planned outages[2,3]. In other words, preventive maintenance aims at preventing the occurrence of faults. This keeps the equipment running in its optimal condition which thus guarantees efficient power supply.

On the other hand, the corrective maintenance is only useful after the occurrence of fault. This situation is often common where non-critical equipment outside the program of preventive maintenance fails [5]. By engaging in maintenance, it is possible to modify the older equipment in order to enhance production or safety. Beyond this, is the fact that the replacement of the older equipment by the new and more energy efficient ones bring about better productivity and quality of service [6].

According to [5], the issue of equipment maintenance is a sensitive matter that has, in recent years, attracted an increasing attention. So, [7,9] stated that maintenance of equipment is tightly related to the reliability of such equipment. Thus, the former influences the efficient and effective functioning of a facility. Recently, a new set of pressure group on climate change has been appealing for installation of more efficient electrical machines for the generation of electricity. This, it is believed, will reduce the volume of exhausted fumes that result in low carbon emission which prevents debilitating climate change and safety issues[8,9].

The research into maintenance culture is very important for NESI in this era of electricity deregulation. This is because maintenance is a complex task that influences several other factors in the industry, ranging from aging of equipment to availability of service, which translates to adequate return on investment (ROI) [2,5]. Due to lack of regular training, the human factor accounts for a great deal of the power sector's current debilitating condition [6,8]. This is aggravated by unavailability of specialized engineers and technicians for certain tasks as well as unpreparedness of the industry to pay equitable amount as hazard allowance and insurance policy attached to the workers. According to [5,7,9], rigid organizational structures can also inhibit change and be detrimental to the effectiveness of maintenance culture.

According to [2], a well developed power system integrates a large number of generating stations, transmission stations, switching stations and then distribution stations. The maintenance of each of these stations has its own peculiarity even though none of them is mutually exclusive in operation. This suggests that lack of good maintenance at any of these stations is capable of sabotaging the quality of service provision of the power supply utility[8, 10].

On the other hand, in the case of NESI, there are many reasons that have contributed to the lacklustre attitudes to the maintenance culture in Nigeria[3,6,9]. These include the Nigerian factor. This is evident in the lack of interest in equipment maintenance once such an equipment is still active in the service delivery. The engineers have reported that at times the money earmarked for maintenance ends up in private pockets[9,11,12]. This is very common where non-professionals are at the helms of affairs in purely an engineering enterprise or corporation. In this kind of situation whereby the equipment can still deliver service, even at a less efficient capacity, these non-professionals would not appreciate the necessity of planned or scheduled maintenance [11,12]. From this, it could be said that the Nigerian environment has not been very conducive for maintenance but for repair of equipment. Another school of thought remarked that since Nigeria is not manufacturing any of the electric power equipment locally, it would become very difficult to ensure that the spare parts for maintenance would always be available [10]. The argument is that the spare parts of a particular model may have been phased out by the manufacturers to pave way for newer and more efficient products, which means that even when the engineers are competent of maintaining such equipment, it becomes very difficult securing appropriate spare parts for necessary replacement of old and worn-out parts of the machinery [2,3,7,10,12].

2.6 The Sad Situation of Power Supply in Nigeria

The current status of electricity generated in Nigeria with regard to its population is grossly inadequate. This challenge has been in existence since 1970s when the Udoji's Federal Government awards improved the economic life of the workers. According to [8], this made the workers to increase their electricity consumption by purchasing several sophisticated and automating machines that consumed quite a lot of energy. The power utility company, on the other hand, was not prepared for this increase in consumption. This challenge has consistently left a deficit in consumption and generated electricity ever since that period in the Nigeria's electricity consumption history. Thus, this has led to consistent imbalance in the demand and the supply of electricity.

Table 2.1 shows the relationship between the generated electricity and *per capita* energy consumption of Nigeria with reference to that of internationally acclaimed world superpower i.e. USA. The electricity consumption in Nigeria is unacceptable for the growth of world economy.

Table 2. 1: Nigeria and USA Power Sector Relationship [9]

Country	Population (Million)	No. of States	Generation (MW)	Per Capita Consumption (KW)	Status
USA	250	51	813,000	3.2	Developed
Nigeria	Over 120	36	Below 4,000	0.03	Under Developed

This challenge further confirms the reason behind a poor performance of the Nigerian economy as reflected in table 2.2 which shows energy with respect to economy as reported for Years 2003 to 2008[10]:

Table 2.2: Relationship between energy and economy [10]

S/N	Indicator	2003	2004	2005	2006	2007	2008
1	Real GDP Growth (%)	9.6	6.6	6.5	6.0	6.2	6.4
2	◦ Major Contributors to GPD @ 1990 Constant Prices:						
	•Agriculture (%)	41.010	40.98	41.19	41.72	42.20	42.07
	.•Crude Petroleum (%)	26.53	25.72	25.26	21.85	19.35	17.54
	◦ Major Contributor to Federal revenue (net)						
	•Crude Petroleum (%)	75.0	77.0	72.4	76.7	67.7	71.8
3	Energy Intensity (kgoe/$) (Energy Consumption/GDP)	0.244	0.186	0.157	0.086	0.063	0.069
4	GPD/Capita (US$)	620.9	673.2	847.4	1,036,2	1,256.6	1,176.1
5	Energy Consumption/Capita (kgoe/capita)	151.3	125.5	132.6	87.1	81.4	80.8
6	Electricity consumption/capita (kWh/capita)	174.6	176.4	181.4	167.6	161.2	142.9
7	Electricity Access (%)	55.2% from 40% in 1993					

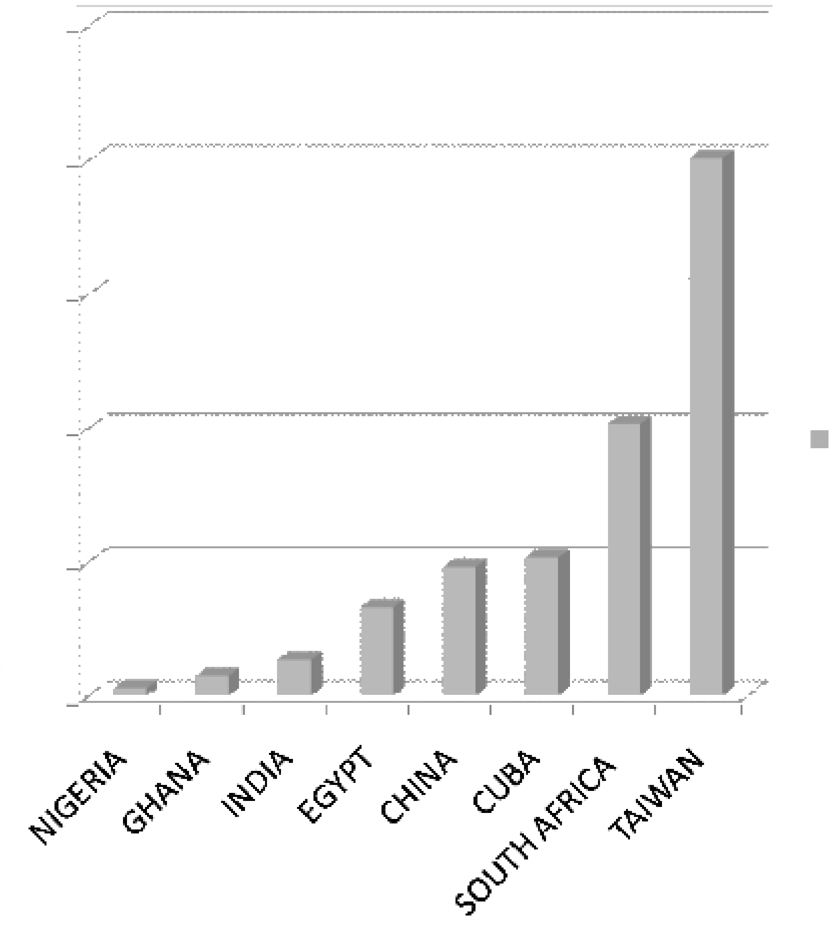


Figure 2.1: Energy per capita for some developing countries [10]

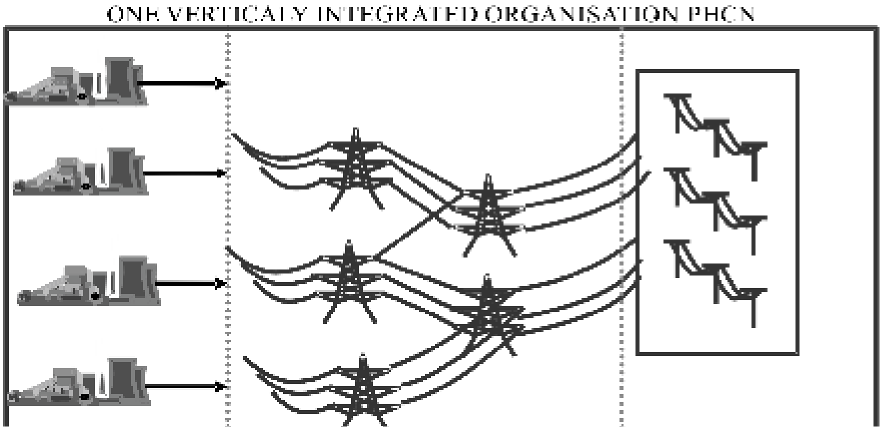
The assessment would not be representative enough if it does not articulate what makes up the infrastructure of NESI. Figure 2.2 presents the structure of the power system as a vertically integrated utility (VIU) [10]. There are three major segments namely: generation, transmission and distribution segments and each of them performs specific duties in the provision of electricity[1]. The generators are the source of the energy which is then transported after transformation of the voltage from low level to high level voltage. At this high level voltage, power losses due to transportation are reduced but not eliminated. At the distribution station, this high voltage is then stepped down. To achieve the various processes mentioned above, the engineers require a lot of expertise and efficient tools to ensure that the generated power is not in any way wasted. This has led to provision of circuit breakers, power transformers; switch gears, instrument transformers, condensers, etc.

All these equipment must be well maintained to ensure that the availability of supply is not curtailed by inappropriate actions by these tools. Table 2.3 compares the available capacities of each of these segments **pre-1999** with those of after**-1999**. Note that Year 1999 is a significant year in the history of Nigeria due to the transmutation of the nation from military rulership to civilian governance. The full import of the profile of the NESI is felt better using a funding chart for a number of years as presented in figure 2.3.

Superimposition of Table 2.3 with figure 2.3 shows a picture that reinforces the fact that funding of the industry was very low or even non-existing between 1983 and 1998. Until the advent of civil rule in 1999, no major development was witnessed in the industry. At this time, the whole infrastructure has become dilapidated and hence needed to be scrapped and rebuilt. Table 2.4 shows the historical background and metamorphosis of electricity industry in Nigeria from 1896 till date, in which case the growing demand for electric power was the moving force behind the expansion and transformation [4].

Table 2.3: PROFILE OF THE ELECTRICITY INDUSTRY INFRASTRUCTURE [10]

	Pre-1999	Post-1999
• Generation		
- Thermal	4,058MW	5,010MW
- Hydro	1,900MW	1,900MW
Installed capacity	5,996MW	6,910MW
Available Capacity	1,500MW	4,451MW
• Transmission.		
- 330kv line	4,800km	4,889.2km
- 132kv lines	6,100km	6,284.06km
Transformer capacity		
330/132KV	5,618MVA	6,098MVA
132/33KV	6,230MVA	7,805MVA
• Distribution.		
- 33kv lines	37,173km	48,409.62km
- 11kv lines	29,055km	32,581.49km
- 415v lines	70,799km	126,032.79km
Transformer capacity	8,342.56MVA	12,219MVA



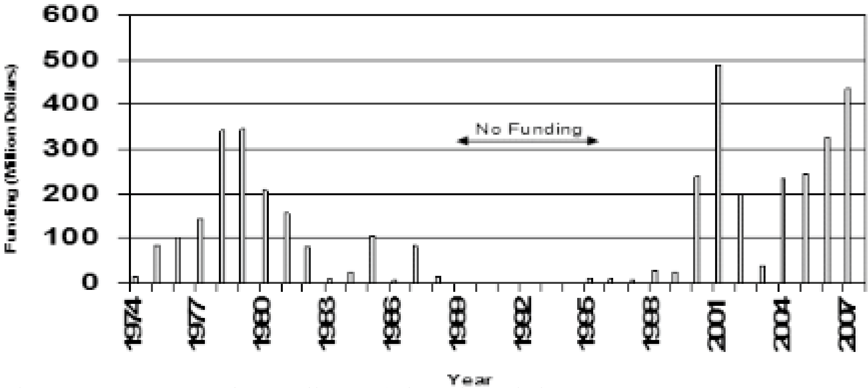


Figure 2.3: Annual Funding of the electricity sector [4]

Table 2.4: Compact Metamorphosis of Nigerian electricity Supply Industry (NESI)

Organisation or authority	Date of transformation
Public Works Department (PWD)	**1896**
Electricity Corporation of Nigeria (ECN)	**1950**
Niger Dams Authority (NDA)	**1968**
ECN + NDA, merged	(NEPA), **1972**
GENCO (6 companies)	NEPA rechristened as PHCN and controlled by NERC, **2002**
TRANSYSCO (1 Txn company)	
DISCOs (11 companies)	

3.0 THE SPIRAL EFFECTS OF INSUFFICIENT FUNDING ON POWR AVAILABILITY

3.1 Lack of Latest (modern) Equipment

Whenever there is no fund, it practically suggests that the necessary and energy efficient machineries will definitely not be made available. Once the old machines are still in service, the frequency of occurrence of faults would be very many. Not only this, old age and long usage always reduce the efficiency of the machines. This means that it will be consuming more fuel than necessary to generate very meagre amount of electricity.

3.2 Policy on Engineering Infrastructure

Due to lack of local factory, it has become seriously difficult for the nation to support the industry with locally manufactured spare parts. The establishment of National Agency for Science and Engineering Infrastructure (NASENI) and operation of Ajaokuta Steel Rolling Mill would have been able to assist in manufacturing some of these electrical equipment. But this is not possible especially because there is no policy that supports the manufacturing of the machines and their peripheries . And the Government has not entered into any franchise with the manufacturers of these equipment [11].

3.3 Low Morale Among the Workers and Embargo On Employment

The Nigerian engineers are among the best in the world, but due to politics of appointing a political figure as the head of the parastatal, they generally lose interest in the system[12]. This is because the competent engineers have seen it as a way of relegating them and their contributions to the industry to the back ground. This has dampened their enthusiasm at developing ingenious maintenance approach for effective and efficient running of the power industry. Most of these non-professionals do not appreciate the essence of engaging in routine maintenance and scheduled maintenance. To further aggravate the situation, there has been embargo on employment of fresh graduates into the industry. This portends a very dangerous signal in the sense that there is imminent crisis of generation gap being created by this kind of policy. That means when the older generation of engineers is retiring there would not be enough tested hands to take over from them[12].

Since engineering is a very dynamic profession, it is compulsory for practising engineers to always be involved in constant and regular training and retraining programmes. This equips the staff with the new challenges related to their fields and how to tackle such challenges in the new century but it is appalling to learn that there is great apathy towards training for some time in the industry.

3.4 Peculiarities of Transmission and Distribution Networks [5,12]

Until recently, there was no serious consideration for the reinforcement of the transmission network. Consider Tables 3.1 and 3.2, if the total installed capacities of all the generating units are added together, there is no way the currently available transmission capacity can transport the power generated. Thus, the recent effort towards the expansion of the existing transmission network is encouraging. This is possibly going to be able to overcome the challenges faced by the existing network which is radial in topology. This kind of connection makes the network very vulnerable and weak in which case whenever a fault occurs the whole nation will be without electricity supply [4,9].

Moreover, the steady increase in distribution power demand has created a chasm in the transmission capacity at the respective transmission stations and the associated distribution feeders, this results in local load shedding [11, 12]. Most of the existing switchgear units are over 30 years old and are no longer serviceable due to lack of spare parts[5, 10,12]. This has resulted in their constant break down which has further aggravated the poor power supply situation.

In the case of the distribution network, some power transformers are faulty thus requiring repairs and /or replacement while many transformers are overloaded leading to frequent load shedding. This is further exacerbated by the unscrupulous practice of connecting several electrical loads without the knowledge of the utility staff. This particular activity has rendered the mathematical modelling developed by the engineers (with respect to real time load requirement and future load forecast) useless.

In many cases, the relays and tripping units for the protection and control of the system lack sufficient substations. Many of the power substations are old/faulty and obsolete in status hence requiring replacement. More often than not, it is observed that there are many 33-kV lines traversing more than 200kilometers of geographical area. These lines are replete with numerous T-offs without sufficient transmission switching stations, thus, resulting in frequently recorded forced outages and high technical losses. This scenario is not limited to only the transmission line alone. As a result of insufficient distribution transformers, many 415-V lines criss-crossing several thousands of kilometres result in poor voltage profile and high technical losses (see table 2.3).

The challenges of overload are very peculiar with many of the overhead conductors and underground cables currently in use. These are grossly inadequate for wheeling the power, thus resulting in high technical losses in the network.

Reference [8] once painted the electricity industry scenario in very articulate fashion when it was stated that a shortfall of between 9,000 and 17, 000MW in energy usage would be recorded between 2010 and 2015 based on the current energy demand and the projected growth rate in industrial development and the population. The projected peak national energy demand is put at between 28,000 and 31,000MW by 2015. Revised demand projection by the Energy Commission of Nigeria (ECN) has suggested a growth rate of 10%. This research has stated that Nigeria's peak demand would be in the neighbourhood of between 175,000 and 192,000MW by 2030. **From this record, the period under review is less than twenty years from now, but there is no concerted effort, yet, by the stakeholders on how to meet this target.**

Table 3.1 : Planned Installed Capacity of electricity supply power plants in Nigeria

Planned Plants	Types	Installed Capacity(MW)	Year To be Commissioned
Papalanto	Gas	330	2007
Omotosho	Gas	330	2007
Geregu	Gas	414	2007
Alaoji	Gas	330	2007
IPP (Oil companies)	Gas	3909	2007 -2008
IPP (Non-oil companies)	Gas	2584	2007 -2008
Total Planned Installed capacity	-	**7897**	-

Sources: National Electric Power Authority. Power reform and generation plans in the public and private sector. Abuja, Nigeria, November 2004.

Table 3.2 : Existing Capacity of electricity plants in Nigeria

Existing Plants	Types	Installed Capacity (MW)	Available Capacity (MW)**	Year Commis sioned
Jebba	Hydro	578.4	165	1984
Kainji	Hydro	320	121	1968
Kainji	Hydro	200	-	1976
Kainji	Hydro	240	-	1978
Shiroro	Hydro	600	234	1990
Afam I	Gas	20.6	}	1963
Afam I	Gas	35	}	1965
Afam II	Gas	95.6	} 7	1976
Afam III	Gas	110	}	1978
Afam IV	Gas	450	}	1982
Ijora	Oil	6.7	-	1966
Ijora	Gas	60	-	1978
Delta I	Gas	72	}	1966
Delta II	Gas	120	} 22	1975
Delta III	Gas	120	}	1978
Delta IV	Gas	600	110	1990
Sapele GT	Gas	300	247	1981
Sapele ST	Gas	720		1978 & 1980
Oji	Coal	300	-	1956
Egbin	Gas	1320	718	1985
AES (Egbin - IPP)*	Gas	270	-	2004
Total Existing Installed Capacity		**6538.3**	**1694.0**	

Sources: National Electric Power Authority. Annual Technical Report. National Control Centre, Osogbo, Nigeria. Various editions (1985- 1992). *National Electric Power Authority: Power Reform and Power Generation plans in the public and private sector, Abuja, Nigeria, November 2004.

*** Generated Power for a particular day in 2006*

4.0 THE GAINS OF IMPROVED MAINTENANCE CULTURE

4.1 Introduction.

The recent investment by the Government in the electricity sector has a promising solution to the challenges of long years of neglect of the industry. There is also a need for concerted efforts in dealing with the issues raised earlier on with regard to the way forward for this very sensitive and important industry. The solution is by implementing an effective maintenance culture.

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For the full appreciation of this**, r**eference [9] compared the electricity consumption *per capita* of the USA with that of Nigeria as shown in figure 2.1. It must be stated that if the maintenance culture is improved upon by Nigeria, then the facilities could witness an improvement in delivery of power beyond the current level.

4.2 Relationship Between National Development and Maintenance Culture

The recent history of NESI has painted a very pathetic picture of the maintenance culture in Nigeria. This has hampered the industry from meeting the statutory obligation of providing cheap, clean and efficient source of energy to the electrical loads. Thus, national development has been **seriously slowed down** . To this end, it is clear from what is on ground now that current and existing state of the facilities and equipment in the industry has led to the below average in the performance of this equipment [3]. This poor performance is very strongly linked with poor maintenance culture by the stakeholders.

Tables 4.1 and 4.2 capture the average system availability with respect to power output from each of the generating stations in the country in **the** Years 2004 and 2005 respectively. Most available capacities of these generating stations are between 60% and 80% of the installed capacities of the various generating stations as evidenced in table 3.2.

The technical reason behind this inefficient performance of the stations is fully portrayed in table 4.3 which identified the status of each of the generating units in each of the generating stations within the period under review.

Tables 4.1 and 4.2 could not have performed better. This is due to the scenario presented in Table 4.3 which showcased the status and condition of operation of each of the units under each generating station in the period under review. It can be seen clearly form Table 4.3 that most of the units are bedeviled by several abnormalities, ranging from high bearing temperature problem to generator-transformer problem which are basically due to deficit in maintenance culture. At the Delta station for example, most of the units are in operation but they are mainly threatened by several faults, ranging from transformer fault, ground fault, and gas fuel problems. At the Sapele station, the case is not different with such faults as high drain oil temperature and turbine failure problems. So also is the case of Egbin, in which case the control valve problems are identified with a number of units. The pathetic case of Ijora is that none of the units in this station is in operation due to poor maintenance culture, while the Calabar station is not even known to many as a generating point due to perennial problems of starting and noise which have rendered two out of the three units in this station redundant.

Table 4.1: Monthly average generated capacities in 2004 [3,4]

MONTHS	KANJI	JEBBA	SHIRORO	SAPELE	AFAM	EGBIN	DELTA	IJORA
	MW	MW	MW	MW	MW	MW	MW	MW
JANUARY 2004	478.10	531.29	551.61	134.42	213.55	1050.48	498.16	11.3
FEBRUARY 2004	489.83	533.79	475.86	138.14	147.93	1046.31	498.45	9.83
MARCH2004	464.55	537.10	459.68	145.97	134.68	990.81	473.23	11.61
APRIL 2004	471.17	531.00	470.00	130.60	130.10	1162.27	466.27	8.00
MAY 2004	427.55	540.00	483.87	160.19	62.00	1225.00	499.61	15.00
JUNE 2004	412.90	493.10	546.97	97.80	98.53	970.33	491.63	15.00
JULY 2004	397.81	540.00	523.61	61.45	159.39	1050.23	437.77	9.19
AUGUST 2004	349.19	445.16	553.52	86.19	156.61	1161.87	475.19	2.90
SEPTEMBER 2004	378.50	461.70	575.03	111.23	189.40	1019.33	357.17	0.50
OCTOBER 2004	382.16	542.84	503.23	128.32	176.06	769.68	397.10	0.00
NOVEMBER 2004	294.43	348.40	380.00	139.40	188.23	945.67	479.63	6.50
DECEMBER 2004	353.39	252.52	358.06	113.81	175.61	1249.84	486.32	6.29
ANNUAL AVERAGE CAPACITY FOR YEAR 2004	408.30	479.99	490.12	120.63	152.70	1053.48	463.38	8.00
INSTALLED CAPACITY	760	578.4	600	1020	969.6	1320	912	40

TABLE 4.2: Monthly average generated capacities in 2005 [3]

MONTHS IN YEAR 2005	KANJI	JEBBA	SHIRORO	SAPELE	AFAM	EGBIN	DELTA	IJORA
	MW	MW	MW	MW	MW	MW	MW	MW
JANUARY 2005	350.65	516.77	391.94	122.35	117.74	1127.90	499.45	0.00
FEBRUARY 2005	394.21	405.00	440.36	121.86	63.39	1259.64	395.00	0.00
MARCH2005	403.42	486.90	442.58	153.77	200.16	1145.42	396.94	0.00
APRIL 2005	368.33	444.67	462.00	152.20	181.50	1216.57	374.63	0.00
MAY 2005	299.39	327.58	421.35	130.52	201.58	1146.97	362.00	0.00
JUNE 2005	509.00	414.00	410.00	148.27	224.07	1191.00	365.27	0.00
JULY 2005	492.26	446.45	521.94	138.26	166.58	1266.45	311.87	0.00
AUGUST 2005	465.87	461.61	488.71	128.45	339.84	1144.84	347.42	0.00
SEPTEMBER 2005	427.17	465.00	405.57	98.33	293.90	1084.63	340.90	0.00
OCTOBER 2005	432.90	513.87	590.32	26.00	309.65	1115.48	401.97	0.00
NOVEMBER 2005	398.60	468.00	600.00	35.90	296.37	1136.63	427.10	0.00
DECEMBER 2005	399.52	502.26	590.32	0.00	259.65	927.81	498.90	0.00
ANNUAL AVERAGE CAPACITY FOR YEAR 2005	411.61	454.34	480.42	104.68	221.20	1147.78	393.45	0.00
INSTALLED CAPACITY	760	578.4	600	1020	969.6	1320	912	40

Table 4.3: Status of Plants in the Power Stations in Nigeria Electricity Supply Industry (NESI) [3]

Power Station / Plant	State of Plant	Duration of Outage	Fault
(a) Sapele P/S □ ST1	Working	Out of Service between September 2005 and December 2005	Fire outbreak on cables after system collapse
□ ST2	Not Working	Out of Service since September 2002	High bearing problem
□ ST3	Not Working	On outage since May 2000	Generator transformer problem
□ ST4	Not Working	Forced out of Grid since 3rd Quarter of 1994	High winding temperature fault
□ ST5	Not Working	On outage since March 1986	Unit transformer and associated switchgear burnt
□ ST6	Working	On and Out of service (intermittently)	Bearing problem

□ GT1	Not Working	On outage since September 1998	Damaged turbine blades
□ GT2	Not Working	On outage since July 2002	High compressor vibration problem
□ GT3	Not Working	On outage since April 1990	Generator-transformer faults
□ GT4	Not Working	On outage since April 1990	Starting equipment failure and generation transformer fault
(b) Afam P/S			
GT1	Not Working	Out of Service Since 4th Quarter of 1993	Beyond rehabilitation
□ GT2	Not Working	Scrapped	Scrapped
□ GT3	Not Working	On outage since February 1990	Damaged exciter and generator baring problem
□ GT4	Not Working	On outage since February 1998	Rotor balancing and labyrinth seal problem
□ GT5	Working	On and Out of service (intermittently)	Requires major overhaul
□ GT6	Working	In service	However, it sparks due to exciter carbon brushes
□ GT7	Not Working	On outage since 2004	Burnt generator breaker and control cable faults
□ GT8	Not Working	Out of service since April 1988	Damage turbine inner casing and turbine blade

			Failure
GT9	Not Working	On outage since 4th Quarter of 1995	Requires Major overhaul
GT10	Not Working	On outage since 2002	Major rehabilitation in progress
GT1	Not Working	On outage since August 1998	Oil drain high temperature
GT12	Not Working	On outage since August 1998	Turbine failure
GT13	Not Working	On outage since February 1997	Compressor blade failure
GT14	Not Working	On outage since April 1992	Require major overhaul
GT15	Not Working	Out of service since 1995	Damaged compressor blades
GT16	Not Working	Out of service since 1992	Loss of excitation
GT17	Working	On and out of service (Intermittently)	Burnt generation circuit breaker, oil leakage, etc
GT18	Working	Out of service 2002	Compressor blade failure
GT19	Working	Intermittently	Stator Earth faults
GT20	Working	Intermittently	Excitation problem
(c) Delta P/S GT1	Not Working	Scrapped	Scrapped
GT2	Not Working	Out of service since July 1998	Require major overhaul
GT3	Working	–	Occasionally have starting problems
GT4	Working	–	Occasionally have starting problems
GT5	Working	–	Occasionally have excitation problems
GT6	Working	–	–
GT7	Working	–	–
GT8	Working	–	–
GT9	Working	Out of service between April 1993 to November 2005	Vibration and compressor blade failure
GT10	Not Working	On outage between July 2002 to November 2005	Tripped on Ground Fault
GT1	Working	Intermittently	Transformer Faults
GT12	Working	Out of service between April	Generator field ground faults

		1998 to November 2005	
GT13	Working	Intermittently	Exhaust Temperature and vibration faults
GT14	Not Working	Out of service since October 1986	Burnt generator winding
GT15	Working	Intermittently	Hydrogen leakage problems
GT16	Working	–	Combustion problem
GT17	Working	–	Gas fuel problem
GT 18	Working	On outage between February to August 2005	Tripped High exhaust temperature
GT 19	Working	On outage since 1988	Combustion problem
GT 20	Working	On outage between January 2004 and September 2005	Accessory gear compartment oil leakage
(d) Egbin P/S ST 1	Working	–	
ST 2	Working	–	Control Valve problem
ST 3	Working		
ST 4	Working		
ST 5	Working	–	Intercept gate control valve
ST 6	Working		
(e) Ijora P/S GT 4		Awaiting commissioning	Inefficient fuel supply
GT 5	Working		
GT 6	Not Working	On outage since May 1999	High vibration

(f) Calabar P/S EE I	Not Working	On outage since March 2002	Burnt bearing
L EE 2	Working	Intermittently	Abnormal noise Problem
L G M6	Working	On outage since May 1999	Starting Problems

Table 4.4: Average availability of Power Stations for 2004 and 2005

Power Station	Average Availability in Jan 2004 (MW)	Average Availability in Jan 2005 (MW)	Half Annual peak (MW)		Annual Average Generation(MW)	
			2004	2005	2004	2005
Sapele	134.4	122.6	160.2	153	120.6	104.7
Afam	213.6	117.7	213.6	224.1	162.7	221
Delta	498.2	499.5	499.6	499.5	463.4	393.5
Egbin	1060.5	112.7	1225	1299.6	1053.5	1147.8

Table 4.5: Summary of PHCN Generation Capabilities as operated in 2004 and 2005 [3]

Power Station	Availability Factor		Average MW Availability		Installed Capacity
	2004	2005	2004	2005	
Sapele	0.1182	0.10	120.6	104.68	1020
Afam	0.2451	0.36	152.7	221.20	600
Delta	0.5081	0.43	463.38	393.45	912
Egbin	0.7981	0.87	1053.48	1147.78	1320
Ijora	0.1230	0.00	8.0	0.00	63
Kainji	0.5372	0.54	408	411.61	760
Shiroro	0.8169	0.80	490.12	480.42	600
Jebba	0.8299	0.79	179.99	454.34	578.4

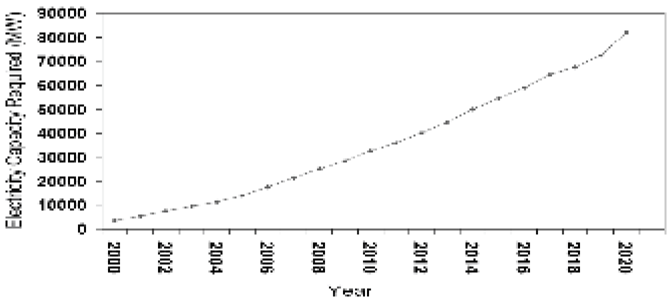

Figure 4.1: Future forecast of electricity demand for vision 20-2020 [4]

In line with this, it can be concluded [13] that for subsistence of engineering facilities and equipment, the capacity building is very crucial. This means that sustainable maintenance culture must be entrenched in electricity industry by all the stakeholders. On the long run, the maintenance plan is further strengthened by the development of Project planning matrix to include monitoring and evaluation with the sole purpose of ensuring a planned and scheduled maintenance.

5.0 Recommendation and Concluding Remarks.

From the foregoing, the assessment of the system availability was carried out by [3,4], some of the reports of the assessment studies are presented in Tables 4.4 and 4.5. In which case, it is concluded that due to the pathetic situation of the supply output from the industry, there are periods in which the available electricity is far below 0.5 per unit which has a grievous impact on national development because, according to [6], it means all the artisans and several commercial and industrial outfits would not be able to contribute productively to the national development through their various trades. The attendant results are the evident poverty and lack of development at all facets of the economy. The influence of the robust maintenance principles cannot be underestimated in the outcome of the level of electricity production and its chain effect on the economy.

The graph in **figure 4.1** shows the projected electricity consumption that the nation needs as forecast by [4]. The work was done to assist the government in realizing its expectation with regard to vision 20-2020. Though, it is a good academic proposal which closely corroborates the one done in ref [8]**,** it is necessary to state that this magnitude of electrical energy can only be achieved when the stakeholders in the electricity industry in Nigeria take into account the importance of good maintenance culture as the unavoidable wheel for driving national development and the ultimate attainment of vision 20-2020.

Although the author is fully aware of the on-going unbundling process, he believes that the myriads of problems plaguing **e**lectricity supply in Nigeria are not beyond the capabilities of Nigerian **e**lectrical **e**ngineers and other allied professionals.

Virtually all universities and polytechnics in Nigeria are currently running accredited / approved electrical engineering programmes; there is no reason these institutions cannot be asked to find solutions to these electricity problems.

In addition to the above, there are many Nigerian electrical engineers on the ground now, who possess the requisite experience to confront such problems if approached.

The government can take the bull by the horn by challenging these Nigerian engineers to find lasting solutions to these problems. In that wise the Federal Government must be ready to make all the necessary wherewithal available to these engineers.

I only wish the Federal Government can listen and act swiftly. It is not too late to find the local solution to the problems of electricity supply in Nigeria.

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