ISSN No:-2456-2165

Economic Condition for Profitable Electricity Generation in Nigeria

Taofeek Olayinka AYINDE
Energy Studies: Oil and Gas Economics
Electrical and Electronic Engineering Department
Petroleum Training Institute, Effurun
Delta State, Nigeria

Abstract:- The increasing demand for electric power in Nigeria,due to population and industrial growth coupled with inadequate supply from hydropower stations is stimulating interest in Gas to Power Projects (GtPP) investments. The country's production is estimable of 8.24 billion standard cubic feet per day and comprises associated gas (98tscf) and non-associated gas (89tscf). However, even with the huge resources, electricity supply is not adequate to satisfy local demand needed to achieve development. One of the reasons for insufficient power supply is gas supply shortage for generating electricity. The study is to investigate economic condition for profitable electricity generation in Nigeria. In this paper, mathematical programming was used. The paper employs its approach by building a deterministic optimization model to capture an energy system and also experiments Monte Carlo simulation in terms of the results to capture uncertainties.The price of electricity generated near the gas fields rose from $0.03/kWh in January, 2013 to $0.07/kWh in December, 2017. It rose sharply to $0.08/kWh in January, 2015 before a fall. Price of electricity generated away from the gas fields rose to $0.09/kWh in December, 2017 from $0.05/kWh in January, 2013. Analyses shows that electricity price for plants located near the source ($0.06±0.02/kwh) and away from the sources ($0.08±0.02/kwh), exhibitednarrow variation. Simulation runs with 20 paths indicated high level of uncertainties in the future prices of electricity; as a result of no clear patterns shown between the different paths. The study concludes that optimisation of electricity cost and distance to gas fields will make it easier to take final investment decision on the profitable electricity generation in Nigeria.

Electricity generation in Nigeria could be said to have began in 1898 when the first generating plant was installed in Lagos under the jurisdiction of Public Works and Transport. Though, the Nigeria Electricity Supply Company (NESCO) commenced operations as an electricity company in Nigeria in 1929 with the construction of a hydroelectric power station at Kurra near Jos, Plateau State. Since then it has undergone many reforms in trying to connect every part of the country to the national transmission grid. In 1950, the British colonial administration passed the Electricity Corporation of Nigeria ordinance, known as the ECN Ordinance No.15 of 1950.

***Keywords**:- Economic, Investment, Profitability, Electricity Generation.*

I. INTRODUCTION

The increasing demand for electric power in Nigeria,due to population and industrial growth coupled with inadequate supply from hydropower stations is stimulating interest in Gas to Power Projects (GtPP) investments.Electricity generation in Nigeria could be said to have begun in 1898 when the first generating plant was installed in Lagos under the jurisdiction of Public Works and Transport. Though, the Nigeria Electricity Supply Company (NESCO) commenced operations as an electricity company in Nigeria in 1929 with the construction of a hydroelectric power station at Kurra near Jos, Plateau State. Since then, it has undergone many reforms in trying to connect every part of the country to the national transmission grid (PTFP, 2015).

In recent years, gas has become the preferred fuel for electricity generation due to higher transformation efficiency, lower relative capital investment and modularity, ease of delivery and reduced maintenance, lower pollutant emissions, increased availability, and lower relative price.

The country's production is estimable of 8.24 billion standard cubic feet per day and comprises associated gas (98tscf) and non-associated gas (89tscf). However, even with the huge resources, electricity supply is not adequate to satisfy local demand needed to achieve development. One of the reasons for insufficient power supply is gas supply shortage for generating electricity. A substantial volume of the associated gas produce is flared, leading to loses estimated at about US$18.2 million daily from revenue losses from flared (PTFP, 2015).

Over 70 percent of Nigeria's electricity generation as at 2015 uses gas as the source of fuel and it is expected that the thermal power plants will continue to be a major driver of domestic utilization of gas after privatization (World Bank, 2015). Also, Gas Monetization Projects would encourage investment in gas infrastructure as well as utilization of gas that would otherwise have continued to be flared. A number of investments in gas-based industries will increase the domestic use of gas.The oxygen of any economy is electricity and access to electricity is a measure of prosperity for any nation (World Economic Forum 2014). In 2015, Nigeria reach an average peak generation about 4,800 Mw. Failure to attain more than 5000MW is attributed to gas supply outage.

Prior to November 2013, all segments of the electricity sector were mainly owned and managed by Nigerian government which also acted as the investor of the whole electricity system. The electricity investment cost was covered through sale price and state subsidies or profit surrender. Spending over US$60 billion to resuscitate the sector has been proved to be abortive because of inadequate supply of electricity to meet the continuous demand for electricity in the country. In addition, majority of Nigerians still live without access to electricity. The sector witnessed another landmark on November 1, 2013 by transferring the ownership of generation and distribution segments to the private investors for the purpose of closing the existing gaps in the area of infrastructure and investment. However, with the changes of ownership in the sector, the country has not been able to generate more than 6000 mw for over the past two year of privatization. In addition, without adequate gas supply to generate the electricity, the capacity of the country's economy to achieve sustained inclusive growth will be unrealistic.

The objective of the study is to investigate economic condition for profitable electricity generation in Nigeria. In other word, to investigatewhen it is more economical to generate electricity either at gas source or a central location away from the gas source.

The research is significant as it will analyse theissue in the country on how the gas could be exploited to boost the power sector since over 70 percent of electricity generation companies use gas as their fuels. This study provides significant contributions in formulating and implementing policies towards effective and efficient exploitation of natural gas to generate optimal electricity as well as enrich the existing literature.Every methodology used is followed by relevant assumptions, data, results and discussions at the same time.

The study used cost data and other related parameters from selected thermal power plants in Nigeria between 2013 and 2017.and simulated parameters for between 2018 - 2030 (from Egbin Thermal Power Station, Egbin, Transcorp Power, Ughelli, Sapele Power Station, Niger Delta Power Holding Company, Sapele and Nigeria Gas Company, Ekpan). This period is based on the reason that privatization of generation segment concluded in 2013, and Paris Conference in December 2015 had taken 2030 as year to end global gas flaring, including Nigeria.

II. THE PRICE OF ENERGY (ELECTRICITY)

2.1 The Price Oil Crude

World oil prices have continued to remain unstable and dangerous, attracting broad interest from decision-makers, investment companies, financial firms, and the university. Figure 1 displays the 15-year historical record of values for specified oil and gas sources, including United Kingdom Brent, West Texas Intermediate andBonny Light on a western oil mart for regulation of dollar within 2000-2015 length of time.

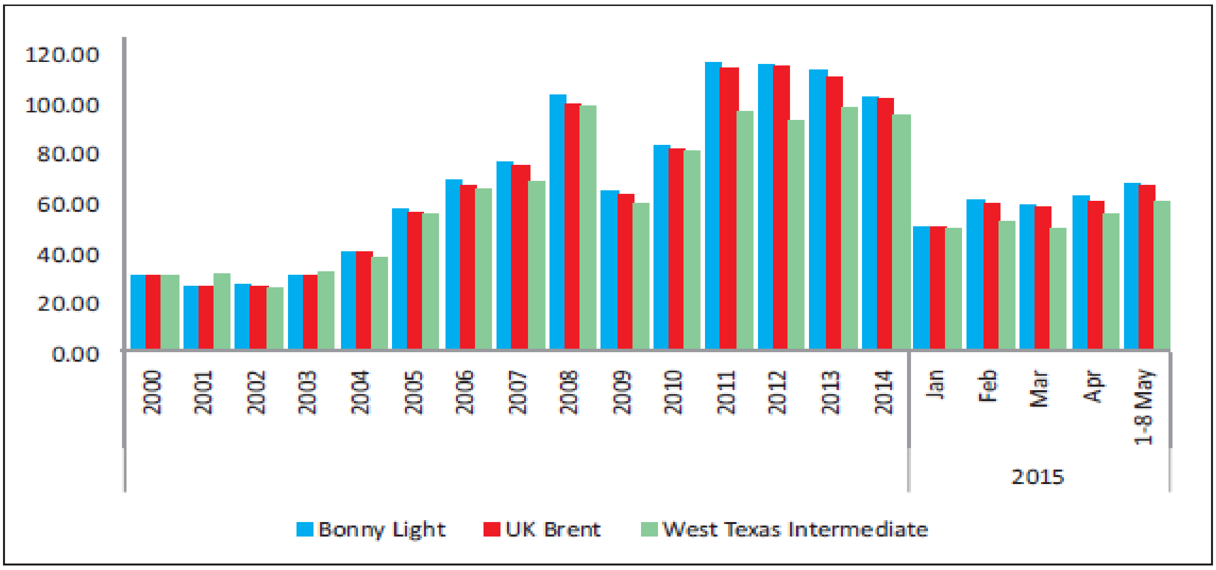

Figure 1: Natural Gas Mean Prices (USD$/barrel, from 2000 to First week of May, 2015)
Source: Reuters, May 2015.

Between 2000 through 2003, global oil procurement was limited to keep pace with the increased production largely fueled by global economic growth, mainly in Asia, contributing to a rise in global natural gas prices. As a result, foreign crude oil prices grew gradually with such a level of USD$ 38 per one barrel of oil in 2004 hitting roughly USD$ 97 and USD$ 101 for a one barrel of Bonny Light andoil forBrent, respectively, from 2008 through 2011. Protracted increment in the requirement for natural gas that originated in some European countries, China, and the United States, which was activated through continuous development in the market growth of these countries led to the oil expansion. However, certain factors that contributed to this include lower labor output of the largest global-producing countries as a direct consequence of reduced funding; political upheaval, particularly Mideast region; and speculation on both the likelihood of more natural disasters such as a severe tropical cyclone often known as hurricane that presaged the supplies of oil and naturalgas and placed more price pressure on them (Rapu*et al.*, 2015).

2.1.1 The Prices of Natural Gas

On the international market, crude prices are indexed on a henry hub and traded on trends in LNG. The prices are determined on the national market by the Oil Producers Exchange Segment (OPTS) NGC and NNPC. On a global scale, price levels between 1991 and 2000 ranged around USD$ 1.70/mBtu- USD$ 4.23/mBtu as shown in Figure 2. Between 2003 and 2008, costs increased from USD$ 5.63/mBtu - USD$ 8.85/mBtu. Crude prices have risen over all these years as a result of exits from current nuclear and coal-fired plants, resulting in increased use of developed gas-fired power stations and new plant production. Following the Kyoto resolution, the constant search for clean power resulted in demand for gas to generate electricity amid controlled supply. The energy transition strategy described gas as the optimal fuel for generating electricity in Nigeria (Energy Information Agency, 2014).

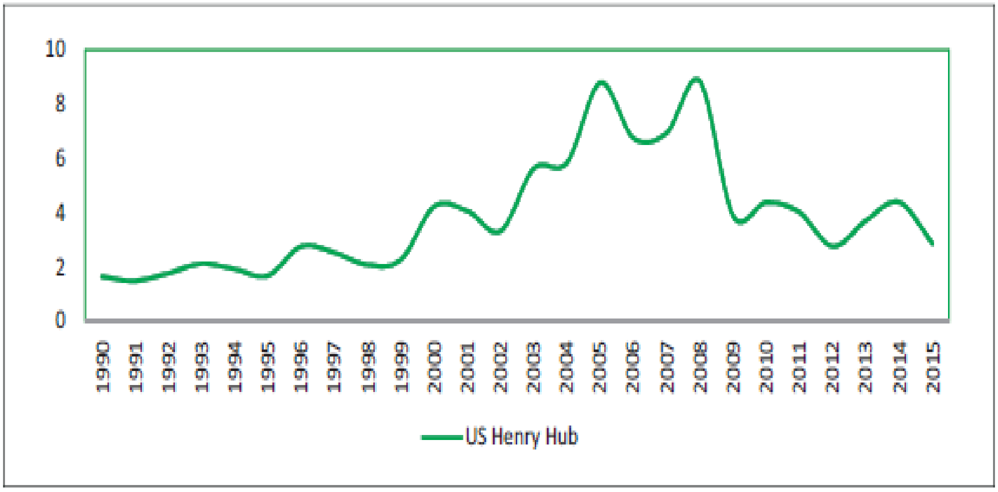

Figure 2: The Valuations of Natural Gas (US$/mBtu) (1990 - 2015)
Source: EIA

2.2 The Energy Production and Usage

The cost of producing and supplying carbon (energy) remains a major limiting factor for a sustainable supply of electricity to support economic integration. While statistics from the Energy Information Administration (EIA) have shown an increase in generating power in the last few years, Nigeria remain behind countries like South Africa, India, Brazil and several others as the country struggles to meet the level of consumption and the supply of electricity to its citizens. The World Bank (2015) observed that Nigeria's overall power production witnessed a 54.5% increase between 2000 and 2011 (Table 1). As of 2000, the overall power production was 14.73 billion kilowatt-hours, however, bumped to 27.03 billion kilowatt-hours in 2011. Furthermore, the state of electricity has not been improved. In 2000 and 2011, respectively, the percentage of total energy production from hydroelectric power stations fell from 38.2% to 20.9%. Conversely, the proportion of overall energy produced from 60.3 and 1.5 per cent in 2000 to 63.3 and 15.8 per cent in 2011 improved. The contribution of 5.6 billion kilowatt-hours of renewable energy in 2000 increased to 8.1 billion kilowatt-hours produced in 2004, but steadily decreased mostly from 7.8 billion kilowatt-hours in 2005 to 7.2 billion kilowatt-hours in 2013.

Prior to the global recession, private energy investment in Nigeria experienced significant growth between 2001 and 2005, rising from USD$ 295 million to as high as USD$ 828 million (Table 1). The consequence of the slowdown was a loss of momentum in the funding of the corporate sector, although it rebounded in 2013, as the spending contribution of the corporate sector rose to approximately USD$ 407.3 million (World Bank, 2015).

Indicators for the growth of the World Bank (2015) showed that overall energy consumption rose by 8.9% between 2012 and 2013. Total energy consumption increased steadily from 9.10 billion kilowatthours in 2000 to 18.00 billion kilowatthours as of 2005, which then substantiallybumped to 30.30 billion kilowatthours as of

ISSN No:-2456-2165

2013. Energy usage concentrations were only 178.38 kilowatthours per unit of population as of 2013 liken to 74.13 kilowatthours per unit of population marked as far back as the year 2000, indicating a huge bump of 140.6 per cent during the time of study. Over the last few decades, this growth has been due to the massive demand for energy consumption from residential buildings and businesses. The overall local population rate with available electric power supply between 2000 and 2010 rose from 28% to 35% as new villages connected to the electricity grid. Nevertheless, the majority of the population in urban areas in terms of access to electric power supply generally recorded between 2000 and 2010 declined from 84% to 79% which was attributed to constant interruption in the regular flow of electric power supply caused byoverloading. As documented over the century, the proportion of the overall sum of power transmitted witnessed a slight decrease from 5.62 billion kilowatthoursto 2.58 billionkilowatthours or from 38% to 10% between 2000 and 2011. Nigeria was rated 141 out of 148 countries in the 2014-2015 World Economic Forum Global Competitiveness Report on electricity efficiency (World Bank, 2015).

Table1: Indicators for NigeriaEnergy (2000 – 2013)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012*	2013*
Electric power consumption (kWh per capita)	74.13	75.20	104.15	101.43	123.02	128.66	111.15	138.11	126.45	119.82	135.40	148.93	163.83	178.38
Electric power consumption (kWh) (Million)	9,109.00	9,476.00	13,459.00	13,444.00	16,730.00	17,959.00	15,929.00	20,328.00	19,121.00	18,617.00	21,624.00	24,453.00	27,400.67	30,318.67
Electric power transmission and distribution losses (% of output)	38.15	38.72	37.53	33.39	31.08	23.71	31.07	11.53	9.42	5.87	17.22	9.55	14.56	16.40
Electric power transmission and distribution losses (kWh) (Million)	5,618.00	5,987.00	8,085.00	6,739.00	7,545.00	5,580.00	7,181.00	2,650.00	1,989.00	1,160.00	4,497.00	2,581.00	4,167.00	4,877.50
Electricity production (kWh) (Million)	14,727.00	15,463.00	21,544.00	20,183.00	24,275.00	23,539.00	23,110.00	22,978.00	21,110.00	19,777.00	26,121.00	27,034.00	31,567.67	35,196.17
Electricity production from hydroelectric sources (% of total)	38.22	38.21	38.22	36.90	33.40	33.00	27.10	27.10	27.10	22.90	24.40	20.90	20.73	19.73
Electricity production from hydroelectric sources (kWh) (Million)	5,628.00	5,909.00	8,234.00	7,448.00	8,108.00	7,768.00	6,268.00	6,227.00	5,721.00	4,529.00	6,374.00	5,650.00	6,638.67	7,199.17
Electricity production from natural gas sources (% of total)	60.29	54.68	40.19	57.40	54.52	56.68	64.34	64.32	64.14	64.29	64.29	63.30	62.97	62.48
Electricity production from natural gas sources (kWh) (Million)	8,879.00	8,455.00	8,659.00	11,586.00	13,234.00	13,343.00	14,868.00	14,779.00	13,541.00	12,715.00	16,794.00	17,113.00	19,938.67	22,137.67
Electricity production from oil sources (% of total)	1.49	7.11	21.59	5.69	12.08	10.31	8.56	8.58	8.75	12.81	11.31	15.80	16.29	17.79
Electricity production from oil sources (kWh) (Million)	220.00	1,099.00	4,651.00	1,149.00	2,933.00	2,428.00	1,979.00	1,972.00	1,848.00	2,533.00	2,953.00	4,271.00	4,990.33	5,859.33
Electricity production from oil, gas and coal sources (% of total)	61.78	61.79	61.78	63.10	66.60	67.00	72.90	72.90	72.90	77.10	75.60	79.10	79.27	80.27
Electricity production from renewable sources (kWh) (Million)	5,628.00	5,909.00	8,234.00	7,448.00	8,108.00	7,768.00	6,268.00	6,227.00	5,721.00	4,529.00	6,374.00	5,650.00	6,638.67	7,199.17
Energy imports, net (% of energy use)	(122.53)	(123.03)	(101.23)	(118.49)	(125.86)	(119.50)	(120.37)	(115.95)	(106.97)	(108.76)	(121.28)	(117.14)	(124.11)	(128.30)
Energy production (kt of oil equivalent)	201,602.98	211,055.86	195,974.18	216,318.83	229,619.19	238,791.65	235,809.72	232,537.45	230,206.53	228,077.63	254,779.14	256,927.24	275,444.28	289,869.08
Energy use (kg of oil equivalent per capita)	737.29	751.03	753.64	746.94	748.17	763.04	746.64	731.61	735.58	703.14	720.93	720.64	732.40	741.15
Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)	259.98	260.09	257.90	237.59	182.58	184.75	171.53	161.58	157.05	144.26	140.98	138.13	134.99	131.92
Energy use (kt of oil equivalent)	90,595.51	94,633.01	97,388.86	99,007.38	101,791.11	106,509.4	107,004.78	107,683.10	111,224.99	109,255.20	115,137.78	118,324.59	123,308.58	127,843.28
Investment in energy with private participation (current US$Mn)	..	295.00	462.00	34.00	na	828.00	na	280.00	na	na	na	na	na	407.30
Fossil fuel energy consumption (% of total)	17.74	19.32	19.47	18.90	19.07	20.71	19.31	17.81	18.47	15.00	17.16	17.40	18.91	20.11
Fuel exports (% of merchandise exports)	99.64	99.66	94.04	97.90	na	na	98.24	93.67	91.74	90.36	87.13	89.13	84.04	87.62
Fuel imports (% of merchandise imports)	1.72	2.17	1.35	16.03	na	na	2.87	1.79	1.61	1.02	1.40	9.95	2.38	20.17
Oil rents (% of GDP)	40.49	36.63	25.67	28.60	32.63	38.24	34.17	31.13	32.04	23.73	16.36	19.12	16.43	13.43
Note: * indicate authors' projections														
Source: World Bank Development Indicators														

2.2.1 Causative agents of Conditions for Energy

Global level, most countries have similar predictors of the energy market situations (Bean and Atallah, 2015). These researchers typically involve changes in supply, changes in demand, consumption and production of crude oil, price increases and pricing for energy, amongst others.

2.2.1.1 On Demand Changes

The number of people living within a geographical boundary, that is, population is reported as one of the main determinant factors of demanding strength. The United Nations Demographic Division reported that the international number of people in the world is projected to rise through to almost 9.0 billion in 2040from more than 7.2 billion in 2014. It is projected that more than 90% of the population increase will emerge from third world countries. India was expected to become more populated than the Republic of China by 2028. The world's Gross Domestic Product is therefore expected to rise from 3.1% as of 2014 to 3.8% as of 2018 because of the rapid growth in the economies of developing nations. Whilst the total number of people increases exponentially, there is an increase in overall demand in the provision of higher living standards. As a result, the long-term effects of population expansion, particularly increasing age systems, will also have implications for power needs and industrial growth. Energy demands, which are expected to grow significantly around 52.0% between 2010 and 2035 that is forecast to become largely determined by economy as well as political development in non-OECD countries (CRA, 2014).

Global oil demand, moreover, has been said to be averaging 1 mb/d per year increase since 2013, and has been projected to extend to 96 mb/d in 2019. As a result, OECD demand is forecast to drop to 45.2 mb/d in 2019 from 45.9mb/d in 2013. Whereas request from Russia and other Eurasia was projected to rise sluggishly, with a yearly increase of 1.1 mb/d, the highest increase on demand is supposed to come from developing nations. In the same vein, in 2015, a demand for non-OECD oil would for the first time be higher than the need for the OECD oil (OPEC, 2014). It is very important for a nation abundant in oil resources, such as Nigeria, and gives the government continuous opportunities to adopt sustainability policies (Ward and Asiodu, 2013).

2.2.1.2 The Supply Changes

The recent explosion in US domestic oil production has contributed to a significant shift in production and consumption outlook for the country. The U.S. production of oil had risen from 7million barrels per day to more than 8million barrels between 2012 and 2014 and now risen to more than 9million barrels per day between the first two months of 2015 according to the EIA (2014). Thus, the US is expected to become one of the major oil suppliers in the world by 2020, mainly determined by a huge increase in oil shale production. The US is developing a lot of interest in transitioning from a country that imports oil to a country that exports oil in 2025.

As of 2014, it was reported that the exportation of natural gas in Nigeria is around 1.5m barrels a day with the United States being the country's biggest buyer. Nevertheless, the need for US oil has declined since 2010, when the economy slowly reached an overflowing amount of energy regarding the production of oil. This distribution complexity as well as chances that the United States will struggle with cheaper energy for the same export market does not necessarily mean that the supply market is somehow constraining, particularly in the case of crude Nigeria. Despite competition still high in non-OECD countries such as China and India, Nigeria was expected to take advantage of this and look for new opportunities outside of us. This is really important given that the oil sector in Nigeria accounted for around 80% of the country's revenues as at the last quarter of 2014 (EIA, 2014).

2.3 Stylized Nigeria Energy Market Facts

2.3.1 Aptitudes

Over the years, Nigeria's concerted effort to generate power has shown an excess of power supplies as regards to oil and natural gas which are sun, hydro,coal, periodic waves, wind, gas, as well as certain components of uranium nuclear energy. In order to promote a robust electricity market, such forms of energy for the generating electric power must prevail in substantial commercial amounts in the greatest natural composition all over the nation. Studies by Ministry ofSteelProduction and Mining, NNPC and Council for Export Growth in Nigeria have shown that Nigeria is imbued with natural and human energy resources. In its 2012 mineral search, the Ministry of Mines and Steel Production discovered an additional quantity of coal found in Kogi, Benue and Nassarawa states, as regards the Enugu state reserves.

Nevertheless, Nigeria was obviously enriched as far as oil and gas is concerned, making it stand out on the global energy market among all the other nations. The gas inventory is appraised at 196 tcf of proven reserves (P1 + P2), including substantial desirable geological upside assets of negligible sulphur and enriched fluids. British Petroleum (2014) has estimated Nigeria's confirmed modern gas deposits to be 182 tcf, rendering it the seventh largest modern gas reserves in the world and Africa's largest. A BMI (2015) estimated that the country had the 9th highest gas reserves in the world, while the NNPC expected a total of 165 tcf of oil and gas reserves, such as 75.4 tcf that are unassociated oil.

The geologic time scale reports of the Federal Ministry of Petroleum Resources as well as NNPC aroundthe year 2008 in the month of May revealed an enormous potential in Nigeria's oil deposits, which might be increased to 600tcf. Correspondingly, the OPECorganisation also revealed productionof Nigeria's oil deposits which was estimated to be 37.1 billion barrels, and have a daily mean production of around crude oil of about 2.0 mbpd, which makesproduction of oil in Nigeria the biggest source in Africa Continent. Majority is shipped except the mandatory 445,000 bpd used entirely for local refining. Nigeria's crude oil, referred to as Bonny Light on the global oil market, contains multiple variants priced on such a crude geological basis and calculated by Sulfur Content, API Gravity, Pour Point, BS and W, RVP and its density. Regarded as light and sweet, it is, however, the best crude. It receives a large price premium reliably beyond the average OPEC basket price (BMI, 2015).

2.3.2 Establishment Provision

The market activity of oil and gas trail inthree interconnected systematic ways consisting of exploration and pre-production (upstream), production (midstream), and refining and selling (downstream) processes controlled exclusively by only the NNPC. The exploration and pre-production stage process involve mining, oil and natural gas development and collaboration operations. Between 1937 and 1993, oil and gas production and extraction activities were limited to on-shore operations;with little offshore operations not reaching 200m water surface. According to the NNPC, the industry experienced significant operations in deep water activity from 1993 to the present, surpassing 2,500m of water surface. Because gas was not made to be the main objective, the gas obtained was bubbled before old fields and environmental problems were required to re-inject, capture and recover gas for additional applications (www.nnpcgroup.com).

Partnership movements are collaborations made together with the NNPC and large oil firms that are also needed by the high advanced techniques and comprehensive reserve prerequisites of an exploration and pre-production. The NNPC was in charge of overseeing the auctioning of oil fields, the awarding of drilling as well as manyother mining certificates. Additional collaborations include Production Sharing Contracts (PSCs), Joint Operating Agreements (JOAs) and Service Contracts. Financially, IOC mostly managed the deepwater company and received USD$864 million for oil and gas exploration operations at the beginning of the deep-water project for six years, which later rose to about USD$ 1.3 billion by the end of 1998 (www.nnpcgroup.com).

The mid-stream covered several NNPC projects, like the Renewable Energy, Fuel to Energy, Greenfield Refinery,Gas Master Plan in Nigeria, among others. Nigeria's downstream industry was established by 4 power stations, 1 each in Warri and Kaduna, and 2 in Port-harcourt. For regulatory domestic crude oil, the gross energy capacity of the power plants is 445,000 bpd. The two Port Harcourt refineries were situated in Alesa-Eleme, having a total CDU efficiency of 210,000 bpd for the name plate. It has a jetty situated 7.5 km from the power plant complex for the import and export of goods. Both the Kaduna and Warri refinerieshave CDU identification plate maximum amounts of 110,000bpd and 125,000bpd respectively. The oil channels alongside the Chemicals Marketing Company (PPMC) finalize the retail market network system under the oversight of the Petroleum Products Price Regulatory Authority (PPPRA) (www.nnpcgroup.com).

2.3.3 Momentums of Market

The market dynamics are characterized by the exchange structure and methods used in the Nigerian electricity market. Beginning with gas sub-sector, two entities work on a market for undisputed exports and domestic exchange. They are two, the first being the NGC, with the second,NLNG. NGC conducts production locally, whereas the second company does only exportations and engage in lengthy-term contracts spanning about 20 years and distributes the goods to the planned stations via pulverized trains discharged into regasified plants (NLNGAR, 2013). In 2013, Asia was responsible for 74% of international sales. The second company really is a stable as well as a competitive industry because the production of shale gas does not jeopardize its sustainability.In 2013 the NLNG produced income after tax of USD$ 1.4 billion after selling 280 LNG cargoes (NLNGAR, 2013). However, the first company owns the local gas economy and renders services to only its clients (fired gas electric power companies, industrial together with commercial industries). The first company releases gas for money to the business subdivision - the lowest customer base, to industry at USD$ 7.3 per mbtu, and US$ 4.30 per mbtu. It is forced to sell at USD$ 2.5 per mbtu to its major customers (electric power firms), which is a major impediment to the Company's revenue.

Trade in oil begins with raising the crude in accordance with each well's corporate structure. The government entered into a partnership agreement with main energy producers and collects tax revenues. From different stations, primarily Okoro and Erha,Bonga, Agbami, Escravos,Forcados, Bonny-Akpo, lifting operations averaged around 40 counts per month. The crudes that have been evacuated are mainly sold to Europe, Asia and South America, in particular to Brazil. The estimated problem of NXP is a major selling tool, and because there is no testing of a well-headed system, output predictions are often dependent on NNPC forecasts. Those make it difficult to account for actual revenue invoices. Electricity trade includes private organizations such as generators (Gencos) and distributors (Discos) there under NERC by means of a multiple year tariff order (MYTO) mechanism. As seen by NERC, MYTO provides Nigerian Electricity Supply Industry (NESI) with at least fifteen years levy schedule (1st July, 2008 -30th June, 2023). A marketing standard that underlie the MYTO direct the industry's activities.

It was noted that NERC was reasonable to approve of an integrative together with a scientific strategy to adjust electricity prices across the board and ensure the gradual evolution of the market through a value-reflective and rational tariff system. Addressing the issue of power supply and decent distribution of power within Nigeria,the involvement of consumers and investors is being considered in this approach. The approach involves NERC introducing the Multi-Year-Tariff-Order (MYTO) approach. The MYTO is the current tariff action that computes the price of electricity premised on industry-wide revenue requirements. This strategy is intended to ensure the support needed for the different sub-sector's operating and operating expenses, that is, generation, transmission, as well as distribution. It is intended to promote the most fair and equitable way of pricing energy (NERC, 2008).

The MYTO was focused on a broad-based market assessment of present and future risks. The costs may include: the nominal electricity prices produced sold to the power grid; the transmission charge; the retail subsidy schedule; the transmission facilitator; the PHCN's head officefee; the law-guiding fee; as well as the refund together with cost of the tariff transfer paid in shared confidence of the distributors for the maintenance of a national standard contract. Price arrangements will also be checked on a periodic basis and changes will be made to the fixed rates if there are substantial variations in inflation, exchange rate and gas prices more than or less than 5.0 per cent (in magnitude) (NERC, 2008).

2.3.4 Economy Commitment

The energy sector contributes to the economy in three loads which include local demand that brings about economic activity; the basis of domestic together with foreign revenues; as well as the tool of global political bargaining.Energy is so crucial for the economy it has been called the economy's oxygen. The absorption of GDP is important in determining the allocation of resources to the country's economic operations. The IEA gathers oil baskets of nations of common interest to reflect the entire nature of resources in the economy that Nigeria serves. Nigeria's 2012 IEA Energy Product Cart(Table 2) summarized Nigeria's power business deals, showing the nation's leading role in oil and gas revenues and a strong focus on unclean energy, including wood, faeces from animals as well ashousehold wastes to sustain the economic system. The nation generated 176m tons of energy (only determined by calories), of which 74% was crude oil, although gas accounted for around 6%. Of the overall production, 148m tons were delivered, leaving just 23m tons of localusage.

Table 2: Nigeria's 2012 Power Cart in ktoe, classified by Net caloriescontent

	Coal	Crude Oil	Oil Products	Gas	Hydro	Biomas	Elect	Balances'
Production	30	129,409		33,645	487	108,142	2469	274,182
Imports	-	-	8440	-	-	-	-	8440
Export	-	126,413	755	21,032	-	-	309	148,509
Domestic Consumption	-	2,996	7,685	12,613	-	108,142	2,164	133,600

Source: International Energy Agency, 2015

2.3.4.1 Keeping the Nation Powered

Nigeria's economy is sparked by impure and typical energy at net calorific value, which accounts for 80.9% of total usage. Safer and more contemporary power, such as electricity and gas, amounted to only 11.1%. This shortcoming is revealed by the massive gap in domestic market between production and consumption of gas and electricity. Nigeria's per capita electricity supply rated among the world's poorest, at 155 kilowatthoursin comparison with Ghana's 384 kilowatthours, South Africa's 4,410 kilowatthours, and Qatar's 15,904 kilowatthours for Qatar (WES, 2014). It gives a massive domestic market potential for gas and electricity use, with a population projected at 170 million (NERC, 2008).

2.3.4.2 RevenueSource

Table 2 above have shown that much of the domestic energy generated was exported on the basis of the typical policy of increasing natural endowment revenue, instead of adopting something similar to only meet the sufficiency of energy produced locally. Only the oil and gas production sub-divisions produce considerable incomes in the mold of petroleum benefit tax, royalty, gains from exports after trading equity shares for money, corporate tax revenue, employment, investment income and corporate social responsibility benefits. It can be gathered from the graph below that oil revenue made a significant contribution more to the Federation's total revenue profile from 1999 through 2008 to 2014, alongside the distinction associated with non-oil incomes. Given the decline in overall incomes between the odd years 2007, 2009 and 2013 (Figure 3), oil share incomes were still higher, respectively, which clearly shows that Nigeria is heavily an oil exports dependent country.

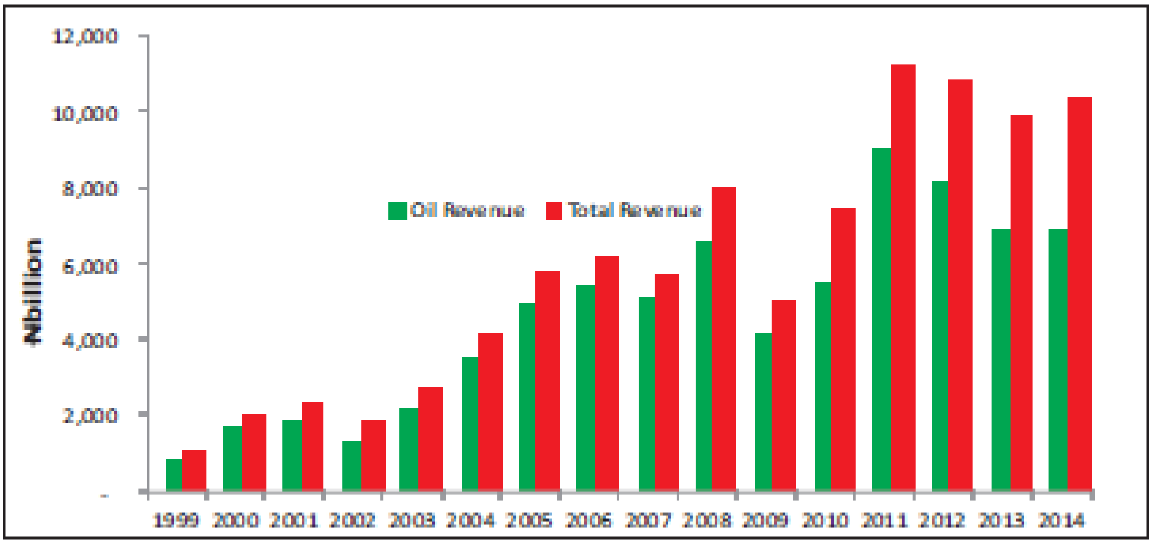

Figure 3: Oil Income in Comparison to Gross Income (Between 1990 and 2014)
Source: Central Bank of Nigeria

ISSN No:-2456-2165

2.3.4.3 Political Important

Nigeria continues to attract global recognition due to its capacity of the country's oil and natural gas investment portfolio regarding verifiedoil reserves together with the world's market rankings in the oil and natural gas sectors. The energy agencies, investment managers and major corporate investors throughout the world consider Nigeria important because of its natural gas reserves. This is exemplified by the effect production of oil has in forecasting world crude prices, especially during upheavals and expected reduced output. The bilateral relationship between Nigeria and the United States (US) was friendly and optimistic, as the United States continued to provide its key provider of crude–Bonny Light in comparison to several different sub-Saharan African Countries. Moreover, given the country's tiny portion in the OPEC basket, Nigeria's oil geological assets help bolster the OPEC basket level, increasing Nigeria's leverage as a member of the cartel (NERC, 2008).

2.3.5 Negative Effect

A substantial negative effect is the massive foreign exchange spending on generating electricity by replacing spare parts and retrofitting some components with no expected results. Available data from the Accountant General Office for the Federationaround 1999-2007 have shown that the FGN was spending USD$ 3.6 billion on increasing the nation's supply of electricity. The overview of the yearly expenditure together with the prevailing currency exchange for various times are shown in Table 3.

Table 3: FGN Discharge of Resources to the Power Sector

Year	₦ (Billion)	US$ (Million)	Average Exchange Rate (₦ per US$)
1999	6.7	72.28	92.6934
2000	49.8	487.73	102.1052
2001	70.9	633.36	111.9433
2002	44.2	394.84	111.9433
2003	5.2	43.00	120.9702
2004	54.5	421.32	129.3565
2005	70.3	531.97	132.1500
2006	72.4	562.77	128.6500
2007	61.1	485.58	125.8300
Total	435.1	3,632.83	

Source: Accountant General Office of the Federation, Nigeria.

Subsequently, additional spending was made until 2014 to introduce the Agenda for the Transformation of the Presidential Power Sector and other presently established intentions. The data from 2008 to date, however, has not been published. In spite of this costs, the insufficient condition of energy power supply stayed virtually the same. The graph below reveals that from 1999 to 2001, after the start of the spending, electric power supply became the worst downward trend. Nevertheless, it increased dramatically from 1,700megawatts to 2,700megawatts between 2001 and 2006. However, the rise did not last long because supply reduced to 2,255megawatts as of 2009. Subsequently, it rose steadily in 2013 to a total of 3,300megawatts as shown in Figure 4.

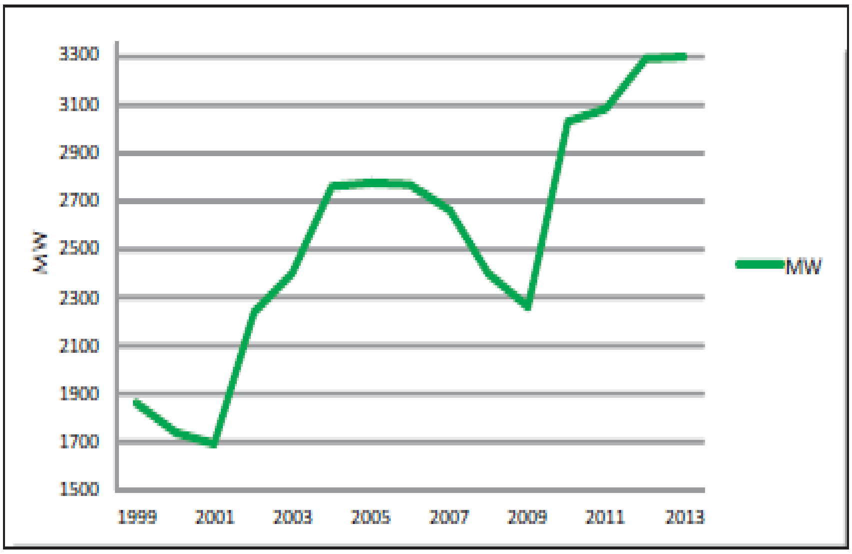

Figure 4: The GenerationElectricity (MW)
Source: PHCN

The secondary negative effect is the rebate problem. Throughout Nigeria, subsidies were initially applied to oil, later expanded to all petroleum products and eventually streamlined for the supply of electricity, premium motor spirit (PMS) as well as household kerosene (HHK). In fact, discounts for diesel and kerosene have been reduced. Both sources of energy were influenced by the redistribution of energy prices. As far as power generation is concerned, other consumer groups, such as residential premises (home, flat or multi-story house); housing vicinities accustomed as industrial operations such uniting by heating and ironing, D1 Single and 3-phase, D2 low voltageComplete Demand and D3 high voltageComplete Demand (11/33 kilo voltage); and magnificent patronizers which include farm and agriculture-alloy factories, water and relief boards. However, because electricity accounts for only 1.62 percent of the Nigerian energy basket's total energy consumption, the financial aid barely significantly affect government incomes as well as foreign reserves.

Subsidy problems are focused in the subsector of petroleum products, in particular PMS and HHK, where large sales are balanced by subsidies on PMS and HHK imports. PPPRA data showed average retail costs per liter between 2009 and 2014. The average retail cost per liter was 91.39 naira in 2009 which became 111.70 naira in 2010 and increased to 145.99 naira in 2011, then further increased to 153.2 naira in 2012. It slightly reduced to 147.76 naira in 2013 and further dropped to 126.89 naira in 2014. The expenses strongly suggest a distinctive for PMS, which must be sustained by subsidizing regulated pump efficiency. In order to obtain the number of subsidies paid, the price of the pump shall be excluded from the gross landing expense which PPPRA calculated and compounded by the overall consumption of PMS.

2.4 Reform in the Energy Sector

Nigeria's energy market has experienced strong and enormous strife from the FGN and a firm establishment of policies, programs and interventions clearly described as an enormous strife from the FGN in the industry's value chain from the exploration and production to the selling aspects of the oil sector. Structural changes, regulatory changes, capacity extension and institutional modernization were some of these measures, each projected to increase the supply of energy.

2.4.1 Electricity

The monopoly market structure, poor regulatory system, large investment deficits, deteriorating and inadequate infrastructure, low prices and revenue loss, including management weakness, have hampered the growth of the power sub-sector. Before the adoption of the Electrical Power Sector Reform Act (EPSRA) in 2005, the FGN's enormous strife in this subsector amounted to USD$ 3.6 billion regarding total expenditure on Independent Power Projects (IPP) between 1999-2007. Introduction of the Electrical Power Sector Reform Act (EPSRA) resulted in the efficient privatization of the establishment, the creation of cohesively organized law-guiding committee, the formation of a functioning market association (Nigeria Bulk Electricity Trader),Nigerian Transmission Company (TCN) as well as a lucrative investment mechanism (Multi-Year Tariff Order).

2.5 Electricity Generation in Nigeria: Sources, Challenges and Reforms

Nigeria's installed generation capacity is 25,255.2MW, of which about 4978MW in available generation capacity (NERC, 2015). The average peak generation capacity in 2015 did not exceed 5000MW compared to the Government's target of 6000MW. Present electricity generation in Nigeria is dominated by thermal generation capacity and most power plants are fuelled by natural gas. Of about 3900 MW available generation capacity on average in 2014, nearly 3500 MW (82%) was from gas sources, and 500MW (18%) was from hydro sources (Figure3). The energy sent out by generation companies in 2014 to the national grid is depicted in Figure 3.2. The highest amount of energy sent out was recorded in May (2621.7Gwh), August (2589.3Gwh), and November (2601.4Gwh) 2014 while June (2248.4Gwh) 2014 witnessed the lowest amount (see Figure 5). The 4044MW actual available generation capacity as at September 2014 later dropped to 3,206.09MW as at Dec. 2 only to drop to 2,954.51 by Dec. 11, a reduction of 251.58MW in nine days and to 3500MW dated 16th December 2014 despite the federal government attempt to provide 5,000 MW available generation capacity as promised. Nigeria's electricity available generation capacity has fluctuated between 3,500MW and 4,400MW over the last two years, due in part to shortage of gas supply (a significant number of gas pipelines were vandalized across the country, which disrupted gas supply to power plants) as well as high transmission/distribution losses (THISDAY, August 21,2014). The decline in energy sent out by generation companies from February to April 2014 was attributable to shutdown of Forcados pipeline. This made power supply worsen by 1000MW (BusinessDay, 25 March 2014).

The reduction in the number of systems collapse as well as improvement in services delivery increased power generation to 4105.90MW in April 2014 (BusinessDay, 24 April, 2014). The peak grid generation further rose to about 4,044MW in September 2015 with per capita electricity consumption of 136KwH.The improvement in the power supply of 4,600 mw is attributed to the absence of gas pipeline vandalism. Similarly, NERC approved interim rules for TEM with the aim of establishing a framework to govern trading arrangements.

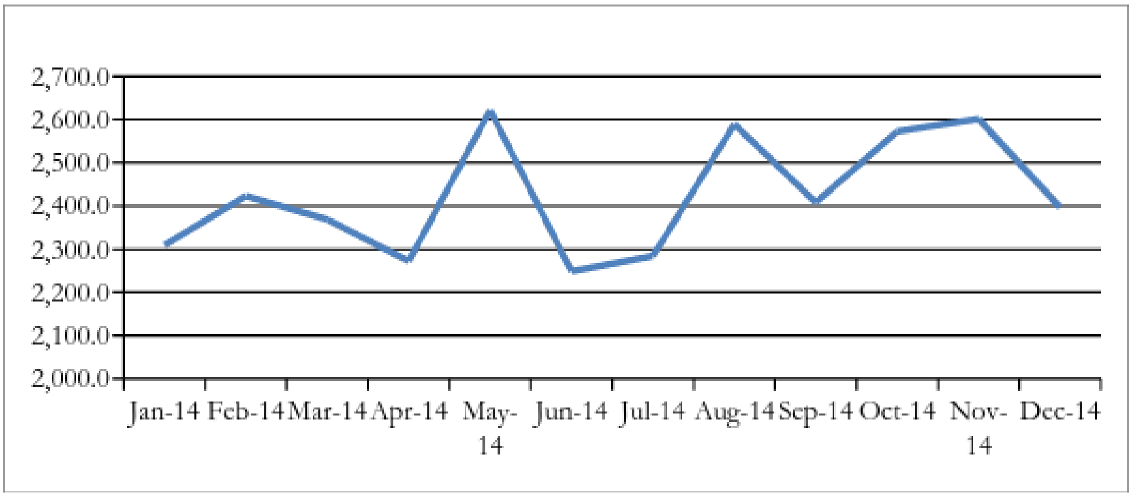

Figure 5: Energy Generated (GWH) by Generation Companies
Source: Nigerian Electricity Regulatory Commission (NERC), 2014

Of recent, the country's total energy sent out as depicted in Figure 6 exhibits the fluctuations between January 2015 and June 2016. The lowest was recorded in May 2015 while total energy sent out attained the highest in February 2016.

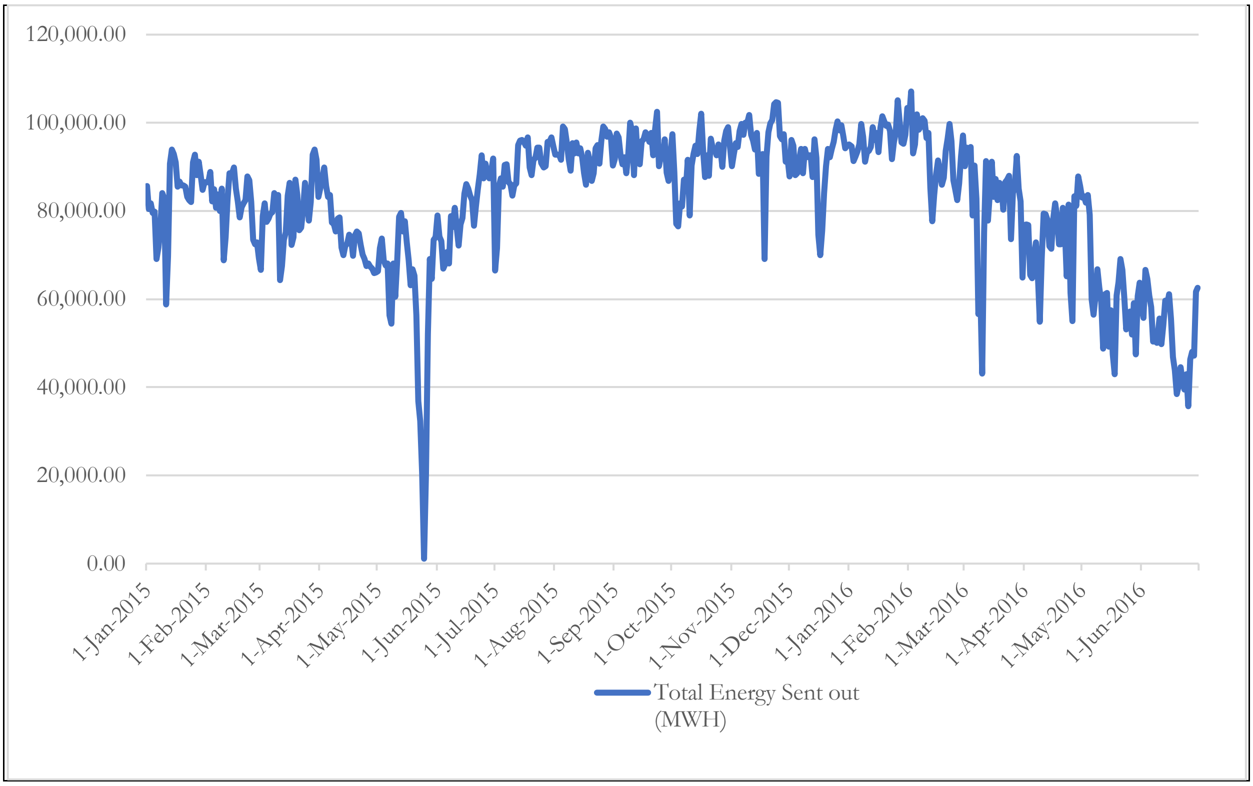

Figure 6: Energy Generated (GWH) by Generation Companies
Source: National Bureau of Statistics (NBS), 2016

The Nigerian electricity generation network is hindered by poor infrastructural facilities and natural gas shortages. The gas supply shortage often occurs because it competes with exports through which gas producers earn more profit by exporting the gas rather than selling them in domestic market at a much lower price. Another important contributor to the shortage of power even after the power sector has been privatized is the dual problem of inability to effectively protect gas pipelines and failure to provide effective policy and commercial frameworks for gas-to-power operators. The Chairman of the Nigerian Electricity Regulatory Commission (NERC) stated that before 2010, there was no effective gas to power policy, which reflected in the disarticulation of the two sectors (Bello, 2014). Gas power plants were established without the certainty of gas supply, although the situation is changing in 2014. Electricity generation in the present Nigerian situation is unrealistic without gas supply because gas powered power plants constitutes above 70% of the country's power generation plants. The gas thermal power still expects to contribute 75% of grid power by 2020 despite greater future power generation from hydro and coal. However, Gas Master Plan launched in 2008 to address these issues by focusing three main components specifically: Energy price scheme, Local gas supply Obligation and electricity facilities.

2.6 Decisions on Investment in Economic Theory

The market for financial strategy is driven by the developer's previous income and the expectation of future gain prospects. Entrepreneurs are also ready to build in inventories, where the choice of such person relies on their previous experiences and the projected markets volume. When preparing for this, the investor considers it, in other words, the anticipated rate of gain and the probability of Various future investment possibilities; and funding costs, on the other hand.When the projected level of gain outweighs the funding around the fringe sufficient to offset the threat factor, entrepreneurs will prefer to pursue the plan (Harcourt *et al*., 1967). The investor's investments decision is arbitrary. The judgment relies on the projected costs, the experience of advanced technologies and his understanding of risk, which is largely a discretionary consideration. Businessmen want to ask the pay-off date of the investment scheme and determine whether or not they will actually make the investment spending (Harcourt *et al*., 1967). To order to make a great investment decision, the buyer needs to fully and properly understand the potential benefits, and these decisions ought not be made in a rush. The incorrect investment decision can even drive businesses to bankruptcies. In order to obtain the highest value from the assessment process, very essential to know the primary concepts of decisions to invest. The metrics pertaining to the particular nature of the system and the knowledge kept by the decision-maker should be used for the investment appraisal (Avram *et al*.,2009). Spending is the distribution of assets for the mid to long term and the intended result is the return of operating costs as well as huge profits. In addition to monetaryassets, capital and real wealth are also utilised.

III. THEORETICAL FRAMEWORK

Theoretical framework for the paperwas based on the irreversible investment theory under uncertainties emanated from the Q-theory of investment. The Q-theory encompasses all the assumption made in the neoclassical theory of investments and also presents appropriate conditions that are more realistic to the electricity generation investment. In order to develop the economic condition process for profitable electricity projects, this analysis would create a decision-making management model by evaluating two technologies. The principle has the idea of irreversibility, which implies that once the investment is made, it will be passed to a sunk that isnot re-sellable. Irreversibility under volatility is an acute expression of the asymmetry of investment-adjusted prices.

3.2 Methodology

The mathematical programming is designed as a measure to address the problem of optimization. According to Winston and Goldberg (1994), the components of a typical optimization problem are objective function, decision variables, and constraints. The objective function is the goal of the problem which is expressed to minimize or maximize a criterion (costs or benefits) or multiple criteria concomitantly (costs and risks). The decision variables capture decisions to be made to solve the problem while constraints refer to conditions that have to be satisfied by any solution. Put differently, constraints limit the values decision variables can take.

The optimization problems are expressed in forms of mathematical models that attempt to determine the values of decision variables that minimize or maximize the goal function among the set of all decision variables under given constraints. These constraints employed to ensure the power and energy demand of an energy system. Additional constraints include technological limitations, environmental constraints, fuel system over the entire planning period (Hobbs, 1995). This section builds aneconomic condition model that entails mathematical programming and Monte Carlo simulation in order to provide answers to the objective of the paper. Combining the two models is a complex task but this paper adapted a technique similar to Feretic and Tom sic (2005) and Hawk (2010). The paperemploys its approach by building a deterministic optimization model to capture an energy system and also experiments Monte Carlo simulation in terms results to capture uncertainties.

Assumptions

The model was built based on the following assumptions:

i. The plant will be generating electricity only, with application of large combine cycle gas turbine using natural gas as fuel source.
ii. The plant will be situated either close to existing gas source (<100km) or away from the gas source (>100km). The type and size of the gas turbines installed will determine the plant's part load efficiency and ramping time. The main point for considering the location is that climate conditions influence the thermal efficiency of the process and also minimizing of the infrastructure investment in term of electricity transmission system is one of the specific objectives of the study.

Input parameters to be used for real option analysis are: investment costs, operating costs and cost of emissions, efficiency and availability, and input values.

3.2.1. Developing Design of Irreversible Investment amid Risks

In relation to the theoretical framework, the design of investment considers gas-to-power generation technologies that are connected with power grid. The electricity cost is of high uncertainty. The two parameters (the electricity cost and the gas cost) are line with the Brownian motion of:

ISSN No:-2456-2165

$$\frac{dP_G(t)}{P_G(t)} = \alpha_G dt + \delta_G du_1(t)$$
3.1

$$\frac{dP_E(t)}{P_E(t)} = \alpha_E dt + \delta_E \sigma_{GE} du_1(t) + \delta_E \sqrt{1 - \sigma^2{}_{GE} du_2(t)}$$
3.2

Where α_i and δ_i are constants of cost drift and cost fluctuations. dt represents infinitesimal time increment. du_1 and du_2 denoting two normal Brownian motion amounts insignificant. σ_{GE} captures the importance of P_G and P_E, which costs are known information at time 0. The significance of σ_{GE} is established even though electrical power is partially influenced by gas cost. The normalized Brownian motion of the price is specified as:

$$P_G(t) = P_G(0)e^{(\alpha_G - 0.5\delta_G^2)t + \delta_G u_1(t)}$$
3.3

$$P_E(t) = P_E(0)e^{(\alpha_E - 0.5\delta_E^2)t + \delta_E \theta u_1(t) + \delta_E \sqrt{1-\theta^2 u_2(t)}}$$
3.4

The random parameters of operational costs (gas cost of electricity generation) is simply considered. Fuel cost of power system is denoted as C_{GP} with the following equation:

$$C_j(P_G(t), P_E(t)) = \frac{P_G(t)}{\varphi_j} + \frac{1-\pi\omega j}{\pi} P_E(t)$$
3.5

Where φ_j measures thermal efficiency, πdenotes the heat concentration (the heat of per kilowatt hour) that is considered as a fixed number.ωj rrepresents the electricity usage level of the mechanism.

The study intends to evaluate the volatility of the cost of electricity (the output cost variable) by making an assumption of being fixed. The system will realize a specified net revenue, obtaining from electrical power sales. The earning denoted as $R_\gamma$minuses generating charges is the cash flow of the mechanisms. Cash flow,τ_j expressed in term of the gas price and electricity price, can be described as:

$$\tau_j(P_G(t), P_E(T)) = R_\gamma - K_{Gj} P_G(t) - K_{Ej} P_E(t)$$
3.6

Where K_{Gj} and K_{Ej} denotes the cost factor, which can be written as:

$$K_{Gj} = \frac{1}{\varphi_j}; K_{Ej} = \frac{1-\pi_{\omega j}}{\pi} \quad 3.7$$

The investment of electricity generation is expected to maintain a permanent cash flow (τ_j) at the cost of sunk (C_t). The value of power plant at any period can be specified as the present discounted value

$$\gimel_j(t) = E_t\left[\int_t^\infty \tau_j(P_G(t), P_E(t) e^{-\theta(\vartheta - t)} dt)\right] \quad 3.8$$

E_t refers to the approach to transfer future cash into present cash. The present value equation can further be expressed as linear function of prices. ϑ denotes the discount factor.

$$\gimel_j(t) = \frac{R_\gamma}{\theta} + \frac{K_{Gj} P_G(t)}{\theta - \alpha_G} - \frac{K_{Ej} P_E(t)}{\theta - \alpha_E} \quad 3.9$$

Projected cost of electricity is expected to rise as time flows with the drift parameter α_i change. This invariably leads to a periodic adjustment of the discount factor ϑ.

3.2.2 Data Source

The paper used cost data and other related parameters from selected thermal power plants in Nigeria between 2013 and 2017and simulated parameters for between 2018 - 2030 (from Egbin Thermal Power Station, Egbin, Transcorp Power, Ughelli, Sapele Power Station, Niger Delta Power Holding Company, Sapele and Nigeria Gas Company, Ekpan). This period is based on the reason that privatization of generation segment concluded in 2013, and Paris Conference in December 2015 had taken 2030 as year to end global gas flaring, including Nigeria.

IV. RESULTS AND DISCUSSION

This section summarizes the basic statistical features for the electricity. These include the trend analysis, mean and coefficient of variation. Specifically, under consideration are; Electricity Price for Plants Located near the Source $/kwh and Electricity Price for Plants Located away from the Source $/kwh.

4.1 Trend

This section begins from examining the peculiar behavior of the monthly historical electricity price from January 2013 to December 2017.

4.1.1 Electricity Price for plants located near the source from January 2013 to December 2017

In Figure 7, the study plots the monthly historical price of electricity for plants located near the source from January 2013 to December 2017. This is obtained from the source in $/kwh and composed of 60 observations. From the plot, the worst declines are recorded around May 2015 and June 2016. The electricity price shows a number of minor and major spikes during the period thus been quiet volatile for the period with a fundamental implication on the strategic decision or planning. The prices fall into a range between 0.03 and $0.08/kwh.

Figure 7: Electricity Price for plants located near the source from January 2013 to December 2017. Source: Field work (2018)

4.1.2 Electricity Price for plants located awayfrom the source from January 2013 to December 2017

Again, Figure 8 depicts the monthly historical price of electricity for plants located away from the source for a period of 5 years, specifically, from January 2013 to December 2017. Just like the other series, the prices of the seriesis obtained from the source in $/kwh and composed of 60 observation. From the Figure, the electricity price shows a number of minor and major spikes during the period and this has made it quite volatile for the period with substantial consequence on the strategic decision-making process. The prices fall into a range between 0.05 and 0.10/kwh.

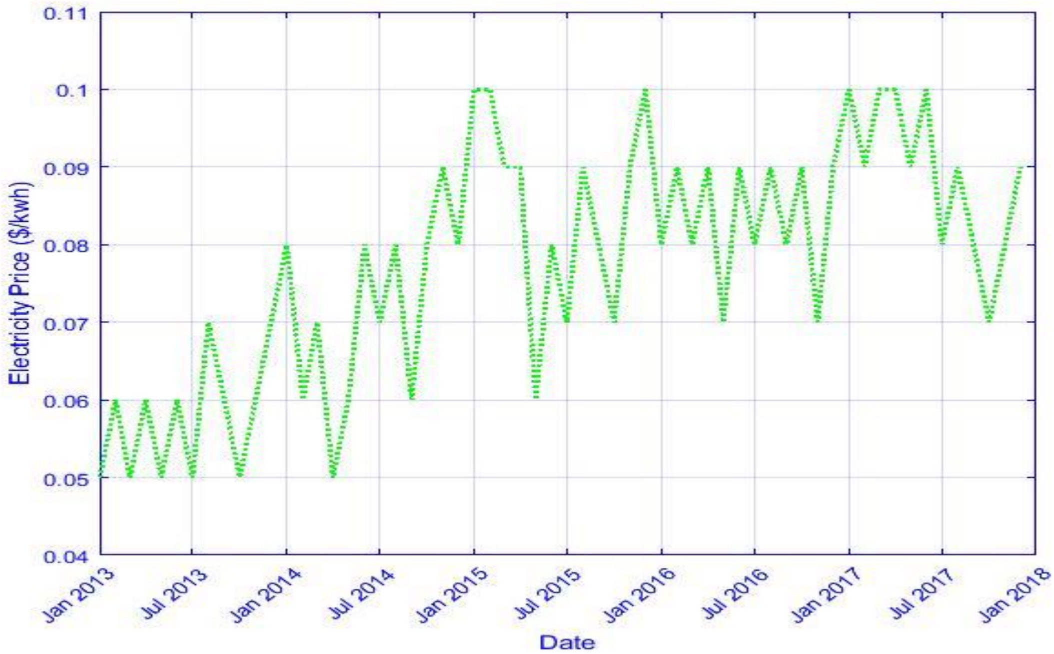

Figure 8: Electricity Price for plants located away from the source from January 2013 to December 2017.
Source: Field work (2018)

4.2 Summary Statistics

A summary of the descriptive statistics of the monthly historical electricity prices is presented in Table 4 below. From the spread, it can be seen that the average price of electricity for plants located near the source is \$0.06/kwh with a standard deviation of 0.02. However, the values range from \$0.03/kwh to \$0.08/kwh during the period. These simply mean that there is not a wide range in the value of the electricity price for the plant located near the source.The price of electricity for plant located away from the source takes values between 0.05 and 0.10 for the period considered in this study. However, the average value is 0.08 which is corresponding to the highest price of electricity for the plant located near the source. Also, with a standard deviation of 0.02 it appears that the price standard deviation equals that of the plant located near the source. In other words, the two energy prices possess equal variations on prices. Following the widely held assumption that the log-returns of energy prices usually follow the normal distribution, the paper endeavors to examine the nature of the prices using skweness and kurtosis. The skewness and kurtosis values of each variable in the Table give mixed result thus indicate that all the variables are not normally distributed. Consequently, the series are transformed to attain normality.

Table 4: Summary Statistics

	Electricity Price	*Electricity Price1*
Minimum	0.03	0.05
Maximum	0.08	0.10
Mean	0.06	0.08
Standard Deviation	0.02	0.02
Kurtosis	-1.11	-0.95
Skewness	-0.29	-0.30

Source: Author's computation, 2018

4.3 Parameter Estimates

In this paper, the value of the prices volatility and its drift are estimated using the monthly historical data with Matlab tool and the results are presented in Table 5. This became necessary as the parameters (growth rate and volatility) will be made use of in the subsequent analysis to capture future uncertainties. Generally, the volatility (□) and growth rate (□) of the prices show some variation from one energy price to another.

Explicitly, the growth rate of electricity price for the source located near the source is 0.059 while that of the plant located away from the plant is 0.077. These undoubtedly show that growth rate of the electricity price for the plant located away from the source is about 30.5% higher than that of the plant located near the source.These give a difference of 0.21. In as similar way, the corresponding stochastic volatility value of the price of electricity for plant located near the source is 0.016 while that of the plant located away from the source is assessed to be 0.015 thus give a difference of 0.001.

Table 5: Parameter Estimates

	Electricity Price	**Electricity Price1**
mean	0.059	0.077
sigma	0.016	0.015

Source: Author's computation, 2018

4.4 Uncertainties Simulation

This sub-section focuses on the simulation of the energy prices using the Geometric Brownian Motion (GBM) approach. The choice of this approach is informed by the stochastic nature of the prices. As mentioned earlier, the results from the descriptive analysis in terms of the estimated parameters (growth rate and volatility) under the first part are used to capture future price uncertainties where Monte Carlo simulate ons are implemented using the models specified in the preceding section with the aid of Matlab tools.

4.4.1 Electricity Price for Plants Located near the Source

For electricity price of the plant located near the source, the N paths for the uncertainties are simulated from time zero until 13 corresponding to the years from 2018 to 2030. In this paper, the Monte Carlo simulation is run with 20 paths using the estimated mu = 0.059 and sigma = 0.016. That is, the number of sample is 20 and the output is presented in Figure 9. Generally, the Figure shows that the future volatility of electricity price located near the source is not constant. Then again, there are no clear patterns shown between the different paths. This indicates that there is high level of uncertainty in the price even in the future. Alternatively, the random movement of the electricity price is seen to have mimicked the Brownian motion theory.

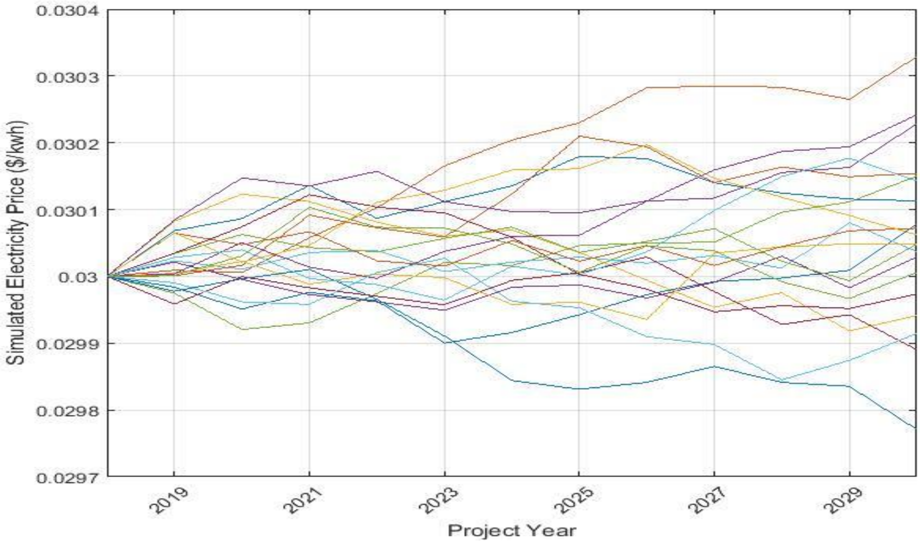

Figure 9: Simulated Electricity Price for the Plant Located near the Source
Source: Field work (2018)

4.4.2 Electricity Price for Plants Located away from the source

Again, for electricity price of the plant located away from the source, the mu = 0.077 and sigma 0.015 used in the simulations are the ones estimated by using the data with 60 observations. Also, the N paths for the uncertainties are simulated from time zero until 13 corresponding to the years from 2018 to 2030. Explicitly, the Monte Carlo simulation is run with 20 paths the output is presented in Figure 10. In general, the Figure shows that the future volatility of electricity price located away from the source have no clear patterns suggesting that there is high level of uncertainty in the future price of electricity. Then again, the haphazard movement of the electricity price is seen to have mimicked the Brownian motion theory.

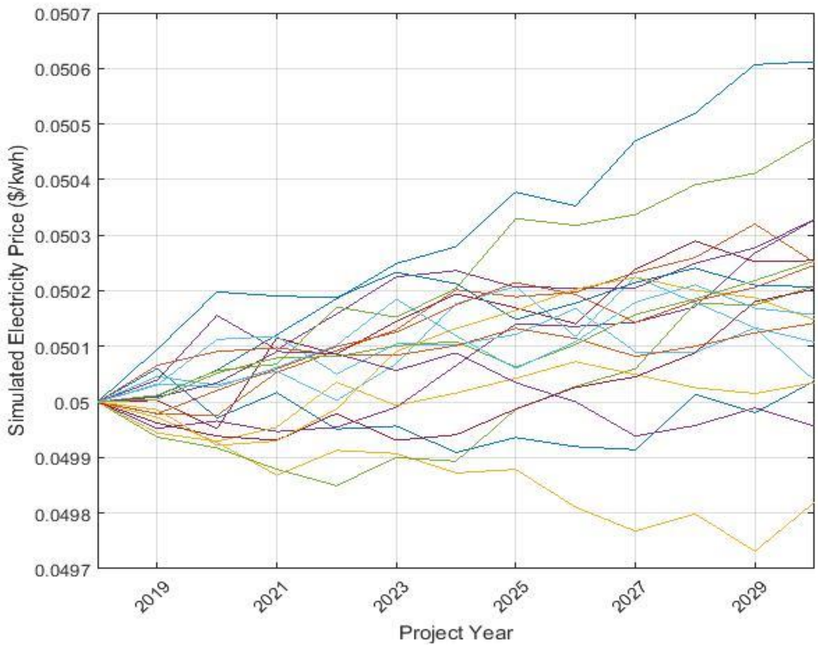

Figure 10: Simulated Electricity Price for the Plant Located away from the Source
Source: Field work (2018)

4.5 Real Option Analysis

In order to capture the specific objectives of the paper that says to investigate economic condition for profitable electricity generation, the study used the decision-making models specified in the preceding section. The software used is MATLAB R2017a adopting Antonio *et al* (2016) code. Furthermore, Faiz (2000) has emphasized that real options has not only proven to be a superior asset valuation than the traditional approaches but also offers a great help on whether and how to pursue opportunity under uncertainty. Thus, in decision making the paper makes use of the ROA with the required input parameters.

To investigate the objectives, additional simulations with the estimated parameters and varying requirements are run. In this, in addition to the estimated parameter in the preceding section; the study makes use of the available information as summarized in Table 6. As in the Table, the current value of cash flows is $1.023million/MW for electricity generated. The investment period considered is ten (10) years and fixed cost is $61.8million. In addition, the future cash flows are assumed to be highly uncertain, and there the study used varying volatilities.

Table 6: Additional Parameters used in the Investment Options.

Parameter	Electricity
Current CF	$1.023million/MW
Fixed investment cost	$61.8million
Time to invest	10 years

4.5.1 Option Value of Investment

Figures 11a and 11b graphically illustrates the option values of electricity price for plant located near and away from the source respectively at different levels of volatility. The 'Electricity NPV' signifies the maximized expected NPV of the GtPPand it is linearly change as far as the gas price is enough to cover the value of investment. Generally, the charts clearly show the sensitivity of option values to uncertainty. As in the Figures, it can be deduced that the higher volatility produces a higher electricity option value. Put differently, a higher investment option value is associated with higher risk.

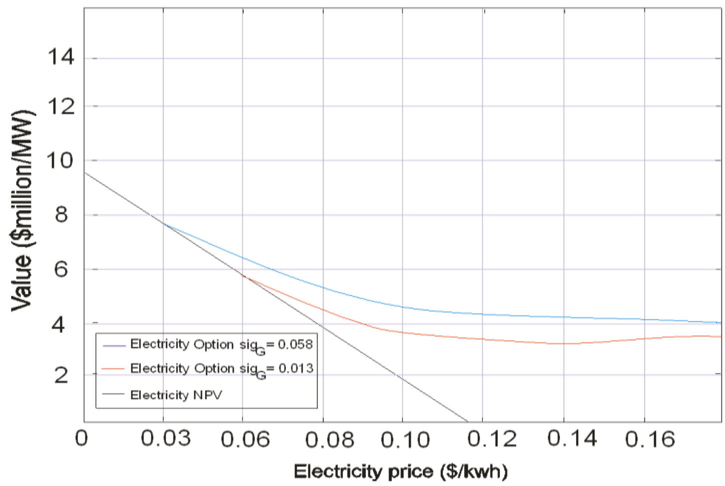

Figure 11a: Option Value for Electricity Price for Plant Located near the Source, (Source: Field work, 2018)

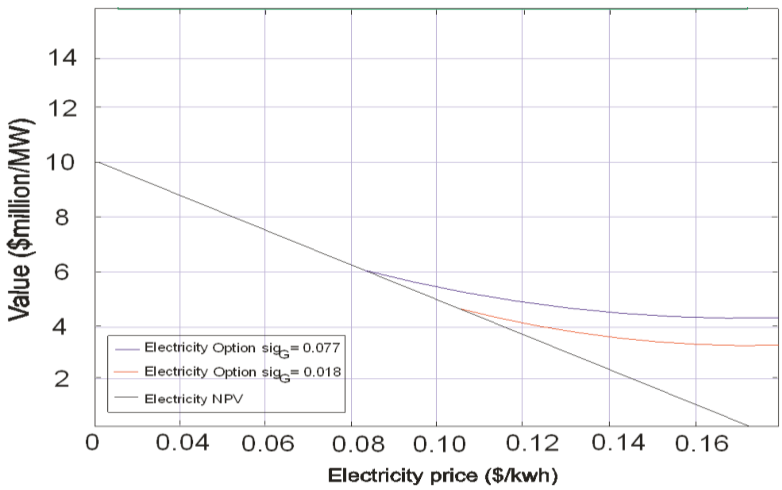

Figure 11b; Option Value for Electricity Price for Plant Located away from the Source, (Source: Field work, 2018)

ISSN No:-2456-2165

4.5.2 Threshold Price

In this sub-section, the study investigates the sensitivity of thresholds to variation in volatility by varying the volatility parameter. In Figure 12, the threshold prices for electricity plants are presented and this shows that the wider spread threshold between the prices of electricity for plant located near the source (E_N) and away from the source (E_A) is associated with higher volatility. This is in line with the saying that higher uncertainty brings about doubtfulness.

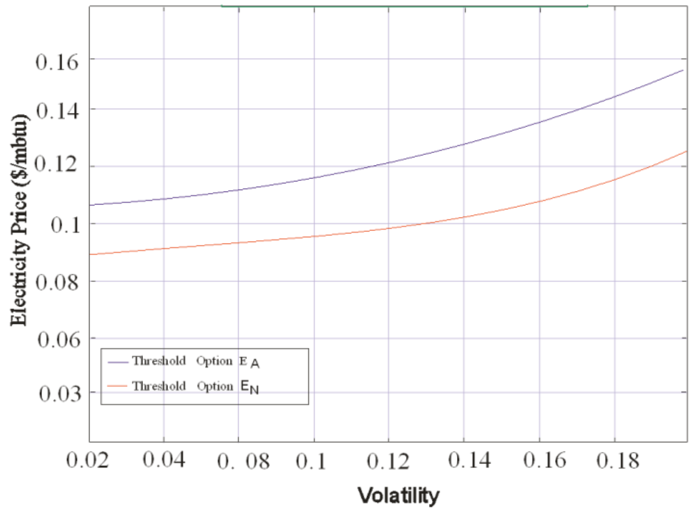

Figure 12: Threshold Price for Electricity, (Source: Field work, 2018)

4.7 Investment Decision-Making

In this section, the study presents waiting and investment regions for profitable electricity generation considered in this paper based on the best information estimated or available and by varying the volatility. In Figures 13, it can be seen that the investor should wait till the price of the electricity for electricity generationnear the source and away from the source are within the E_A and E_N regions respectively; otherwise the investor may have to wait. Explicitly, under different volatility, we find regions to wait and invest for the electricity generation plants in the Figure. For instance, for $\sigma \geq 0.129$ investment decision in electricity plant near the source is to be ignored. That is the investor needs to wait. However, for the $\sigma< 0.129$ and the electricity prices above lower and upper investment regions (the red lines) decision to invest in electricity generation near the source is to be made. For instance, for σ= 008 the investor should wait until the electricity price increases to the lower investment region; that is when the price is roughly \$0.078/kwh. Furthermore, the decision to invest is to be made in electricity generation plant near the source (E_N) when the price is or on the upper region (red line) or in electricity generation plant away from the source (E_A) if the price increases to or above the blue line.

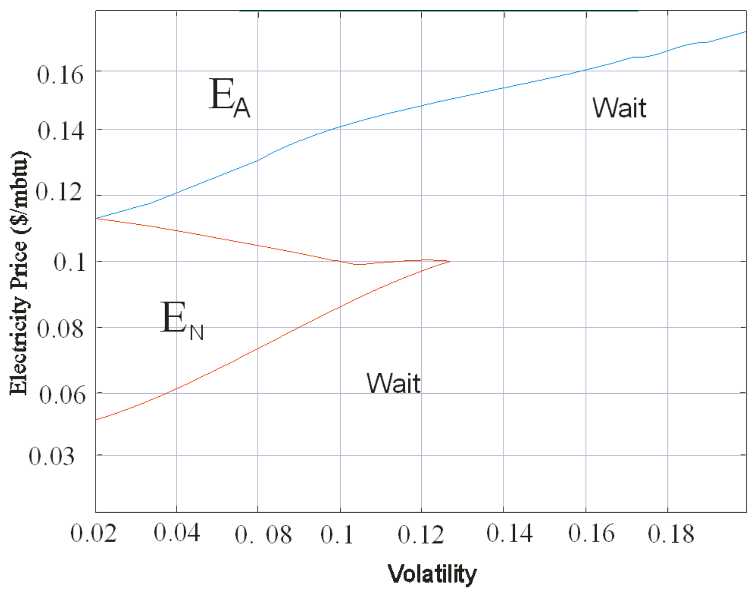

Figure 13: Investment Option (Source: Field work, 2018)

V. CONCLUSION

This study has shown economic condition for profitable electricity generation in Nigeria. Investment timing and technology choice are of principal interest not only to policy-makers but also to the various market participants. With the help of the range of the economic indices shown in the results obtained, it is a project that investors will be willing to undertake. The model developed help investors and policy-makers to establish an investment pattern that accounts for the uncertainties in costs and revenues, as well as the flexibility of investment timing. However, understanding the trends discovered in the study will be key to making final investment decision on the electricity generation in Nigeria aimed at maximizing profit or minimizing the investment risks. The study investigates the optimal technology choice and optimal time to invest for the case that an electricity sector has the choice of building a new power generation unit in specific locations of the country.Given the fact that high level of uncertainty arises from highly volatile price, the dynamic approach and stochastic modelemployed in this study enables us to make investment decisions at different points in time. An interesting result obtained is that future volatility of energy prices has no clear patterns suggesting that there is high level of uncertainty in the future prices.

REFERENCES

[1]. Antonio J. Conejo, Luis Baringo Morales, S. Jalal Kazempour, Afzal S. Siddiqui, 2016. “Investment in Electricity Generation and Transmission: Decision Making under Uncertainty”, Springer International Publishing Switzerland, 1-389.

[2]. Avram E. L. *et al*., 2009. Investment decision and its appraisal, DAAAM International, Vienna, Austria, EU, 2009, Vol. 20, No. 1, p. 1905-1906.Barberis, N. and Thaler, R. 2003. A survey of behavioral finance in G.M. Constantinides, M. Harris and R.M. Stulz (Eds) Handbook of the

[3]. British Petroleum, 2014. Global Energy Statistical Review, July.

[4]. EIA, 2014. Energy Outlook for the yearwith predictions to 2035, "National Energy Information Centre, EI-30, Forrestal Building, Washington, DC 20585, April.

[5]. Faiz, S. 2000. “Real options application: From successes in asset valuation to challenges for an enterprise-wide approach”, In: Proceedings - SPE Annual Technical Conference and Exhibition. PI, 243–250

[6]. Harcourt, G.C. *et al*. 1967. Economic Activity, Cambridge University Press, New York, Re-issued in this digitally printed version 2008

[7]. Nigeria Bureau of Statistics Annual Report, 2016.

[8]. NERC, 2008. “Multi-Year Tariff Order regulating rates and prices for power supply, transmission and retail prices (July 1, 2008 to June 30, 2013), Order Number: NERC / GL 059, Abuja.

[9]. NERC, 2014.

[10]. Nigeria LNG Limited, 2013. NNPC Company Upstream and Deep-Water Exploration, Corporate Annual Report and Financial Statement.

[11]. OPEC, 2014. “Implications to Global Oil Stability”, Energies, ISSN 1996-1073. Oxford Business Group. Nigeria Report 2013

[12]. Presidential Task Force on Power (PTFP),2015. “2014 year in review”. Annual report of the Presidential Task Force on Power (PTFP), Nigeria. Retrieved from http://www.springer.com/978-94-007-0634-7

[13]. Rapu S. Chukwueyem, Adeniyi O. Adenuga, Williams J. Kanya, Magnus O. Abeng, Peter D. Golit, Margaret J. Hilili, Ibrahim A. Uba, Emeka R. Ochu, 2015. Analysis of Energy Market Conditions in Nigeria.Central Bank of Nigeria, 33 Tafawa Balewa Way, Central Business District. P. M. B. 0187, Garki Abuja, Nigeria

[14]. World Bank, 2015. "Indicators of Electricity Production," Quarterly Paper, Washington D.C., March.