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Ways of Achieving Stable and Uninterrupted Power Supply of Electricity in Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors KKO and AMO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and manage the literature searches. Authors KKO, AMO and AOA managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The supply of stable power supply of electricity to consumers is the backbone of socio- economic growth of any nation and Nigeria is not an exception. The Power sector in Nigeria has multidimensional problems such as: use of overloaded power transformers in the grid substation, Altitude of top Management, Government altitude and contractors' altitude toward power generation, corruption and mismanagement of funds. These factors affects the performance indices (efficiency, number of consumers connected to distribution line per unit transformer, transmission losses and maintenance cost) of electricity utilities in the country. Electric power is the engine that drives industrialization, which improves communication, helps innovation in science and Technology, provides sound healthcare delivery system and improve citizens standard of living. The review revealed that the total grid capacity of 7,139.60 MW with 3,572.6 MW (peak generation), 3,091.8 MW (lowest generation), 80,308.49 MWH (energy recorded), 49.232 Hz (lowest system frequency),

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51.18 Hz (highest system frequency), 347 Kv (highest voltage recorded), 300 Kv (lowest voltage recorded) as at February 18, 2015 and 3,490.7 MW (generation at 06:00 Hrs) as at February 19, 2015. Hence, this paper investigated into the causes of unstable power supply of electricity in Nigeria and proffers solutions to the problem. One of the solution proffers in this paper is the use of alternative means of generation which will go a long way in solving stability of electric power problem in Nigeria. Aim of this paper is to ensure efficient, safe and adequate production of electricity, evolve stable and equitable rates thereby ensuring reasonably profits in power sector.

Keywords: Generation; transmission; distribution; power station installed capacity; Megawatt (MW); National Independent Power Projects (NIPP); Integrated Power Producers (IPPs); transformers; cables; power lines.

1. INTRODUCTION

Provision of stable and uninterrupted power supply of electricity is key factor for spontaneous growth in economic and industrial development of any country. Researchers are quick to point out that Nigeria's quest to become one of the 20th economies in the world may as well be a mirage without stable electricity supply. It was also pointed out that stable electricity supply will reduce costs, improve efficiency and stimulate growth for small business that rely on electricity, which will have huge impact on the lives of rural and urban dwellers by creating jobs. Whereas, unstable power supply of electricity will hinder the growth of any company in terms of socio-economic growth, endangering of lives of citizens and the likes which will be discuss in this paper. However, in spite of its importance, efforts to guarantee sustainable stability in the power supply chain have remained elusive despite huge investments in the sector by successive administrations since independence. The objective of this paper is to provide possible means of achieving uninterruptible and stable supply of electricity in Nigeria. However, in achieving this goal, we have to look at the three stages of delivering electricity to consumers at residential, industrial, commercial, and administrative areas which are electrical power generation, transmission and distribution.

2. GENERATION OF ELECTRICITY IN NIGERIA

Electricity is the science, engineering, technology and physical phenomena associated with the presence and flow of electric charges. Electricity gives a wide variety of well- known electrical effects, such as lighting, static electricity, electromagnetic induction and the flow of electrical current in an electrical wire (IEEE, 2008). Electricity permits the creation and reception of electromagnetic radiation such as radio waves. Before electricity can be delivered to the consumers for use, it has to be generated, which brings about the phenomenon of electricity generation (Franklin, 1869).

Electricity generation is the process of generating electric power from other sources of primary energy like mechanical, thermal and chemical. Electricity is most often generated at a power station by converting the mechanical energy caused by movement of a loop of wire or disc of copper between the poles of a magnet or machine to electricity energy using electromechanical generators. There are several types of generating stations, which are: hydro-electric power station, thermal, nuclear, wind, solar and magneto- hydro. However, there are only two forms of generating electric power in Nigeria, namely; hydro and thermal (gas and steam).

There are two methods of generating electricity namely: conventional method (generation with the use of prime movers- steam turbine, petrol engine, water and diesel engine) and non conventional (generation without use of prime movers- e.g. solar, magneto-hydro, wind etc). Most of electricity generators are three phase-ac generators known as synchronous generators or alternators. They use rotating rectifiers called brushless excitation systems to maintain the generator voltage and control the reactive power flow at 30 kv, 50 Mw to 1500 Mw capacities [1].

The first electricity generating plant in Nigeria was installed in Lagos in 1896. The plants were installed at isolated units owned and operated by either Native Authorities as in Ibadan and Kano, or by the public works departments as in Warri and Port-Harcourt. The isolated units were merged together when Nigerian Colonial Government passed the ordinance No.15 of 1950 which set up the Electricity Corporation of Nigeria [2]. The corporation and the Niger dams Authority set up by an Act of Parliament in 1962 to exploit the water resources of the River Niger were unified into the National Electric Power Authority in 1973 through the Federal Military Government Decree No. 24 of June 27, 1972 [2]. The first electricity generating plant to be commissioned in Nigeria was Ijora 'B' Power station (Lagos) in 1956 by the head of British Common Wealth and Queen Elizabeth.

2.1 Thermal Power Plant

In thermal power plant, coal is burnt to produce high temperature and high pressure steam in a boiler. The steam is passed through steam turbine to produce rotational motion. The generator, mechanically coupled to the turbine, thus rotates producing electricity. Chemical energy stored in coal after a couple of transformations produces electrical energy at the generator terminals depicted in the diagram below. The speed of alternators used in thermal power plant is 3000 rpm which means two poles alternators are used in such plants [3].

2.2 Hydro Power Plant

In hydro power plant, water head is used to drive water turbine coupled to the generator. Water head may be available in hilly region naturally in the form of water reservoir (lakes etc.) at the hill tops. The potential energy of water can be used to drive the turbo generator sets installed at the base of the hills through piping called Pen stock. Water head may also be created artificially by constructing dams on a suitable river. In contrast to thermal plants, hydro power plants are eco-friendly, neat and clean as no fuel is burnt to produce electricity. Water turbine usually operates at low rpm, so numbers of poles of the alternators are high. For example, a 20- pole alternator, the rpm of the turbine is only 300 rpm [3].

A modern power station has more than one generator and these generators are connected in parallel. Also, there exists a large number of power station spread over a country, which gives rise to a regional power grid created by interconnecting these stations through transmission lines. A grid power transmission system that evolved connecting large power stations in Kainji, Jebba, Shiroro, Afam, Delta (Ughelli), Sapele (Ogorode) and Egbin (Lagos) came into being in the first half of the 1960s. That grid system served every state capital in Nigeria. In 1992, the total electricity available was 5,900 Mw. The total electricity available was 3,000 Mw and the coincident maximum reached 2,400 Mw [2]. In 2009, the electricity generating station installed capacity in Nigeria was 5,000Mw, but only 2900 Mw was generated as at November, 2009 [4]. There are currently 23 grid-connected generating plants in operation in Nigeria Electricity Supply Industry (NESI) with a total installed capacity of 10,396.0 Mw and available capacity of 6,056Mw. Most generation is thermal based, with an installed capacity of 8,457.6 Mw (81% of the total) and available capacity of 4,996 Mw (83% of the total). Hydro power from three major plants account for 1,938.4 Mw of total installed capacity and an available capacity of 1,060 Mw. Some of the thermal plants are owned by Independent Power Producers (IPPs)-Shell- Afam vi (642 Mw), Agip - Okpai (480 Mw) and AES Barges (270 Mw). National Integrated Power Project (NIPPs).

Fig. 1 shows basic component of thermal generating unit, Table 1 below shows name, type of generating plants, location, installed capacity, available capacity, number of units and operational features of each in Nigeria. Fig. 2 shows main component of hydro generating unit.

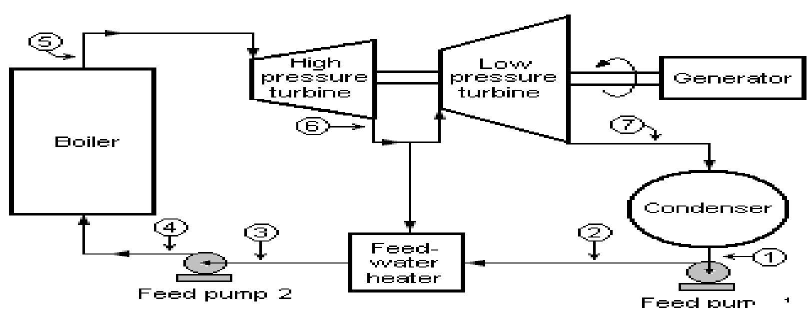

Fig. 1. Basic component of thermal generating unit
Source: Version 2 EE IIT, Kharagpur

Table 1. Fossil fuel power stations

Natural Gas

Power station	Community	Type	Capacity	Status	No of unit	Year completed	Additional description
AES Barge	Egbin	Simple cycle gas turbine	270 MW	Operational	5	2001	Independent Power Project. Light inside: the experience of independent power projects in Nigeria. Nine gas turbines are mounted on barges.
Aba Power Station	Aba Abia State	Simple cycle gas turbine	140 MW	Taking off (I Quarter 13)	20	2012	It is private integrated power project being built by Geometric Power Systems.
Afam Iv-V Power Station	Afam Rivers State	Simple cycle gas turbine	726 MW	Partially Operational	20	1982 (Afam IV)-2002 (Afam V)	Afam IV -6 x 75MW (GT 13-18), Afam V -2 x 138MW (GT 19-20).
Afam VI Power Station	Afam Rivers State	Combined cycle gas turbine	624 MW	Operational	3	2009 (Gas turbines) 2010 (Steam turbines)	
Alaoji Power Station(NIPP)	Abia state	Combined cycle gas turbine	1074 MW	Partially operational (225MW)	4	2012-2015	4 x 112,5MW turbines and later 2 x 255MW steam turbines. Plant is delayed due to evacuation capacity.
Calabar Power Station(NIPP)	Calabar	Simple cycle gas turbine	561 MW	Under Construction	5	2014	5 x 112,5MW turbines, Gas supply will available from 2014.

Power station	Community	Type	Capacity	Status	No of unit	Year completed	Additional description
Egbema Power Station(NIPP)	Imo State	Simple cycle gas turbine	338 MW	Under Construction	3	2012-2013	3 x 112,5MW turbines. Plant is waiting for evacuation infrastructure.
Egbin Thermal Power Station	Egbin	Gas-fired steam turbine	1320 MW	Partially Operational (994MW)	6	1985-1986	Has six 220-MW independent units.Egbin - Thermal Power Station in Egbin.
Geregu I Power Station	Geregu Kogi State	Simple cycle gas turbine	414 MW	Operational	3	2007	The plant is during privatisation process.
Geregu II Power Station(NIPP)	Geregu Kogi State	Simple cycle gas turbine	435MW	Operational	3	2012	3 x 146-MW SGT5-2000E gas turbines, 3 x SGen5-100A generators, SPPA-T3000 control system [1]
Ibom Power Station(NIPP)	Ikot Abasi	Simple cycle gas turbine	190 MW	Partially Operational (60MW)	2	2009	The plant's overall generating capacity is technically constrained by existing transmission and distribution facilities of PHCN and theTransmission Company of Nigeria(TCN), to only 60MW.
Ihovbor Power	Benin City	Simple cycle gas	450 MW	Under	4	2012-2013	4 x 112,5MW turbines,

Power station	Community	Type	Capacity	Status	No of unit	Year completed	Additional description
Station(NIPP)		turbine		Construction			Plant can't be launched due to delayed evacuation capacity.
Okpai Power Station	Okpai	Combined cycle gas turbine	480 MW	Operational	3	2005	Independent Power Project. Light inside: the experience of independent power projects in Nigeria.
Olorunsogo Power Station	Olorunsogo	Simple cycle gas turbine	336 MW	Partially Operational	8	2007	8 x 42 MW.
Olorunsogo II Power Station(NIPP)	Olorunsogo	Combined cycle gas turbine	675 MW	Partially Operational	4	2012	4x112,5MW and 2x112,5MW steam turbines.Working below capacity due to gas supply issues.
Omoku Power Station	Omoku	Simple cycle gas turbine	150 MW.	Non Operational	6	2005	6 x 25MW gas turbines
Omoku II Power Station(NIPP)	Omoku	Simple cycle gas turbine	225 MW	Under Construction	2	2013 [28]FMI	2 x 112,5 MW gas turbines emails and other details are not available at the moment.
Omotosho I Power Station	Omotosho	Simple cycle gas turbine	336 MW	Operational	8	2005	8 x 42 MW
Omotosho II Power Station(NIPP)	Omotosho	Simple cycle gas turbine	450 MW	Operational	4	2012	4x125MW.
Sapele Power Station	Sapele	Gas-fired steam turbine and Simple cycle gas turbine	1020 MW	Partially Operational	10	1978 - 1981	Most of units requires major overhaul. Plant is build in 2 phases. Phase I: 1978-

Power station	Community	Type	Capacity	Status	No of unit	Year completed	Additional description
							1980 6 x 120MW Gas-fired steam turbines, phase II: 1981 4 x 75MW gas turbines.
Sapele Power Station(NIPP)	Sapele	Simple cycle gas turbine	450 MW	Operational	4	2012	4x125 MW. Despite power plant activity, power outage cripples local business activities in Sapele.
Ughelli Power Station	Delta State	Simple cycle gas turbine	900 MW	Partially Operational		1966-1990	Most of units requires major overhaul. Plant is build in 4 phases. Phase I: 1966 (decommissioned today), phase II: 1975 6 x 25MW turbines(GT 2-8), phase III: 1978 6 x 25MW turbines(GT 9-14), phase IV: 1990 6 x 100MW turbines(GT 15-20).

Coal

Power station	Community	Type	Capacity	Status	Year completed	Additional description
Itobe Power Plant	Itobe Kogi State	Circulating Fluidized Bed technology	1200 MW	Planned	2015-2018 (first phase 600 MW)	The first phase consist of four 150MW units. Actual effort is focused on development mining to establish additional coal resources. The project is actually a 1200MW power plant to be divided into 4 phases of 2 units each. Project is almost achieving financial close and execution of construction agreement.

Hydroelectric

In Service

Hydroelectric station	Community	Type and unit	Capacity (MW)	Year completed	Name of reservoir	River
Kainji Power Station		Reservoir, 12	800	1968	Kainji Lake	Niger River
Jebba Power Station		Reservoir, 6	540	1985	Lake Jebba	Niger River
Shiroro Power Station		Reservoir, 6 units	600	1990	Lake Shiroro	Kaduna River
Zamfara Power Station		Reservoir	100	2012	Gotowa Lake	Bunsuru River

Under Construction or Proposed

Hydroelectric station	Community	Type	Capacity (MW)	Year completed	Name of reservoir	River
Kano Power Station		Reservoir	100	2015		Hadejia River
Zamfara Power Station		Reservoir	100	2012	Gotowa Lake	Bunsuru River
Kiri Power Station		Reservoir	35	2016		Benue River
Mambilla Power Station	Taraba State	Reservoir	3050	2018	Gembu, Sum Sum and Nghu Lake	Donga River

(http: //en.wikipedia.org/wiki/List_of_power_stations_in_Nigeria)

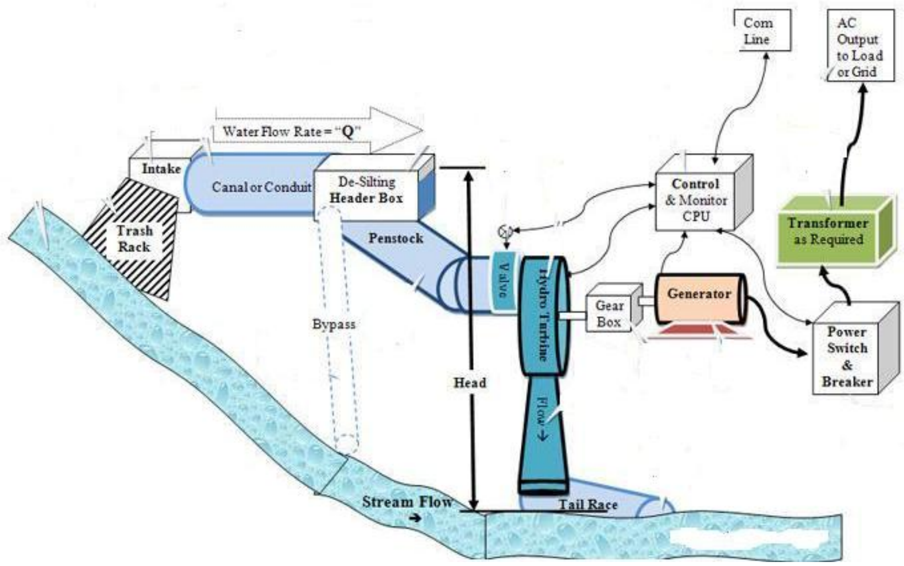

Fig. 2. Basic components of hydro generating unit
Source: Version 2 EE IIT, Kharagpur

3. ELECTRIC POWER TRANSMISSION

Electric-power transmission is the bulk transfer of electrical energy, from generating power plants to electrical substations located near demand centers. Transmission system fundamentally delivers electric power from power stations to industrial sites and substations and later to distribution system which in turn supply the residential and commercial end consumers. This is distinct from the local transmission lines between high-voltage substations and customers, which is typically referred to as electric power distribution. Transmission lines, when interconnected with each other, become transmission networks. The combined transmission and distribution network is known as the "power grid". Electricity is transmitted at high voltages (330 kV or above) to reduce the energy losses in long-distance transmission [5]. In Nigeria, Power is transmitted through overhead power lines (High-voltage overhead conductors are not covered by insulation but insulators are used, example of which are Glass, Porcelain and silicon composite with gray or dark brown color, but most commonly used for long lines is gray).

Most transmission lines are high-voltage three-phase alternating current (AC), a key limitation of electric power is that, with minor exceptions, electrical energy cannot be stored, and therefore must be generated as needed. A sophisticated control system is required to ensure electric generation very closely matches the demand. If the demand for power exceeds the supply, generation plant and transmission equipment can shut down, which in the worst case may lead to a major regional blackout as that of 2003, 2004, 2005 and 2014. It is to reduce the risk of such a failure that electric transmission networks are interconnected into regional, national or continent wide networks thereby providing multiple redundant alternative routes for power to flow should such equipment failures occur.

Daily analysis should be done by transmission companies to determine the maximum reliable capacity of each line (ordinarily less than its physical or thermal limit) to ensure spare capacity is available should there be any such failure in another part of the network. Engineers should design transmission networks to transport the energy as efficiently as feasible, while at the same time taking into account economic factors, network safety and redundancy. These networks use components such as power lines, cables, circuit breakers, switches and transformers. The transmission network is usually administered on a regional basis by an entity such as a regional transmission organization or transmission system operator.

There are thirty-four stations which transmit bulk energy of electricity energy from generating power plants to electrical substations located near demand centre (transmitting stations). in Nigeria, but there are 27 currently working as at

May 2014, namely: Birnin Kebbi T.S, New haven T.S, Kaduna T.S, Kano T.S, Jebba T.S, Jos T.S, Gombe T.S, Ikeja- west T.S, Katampe T.S, Ganmo T.S, Yola T.S, Benin T.S, Aja T.S, Okpai T.S, Alaoji T.S, Osogbo T.S, Ajaokuta T.S, Lokoja T.S, Sakete T.S, Ayede T.S, Onitsha T.S, Olorunsogo T.S, Olorunsogo Nipp T.S, Omotosho phase 1 T.S, Omotosho phase 2 Nipp T.S, Akangba T.S and Sapele T.S (transmitting station).

In 2005, the transmission network consisted of 5000 km of 330 kv lines, and 6,000 km of 132 kv lines. The 330 kv lines fed 23 substations of 330/ 132 kv rating with a combined capacity of 6,000 MVA at a utilization factor of 80%. In turn, the 132 kv lines fed 91 substations of 132/ 33 kv rating with a combined capacity of 7,800 MVA or 5,800 MVA at a utilization factor of 75%.

4. GEOGRAPHICAL LAYOUT OF ELECTRIC POWER GRID

4.1 Electricity Distribution System in Nigeria

Distribution is the final stage in the delivery of Electricity to the end users. The network of a distribution system carries electricity from the transmission system and delivers it to the consumers. Distribution system begins at as the primary circuit leaves the substation and ends as the secondary service enters the consumer's meter. The consumer may be industrial, commercial or domestic. Industrial consumers and some Commercial Consumers receive power supply at high voltage because of the sizes of their loads while domestic consumers generally receive power at low voltage [6]. In Nigeria, the distribution voltages are 33 kv, 11kv and 415/ 230 v. The low voltage phase- to-phase voltage is 415 volts while the phase- to-Neutral voltage is 230 volts.

The National Electric Power Authority (NEPA) was established by Decree No 24 of 1st April, 1972, with the amalgamation of Electricity Corporation of Nigeria (ECN) and Niger Dam Authority (NDA). NEPA was empowered to maintain an efficient, coordinated and economic system of electricity supply to all nooks and crannies of nation. In 2005, NEPA changed its name to Power Holding Company of Nigeria (PHCN), plc with the aim and objectives of providing effective power supply to the nooks and crannies of the country. However, not all parts of Nigeria are directly connected to the Grid which results to unavailability of electric power supply in those areas (e.g.- Durumi, Shappe, Waru and many others).

Power system should pay much attention on life expectancy of its component and plant and major accessories in Nigeria, periodic/ monthly maintenance be carried out regularly and change expired equipment before breaking down. Examples of factors reducing the life span of electrical component are: High Temperature, Electrical stress, radiation, humidity, chemicals and dust/ dirt.

Fig. 3 shows the geographical layout of electric power grid in Nigeria. Table 2 below describe the life expectancy period of some electrical equipment.

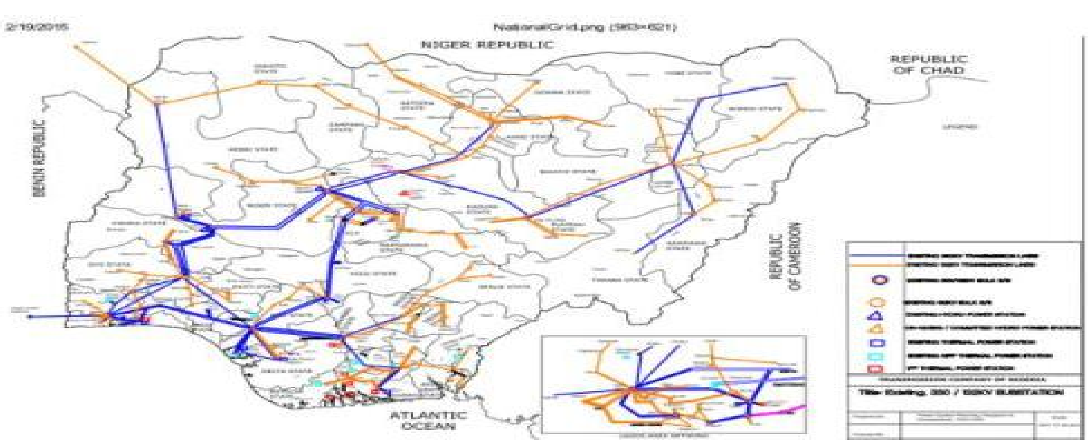

Fig. 3. Geographical layout of electric power grid in Nigeria

Table 2. Life expectancy period of electrical equipments

S/no	Equipment	Life expectancy (years)
1	Power transformer	50
2	Grounding transformer	25
3	Distribution transformer	25
4	Circuit breakers	25
5	Transformer line tower	50
6	Current transformer (CTS)	30
7	Potential transformer (PTS)	30
8	Capacitor banks	10
9	Protective relays	20
10	System control and Data Acquisition (SCADA)	10

(Source: Shomolu 1996: 160)

5. BENEFITS OF ELECTRICITY

Electricity is one of the discoveries that have changed the daily life of everybody on the planet. Electricity is the key component to modern technology and without it most of the things that we use everyday could not work, and would never have been created. Our mobile phones, computers, the internet, our heating system, our televisions, and our light bulbs nearly everything we use in the home would be completely different. There would be completely different systems put in place in the home to ensure that we can remain warm or cool, and to ensure that we can live properly every day.

Indeed, modern society would have been incredibly different without electricity. Imagine how different things would be today without the internet. The World Wide Web has effect on our lives. It has made everybody more aware of the world they live in, and it's allowed them to learn about their surroundings and know more about how near enough everything within modern society works. It is our gateway for knowledge, and allows us to find out nearly anything within a matter of seconds, hence, electricity has made us incredibly intelligent and aware of the society.

It's also allowed us to become healthier. Without electricity, hospitals would have significantly less medical equipment available to help people with medical problems. Electricity, hence, saves lives and allows people to live longer. As long as the electricity is available, no one thinks much about it. The importance is realized when there is power outage. So not only are we more aware and intelligent but we have become much healthier. Our lives are improved by electricity, and it's certainly true that most peoples' living quality would rather be significantly reduced and affected if electricity were to somehow disappear.

If there is no electricity in the world, even Thomas Edison's great invention like the light bulb, won't be as great as it is, if it does not have electricity to power it. Electricity is the basis of most modern inventions and naturally without it, the 21st century would be comparable to the 19th.

5.1 Effects of Unstable Power Supply of Electricity/ Power Outage

i. Security problem
ii. Endangering of life
iii. Loss of satellite signal in area with high-rise structures
iv. Inadequate initial information
v. Access denial in some residential area
vi. Inability of industries/ companies to work adequately e.g. petrol stations cant pump petrol without supply of electricity.
vii. High rates of accidents on the main roads due to ineffectiveness of traffic control signal as a result of power outage
viii. Inability to communicate effectively
ix. High death rate due to inability to power medical equipment required to save people in hospitals

5.2 Constraints for Unstable Power Supply of Electricity in Nigeria

i. Inadequate and erratic gas supply to the thermal stations as a result of Niger Delta crisis which leads to the vandalization of oil and gas pipe lines, oil gas exploration and exploitation facilities.
ii. Overloaded power transformers in the grid substations, 80% of which are overloaded which could lead to tripping of transmission lines, loss of voltage or breakdown of the transformer.

iii. Delayed rehabilitation of plants and power supply equipment
iv. Lack of spare parts
v. Obsolete equipments
vi. Transmission line losses due to long distance between generating stations and load centers.
vii. Low level of annual rainfall in Nigeria due to global warming which leads to global climate change that affects water level at hydro generation stations. Reliance on Hydro can be constrained by the volume of water available during the period of draught and during the months of March to June when water level goes down [7].
viii. Electricity transmission and distribution lines collapse due to heavy winds, water as well as vandalization of lines by thieves, construction workers.
ix. Non diversification of existing electricity generating potentials in Nigeria.
x. Monopoly and Inadequate funding
xi. Poor electricity pricing by the consumers and are highly indebted to PHCN as a result of non settlement of electricity bills or corruption by bill collectors
xii. Lack of energy mix Technology
xiii. Poor maintenance planning
xiv. Bribery, corruption and Mismanagement in the power sector
xv. Inadequate manpower training/ education
xvi. Altitude of top Management, Government altitude and contractors altitude toward power generation
xvii. Wrong location of power stations
xviii. Use of underrated cable and overloaded feeder pillar

6. METHODOLOGY

Problems listed above can be rectified thus; introducing governor system to power plant, introducing ring circuit, use of standard static Var compensator and using alternate means (that is; solar and wind) of generating electricity in areas beyond the nation's grid.

Static Var compensators (set of electrical devices for producing fast- acting reactive power on high voltage electricity transmission networks, also used for regulating voltage, power factor, harmonics and stabilizing the system) in transmitting station to compensate for losses during long distance transmission of electricity. Examples include: capacitor, thyristor, reactor and many others.

Use of Governor System in power stations. Governor system acts as a system that controls the imbalance between the generator and load. It controls the speed of a machine in power stations. If all power systems are working on governor system, there won't be frequency problem which later lead to power outage. In the sense that, if the frequency is high above nominal frequency (50 Hz), Governor System will automatically reduce the generation and vice versa.

Using an alternate method/ means of generating electricity in Nigeria for areas not connected to the main grid with the use of solar and wind. Solar energy as a means of generating electricity can be done using solar panels which change energy from the sun's rays directly into useful energy that can be used in homes and business. There are two main types: solar thermal and photovoltaic (PV). Solar thermal panels use the sun's energy to heat water that can be used in washing and heating. PV panels use the photovoltaic effect to turn the sun's energy directly into electricity, which can supplement or replace a building usual supply. When sunlight strikes the PV panel (which consists of a semiconducting material usually silicon-based, sandwiched between two electrical contacts) and is absorbed, it knocks loose electrons from some of the atoms (antireflective substance) that make up the semiconductor. The semiconductor is positively charged on one side and negatively charged on the other side, which encourages all these loose electrons to travel in the same direction, creating an electric current which later captures this current in an electrical circuit. The electricity PV panel generate is direct current (DC) which must be converted using an inverter into alternating current (AC) before it can be used in homes and business. The inverting current then travels from the inverter to the building fuse box and from there to the appliances that need it. PV systems installed in homes and businesses can include a metering box that measures how much electricity the panels are generating [8].

Wind energy as a means of generating electricity can be done using wind turbines that are typically above 200 feet or more above ground to harness the wind and turn it into energy. When the wind blows, it turns the turbines blades. The blades are connected to a drive shaft that moves with blades. The shaft is attached to a generator, which creates electricity which is in form of alternating current [8].

7. RESULTS AND DISCUSSION

The results obtained from the project have assisted the power system in the following areas;

- Monitoring the status of the facilities/ equipment in the generating stations.
- Information on the appropriate cable to be used for transmission of electricity from the generating stations to the final consumers.
- Cost of replacement of expired/ damaged cable to be known and calculated.
- Prioritization of expired equipment replacement based on the available information on life expectancy of each equipment.
- Effective mode of generating electricity.
- Use of Governor system in generating stations to acts as a system that will control the imbalance between the generator and load.
- Use of Static Var compensators for regulating voltage, power factor, harmonics and stabilizing the system and in transmitting station to compensate for losses during long distance transmission of electricity.
- Use of renewable energy (sun and wind) to generate electricity for areas that are off grid.
- Applying the use of simple plant design in power.
- Restructuring of radial interconnected electricity generation station grid system.

8. PROPOSED FUTURE MODE OF ELECTRICITY TRANSMISSION AND DISTRIBUTION IN NIGERIA

Through research and findings made, it can be concluded that if all the minor and major problems facing unstable supply of electricity in Nigeria are solved, Nigeria can adopt another new technology means of electricity transmission and distribution. New modern means of transmitting and distributing electricity has been discovered by technologist and further research is been carried out every day in order to reduce losses during transmission and distribution of electricity. The new modern means proposed are High voltage direct current (HVDC) and high temperature super conductors (HTS).
High voltage direct current (HVDC) can be used to transmit large amounts of power over long distance or for interconnections between asynchronous grids. HVDC links can be used to control problems in the grid with AC electricity flow. The power transmitted by an AC line increases as the phase angle between source end voltage and destination ends increases, but too large a phase angle will allow the systems at either end of the line to fall out of step. Since the power flow in a DC link is controlled independently of the phases of the AC networks at either end of the link, this phase angle will limit does not exist, and a DC link is always able to transfer its full rated power. A DC link therefore stabilizes the AC grid at both ends because power flow and phase angle can be controlled independently [9,10]. For example, to adjust the flow of AC power on a hypothetical line between kano and Lagos would require adjustment of the relative phase of the two regional electrical grids. This is an everyday occurrence in AC systems, but one that can become disrupted when AC system component fail and place unexpected loads on the remaining working grid system. With an HVDC line instead, such an interconnection would: (1) Convert AC in Kano into HVDC; (2) Use HVDC for the 3,000miles of cross-country transmission; and (3) Convert the HVDC to locally synchronized AC in Lagos, (and possibly in other cooperating cities along the transmission route). Such a system could be less prone to failure if parts of it were suddenly shut down.

Use of high temperature super conductors (HTS) will revolutionize power distribution by providing lossless transmission of electrical power. The development of superconductors with transition temperatures higher than the boiling point of liquid nitrogen has made the concept of superconductors' power lines commercially feasible, at least for high- load applications [11]. It has been estimated that the waste would be reduced to half using this method. Superconducting cables are particularly suited to high load density areas such as the business district of large cities, where purchase of an easement for cables would be very costly [12].

9. RECOMMENDATIONS

I. Nigerians should desist from illegal connections of electricity and ensures settlements of bills are paid appropriately.
II. Electricity poles should not be used as speed breakers by reckless drivers; we should all protect infrastructure from being damaged.
III. Using equipment of longer life span and proper capacity in power stations.

IV. Proper maintenance should be carried out regularly to avoid breakdowns.
V. Apply the use of simple plant design in power station which will save cost and running the power station at high load factor.
VI. A consumer friendly billing system should be developed and implemented by the appropriate government agencies.
VII. Transmission and distribution transformers loads should be reduced to at least 10 consumers per distribution transformers to avoid loss or breakdown.
VIII. The restructuring of the Nigerian radial interconnected electricity generation station grid system.
IX. Running of power stations should be at high load factor.
X. PHCN's equipments should be upgraded to be able to meet up with the demands of its numerous customers for better service.
XI. PHCN's management is advised to employ and train more staff in order to withstand the challenge of providing quality service to its numerous customers.
XII. There should be proper provision of community and military security to prevent vandalism of oil, gas and electrical equipment and lines.
XIII. Government should ensure level playing fields for the independent power producers and other genuine investors in the power business
XIV. 30% of annual budget should be set aside to take care of power generation expansion program for the next twenty five years.
XV. There should be unlimited quantity of gas and crude oil in power generating system
XVI. There should be abundant hydro reserve and reserve of renewable: Wind and Solar.
XVII. There should be high investment opportunities to meet economic needs.
XVIII. The bureaucracies surrounding the procurement of electricity meters should be jettisoned to encourage consumers to pay and have their meters within a reasonable period of time.

10. CONCLUSION

Electricity is an essential part of our everyday lives that we often take for granted. We take it for granted, that is, until we have to do without power for one reason or the other. Absence of electricity for long periods, causes discomforts and hampers productivity. In order to maintain adequate power supply to the consumers in any part of the globe is a very challenging task, which require dedication and faithfullness. Consequently, We don't normally see them, but behind the scenes many people are working to ensure that we have a clean, safe, reliable source of power; that we don't have unpredictable or inappropriate current to power our infinite variety of devices, the supply is readily available when we need it and at reasonable and affordable price.

It can be concluded that any country that want progress for stability of power should first improve generation before transmitting and distribution. Also, some practical solutions discussed earlier in this research manuscript can be adopted by underdeveloped countries facing the same problems.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hadi S. Power system analysis (5th Edition). New Delhi: Tata McGraw- Hill Company; 2004.
2. Uwaifo SO. Electric power distribution planning and development (1st Edition). Lagos: Malt- house Press Ltd, Marina, Nigeria; 1994.
3. Version 2 EE IIT, Kharagpur.
4. Babalola R. 6000 Mw power target report card, Daily Trust Newspaper. 2009; 22(94);1.
5. A Primer on Electric Utilities, Deregulation, and Restructuring of U.S. Electricity Markets" (pdf). United States Department of Energy Federal Energy Management Program (FEMP); 2002.
6. Webb B Garrisson, Abdelhay A. Sallam, an Omp Malik. Electric distribution systems; 2011.
7. Sada I. Analysis on generation transmission and distribution of nigeria power for national development. A paper presented at 2nd National Conference of colleges of Agriculture, Environmental, Engineering and Science and Technology,

Hassan Usman Katsina Polytechnic. 2007; 2.

8. Arthur Stinner. Solar and wind power; 2007.
9. Raghuvir Srinivasan. Power transmission business is a natural monopoly; 2004.
10. Lynna. Rethink the natural monopoly justification of electricity regulation. Kiesling; 2003.
11. Jacob Oestergaard, et al. Energy losses of superconducting power transmission cables in the grid. IEEE Transactions on Applied Superconductivity; 2001.
12. Jacob Oestergaard, et al. 600 m superconducting electricity line laid in New York and superconducting cables will be used to supply electricity to consumers. IEEE Transactions on Applied Superconductivity; 2001.

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