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Review of Utilization of Coal, Natural Gas and Hydro for Sustainable Power Generation in Nigeria

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Abstract

The geometric increase in a nation's population vis- a- vis the increase in energy demand in order to power the various sectors of the economy is a source of concern to all citizens and sundry. This paper presents an overview on the alternative sources of power generation and its associated problems and prospects in Nigeria. It starts with historical review of development and demonstrates the reasons. It also goes further to explain the need for using coal, natural gas and hydro means for power generation. Following this, different sources of power generation approaches are compared in order to determine what source is best to consider and the possible energy harvesting means are reviewed. Furthermore, state of the art technology known as carbon capture system is developed and x- rayed. Finally, conclusions are drawn based on the reviewed documents cited in this paper and a research work is initiated.

Keywords: Coal; Natural Gas; Hydro; Population; Energy

1. Introduction

Energy is a requirement in our everyday life as a way of improving human development leading to economic growth and productivity. The importance of natural resources cannot be over emphasized as it serves as the bedrock of human existence and survival. Nigeria is a nation endowed with numerous energy sources e.g. coal, gas, thermal, solar, hydro and wind etc. All available in Nigeria; a country located in the world best geographical zone or belt but fails to tap the abundant resources optimally hence the constant collapse of the national power grids and total blackout across the states of the nation(Adewole et al., 2000). The famous saying that erratic power supply is one of the problems facing under developed and developing countries is valid as long as we fail to utilize all sources of power generations at our disposal to drive the economy. Coal was formerly a source of income in Nigeria as it brings foreign earnings to the nation when exported to the Western world where it is used to supply energy for the industrial sector before the discovery of oil (Ejiofor, 1991). According to (Odesola et al., 2013), Nigerian coal has been found suitable for

use as boiler fuel, production of high calorific gas, domestic heating, briquettes, formed coke and manufacture of a wide range of chemicals including wax, resins, adhesives and dyes. Coal generated employment for the teeming population and also served as solid sources of energy for both domestic and industrial users in Nigeria. The discovery of oil made the government of the day to shift her attention from other natural resources including coal to oil exploration, production and exportation. This made oil to be the chief source of revenue to the country amounting to 80% of her total annual revenues (Ibeneme, 2000; Ilesanmi et al., 1997).

2. Analysis

2.1. The Energy Sources

A cursory look at the power sources in the seven continents reveal that the practice of energy mix is a welcome development for national economic growth. In Nigeria, the quest for an improved or an appreciable increase in the nation's external reserve cannot be achieved if the country's Gross Domestic product (GDP) is not boosted. This could only be achieved when all the productive men and women workforce are fully employed.

The main backbone of the industrial sector is the generation and distribution of power (electricity) to meet their production targets. Within the continent of Africa, Nigeria energy generation plants depends largely on energy derived from the gas obtained from her crude oil exploration and hydro power generation plants but the geometric population explosion and increased urbanization has made power supply to be inadequate and erratic hence the need to diversify to alternative power generation method to compensate for the shortfall in energy need of the nation. The following energy sources are identified across the globe; coal, wind, gas, solar, thermal, hydro etc.

2.2. The African Perspectives: Nigeria

The use of coal as an energy source can be dated back to the prehistoric times. Coal was first discovered in Nigeria in 1909 at the Udi Ridge in Enugu by a British mines engineer named Albert Kitson but till date Nigeria is yet to transform 2.8 billion metric tons of coal in seventeen (17) fields into wealth (Adewale, 2000, Adepo and Ayodele, 2003). Albert Kitson had been prospecting for silver but stumbled on coal, this made him to start exploration and by the year 1914, Nigeria's amalgamation, the first consignment of coal made was transported to the United Kingdom from the newly created ports at Port Harcourt. This commonwealth made Enugu to be the business hub of the region as it contributed to the rapid development of the town.

The wealth generated from coal was so strategic that Enugu became the capital of the Eastern Region in 1938. The wide spread of coal wealth also led to the establishment of a thriving port at the area now known as Port Harcourt - a city to be reckoned with when it comes to transporting coal by rail to Port Harcourt for onward shipment to Europe. Coal mining quickly spurred the growth of the population of Enugu with the influx of miners, the total number of miners working in the region jumped from 6,000 men in 1948, to 8,000 men in 1958. In 1916, the Ogbete Mine was in full operation and in that year alone, it yielded 24,511 metric tons of coal. Over time, other mines sprang up in the region which became the modern day Enugu State. Coal production

hit an all-time high of 790,030 metric tons before it faced a steady decline due to reasons such as lack of improved technologies in the utilization of coal, poor government policies, system failure and poor means of transportation, poor coal corporation management etc.

The core domestic market for coal production in Nigeria was its emerging rail system which depended heavily on the produce to power its locomotive engines. But with the sudden discovery of hydrocarbons in the late 1950s, the Nigerian Railway Corporation switched from coal to diesel powered energy. The Electric Company of Nigeria also converted its power generation from coal to diesel. The loss of these two big clients played a major role in the decline in coal production as the government did not think it feasible to continue to heavily invest in the sector. Besides, the recent discovery of crude oil at Oloibiri held the promise of greater revenue through exports for the newly independent nation. The Coal Corporation survived the onslaught of crude oil especially because it continued to enjoy a national monopoly on coal production. Attempts at mechanizing the mines in the late 70s and 80s failed, further plummeting production. Another concern in the 1980s and most of the 1990s was the poor management of the Nigerian Coal Corporation.

The then military government had a perchance for randomly appointing personnel with little or no experience in management or without technical knowledge to manage public enterprises. The Nigerian Coal Corporation was no exception. The final blow was in 1999, when the Nigerian government sought to increase direct foreign investment in the country by privatizing the Corporation and opening the nation's solid mineral market to large private investors, the strategy failed. With the withdrawal of support from the government, the Corporation lost its steam. It however remained in operation till 2002 before eventually shutting down. Unsuccessful in its privatization bid, the Federal Government in 2013 sold off some of the Corporation's assets to the Enugu State government in order to offset outstanding debts.

2.3. Expected Energy Generation from using Coal

The quest for alternative power supply is on the increase as energy demand or consumption increases with population growth. A power mix- summit where stakeholders in the power sector would deliberate on how to adopt coal as a source of power generation in Nigeria is highly needed. Coal could contribute about 6% of the 40GW energy target, this is achievable if some of the planned coal power plants will be in Enugu (1600 MW), Kogi (1000MW) and Benue (1200 MW).

2.4. Carbon Capture Utilization and Storage Technology

Energy is an important factor in all modern industries of today and one of the ways to generate this in a relative safe manner is by the use of boiler to raise the temperature or pressure of the given medium and then use it as heat source for factory need but emissions are inevitable (Espie, 2005). Carbon Capture and Storage is a clean technology that entails capturing, transporting, storing and treatment of gaseous substance from industrial or large power plants to a geological formation for sound monitoring and final ejection into a safe haven.

Though coal exploration is deadly particularly to the host communities but its impact on climate change is enormously dangerous to human existence especially in the area of carbon dioxide emission but Nigeria needs to explore a new clean technology for trapping and capturing the carbon dioxide emissions from coal exploration, cleaning to remove some impurities like coal

ash and sulphur, transportation, crushing into powder form, charging into the boiler to generate high pressure super- heated steam which can then be used to drive turbine already connected to an electric generator for electricity. In this context, coal is used to fuel a mini power plant for electricity generation and the amount of carbon dioxide emission is captured to reduce the amount of CO_2 already in the atmosphere thus causing global temperature increase.

This technology is known as carbon capture and sequestration and it is a process where carbon dioxide from large stationary source like power plants are captured before it is released into the atmosphere. The three stages involved are, capture, transport and geological storage. Figure 1 and Figure 2 show schematic diagrams of pulverized coal fired plant and Carbon Capture Utilization and Storage Technology.

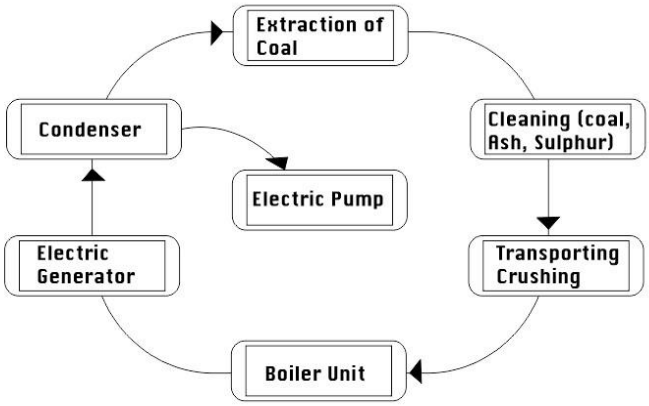

Figure 1. Schematic flow process of pulverized coal fired plant.

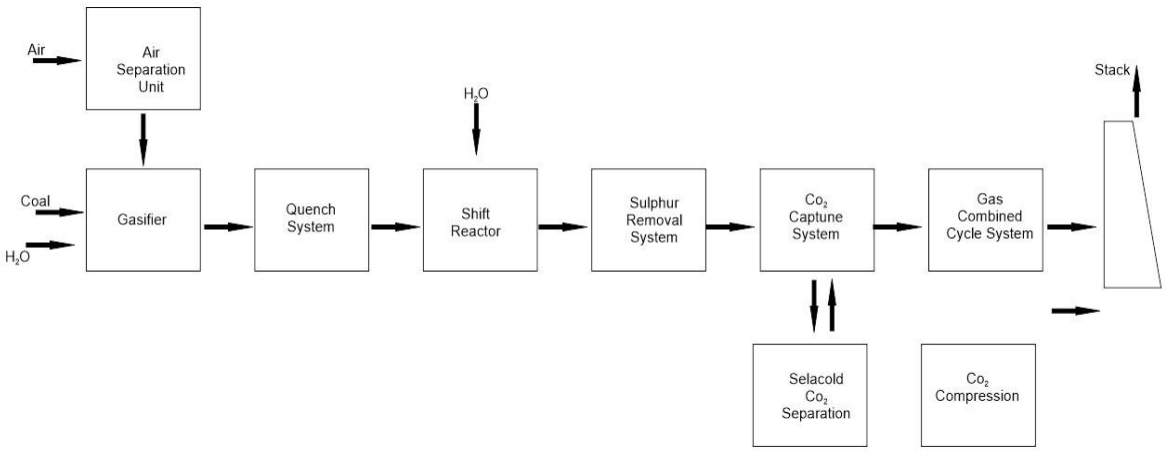

Figure 2. Schematic diagram of carbon capture utilization and storage technology.

2.5. The Asian Perspective: China

China's energy structure is dominated by coal, this is because renewable energy sources such as wind, solar are intermittent and unstable hence the direct need to rely on a more reliable and stable source of energy generation. Coal is readily available in large quantity and quality and this is the major source of energy generation in China, a country that is still trying to develop technology on renewable energy to complement her industrialization needs. i. e. China is an industrialized country with a coal deposit amounting to 56.8% of China's domestic energy generation

in the year 2020 though China was adjudged as the world's heavier emitter of carbon dioxide [CO_2]. According to a US based Global energy monitor, China is a major designer, developer and supplier of coal fired power plants and has been constructing same for several developing countries. Figure 3 Show typical of a coal fired plant.

Figure 3. Typical example of a coal fired plant.
Source: Qilai Shen/Bloomberg via Getty image.

2.6. The American Perspectives- North and South America

Coal is still a solid mineral in used in about 18 states in the United States of America for electricity generation; coal is still the most prevalent fuel for electricity in parts of Appalachia, including Ohio, Kentuchy and West Virginia. In USA, precisely North Dakota; coal is first burned in large vessel in order to convert it into gases and liquid known as synthetic fuel or syngas. This synthetic fuel produces fewer air pollutants when burned than burning coal directly, it is then used to produce electricity and hydrogen.

The energy mix techniques in the US have made it possible to have enough energy to power each region. Coal fired power plants burn coal to make steam and the steam turns turbines to generate electricity, this has made it possible for many industries and businesses to have their power plants and some use coal as their source of power mostly in combine heat and power plants. Figure 4 shows US coal consumption by major end users, 1950-2020.

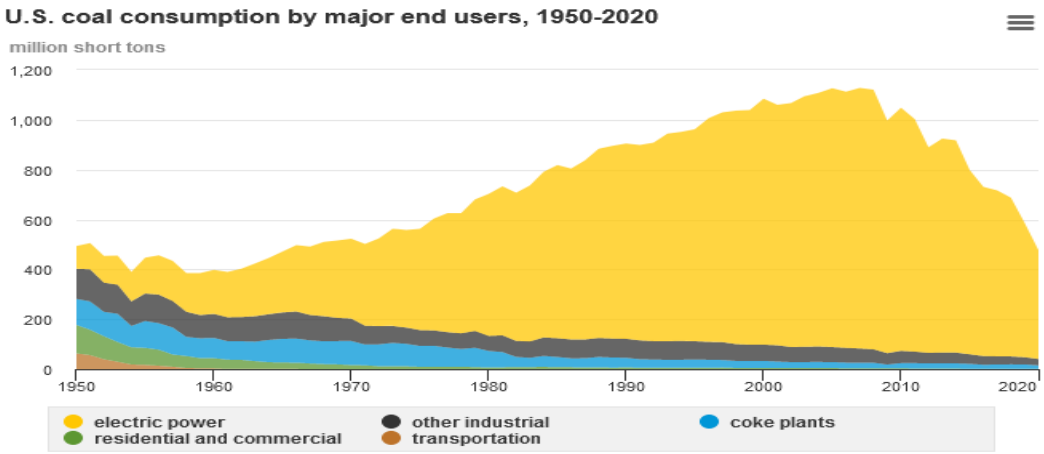

Figure 4. US Coal consumption by major end users.

Source: US Energy Information Administration

The figure above summarizes US coal consumption up to year 2020, an indication that coal is a major source of power generation via its high tech conversion to synfuel or synthetic fuel so as to reduce its pollutant content. The three major categories for electricity generation in the US are fossil fuel, nuclear energy and renewable energy as depicted in Table 1 US Electricity Generation by major energy source is also shown in Figure 5.

Table 1. US Electricity Generation by major source.

Fossil fuel	Nuclear energy	Renewable energy
• Coal (9%) • Natural gas (40%) • Petroleum (1%)	Nuclear reactors (20%)	• Solar 10% • Wind 40%

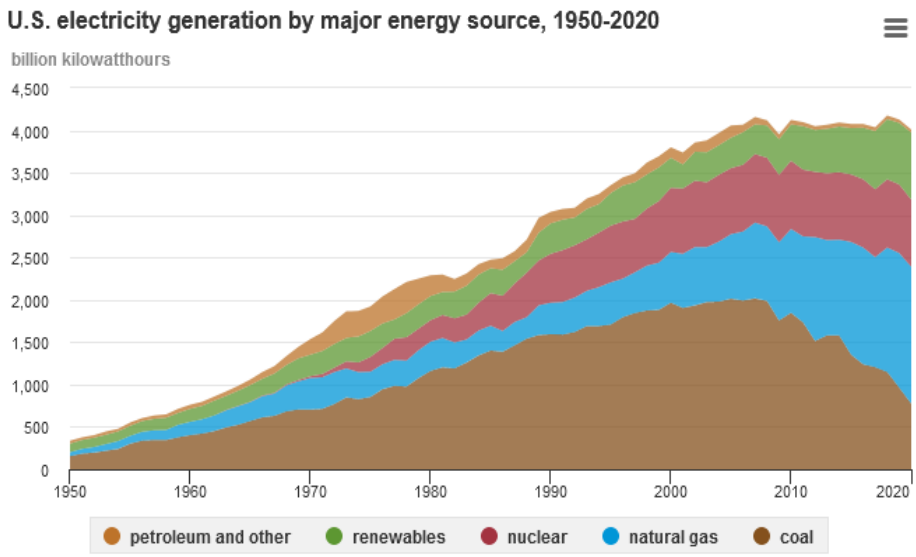

Figure 5. US Electricity Generation by major energy source.

Source: US Energy Information Administration, Monthly Energy Review, February, 2022.

2.7. The Europe Perspective: United Kingdom and Poland

Poland is the second largest coal mining country in Europe and the ninth largest coal producer in the world. Coal mining in Poland produced 144 million metric tons of coal in 2021 alone providing 55% of the country's energy consumption and 75% of the total electricity generated. Despite this, Poland diversify its energy mix in the area of using biomass and waste which gives an estimated 8.9% of their total primary energy supply with 6.1% electricity generation. Table 2 depicts UK and Poland electricity generation by major sources.

Table 2. UK and Poland Electricity Generation by major sources.

Fossil fuel	Biomass & Waste	Renewable energy
• Coal (75%)	Biomass and waste (6.1%)	• Solar 10% • Wind 9%

2.8. Lessons to Learn

Nigeria has a very rich coal deposit in large quantity and it will not be out of place if Nigeria could adopt energy mix development (coal, hydro, wind, solar, gas and thermal) for national economic growth in order to meet her ever increasing demand for energy to power all sectors of the economy. Technology is the zing thing in order to achieve this great feat in the comity of nations hence the dire need to call for an energy debate about energy future of this country.

3. Conclusion

The amount of CO_2 in the atmosphere is at a recording high level thus its continuous release or emission causes climate change, deadly respiratory diseases from smog and air pollution, extreme weather, food supply disruption and increased wild fires are other effects of climate change caused by greenhouse gases but carbon capture sequestration is a clean technology needed for the reduction of the amount of CO_2 released into the atmosphere as a result of various energy generation technologies.

4. Recommendations

This paper has been able to peruse through the various global best practices in the area of power generation and sustainable environment hence the following recommendations are made:

a. Nigeria as a developing nation could adopt coal with an improved technology to power some parts of the country.
b. Government should organize a power- mix summit to review her energy requirement from every sector of the economy and adopt an alternative power supply.
c. Solar method should equally be used in regions with high degree of sunlight energy e.g Sokoto, Kaduna, Yobe.
d. Wind energy in some hilly parts of the country like Plateau Enugu, Katsina states as the whirlwind could be trapped by windmill connected to turbine which converts the mechanical energy into electrical energy needed.

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