ABDULLAHI, D., SURESH, S., RENUKAPPA, S. and OLOKE, D. 2017. Power sector development reforms in Nigeria: the roots to the challenges. In *Laryea, S. and Ibem, E. (eds.) Proceedings of the WABER (West Africa built environment research) conference: knowledge, interaction, people and leadership, 16-18 August 2017, Accra, Ghana*. Johannesburg: WABER [online], pages 1111-1122. Available from: https://tinyurl.com/f6897nsn

Key barriers to the implementation of solar energy in Nigeria: a critical analysis.

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2017

POWER SECTOR DEVELOPMENT REFORMS IN NIGERIA: THE ROOTS TO THE CHALLENGES

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Nigerian socioeconomic development has been threatening persistently with severe power shortage and they are currently experiencing growth in demand for electricity. Various factors are responsible for the challenging situations such as oil pipeline vandalizations, stealing of high-tension cables and economic sabotage. Although several reforms, policies and regulations have been applied to address the insufficient electricity supply for over 120 years in Nigeria, yet the problem of inadequate electricity supply is even getting worst. The complexity of possible inference of the data for the inadequate electricity supply is not well understood. The research examined the various electricity reforms, policies and regulations adopted since 1896 till date to determine the status of the power supply and demand, and the key factors responsible for it. The research adopted a literature-based from peered review methodology to analyse electricity reforms adopted. The result from the peered review indicated that Poor maintenance culture, corruptions, inadequate funding, insecurity and lack of turnaround in energy mix are the key challenges facing the power industry, making it incapable to generate, transmit and distribute adequate and efficient electric power in the country. The finding also showed that Government lack understanding of the economic benefits of the power sector, thus leading to lack of comprehensive review of their reforms and polices. The paper also suggested that tapping from other sources of energy such as renewable energy, i.e. solar with sounds polices and best practices is essential to supplement the existing source of energy while improving other key challenges identified.

Keywords: Nigerian electricity, power sector reform, electricity supply, privatisation

BACKGROUND OF CURRENT STATE NIGERIA'S ELECTRICITY

The total electricity generated by Nigeria's central grid oscillates about 5,000MW. Sharing that total electricity to the country's population

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Abdullahi, D., Suresh, S., Renukappa, S. and Oloke, D. (2017) Power sector development reforms in Nigeria: the roots to the challenges *In: Laryea, S. and Ibem, E. (Eds) Procs 7th West Africa Built Environment Research (WABER) Conference,* 16-18 August 2017, Accra, Ghana, 1111-1122

(estimated at about 186 million) placed Nigeria as one of the lowest per capita power supply world-wide (Ingwe, 2014). The effect of inadequate electricity supply has resulted to slow or stagnant economic growth in Nigeria, especially the manufacturing sector and the household consumption (Okeke, *et al*. 2014). The inadequate electricity power system is associated with poor maintenance, obsolete equipment, illegal connections and theft of high voltage cables and sub-stations equipment, growth in population and loss of electricity energy on transmission (Emodi and Yusuf, 2016). Past government dictator's regimes in the 1980s also formulated poor policies such as the structural adjust program/policy that negatively impacted on the economy and the standard of living (Alley, *et al.* 2016). Consequently, these have led to many negative activities such as high crime rate and upraising of insurgencies.

Security of life and property has degenerated from normalcy to insecurity as a result of upraising of insurgent terrorist group such as Boko Haram insurgencies, the Odua People's Congress (OPC), The Niger Delta militants and Movement for the Actualisation of the Sovereign State of Biafra (MASSOP). Among other criminal vices are the increase in the number of armed robberies, kidnapping, rapes and advanced fee fraud (Amobi, 2007). These activities have further affected the normal generation and distribution of electricity due to increase in the bombing of oil pipeline that supply gas to the thermal plants in Nigeria by various insurgents (Emodi and Yusuf, 2016). Struggling to provide a means to curtail and control such activities with limited resources have plunged the economy and the standard of living into an unacceptable recession (Aliyu, *et al*. 2015), thus leading to an increase in poverty.

There is an increasing number of poverty because of various insurgent and terrorist activities, disrupting the economic operations in the country. For example, internationally comparable poverty i.e. people living beneath the poverty line (US$2/day) were over 90% of Nigeria's total population (UNCTAD, 2010; World Bank Group, 2017)). Income distribution among Nigerians since independence has exhibited enormous inequality with one percent of the population, stealing about 90% of all earnings from various sources, including oil and gas revenues (Gujba, et al. 2010). However, the government has called for urgent economic reforms and total restructuring of infrastructure in Nigeria yet the level of progress achieved in economic growth is minimal (Husseini and Abdull Majid, 2015).

Economic progress, goes hand in hand with improved energy efficiency as a driving force for socioeconomic development (Aliyu et al. 2015. It is unclear, how well the different governments understood the challenges facing the power sector since 1896 and the frameworks developed to address it in relation to sound socioeconomic activities (Jacob and Abubaker, 2015). Therefore, it is of paramount importance to have a clear understanding and proper assessment of why the various reforms failed to address inadequate electricity supply and to identify the key factors responsible for the failure, so that inform suggestion can be made (Obi and Uzodigwe, 2016). In order, to examine and determine the factors affecting the efficiency of electricity

supply in Nigeria, the next sections below provided information on Nigeria Electricity Transition between 1896 to 2016, Nigeria electricity capacities, Nigeria electric power sector reforms act, Generation company of Nigeria (GENCO), Transmission company of Nigeria (TCN), Distribution company of Nigeria (Disco), The factors responsible for erratic power failure in Nigeria, the research methodology applied, the findings from the study and lastly the conclusion (Oseni, 2011; Saidu, 2011; Sulaimon, 2016).

FINDINGS

Nigerian electricity transition (1896-2016)

Table 1: Nigerian electricity development between 1898 – 2016

S/N	Period	Development activities
1	1896	Electricity was first installed and generation began in Marina Lagos Nigeria
2	1929	Nigerian Electricity Supply Corporation (NESCO) started operation with the construction of a hydro power station at Kuru Plateau Jos, Nigeria.
3	1951	Electricity Corporation of Nigeria (ECN) was a central body created to regulate coal and diesel plants throughout Nigeria.
4	1956	With the increase in demand for electricity, project such as Ijora in Lagos, Oji in Enugu, Kano and Ibadan was commissioned for expansion purpose.
5	1962	Niger Dam Authority (NDA) and Kainji Dam was completed in 1968, while the first 132 KV lin between Lagos and Ibadan was constructed
6	1972	ECN and NDA were integrated to form the National Electric Power Authority (NEPA), which was saddled with generation, transmission, distribution and marketing to consumers solely owned by the Nigerian Government.
7	1968-1990	The Four major stations: Kainji Hydro, Ijora, Afam, and Delta stations were established to operate with full responsibility for power supply.
8	1998	IPPs came on board and the NEPA high-class monopoly of generation, transmission, distribution and marketing was sculpted down.
9	2000	Electric Power Implementation Committee (EPIC) was set up to advocate privatisation including a full report to National Council on Privatisation.
10	2001	Out of the report submitted by NCP, the National Electric Power Policy was born based on the recommendation of the EPIC.
11	2004	NEPA installed a capacity of 5,906 MW, but only generate 3,400 MW due to several issues within the sector. It was therefore necessary to call for a reform
12	2005	The Electric Power Sector Reform Act (EPSRA) was enacted to unbundle and restructure the Nigerian power sector. The Nigerian Electricity Regulatory Commission (NERC) was established to regulate the electric power and tariff in the sector. Rural Electrification Agency (REA) was established. Nigerian Electric Power Authority (NEPA) was unbundled into six (6) generating companies, one (1) transmission company and Eleven (11) distribution companies.
13	2009	National Power Training Institute of Nigeria (NAPTIN) was established and Rural Electrification Policy (REP) was also approved to work with REA.
14	2010	Roadmap for power sector Reform was launched as policy documents to help the restructuring of PHCN.
15	2012	PHCN was liquidated which relinquished 70% of ownership shares to generation and distribution private companies and retained the ownership of the transmission company.
16	2013	The successfully privatised generation and distribution was handed over to the successor private owners known as GenCos and DisCos.
17	2014	Strengthening of renewable energy programs and seven out of ten NIPP generation asset sales are completed.
18	2015	Power Purchase Agreement (PPA) were established, Transnational Stage Electricity Market (TEM) satisfied by the NERC. The TCN Independence System Operator were made public. National Renewable Energy and Energy Efficiency Policy (NREEEP) were approved to drive the power sector reform.
19	2016	Draft for Mini-Grids operation approved (NERC, 2016). National Renewable Energy Action Plans (NREAP) approved (NREAP, 2016).

Source: ECN (2016); NERC (2014); Abam, *et al*. (2014); Awosope, (2014); Aliyu, *et al*. (2015); Emodi and Yusuf (2015).

Nigerian electricity has developed through various processes over a period, which can be traced back to the 19th century, just 15 years after it was introduced in England (Awosope, 2014). The sector developed through various transformations from one company to another, until it was unbundled during the privatisation exercises which resulted in three companies serving the generation, transmission and distribution as shown in the table 1.

From the table, above, it is evident that the Nigerian Electricity developed gradually under different phases aimed at improving the supply of the electricity to meet the demand of the Nigerian population (Aliyu, et al. 2015). The inability for the industry to generate, transmit and distribute adequate electricity to maximum capacity has resulted in crippling the commercial industries. Individuals and various organisations depend heavily on self-generated electricity from Generators (Gujba, et al. 2011), thus increasing operational cost, increase on Co2 emission, poor quality of life, etc. Therefore, the next section presented various sources of electricity generation.

Electricity generated capacity

The Nigerian electricity is sourced from thermal power plants and four (4) major hydroelectric stations as shown in the table (2) below.

Table 2: Commissioned large hydropower stations in Nigeria

S/N	Location	Capacity (MW)	Commissioned Date	Rivers	State
1	Kainji Dam	760	1968	Niger	Niger
2	Jebba Dam	570	1984	Niger	Niger
3	Shiroro Dam	600	1990	Kaduna	Kaduna
4	Zamfara Dam	100	2012	Bunsuru	Zamfara
	Total	2,030			

Source: Aliyu, *et al*. (2015); Emodi and Yusuf (2015)

Table 2 above shows four major commissioned dams for hydroelectricity built between 1968 and 2012. Thus, the output capacity from the table above is 2,030MW is inadequate compared to the growing demand of electricity and the population growth, to sustain the socioeconomic development activities in the country. Hence, the additional capacity of power generation via hydroelectricity from dams to support the high demand was proposed. The seven more dams initiated to further generate 8, 602 MW of electricity from hydro throughout the country as part of the power sector reform.

From the tables, the available electricity generated from hydro is inadequate since the major four dams in Nigeria only generate just above 2,000 MWs at full capacity while the additional proposed hydroelectricity is expected to generate additional 8, 602 MW when they are fully operational (Aliyu, et al. 2015). This means that the total electricity to be generated once

these projects are completed and fully operational will be 10, 602 MW against nearly 184 million Nigerians (Emodi and Yusuf, 2015). This indicated that demand will surpass electricity supply, which will still be a threat to socioeconomic activities (The World Bank, 2017). The next section provides detail analysis of Nigeria Power reform.

Table 3: Planned large hydropower stations in Nigeria

S/N	Location	Capacity (MW)	Commissioned date	Rivers
1	Ikom	730	N/A	Cross River
2	Lokoja	1050	N/A	Osse River
3	Zungeru	450	N/A	Kaduna
4	Mambilla Hydro	3960	N/A	Donga River
5	Makudi Hydro	1062	N/A	Benue
6	Onitsha Hydro	1050	N/A	Cross River
7	Gurara Hydro	300	N/A	River Kaduna
	Total	8602		

Source: Aliyu, *et al*. (2015)

Nigerian Electric Power Sector Reform Act (NEPSR, 2005)

The Nigerian electric power sector has been experiencing an enormous transformation for years with an effort to pull together strategies towards achieving stable power supply through generation, transmission and distribution projects as part of the Federal Government Economic Reforms (Oyedepo, 2014). Although, the expansion plans indicate that the power sector will undergo significant changes soon to achieve the vision 20:20 as indicated in (table 3) and this is further expected to increase almost four times by the year 2030 to accomplish the Independent Power Producer (IPP) plans (Aliyu, et al. 2015).

Oyedepo, (2014) argued that the current situation of the Nigerian power sector is dilapidated, as 70-80% of the powers, generated are thermal and 20-30% are hydroelectric, though, only about 40-51 % of Nigerians have access to electricity and only 18% of the rural dwellers have access to electricity. In other words, those who are connected to the national grid face extensive power interruption throughout the year (Ikeme and Ebohon, 2005). As shown in table 2 above, the total capacity generated before 2012 was only 2,030MW to serve 160, million Nigerians (Gatugel, *et al*. 2015). It was, therefore, apparent for the government to showcase alternative plans to boost electricity by reinvesting more on large hydroelectric plants as well as diversifying to energy mix (Aliyu, et al. 2013).

In 2005, the Nigerian Government raised concerns over compelling issues, principally; power outages, unreliable services, unrealistic bills and many other issues emerged for need of action to enact the Electric Power Sector Reform Act of 2005 (TCN, 2005). The act called for unbundling the National Power Utility Company into a series of six generating companies, twelve distribution companies while retaining the ownership and management of

the transmission company to the Federal Government of Nigeria (NERC, 2015). Eve though, the reform was aimed at finding a solution to the long experiences of inadequate electric power supply in Nigeria, there was little indication in the reform to diversifying into renewable energy projects as support for the Independent Power Producers (IPP) (The World Bank, 2012). The next three sections discuss the outcome of the privatisation and unbundling the defunct Power Holding Company of Nigeria (PHCN) into generation, transmission and distribution companies of Nigeria.

Generation Company of Nigeria (GenCo)

The generation company of Nigeria, popularly known as GENCO was the first company among the three born out of PHCN to be found as part of the IPP to a private company. Thus, the Nigerian Electricity Supply Industry (NESI) processed 23 grid-connected generating plans with total capacity of 10, 396.0 MW, in which, the available capacity at the time of this exercise was to be 6, 056 MW. However, among the installed capacity, the mainstream of the generation is a thermal power plant with total installed capacity of 8, 457 MW (81%) and available capacity of 4, 996 MW (83%) (Nnemeka, et al. 2015) Emodi and Yusuf (2015), further emphasised that, hydropower from the three (3) plants account for 1, 938.4 MW, of which 1, 060 MW, is the available for transmission.

Table 4: Generation Company of Nigeria

S/N	NIPPs	CAPACITY (MW)
1	Alaoji Generation Company Nigeria Limited	1,131
2	Benin Generation Company Limited	508
3	Calabar Generation Company Limited	634
4	Egbema Generation Company Limited	381
5	Gbarain Generation Company Limited	254
6	Geregu Generation Company Limited	506
7	Ogorode Generation Company Limited	508
8	Olorunsogo Generation Company Limited	754
9	Omoku Generation Company Limited	265
10	Omotosho Generation Company Limited	513
	Total	5, 454 Megawatts

Source: ECN (2016); NERC (2014)

The table 4 above shows that, the NIPP can generate up to 5, 454 MW of electricity for six geopolitical zones in Nigeria. Although, the amount of MW that is available for the TCN to distribute to Discos centres cannot be quantified due to loss of electricity on transmission lines (Emodi and Yusuf, 2015).

Transmission Company of Nigeria (TCN)

The transmission Company of Nigeria (TCN) is one of the successors of the PHCN, after the unbundling of the power sector. Though, the TCN remains the only company that was not privatised during the privatisation process

of PHCN (NBET, 2016). The federal government of Nigeria contracted the TCN to a Canadian firm; Manitoba Hydro International (Canada) whose major responsibility, among others, is to ensure market operator (MO), the system operator (SO) and Transmission Service Provider (TSP) become autonomous (ECN, 2015). The TCN holds the PHCN grid assets and manages it on behalf of the Nigerian government.

Distribution Company of Nigeria (DisCo)

The Nigerian Distribution Company (Disco) was born out of the Nigerian Power sector reform proposed in 2005, through 2013 and beyond (NBET, 2016). As part of the privatisation exercise, the Power Holding Company of Nigeria's (PHCN) distribution was broken into eleven (11) regional grids, which were acquired by private local and foreign investors (Transmission Plans, 2013). Each distribution company is allocated a certain amount of grid energy even though the amount of grid varies in quantity to match the demographic population demand (The World Bank, 2017). The distribution companies are faced with numerous challenges, including distribution losses and technical difficulties. Other challenges are associated with commercial and billing system, which the distribution company was not anticipating after the handover of assets to them by the PHCN in 2014. It was estimated that technical barriers caused a loss of (12%), commercial (6%) and collection of revenues (28%) respectively. The table below shows the Distribution companies of Nigeria after the privatisation exercises.

Table 5: Distribution Companies of Nigeria (ECN, 2016)

s/n	Distribution company of Nigeria (DISCO)	Percentage %	Location/Region
1	Abuja Distribution Company Plc	11.5	FCT, Kogi, Nassarawa & Niger state
2	Benin Distribution Company Plc	9	Edo, Delta, Ondo and Ekiti
3	Eko Distribution Company Plc	11	Lagos, Island, VI, Lekki and Epe
4	Enugu Distribution Company Plc	9	Enugu, Abia, Anambra, Ebonyi & Imo
5	Ibadan Distribution Company Pl	13	Oyo, Kwara, Ogun, and Osun
6	Ikeja Distribution Company Plc	15	Lagos, Mainland, Ikeja, and Badagry
7	Jos Distribution Company Plc	5.5	Plateau, Bauchi, Gombe, Benue and Kogi state
8	Kaduna Distribution Company Plc	8	Kaduna, Kebbi, Zamfara, Sokoto and Niger state
9	Kano Distribution Company Plc	8	Kano, Jigawa and Katsina state
10	Port Harcourt Distribution Company Plc	6.5	Rivers, Akwa Ibom, Bayelsa and Cross River state
11	Yola Distribution Company Plc	11.5	Adamawa, Borno, Taraba and Yobe

Source: Aliyu et al. 2015

The Nigerian Government made efforts to actualise reforms over the years to tackle the decaying electricity source industry from the generation to transmission and to distribution (Awosope, 2014). However, the reforms are basically conventional and therefore, not far from the old systems of fossil fuel. Literatures have proven that the reforms pay little or no attention to

renewable energy sources. The table below is a comparison for generated electricity versus population growth.

Table 6 Installed and available power generation versus Nigerian population

Year	Installed Capacity (MW)	Available power (MW)	Population (Million)
1980	2507	783	73.7
1985	4192	1133	83.9
1990	4548	1537	95.6
1995	4548	1810	108
2000	5580	1738	122.9
2005	6538	2494	139.6
2010	6904	3358	159.7
2014	8876	3795	177
2016	13761	4285	184

Source: World Bank, 2014; Oyedepo, 2014

The section below discussed the factors responsible for inadequate power supply in Nigeria.

Factors responsible for erratic power failure in Nigeria

The consistent failure of power supply in Nigeria does not occur naturally, it is associated with some factors, which can be classified as man-made (Igwe, 2014), such as Economic factors, Government policies, Social factors, Technological factors, Security, and Corruption. The factors are further discussed:

1. Government Policy: The inconsistency in the Nigerian government policies towards power sector is one of the major challenges that led to the inability to find a sustainable solution to the electricity power crisis (Doner, 2007). For instance, the experienced unstable policies which began from ECN, NEPA, PHCN among others, which was entirely under government control, yet no positive impact can be traced to the reforms and policies over the years. The current failure of the privatisation scheme adopted to foster generation and distribution of electricity by various companies is an indication that the earlier policies failed (Ferroukhi, et. 2013).

2. Social Factors: While our communities need electricity for local household and small-scale industries, the attitudes towards payment of bills, for the services are inevitably discouraging (Olawunyi, 2013). Thus, the providers of the services are reluctant to improve services and infrastructure for the electricity in the communities (Akinwale, *et al*. 2014).

3. Financial Factors: Nigerian electric power sector is one, which it financing is solely from the government. Over the years, the entity is wholly owned by the government and therefore, no private individual had any opportunity to invest to help in reviving and restructuring the facilities to improve service efficiency (Kar and Sharma, 2015).

4. Security Factors: The Nigerian electricity power sector has suffered a series of insecurity challenges, ranging from equipment vandalism, cable theft, diversion of gas supplies and sabotage (Afe and Emmanuel, 2013). It was further argued that Insecurity from ethnic clashes and religious violence has also resulted to the poor access of technical expertise to monitor the utilities of electricity in the communities (Ingwe, 2014). Insecurity will, therefore, encompass that issue-hindering guarantee of safety, peace, justice, health and economic growth (Nkemdili, et al, 2013).

5. Corruption: The misuse of public office to private gain, immoral and unethical phenomenon, bribery, and illegal behaviour in the industry is alarming (Raimi, 2015). It is evident by the anti-corruption agencies in Nigeria that the electricity sector is broadly bounded with a lot of corruption and there was a need for unbundling it to public and private partnership investment (PPI) in 2005 (Afe and Emmanuel, 2013). Monies meant for new equipment, refurbishment, maintenance and new projects are diverted to private use, hence, the existing infrastructure became dilapidate and decay to a point whereby they no longer support production (Nkemdili, et al, 2013).

METHODOLOGY

The method adopted for this research was based on desk study, otherwise known as literature-based from peered-reviews. The secondary databases were searched from published resources from 2003 through 2017, with key articles obtained from PsyCho Info, ERIC, ProQuest, Science Direct, SocSci Search, EBSCO and COPAC which are systematically narrowed to a search of an information. To ensure that relevant studies were not omitted, the search terms remain broad. These were ("Nigeria", "Electricity", "Electricity", "Power* generation", "*Demand * Supply for power", "power*reforms" "challenges*Drivers", "Solar *potential" etc.). The peer-reviewed literature strategy was taken using the De Montfort University Library and University of Wolverhampton Library database. The search yielded a solid payload of data around the Nigerian power sector, the status, challenges and potentials for solar energy. Relevant literature where themed for critics, analysis, comparison and contraction to the sentiments of the literature and the outcome formed the finding of this inquiry.

DISCUSSIONS

The study showed that the 2005 power reform act yields a slight improvement by unbundling the power holding company of Nigeria into three companies; Genco, TCN and Disco. However, there is a lack of understanding of the economic benefits of power supply. No comprehensive review is traced to key policies laid by Nigerian Government that could involve local technical and technological industries to play a vital role in the generation, transmission and distribution of electricity or tapping from other sources of energy such as renewable energy in the country. The finding also identifies weakness of the Government for the inability to secure and put control measures that would mitigate the issues of infrastructure

vandalism, electric copper cable theft and diversion of Gas supply. The Industry suffered a pathetic supply output because it lacks long-term policies to confront the full-scale development challenges that face the fast-growing population in Nigeria.

CONCLUSION

The challenges faced by the Nigerian power sector are traced to poor policies since inception of the industry 1896, 15 years after it was discovered in the United Kingdom in 1883. The infrastructure and facilities continued to decay and became obsolete resulting in difficulty in generating adequate power supply to nearly 184 million Nigerians. Various factors were responsible for the power failure, including government policies, financial factors, social factors, technologies, security and corruption within the industry. It was clear that the government lack understanding of these factors, thus, long-term policy, reliable measures, security for infrastructural facilities and adequate funding to the sector were completely ignored. The power sector saw a series of reforms in the past, until the government saw the need to unbundled the company in the private public partnership which resulted in the generation, transmission and distribution companies of Nigeria. Nigerian government retained the ownership of the transmission company of Nigeria (TCN). The power sector reform Act was a stepping stone for the industry not only to private sector participation but also for the diversification in the energy mix. The research therefore, suggest the government and private investors diversify the sources of power into renewable energy by formulating sound policies and best practices to supplement the crippling industry and to improve the efficiency and socioeconomic growth.

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