

An Investigative Analysis on The Performance of The Nigerian Electricity Supply Industry (NESI)

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Generation,
Transmission, Distribution,
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Abstract

Over the years, the quest for a stable power supply in Nigeria has become insatiable, due to epileptic nature of power availability and incessant outages in the country. This paper tends to dissect the power crisis in Nigeria with a view to narrowing down the malady in the industry to the various sub-sectors and proposing a suitable panacea. Whereas the quantum of energy being generated is abysmal for a country like Nigeria to start thinking of energy sufficiency, the transmission infrastructure is incommensurate with the capacity demand of power transmission. The distribution sub-sector on its part is; among others, bedeviled with revenue collection shortfalls, enough to impede the progress of the entire sector. With a conscious effort to expand the power generation base, by aggressively investing in Combined Cycle Gas Turbine (CCGT), the decentralization of the transmission Infrastructure and stringent monitoring of the distribution sub-sector for improved accountability and system reliability, the dream of energy sufficiency in the Country will substantially be actualized.

1. Introduction

Electricity generation is the process of deriving electric power from sources of primary energy and it is the first stage in the delivery of electricity to the end users in the electric power industry. Other stages being transmission, distribution and energy storage/recovery, using pumped-storage methods [1]. A characteristic of electricity is that it is not a primary energy freely present in nature in remarkable amounts and it must be produced. Production is carried out in the power plants. Electricity is most often generated at a power station by electromechanical generators, primarily driven by heat engines fueled by either combustion or a nuclear fission. It could also be by other means such as the kinetic energy of flowing water and wind as well as solar photovoltaic and geothermal means [2].

The world's total energy supply (TES) increased by 68.2% from 1990 to 2019, surpassing 600Exajoules for the first time. The primary energy production reached 613EJ, a 2.0% increase over 2018 and a 69.6% increase compared to 1990. The increase was driven by Asia, responsible for 83.6% of the world growth in the period. Chinese alone increased her TES 4.5 times, accounting for over a fifth of world TES in 2019. Oil, coal and natural gas, in this order, are the largest energy sources, representing 82.0% of total primary energy production and a combined share that barely changed since 1990 [3]. Six countries alone produced almost 7/8 of all primary coal (86.3%), with China alone producing almost half (47.7%) of the world coal energy. The United States topped the oil producers with roughly 1/6 of the world production. Five countries concentrated more than half of all primary oil production (52.6%) whereas four natural gas producers (United States, Russian Federation, Iran and China) produced more than half of all energy from natural gas (51.6%) [4].

1.1. Power Supply in Africa

Over the years, stable electricity generation and supply has been a challenge in many African countries. In 2014, only 45% of the continent's 1.2 billion people had access to electricity, with the figure

dropping to less than 30% on the exclusion of North African countries. In 2015, the 48 countries in Sub Saharan Africa produced around 80,000Megawatts of electricity with South Africa alone accounting for more than half of that figure [5]. Challenges with Africa's energy systems extend beyond power generation, as transmission and distribution are equally poor, resulting in incessant outages at the customers' end. Nigeria's total energy capacity stands at about 12,000 megawatts with only about 4,000 megawatts being supplied to consumers. This struggle in the Nigerian Electricity Supply Industry (NESI) emanates from problems across all subsectors of generation, transmission and distribution. In the first six months of 2022 alone, the country's national grid had collapsed at least five times [6].

With the global electricity coverage standing at about 90 percent, Continents like Europe, Central Asia, North America and Latin America have electricity access to nearly 100 percent of their population. Whereas the Arab world is almost at par with the global coverage, Sub-Sahara Africa is unable to hit 60 percent electricity coverage of her population as displayed in Figure 1. The entire population of Countries like Germany, France, Mexico, Singapore and Egypt have access to electricity whereas South Africa is having a little above 80 percent of her population with electricity. In Nigeria, this figure is less than 60 percent, [7] see Figure 2. An analysis of the number of people without access to electricity in relation to the total population of Countries (in millions) is presented in Figure 3[8, 9].

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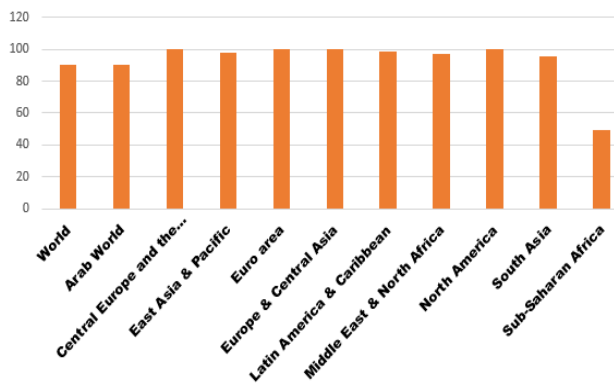


Figure 1. Global Electricity coverage, by Continents

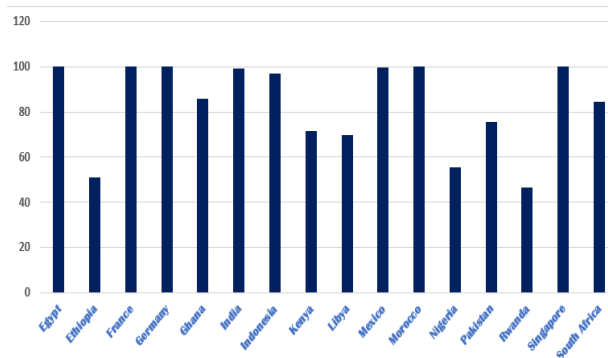


Figure 2. Access to electricity (% of population [7])

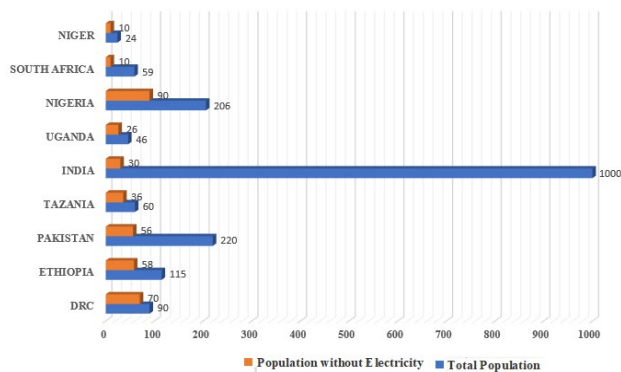


Figure 3: Counties population against electricity coverage

2. Materials and Methods

2.1. Materials

The materials used are mainly software for research and data presentation such as internet network access, Microsoft office suits; (word, excel, power point etc.). Other communication tools were equally employed in local data collection.

2.2. Methods

The performance of the Nigerian Electricity Supply Industry (NESI) was continually monitored for four quarters (2020-2021), by data gathering from the Nigerian Electricity Regulatory Commission (NERC) [10, 11], the market operators of the Transmission Company of Nigeria (TCN) [12] as well as the Ministry of power, Nigeria [13, 14]. Several visits were paid to the power stations; Transcorp power plant Ughelli, TranAfam power plant, Afam VI power plant and NDPHC's Olorunsogo II. The proceedings of stakeholder's meetings in the power industry, locally and internationally were keenly monitored [15 – 24] and the information collated was analyzed to ascertain the true position of NESI as well as proffer probable solutions. The thesis report

involves researching through the internet and collating materials from various plant Manuals in addition to technical field experience gained.

3. Results and Discussion

The Results are presented on sub-sectoral basis and a critical analysis is undertaken to arrive at the presented conclusion.

3.1. Generation

With the Installed Capacity of Nigeria grid Generation standing at 13,014.40Mwatts, the total amount of energy available for transmission was found to be 7,652.60Mwatts [12, 25]. This figure of available capacity is at par with data obtained from the ministry of power about five years ago [14], as displayed in Figure 4 and Tables 1.

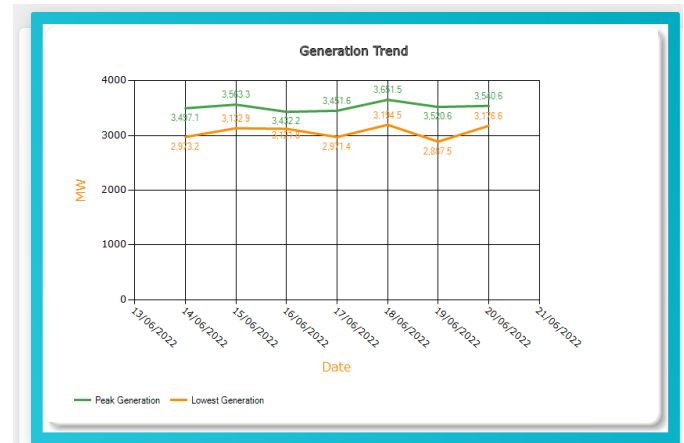


Figure 4. Grid Performance in June, 2022 [25]

Table 1. Status of Nigeria Electricity grid (2020. 2021) [12]

S/no	Metric	Value (MW)	Date attained
1	All-Time Peak Generation Ever Attained	5,801.60	01/03/2021 @ 21:30hrs
2	Grid Generation Installed Capacity Available	13,014.40	07-01-21
3	Generation Capacity Transmission	7,652.60	03-03-20
4	Wheeling Capacity (Validated)	7,300.00	04-03-20
5	Maximum Daily Energy Ever Attained (MWH)	119,471.15	05-03-21
6	Maximum Daily Energy Ever Transmitted (MWH)	117,557.27	05-03-21

3.1.1. World Energy Outlook

The 2015 United Nations Convention on Climate Change held in Paris, agreed to pursue all efforts in limiting the rise in global temperatures to 1.5°C above pre-industrial levels by 2050 [26]. Whereas most industrialized nations are officially calling for a reduction in the reliance on polluting fuel, their statistical consumption patterns tell a different story.

China is the world's largest coal producer and consumer, with the Coal used by coastal power plants at five major Chinese utilities hit 488,800 tons during the last week of March 2022. Despite the green rhetoric, China's coal consumption in 2019 was up by 1% over the previous year, driven by stronger energy demand. Additionally, the government is permitting more domestic coal production, with expectation that China will boost coal production, build more coal-fired plants, and also ease pressure on local governments to shut older and inefficient coal mines. The Country's Energy Administration has admitted plans to boost daily domestic oil production by 1% and increase natural gas production by 4.3% year on year [27]. In the U.S., Energy Infrastructure Update reveals that renewable energy sources, including solar, onshore and offshore wind, biomass, geothermal, and hydropower, accounted for about 21% of total generation in 2021 [28] and about 24 % in Germany. According to Tehran Times (May 2019), Iran's nominal electricity generation capacity has reached 81GigaWatts total capacity, with 68 GW produced by the thermal and combined cycle power plants [29]. The European Commission resolved to consider natural gas as green energy source. Under this arrangement, economic activities that may help EU countries meet their energy needs while shifting from coal power, can be considered sustainable [30], whereas in South Africa, Coal constitutes over 75% of the grid energy supply [31]. The world energy outlook by sources is shown in Figure 5 below.

Ultimately, Africans deserve the same level of energy access and security as the rest of the world. The number of people left behind is simply too large to allow foreign agendas to take viable options off the table. If we must live in reality, the goal of green energy is neither feasible nor advisable in today's Africa [34]. The National Association of Petroleum Explorationists (in Nigeria) has insisted that oil and gas remain the choice fuel till 2070 [35].

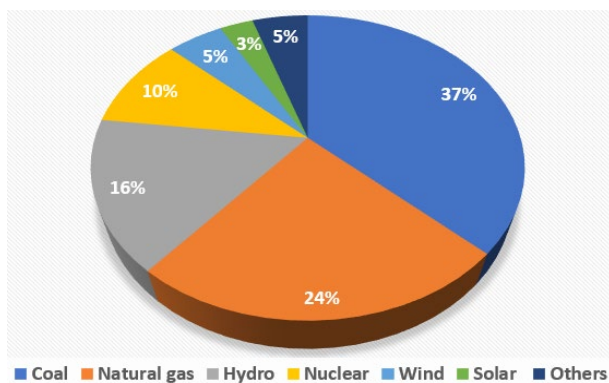


Figure 5. 2019 world electricity generation by source [32, 33]

For us to live in this world, we need energy. Development without energy increase, is not possible because there is a direct correlation between energy and GDP. So, you cannot say let us stop greenhouse emissions and climate change effects, and the impact of human footprints on the earth by eliminating human beings or by stopping the use of fossil fuels [21].

3.1.2. The Combined Cycle Gas Turbine (CCGT)

The CCGT is driven by both steam and natural gas and generates power by burning natural gas in a gas turbine and using its residual heat to generate steam. It refers to a combination of two thermodynamic cycles; the Brayton cycle and the Rankine cycle. The gas turbine exhaust, typically at a temperature of 773K-873K, is used to raise steam in a Heat Recovery Steam Generator (HRSG) which is used in a steam turbine to drive another generator.

Nigeria currently has 206 trillion cubic feet of gas reserves which was accidentally discovered while prospecting for oil. The Country holds a firm believe that if she aims to look for gas dedicatedly, there is a tendency of obtaining up to 600 trillion cubic feet of gas [36]. The Nigerian government has maintained that it would be unfair to call on developing countries to rely on renewable energy, especially for industrialization as no nation can industrialize using renewable energy alone. It therefore holds gas as zero transition fuel given the

fact that some countries, especially developing countries, are fossil fuel rich and that inadequate access to electricity with its associated problems is closely tied to poverty [17].

3.2. Transmission

The grid performance which directly relates to power transmission, focuses on four (4) Key Performance Indicators (KPI) which include; the transmission loss factor (TLF), incidence of system collapse, the stability of grid frequency and voltage fluctuation. TLF refers to the proportion (in percent) of the total energy sent out by the power plants that was lost in transmission and unaccounted for as either delivered to the Disco or exported. With 8.05% being the industry Multi-Year Tariff Order (MYTO) reference loss factor, the TCN did an average of 7.51% in the period under review, indicating an improved performance in its operation. However, without a catalyzing MYTO, the TCN probably became engulfed with complacency, leading to incessant grid collapse in the first half of 2022. The frequency, which is expected to be between a lower limit of 49.75Hz and an upper limit of 50.25Hz, with a bound stress limit of 1Hz (upper and lower) was found mainly to remain steadily in the bound stress limits throughout the period under review (as shown in Figure 6), without conforming with the statutory limits of $49.75\text{Hz} < \text{frequency} < 50.25\text{Hz}$ as set in the grid code.

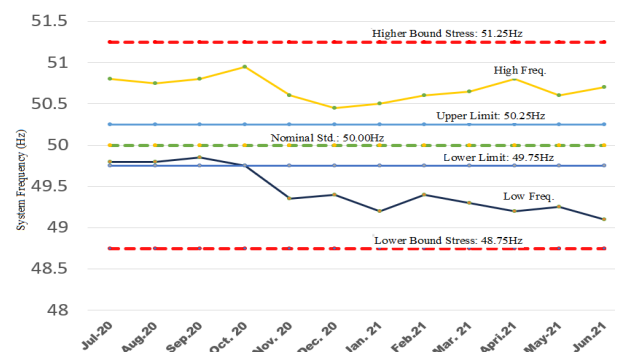


Figure 6. Grid performance in terms of frequency

3.3. Distribution

The Distribution subsector (DISCO) has been the weakest link in the entire chain. The liquidity issue that has been a bane in the industry is largely a product of Disco's underperformance. The commercial viability of the DISCOs was evaluated upon; billing efficiency, collection efficiency, minimization of Aggregate Technical Commercial and Collection (ATC&C) losses as well as their remittances as shown in Figure 7-10. In the second quarter of 2021; whereas about Two Hundred- and Seventy-billion-naira (₦270Billion) worth of electricity was issued to customers, the industry was only able to recoup One Hundred and Eighty billion naira (₦180Billion) -Figure 7. In terms of revenue collection; whereas Abuja, Eko and Ikeja DISCOs stood out in the four quarters under review, the performance of Kaduna DISCO was worst with a maximum of 38% efficiency -Figure 8. With the Average ATC&C losses by MYTO target being 22.11%, none of the DISCOs was able to live up to expectation. However, Eko and Ikeja DISCOs were able to keep their losses lower than 30% throughout the period under review with Kaduna and Yola DISCOs losing over 70% of the total energy received in each quarter -Figure 9. Owing to the afore mentioned reasons, Yola DISCO was only able to account for about 10% of the energy it received. The percentage remittances of the DISCOs are displayed in Figure 10.

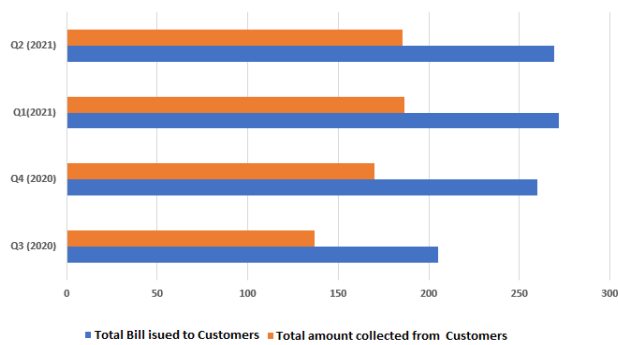


Figure 7. Overall Disco Collection outlook (in Nbillions)

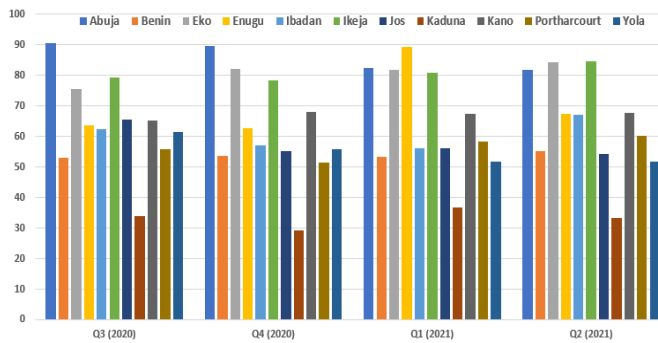


Figure 8. Revenue Collection Efficiency of DISCOs

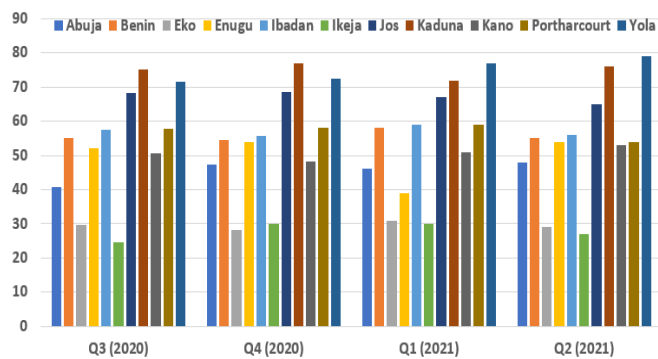


Figure 9. Percentage ATC&C Losses by DISCOs

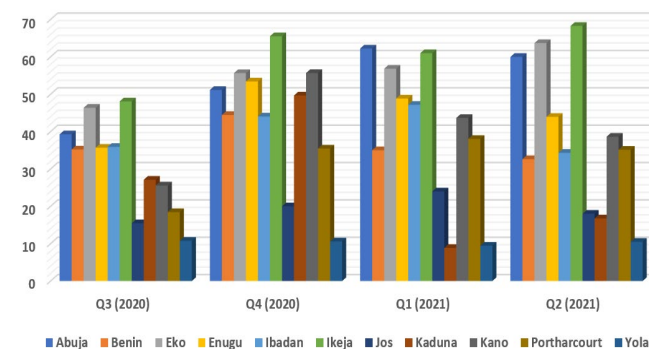


Figure 10. Percentage Remittances by DISCOs

4. Conclusions

The amount of power generation in Nigeria is abysmal in relation to her population, making it impossible for any meaningful development. In order to attain energy sufficiency, the country needs to make a conscious effort to expand the power generation base, by aggressively investing in Combined Cycle Gas Turbine (CCGT) especially now that Natural gas has been labeled “sustainable” and

also based on its comparative cost advantage to the nation, while deliberately ignoring other sources of power generation, in the interim. The transmission Infrastructure should be scaled up to cope with the increasing generation and then decentralized in order to streamline the problem of the grid and minimize total collapse whereas the distribution sub-sector should be stringently monitoring for improved accountability and system reliability in a manner that rewards commitment and punishes defaulters.

Declaration of Conflict of Interests

The author declares that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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