

# CONVENTIONAL ENERGY SOURCES IN NIGERIA: A STATISTICAL APPROACH

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## ABSTRACT

Energy has always been one of the basic requirements of human societies, and today its demand is far greater than ever in our highly technological world. This is buttressed by the fact that energy is vital for human life, and for technological advancement. Presently, major electricity generation takes place at central power stations which utilize coal, oil, water, gas or fossil nuclear materials as the primary fuel sources. There are problems facing the further development of generating methods based on any of these conventional fuels. The continued large-scale use of oil and gas in countries not blessed with indigenous reserves is particularly doubtful because supplies are expensive, rapidly diminishing, and politically controlled. Hydro-electrical power generation is restricted to geographically suitable areas, and reserves of coal, although presently plentiful, are regrettably not renewable. This paper therefore looks into thermal power stations in Nigeria, the trend of the thermal power sources and makes recommendation on how to manage the nation's natural reserves for efficient, coordinated and constant power supply.

**Index Terms:** *Non-renewable energy, statistical analysis, power generation, conventional fuels.*

## 1. INTRODUCTION

Energy is considered as one of the most important resources of any country. It is a well known fact that high rate of industrial growth of any country is a function of the amount of energy available in that country and the extent to which this energy is utilized. Nigeria is an energy-resource rich country blessed with fossil resources such as crude oil, natural gas, coal and renewable energy resources like solar, wind and biogas [1, 2, 3].

In Nigeria, the availability of a reliable power supply is part of the enabling environment for industrialization and therefore needs to be addressed in national policy. The utilization of renewable energy sources in Nigeria remains quite limited. Although use of solid biomass such as firewood, is prevalent and constitutes a major energy source for most rural dwellers in Nigeria; unfortunately, its continuous usage lead to deforestation [4, 5].

Nigeria's usage of hydropower, geothermal and solar energy is still low. Nigeria has good radiation sites that

can boost the development of solar energy; yet research efforts and government attention in that direction have yielded little results. The seasonal nature of Nigeria's rainfall limits hydropower usage from increasing in importance [6].

This paper is organized as follows. Section two looks at the type and state of thermal power stations in Nigeria. Section three presents the conventional energy sources in Nigeria. In section four the statistical analysis of natural gas, crude oil and coal production in Nigeria is carried out. Finally, section five states our conclusions with relevant recommendations.

## 2. THERMAL POWER STATIONS IN NIGERIA

The bulk of the supply for electrical energy in Nigeria has been from the National Electric Power Authority (NEPA). Demand for electrical energy has been on the increase among residential, commercial and industrial consumers as shown in Figure 1. This informs why NEPA continues to expand annually in order to counter these increasing demands. Presently, that task is being performed by the Power Holding Company of Nigeria, PHCN [7]. Thermal power stations provide the bulk of the nation's energy needs. Table 1 shows the nation's thermal and Hydro power stations and their locations.

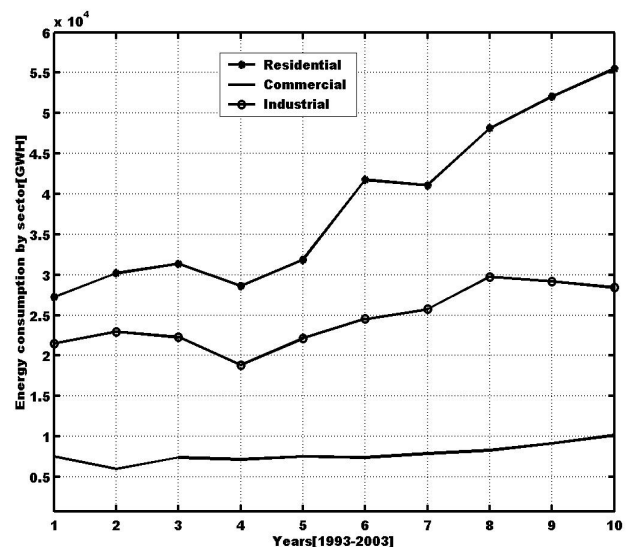


Figure 1: Energy Consumption patterns by sector.

**Table 1:** Thermal and Hydro Power stations in Nigeria[14,16].

Power station/ location	Type	Year of commissioning	Generation capacity (MW)	Remarks
Lagos station @ Egbin	Thermal (gas)	1985 – 1987	1,320	6 x 220MW reheat steam turboelectric unit
Sapele station @ Ogorode	Thermal (gas)	1978 – 1990	1,020	6 x 120MW steam and 4 x 75 MW
Delta TV @ Ughelli	Thermal (gas)	1966 – 1990	832	Including 6 x 100 MW
Afam	Thermal (gas)	1975 – 1982	710	
Oji	Thermal (coal)	1956	30	Not functional
Ijora station Lagos	Thermal (gas)	1978	60	3 unit x 20MW (2 units working)
Lagos IPP (Enron/AES)	Thermal		170	Maximum planned is 270MW
Abuja IPP	Thermal		30	
River IPP (Trans-Amadi Station)	Thermal	2000 – 2002	30	
Kainji	Hydro	1968,1976, 1978	760	Some Generators require major overhaul
Jebba	Hydro	1986	540	All units available
Shiroro	Hydro	1990	600	Some units require repairs

It is important to note that thermal power stations provide the bulk power consumed by the nation going by their generating capacity as compared to hydro-power stations.

### 3. CONVENTIONAL ENERGY SOURCES IN NIGERIA

Electricity energy production in Nigeria over the last 40 years varied from gas – fired, oil – fired, hydroelectric power stations to coal-fired with hydroelectric power system and gas – fired system taking precedence [8, 9].

This is predicated by the fact that the primary fuel sources (coal, oil, water, gas) for these power stations are readily available. Nigeria's coal reserves are large and estimated at 2 billion metric tonnes of which 650 million tonnes are proven reserves. About 95% of Nigeria's coal production has been consumed locally; mainly for railway transportation, electricity production and industrial heating in cement production.

Nigeria has an estimated 176 trillion cubic feet of proven natural gas reserves, giving the country one of the top ten natural gas endowments in the world and the largest endowment in Africa. Natural gas is a natural occurring gaseous mixture of hydrocarbons gases found in underground reservoirs. It consists mainly of methane (70% - 95%). With small percentage of ethane, propane, butane, pentane and other heavier hydrocarbons with some

impurities such as water vapour, sulphides, carbon dioxides, etc. [10]. Apart from the export potential of the Nigerian gas, local demand opportunities are power generation, cement industry, iron and steel plants. The largest single consumer of natural gas in Nigeria is PHCN and it accounts for about 70% used to operate electricity generating gas plants at Afam, Ughelli, Sapele and Egbin.

The third major sources of energy, oil, is Nigeria's major sources of revenue used for development. Nigeria has 35.2 billion barrels of proven crude oil reserves. The Nigeria government plans to expand its proven reserves to 40billion barrels by 2010. The consumption rate of petroleum product in Nigeria has increased tremendously in 1990- 2004 with motor gasoline and diesel oil taking a significant lead. The consumption of petroleum products stood between 80% and 90% of the total commercial energy consumption over 35 years. The growth rate over the period averaged about 22 % with gasoline 28%, kerosene 19% and diesel 18%. Gasoline and diesel are mainly used for transportation which accounts for 87%. About 95% of the Nigeria crude oil is produced in the Niger-Delta region resulting in the concentration of the operation of multinational companies like Shell-BP, Agip, Mobil, Chevron in that region.

### 4. STATISTICAL ANALYSIS OF CONVENTIONAL ENERGY SOURCES IN NIGERIA

Here, we set out to determine approximately the relationship between two varying quantities (Energy

Sources and Years). Consequently, any one variable could be used to predict the other in any given year. A regression analysis is used. If we assume that the total coal production, total gas production and total crude oil production are related with years, then time becomes an independent variable while total production of the resources become the dependent variable.

Linear and quadratic relationships between the variables can be written in the form [11]:

$$y = mx + c \text{ (Linear)} \quad 1$$

$$y = a_0 + a_1x + a_2x^2 \text{ (Quadratic)} \quad 2$$

Where,  
 $y$  = total production  
 $x$  = year

The constants  $m$ ,  $a_0$ ,  $a_1$ ,  $a_2$  and  $c$  can be evaluated using the relations given by equations (3-7).

$$m = \frac{n \sum x_i y_i - (\sum x_i)(\sum y_i)}{n \sum x_i^2 - (\sum x_i)^2} \quad 3$$

$$c = \frac{(\sum y_i)(\sum x_i^2) - (\sum x_i)(\sum x_i y_i)}{n \sum x_i^2 - (\sum x_i)^2} \quad 4$$

$$a_0 n + a_1 \sum x_i + a_2 \sum x_i^2 = \sum y_i \quad 5$$

$$a_0 \sum x_i + a_1 \sum x_i^2 + a_2 \sum x_i^3 = \sum x_i y_i \quad 6$$

$$a_0 \sum x_i^2 + a_1 \sum x_i^3 + a_2 \sum x_i^4 = \sum x_i^2 y_i \quad 7$$

Where,  
 $n$  = number of years.  
 With the date collected as in references [12-13], the equations were solved by developing MATLAB programs for all the conventional energy sources [15].

#### 4.1 ANALYSIS RESULTS.

Figure 2 shows the graph of the trend equation for the crude oil production. It is seen that the trend equation is approximately linear. This implies that the total crude oil production in Nigeria relates linearly with the number of years.

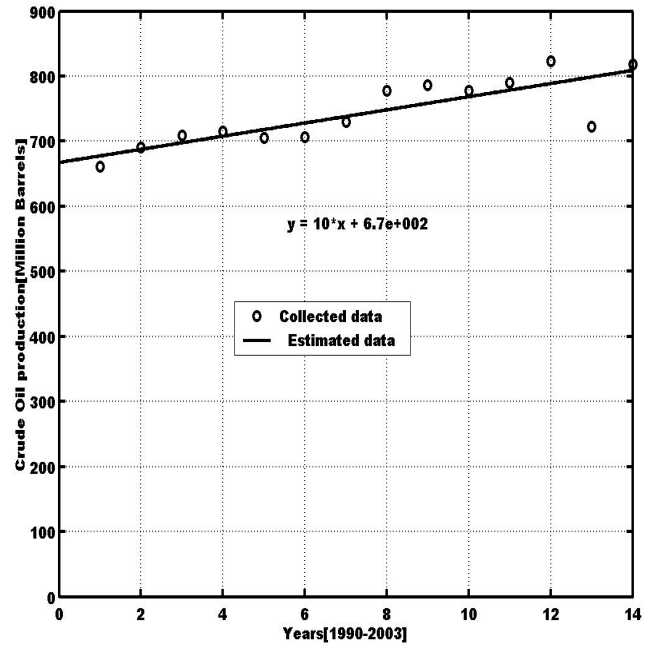


Figure 2: Crude oil production

We can then use the trend equation to estimate the crude oil production for any year of interest.

The regression analysis result for natural gas production is shown in Figure 3. From the graph, we can observe a quadratic relationship existing between the two variables. Thus, natural gas production in Nigeria increases as the number of years increase.

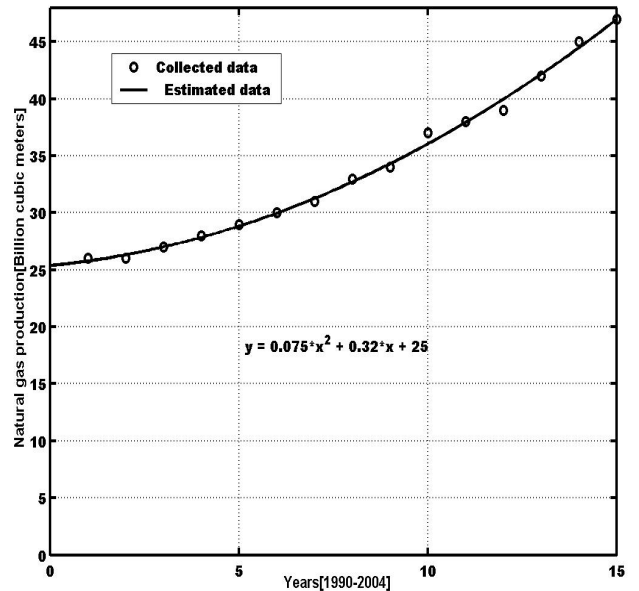


Figure 3: Natural gas production.

The trend equation of Figure 4 shows a non-linear relationship between coal production and number of years. Again, from the graph we observe that coal production in Nigeria has been at a steady decline due to

government's indifferent attitude to investing in the coal industry. The Nigerian Coal Cooperation (NCC) has been moribund with low morale of workers due to delayed and sometimes non-payment of salaries.

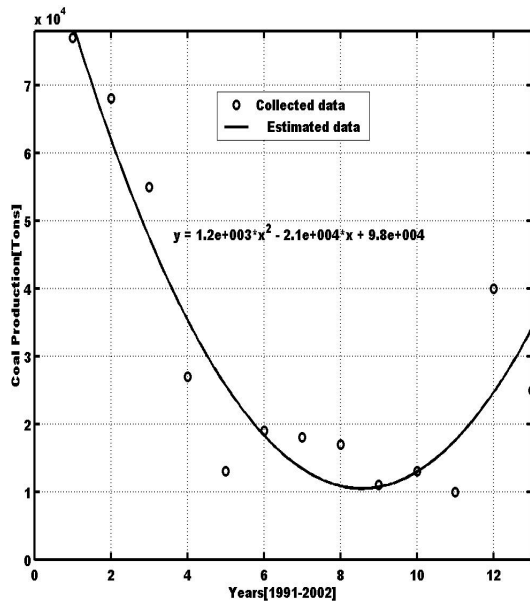


Figure 4: Coal Production

Figure 5 shows the graph of trend equation for the gas consumed in the Delta power station. It is seen that the relationship is quadratic. This is understandable as the incessant disruption of gas production by the restive militant around the Niger Delta region does not guarantee even production.

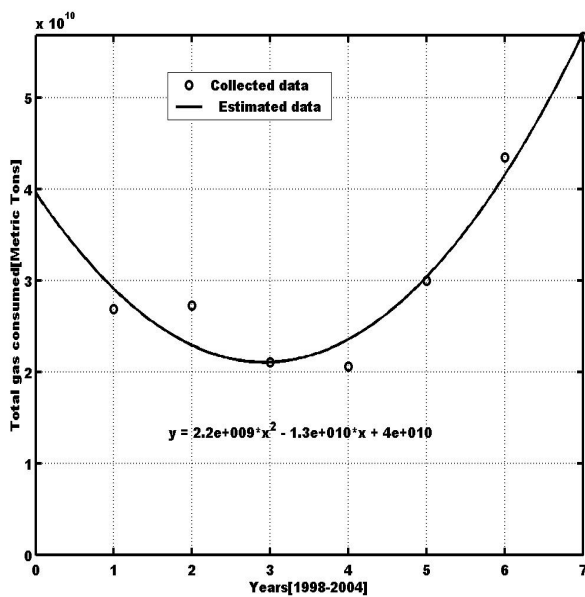


Figure 5: Gas Consumed in Delta Power Station.

## 5. CONCLUSION

In this paper, we have attempted to look at the trends of thermal power sources in Nigeria using statistical

methods. It has been established that the future of thermal power stations in Nigeria depends in part on the availability and prudent utilization of these sources. Therefore, the need for up - to - date and accurate statistical analysis cannot be overstressed, for it is one of the props on which future plans must stand. Any development plan and future predictions based on unreliable statistic are bound to fail as the basis for such plans are not well founded. It is important to state that the prognosis made for the thermal power sources – coal, gas and crude oil using regression analysis may not be very accurate. This is because we have considered the simple case of regression analysis depending on two variables. For very accurate work, multiple regression analysis needs to be employed. However, the method of analysis used is dictated by the data available.

In conclusion, the following observations are in order:

- (i) As of now the internal markets for coal are restricted as they cannot compete favourably with crude oil and natural gas. As a matter of fact, there is a need to de-emphasis coal-fired thermal power stations in Nigeria for the near future.
- (ii) The advantages of natural gas over other forms of fuel are numerous. It is less expensive, clean and abundant. Also storage, transportation and safety problems are minimal. Nigeria has three times more gas, in crude oil equivalent than crude oil. Therefore, natural gas must appropriately replace crude oil in terms of power generation in the years ahead. As of the moment, the national investment in oil-fired power station may be discouraged.
- (iii) Due to the lower operating and maintenance costs of hydro plants, joint investment in hydro and gas-fired thermal power stations will be an ideal for the Nigerian economy. This is because hydro-electric plants do not require any fuel and are quicker to start up on load, hence could always be used when there are emergency power outages in the existing thermal power stations.
- (iv) The future of gas-fired thermal power stations will continue to be bright if measures are taken to ensure prudent use of our gas resources and will turn out to be the major power source in Nigeria for the future. The dogged insistence by the Federal government of Nigeria on the enforcement of the spirit of the degree on gas regulation through NNPC is one such measure. The associated gas re-injection degree encourages the producing companies to re-inject back into the ground any gas produced in association with crude oil, instead of flaring it. Instead, such flared associated gas could then be directed into thermal power stations for power generation.

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