

The Economic Potential of Natural Gas in Nigeria

By

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DEDICATION

The dissertation is dedicated to my husband, Ejiro Philip Emifoniye. He is my source of inspiration and encouragement.

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The dissertation is a product of different individuals and corporate bodies. Their thoughts, ideas and perspectives created the knowledge developed in this research work.

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ABSTRACT

Nigeria is blessed with a huge reserve of natural gas. Currently, Nigerian natural gas reserve is estimated at 185 trillion cubic feet (Tcf). Until recently, most of the gases produced in the course of crude oil exploration were being flared. The purpose of this dissertation was to investigate the potential value of the natural gas on the economy of Nigeria. The economic growth model developed was based on an estimate of the potential gas production and exploration. GDP and per capita GDP were the economic indicators used for the model. Nigerian natural gas availability, competitiveness as well as available gas market were also evaluated.

For the period of 6 years (1999 to 2005), total natural gas utilization would have accounted for an estimate of 0.577% and 0.558% annual growth rate of Nigerian GDP and per capita GDP respectively. The evaluation of natural gas contribution to the Nigerian economy for the next 30 years (2005 to 2035) using proportional growth rate and learning curve predicted that Nigerian GDP and per capita GDP growth rate would increase as a result of total gas utilization.

This research work concluded that Nigeria will be a major supplier of natural gas in future, having USA, Germany, Italy and Ukraine as predictable major gas market. More so, GDP, GDP per capita and economic growth would improve as a result of natural gas utilization. The economic potential of natural gas in Nigeria can significantly improve the standard of living of Nigerians. Hence, the government should put in more effort to stop the flaring of natural gas and utilize it.

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LIST OF ACRONYMS

AG	Associated gas
AvDA	Average degree of agreement
Aver.	Average
Bcf	billion cubic feet
Btu	British thermal units
CNG	Compressed natural gas
EGP	Escravos gathering Project
EGTL	Escravos gas to liquid
GDP	Gross domestic product
JV	Joint venture
LNG	Liquefied natural gas
LPG	Liquefied Petroleum gas
Mcf	thousands of cubic feet
MW	Mega watts
MMcf	millions of cubic feet
MSCF	billion standard cubic feet
MTLNGP	Million tonnes LNG produced
NAG	Nigeria Associate Gas
NEPA	Nigerian Electric Power Authority
NGCS	Natural gas consumption
NGL	Natural Gas Liquid
NGP	Natural gas production
NLNG	Nigeria Liquefied Natural Gas
NNPC	Nigeria National Petroleum Corporation
OPEC	Organisation of Petroleum Exporting Countries
PFDB	Population from data base (Air Ninja)
SUM	Summary of deficit/excess
Tcf	Trillions of cubic feet
WAGP	West Africa Gas Project

CHAPTER ONE

1.0 INTRODUCTION

Energy is the ability to accomplish physical work. It can be converted from one form to another. This artful manipulation of energy has been an essential component of the human ability to survive and to develop socially. Energy is valued as an input in many processes of production. It is usually utilized in a process to yield a final product. Energy is mostly used in residential, commercial, transportation as well as industrial and power generation sector of the economy. It has been a key to increased industrialisation of Europe and the United States (*Dorf. R. C. 1978 Pg 2*).

The world has entered an era of profound alteration in the traditional patterns and trends of energy. There is a challenge to the supply of energy in a way compatible with a wise use of the environment and the earth resources not to talk of increase in the price of energy. Natural gas appears as a cleaner and cheaper fossil fuel set to play a greater role in satisfying increasing energy demand. For an equivalent amount of heat, burning natural gas produces about 30% less carbon dioxide than burning petroleum and about 45% less than burning coal (*WEC 2001*).

This need has led to a sudden change in natural gas demand pattern. There is a recent increase in gas production and demand in the Asia Pacific region and Africa (*Gass, J, 2004*). In Europe, natural gas demand is projected to grow by 2 to 3 percent per year for the next 20 years, from roughly 45 to 65 billion cubic feet a day (*Gass, J, 2004*). There is also the prospect of market incentives promoted by the Clean Development Mechanism established by the Montreal and Kyoto Protocol as shown in "*Kyoto 2006*". It is assumed that the current increase in demand for natural gas is an indication of a long-term trend.

Hydrocarbon is a predominant source of energy supply for the global economy. It has been at the centre-stage for over half a century now. Nigeria has recorded about 40 years of successful oil exploration. However, the level of gas utilization in the country for both domestic and industrial purposes is relatively low. For the past four decades, there has

been massive injection of natural gas into the atmosphere. This has led to Considerable economic, social and environmental problems.

1.1 Background

Before 3000BC, many ancient temples of worship were built in the vicinity of known natural gas seepage locations. The Chinese were drilling gas wells as early as 1000BC to produce natural gas for space heating and lighting (*Ingersoll J G.1996, Pg 53*). They also piped natural gas through hollow bamboo poles to boil ocean water for salt (*Rebecca L.B. 1999, Pg 5*). Other nations like Greece, Persia and India discovered natural gas centuries ago. Temples were built to house the natural gas mysterious eternal fire that was regarded as reverence and superstitious (*Ingersoll J G.1996, Pg 53*). By 1900, natural gas had been discovered in 17 countries. However, this did not result to its wide usage.

In the 1920s seamless steel was introduced, resulting to the transfer of natural gas through some distance (*Rebecca L.B. 1999, Pg 11*). The beginning of 1930s became the landmark for the awareness of gas importance (*Rebecca L.B 1999, 11*). By late 20th century, natural gas had become an indispensable energy resource throughout most of the industrialized world. Today, it accounts for about a quarter of the energy used in the world (*Rebecca L.B 1999, 11*). Although some countries like Nigeria are fortunate enough to possess an abundant availability of natural gas, others like Japan are unfortunate. They must import nearly all the gas they need.

Historically, the crude oil industry began in Nigeria in AD1908 by the German Bitumen Corporation (*Nwosu et al 2006, Pg 1279*). In 1937, an Oil Prospecting Licence (OPL) was granted to Shell-D_ Arcy_s exploration organisation (*Nwosu et al 2006, Pg 1279*). However, it was not until 1953 that the first marginal gas well called AKATA1 was drilled. In 1956 shell BP eventually struck its first commercial well at Oloibiri in present day Bayelsa state (*PW Guides 2006, MSI 2006*). This marked the beginning of petroleum era in Nigeria. Gas flaring began simultaneously with oil extraction in the 1960s by Shell-BP (*Feo 2005*).

Nigerian natural gas reserves are well over 176 trillion ft³ in Nigeria (*MBendi 2005b*). The gas reserves are three times as substantial as the crude oil reserves. This is equivalent to one-third of Africa's total gas reserves. It is believed that Nigerian natural gas reserves

consist of about 50 per cent associated and 50 per cent non-associated gas (*Michael et al 2004*). The non-associated gas is fairly explored while the associated gas is constantly flared during oil exploration. The cost of the gas flared per annum at an average of \$3 per thousand cubic feet (mcf) is estimated to be \$2.5 billion. It has been said that Nigeria loses 18.2 million USD daily (*Online Nigeria 2006*).

There are a number of so-called natural gas based projects, presently in the country, aimed at utilizing the huge gas resources. The biggest natural gas initiative is the Nigerian Liquefied Natural Gas Company, which is operated jointly by several companies and the government. It began exploration and production in 1999. Chevron is also in the process of establishing the Escravos Gas Utilization project, which will be capable of producing 160 billion standard ft³ of gas per day (*Gass 2004*).

Nigeria has had regulations in the books banning gas flaring which includes fines if not adhered to, for more than a quarter of a century with a deadline of 2008 (*Ishisone 2004*); However because the Nigerian government is politically unstable and non-transparent, it is difficult for them to effectively implement the policies. The question that comes to mind is “how keen are these oil companies to meet the deadline to stop gas flaring in 2008?” They are keen at making profit from oil exploration instead of utilizing the associated gas. Oil companies find it more economically expedient to flare the natural gas and pay the insignificant fine (*Ishisone 2004*).

1.2 Problem statement

The overall purpose of this research investigation is to study the economic potential of natural gas in Nigeria. Nigeria has huge amount of natural gas reserves. Presently, a higher percentage of the natural gas produced is flared instead of utilized. The research work seeks to contribute to the change of this situation by predicting the economic gain that Nigeria will enjoy if this resource is fully utilized.

In order to assess the potential of Nigerian natural gas if totally utilised, the research work specifically aimed to answer the following questions:

- What is the present state of natural gas available in Nigeria?
- How could natural gas utilization affect the Nigerian economy?

- Is there any available market for Nigerian natural gas?
- Can Nigerian natural gas compete with other natural gas producing countries?

1.3 Purpose of the Study

The purpose of this research project is expressed into the following statements of objective.

- To carry out an in-depth investigation of the economic potential of natural gas in Nigeria.

Having the following stated aims.

- To estimate and predict by surveying authoritative literature the availability and reliability of Nigerian natural gas.
- To estimate the potential market for Nigerian natural gas.
- To predict the contribution of natural gas to Nigerian economy, if fully utilized.

1.4 Significance of the Study

The dissertation aims to highlight how natural gas could affect the economy of Nigeria. It could serve as an eye opener to Nigerian government on the economic potential of natural gas with respect to Nigerian GDP, GDP per capita and economic growth. The research work could also be of great significance to strategic planners, petroleum economists, new product's developers, researchers, decision makers in the chemical, petroleum and energy industries as well as government agencies.

1.5 Scope of the Study

The research study basically looked into the evaluation and assessment of the Nigerian natural gas economic potential with respect to its prospect in natural gas to meet future demand; Nigerian available international gas market, Nigerian competitiveness in the gas market as well as economic growth contribution. For the economic growth evaluation, GDP and GDP per capita were used as economic indicator in estimating natural gas potential on the Nigerian economy if fully utilized.

This dissertation presents an evaluation of the economic potential of natural gas in Nigeria. It looks into natural gas composition and properties. It elaborates on the formation of natural gas and how it is trapped underneath the earth's crust. It also discusses Nigerian background, its energy sector as well as its various natural gas projects

In this study, both historical and current data were used in the natural gas economic potential correlation and analysis. The data collection was from open literature sources. Such literature sources are oil and gas handbooks, oils and gas journals and reports as well as reliable Internet sites.

The various analytic results were verified through comparison with the ideas in reliable open literature theories and data.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Natural Gas

Natural gas is a vital component of the world's supply of energy. It is one of the cleanest, safest, and most useful of all energy sources. It is a gaseous fossil fuel. Natural gas is a combustible mixture of hydrocarbon gases that occurs in the porous rock of the earth crust. It comprises basically 75 to 99% methane, the lowest molecular weight hydrocarbon (*Don K. R. 1981, Pg 49*). It is found in oil fields and natural gas fields, and in coal beds. Gas produced from oil wells is called casing head gas or associated gas (*Wikipedia 2002*). Gases from natural gas wells are called non-associated gas.

Natural gas containing 85% methane might include ethane, propane, and other hydrocarbons (*Don K. R. 1981, Pg 49*). Other components could be hydrogen sulphide, carbon monoxide, or dioxide, hydrogen, nitrogen, helium, and water (*EIA 2005b*). Natural gas is said to be 'dry' when it is almost pure methane having less than $0.013\text{dm}^3/\text{m}^3$ of other hydrocarbons (*Robert H.P and Don W.G 1998, Pg 27-11*). Above this amount, it is termed 'wet'.

The explored natural gas is refined to remove impurities like water, other gases, sand, and other compounds. Some hydrocarbons are removed and sold separately, including propane and butane. Other impurities removed, are Organic sulfur compounds and hydrogen sulfide. Gas with a significant amount of sulphur impurities, such as hydrogen sulfide, is termed sour gas and often referred to as "acid gas" while that without sulphur is called "sweet gas" (*Robert H.P and Don W.G 1998, Pg 27-11*).

2.1.1 Measurement of Natural Gas

Natural gas can be measured in different ways. In gaseous form, the volume it occupies at normal temperatures and pressures is commonly expressed in cubic feet. Production and distribution companies commonly measure natural gas in thousands of cubic feet (Mcf), millions of cubic feet (MMcf), or trillions of cubic feet (Tcf).

Measuring natural gas as a source of energy could be expressed in British thermal units (Btu). One Btu is the amount of natural gas that would produce enough energy to heat one pound of water by one degree at normal pressure. One cubic foot of natural gas contains about 1,027 Btu. When natural gas is delivered to a residence, it is measured by the gas utility in 'therms' for billing purposes. A therm is equivalent to 100,000 Btu, or just over 97 cubic feet, of natural gas (NGSA 2006a).

2.1.2 Natural Gas Composition

The composition of natural gas can vary widely; table 2.1 shows the typical makeup range of natural gas composition before it is refined. The structure is as shown in figure 2.1

Table 2.1 Typical Composition of Natural Gas (NGSA 2006a)

Component	Formula	Composition
Methane	CH ₄	70-90%
Ethane	C ₂ H ₆	0-20%
Propane	C ₃ H ₈	
Butane	C ₄ H ₁₀	
Carbon Dioxide	CO ₂	0-8%
Oxygen	O ₂	0-0.2%
Nitrogen	N ₂	0-5%
Hydrogen sulphide	H ₂ S	0-5%
Rare gases	A, He, Ne, Xe	Trace

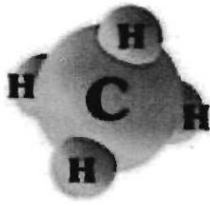


Figure 2.1 A Methane Molecule, CH₄ (NGSA 2006a)

2.1.3 Natural Gas Properties

The properties that make natural gas unique are stated below:

- It is colourless, tasteless, and shapeless.
- It is odourless; hence it is odorized with thiols, to assist in leak detection during gas distribution to end-users.
- It is highly flammable; Methane being the main constituent has a lower explosive limit of 5% in air, and an upper explosive limit of 15% (*Wikipedia 2002*)
- It has a low density; Natural gas is lighter than air, and so tends to dissipate into the atmosphere.
- It is combustible; when burnt, it gives off a great deal of energy. It has a heating value of about 38 (10.6 kWh) mega joules/cubic metre, Equivalent to 1031 British Thermal Units/cubic foot (*Robert H.P and Don W.G 1998, Pg 27-12*).
- It emits less greenhouse gases; natural gas is clean burning and emits lower levels of potentially harmful by-products into the atmosphere.
- It is a simple asphyxia; it can kill if it displaces air to the point where the oxygen content will not support life.
- It has a specific gravity of between 0.586 and 0.641 in air at 15°C (*Robert H.P and Don W.G 1998, Pg 27-12*).

2.1.4 Formation of Natural Gas

Millions of years ago, the remains of plants and animals decayed and built up in thick layers. This decayed matter from plants and animals is called organic material. These plants and animals were once alive as shown in figure 2.2. Over time, the mud and soil

changed to rock, covered the organic material and trapped it beneath the rock. Pressure and heat changed some of this organic material into coal, some into oil (petroleum), and some into natural gas with or without the assistance of bacteria. There are many different theories as to the origins of fossil fuels.

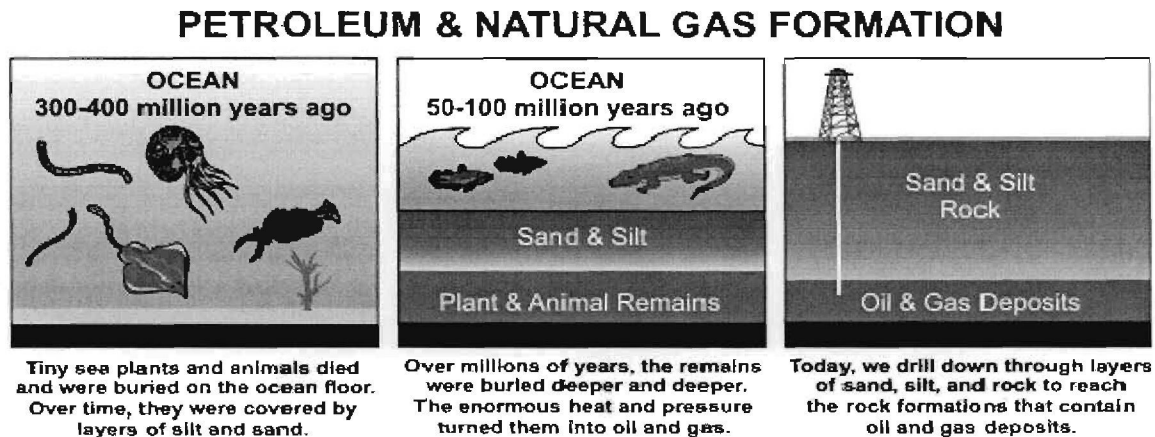


Figure 2.2 Formation of Natural Gas under the Earth Crust (EIA 2005b)

2.1.4.1 Thermogenic Natural Gas

Thermogenic methane is the natural gas found when organic matter (such as the remains of a plant or animal) is compressed under the earth, at very high pressure for a very long time. This compression, combined with high temperatures found deep underneath the earth, break down the carbon bonds in the organic matter. Temperature gets higher deeper under the earth crusts. At low temperatures (shallower deposits), more oil is produced relative to natural gas. At higher temperatures, however, more natural gas is created, as opposed to oil (*Donald Et al 1959*).

Natural gas usually associates with oil in deposits are 1 to 2 miles below the earth's crust (*Donald Et al 1959*). Hence the deeper the deposits underground the more percentage of natural gas that is found. The bulk of all the natural gas (about 65%) is formed in the Mesozoic era; about one fourth is found in Paleozoic era, reservoirs and the balance; say 10%, is formed in the tertiary epoch or early Cenozoic era (*Donald Et al 1959*).

2.1.4.2 Biogenic Natural Gas

Biogenic natural gas is formed through the transformation of organic matter by tiny micro-organisms called Methanogens (*Donald Et al 1959*). They chemically break down organic matter to produce methane. They are found near the surface of the earth that is void of oxygen. Hence methane formation takes place close to the surface of the earth. This methane produced is usually lost into the atmosphere. However, this methane can be trapped underground and recoverable as natural gas. An example of biogenic methane is landfill gas (*Donald Et al 1959*).

2.1.4.3 Abiogenic

Natural gas could also be formed through abiogenic processes. Extremely deep under the earth's crust, there exist hydrogen-rich gases and carbon molecules. In the absence of oxygen they react with minerals that also exist underground to form elements and compounds that are found in the atmosphere (including nitrogen, oxygen, carbon dioxide, argon, and water) (*Donald Et al 1959*). Under very high pressure, these gases could move towards the surface of the earth to form methane deposits.

2.1.5 The Trappings of Natural Gas underneath the Earth

Although natural gas is formed in different ways, it exists underneath the surface of the earth within geological formations. Geological formations are made up of layers of porous, sedimentary rock (kind of like a sponge, that soaks up and contains the gas), with a denser, impermeable layer of rock on top (*Rebecca L.B. 1999, Pg 15*). Due to its low density, it tends to rise to the surface of the earth but get trapped in this formation. This impermeable rock traps the natural gas under the ground. A great deal of natural gas is trapped underground, in what is known as a reservoir if the formations are large.

There are a number of different types of these formations, but the most common is created when the impermeable sedimentary rock forms a 'dome' shape, like an umbrella that catches all of the natural gas that is floating to the surface (*NGSA 2006a*). This dome could be formed in different ways. One of such ways is when the normal sedimentary layers sort of 'split' vertically, so that impermeable rock shifts down to trap natural gas in the more permeable limestone or sandstone layers.

2.1.6 General Natural Gas Uses

2.1.6.1 Power Generation.

Natural gas is a major source for electricity generation through the use of gas turbines and steam turbines. Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. Natural gas burns cleaner than other fossil fuels, such as oil and coal. It produces less greenhouse gas per unit energy released. Combined cycle power generation using natural gas is thus the cleanest source of power available using fossil fuels. Fuel cell technology may eventually provide cleaner options for converting natural gas into electricity, but as yet it is not price-competitive.

2.1.6.2 Transportation

Compressed natural gas (CNG) is used as a clean alternative to other automobile fuels. As at 2005, the countries with the largest number of natural gas vehicles were Argentina, Brazil, Pakistan, Italy, and India (*Gass, J, 2004*). The energy efficiency is generally equal to that of gasoline engines, but lower compared with modern diesel engines, partially due to the fact that natural gas engines function using the Otto cycle, but research is on its way to improve the process (Westport Cycle). Natural gas can also be used to produce hydrogen that can be used in hydrogen vehicles.

2.1.6.3 Residential Domestic Use

More than 62.5 million homes worldwide use natural gas to fuel stoves, furnaces, water heaters, clothes dryers and other household appliances (*Wikipedia 2002*). Natural gas is supplied to homes for such purposes as cooking in natural gas-powered ranges and/or ovens, natural gas-heated clothes dryers, and heating/cooling. Home or other building heating may include boilers, furnaces, and water heaters. CNG is used in rural homes without connections to piped-in public utility services, or with portable grills.

2.1.6.4 Industry

Natural gas has thousands of uses in the industry. It is an essential raw material for many common products, such as: paints, fertilizer, plastics, anti-freeze, dyes, photographic film, medicines, propane, explosives steel, glass, paper, clothing, brick, electricity and much more.

Figure 2.3 is a pie chart that shows the summary of the world's usage of natural gas (EIA 2005a). It clearly points out industry as the biggest user of natural gas when compared to the other users.

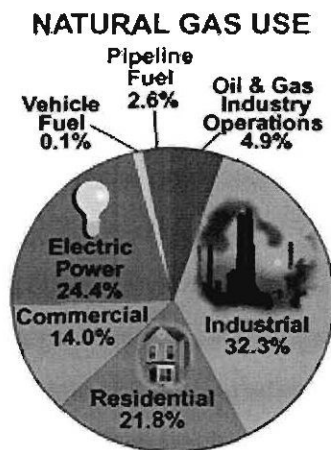


Figure 2.3 World's Natural Gas Usages (EIA 2005b)

2.2 Historical Background of Nigeria

The Federal Republic of Nigeria is the most populous country in Africa. It was created during the colonial period in the nineteenth century. It got her independence in 1960, and became a republic in 1963 (EIA 2005a). It is a member of the Commonwealth of Nations and OPEC. Nigeria has strong economic ties with Britain, Japan, France, Germany and United States of America. The official language is English with 250 other languages. It is made up of 36 states with Abuja as the Federal Capital Territory. Nigerian map is shown in figure 2.4.

2.2.1 The Geography of Nigeria

It has a population of about 140million based on 2006 census (Olori .T. 2007). It has an area of 923,800 square kilometres occupying about 14% of West Africa land scale (EIA 2005C). The country lies between 4°N and 14°N and between 3°E and 15°E. It is bordered on the north, east, and west by Niger, Cameroon, and Benin Republic, respectively. The Atlantic Ocean forms the southern boundary. Nigeria is located within the tropics and therefore experiences high temperatures throughout the year. The Average

maximum temperatures vary from 32°C along the coast to 41°C in the far north, while mean minimum figures range from 21°C in the coast to under 13°C in the north (*EIA 2005C*).

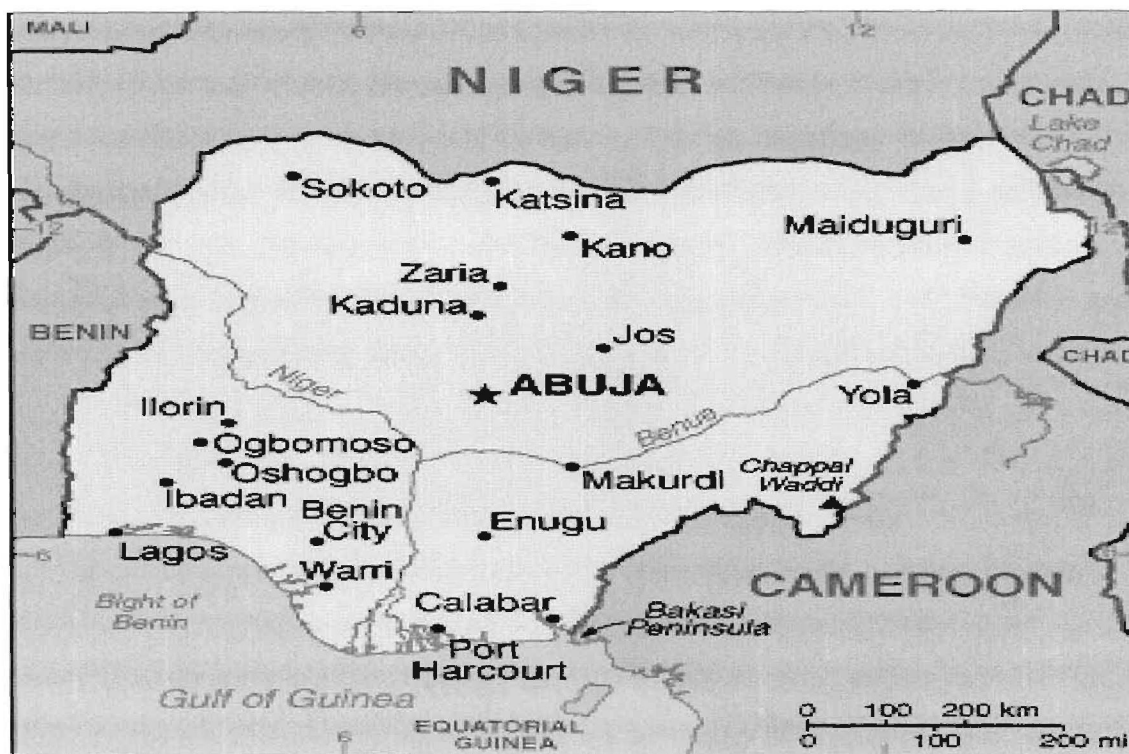


Figure 2.4 Map of Nigeria (*CIA 2007*)

2.2.2 Socio-Economic Structure of Nigeria

Nigerian Gross Domestic Product grew very slowly, by 2.7% between 2001 and 2002. In the 1970s, GDP grew by 7 to 8% in the 1970s and the first half of the 1980s (*EIA 2005C*).

As at 2001, Nigerian economy heavily depended on the oil sector, which accounted for 90-95% of export revenues, over 90% of foreign exchange earnings and nearly 80% of government revenues (*Jekwu .I. 2005*). Real GDP was estimated to have grown by 3.0% in 2001, but International Monetary Fund (IMF) estimation for 2002, saw GDP declining by 0.9% (*EIA 2005C*). Presently, the Nigerian economy is heavily dependent on the oil sector, which accounts for 95 percent of government revenues (*Wikipedia 2006a*).

The GDP shown in table 2.2 is based on economic sectors distribution and reflect Nigeria dependency on oil.

Table 2.2 Percentage Distribution of GDP by Sector (CBI 2003)

CATEGORY	1993	1994	1995	1996	1997
GDP	100	100	100	100	100
Agriculture	37.78	37.19	38.24	39.01	39.17
Industry	20.71	20.07	19.57	19.83	20.22
Petroleum	13.08	12.58	12.62	13.03	13.63
Mining & Quarrying	0.29	0.30	0.30	0.30	0.30
Manufacturing	7.34	7.18	6.65	6.48	6.29
Services	41.52	41.75	41.69	41.15	40.60

Nigerian central bank (CBN) estimates showed that the economy grew by 3.3% in 2002, below the targeted 5.0% (CBI 2003). In 2000, Nigerian total external debt was estimated at approximately \$32 billion with a debt servicing of \$400-\$500 million (CBI 2003). Nigerian dependence on crude oil is expected to lessen as the natural gas industry develops. Even with the substantial oil and gas wealth, Nigeria ranks as one of the poorest countries in the world, with a \$1,000 per capita income and more than 70 percent of the population living in poverty (EIA 2005 a). This has led to high unemployment and declining standard of living.

2.2.3 Nigerian Energy Sector

2.2.3.1 Power Supply to the Nation

Nigeria faces a serious energy crisis due to declining electricity generation from domestic power plants. Power outages are frequent and the power sector operates well below its estimated capacity. Power generation in July 2000 fell to 1,500 MW (CBI 2003). Currently, only 10% of rural households and 40% of total population have access to electricity. Nigeria electricity consumption per capita is 111 kWh, which is one of the lowest in sub-Saharan Africa (CBI 2003). This is due to suppressed demand caused by deteriorated electricity supply infrastructure. Its dominance will increase as the population increases and as the industrial sector expands.

2.2.3.2 Natural Gas as a Source of Energy

Nigeria is a gas province with a lot of gas reserves (within the top 15 globally). Gas reserves stood at 110,000 billion cubic ft in 2000 estimate. Apart from deep water oil fields, natural gas reserve stands at an equivalent of 250 gigawatts of electricity which is 2000 percent of current installed hydropower capacity and 500 percent of the hydropower that could be exploited by 2025 (Adesanya O.2002). Consumption of gas is however limited, as up to 75% of the gas produced in association with oil is flared.

Domestic gas demand is about 400 million cubic feet a day (MMcf/d) (WEC 2004). From table 2.3 below, one could see that natural gas as an energy source is under utilized, considering the size of Nigerian population and her gas resources.

Table2.3 Natural Gas Reserves, Production and Consumption as Related to Other Fossil Fuel (Center for energy economics)

Fossil Fuel Reserves, Production and Consumption in Nigeria (01/01/2002)

	Proved Reserves	Production	Consumption
Oil	3.1 billion t. (22.5 billion b.)	104 MT/yr (2.1 mb/d)	14 MT/yr (292,000 b/d)
Natural Gas	4.8 tcm (170 tcf)	52 bcm (5.1 bcf/d)	27 bcm (2.6 bcf/d)
Coal	209 million short tons	0.07 million short tons	0.08 million short tons

Sources: Energy Information Administration, National Petroleum Investment Management Service (NAPIMS)

2.3 Nigerian Natural Gas

Nigeria is viewed as a gas province with significant oil accumulations. The world proven natural gas reserves, as reported by Oil & Gas Journal, 5 were estimated at 6,112 trillion cubic feet as at January 2006 (EIA 2005C). Nigeria had an estimated 185 trillion cubic feet (Tcf) of proven natural gas reserves. She had a substantial increase of 9 trillion cubic feet as compared to 2005 estimation (EIA 2005C). This increment, when compared to the rest of the world is 5 percent. This makes Nigeria the seventh largest natural gas reserve holder in the world and the largest in Africa. NNPC estimates that probable gas reserves may be over 600Tcf (Adegbulugbe A.O 2006).

The vast majority of natural gas found in Nigeria is associated, meaning that it occurs in crude oil reserves as free gas. There exist non-associated gas reserves, but they are yet to be fully exploited. The current producing fields are located within water depths of 200 meters or less (CBI 2003). The majority of these reserves are found in relatively simple geological structures along the country's coastal Niger-Delta River, but newer reserves have been discovered in deeper waters' offshore of Nigeria. However, in the past four decades alone, the country's oilfields have produced about 23 trillion cubic feet of gas, most of which has been flared (CBI 2003).

2.3.1 Impediments to Gas Development in Nigeria

Although Nigeria is blessed with a huge amount of natural gas resource, yet the development of gas projects is at a slow pace. Oil companies rather flare the gas than utilize it. Stated below are some of the hindrances to gas development in Nigeria.

1. Inadequate gas supply infrastructure (Adegbulugbe 2006).
2. Inappropriate/ unrealistic pricing of gas, especially for domestic use (Adegbulugbe 2006).
3. Absence of Institutional and regulatory framework (Adegbulugbe 2006).
4. Low level of industrialization (Adegbulugbe 2006).
5. Inadequate consumptive capacities (Adegbulugbe 2006).

2.3.2 Gas Flaring in Nigeria

Flaring is a means of safely disposing of waste gases through the use of combustion (Chijoke .E. 2002). More than a thousand flares stacks as shown in figure 2.5 burn in and off the Niger-Delta, a 70,000-sq.km region that produces much of Nigerian oil, and where natural gas has been going up in flames ever since oil production began more than 40 years ago in the West African country (Irin 2001). The Niger-Delta region is comprised of nine states, covering an area of 112,110 km² with a population estimate of 28.9 million people for the year 2005 (Statoil 2006, Pg14).



Figure 2.5 The Flare Stack in Niger-Delta (*Statoil 2006*).

It is costly to separate commercially viable associated gas from the crude oil. In order to increase crude oil production, the gas found in association with the crude oil is often burnt off. Nigeria flares more natural gas than any other country in the world. An estimate of 3.5 billion cubic feet of associated gas (AG) produced annually is wasted via flaring (*Foe 2005*). Although the percentage of gas flared has fallen from 92% in 1981 to around 70%, the overall amount of flared gas has increased from 2.1 billion cubic feet to 2.5 billion cubic feet due to increase in oil exploration (*Ishisone 2004*).

Gas flaring releases large amounts of methane, which has very high global warming potential, due to incomplete combustion. The methane is accompanied by the other major greenhouse gas, carbon dioxide, also some combustion by-products which include nitrogen dioxide, sulphur dioxide, volatile organic compounds like benzene, toluene, xylene and hydrogen sulfide, as well as carcinogens like benzopyrene and dioxin. Inhabitants of the region complain of health problems - mainly respiratory - as well as damage to wildlife, homes and vegetation (*Foe 2005*). The negative impact of gas flaring to the environment led to, the Kyoto frame in "Kyoto Protocol 2006"

Figure 2.6 below shows gas flaring and utilization from 1965 to 2004 while figure 2.7 below shows the projected reduction of gas flaring by 2008. However this is not feasible as gas flaring was still as high as 70% in 2006. Most of the projects proposed to reduce this gas flaring are yet to be fully established.

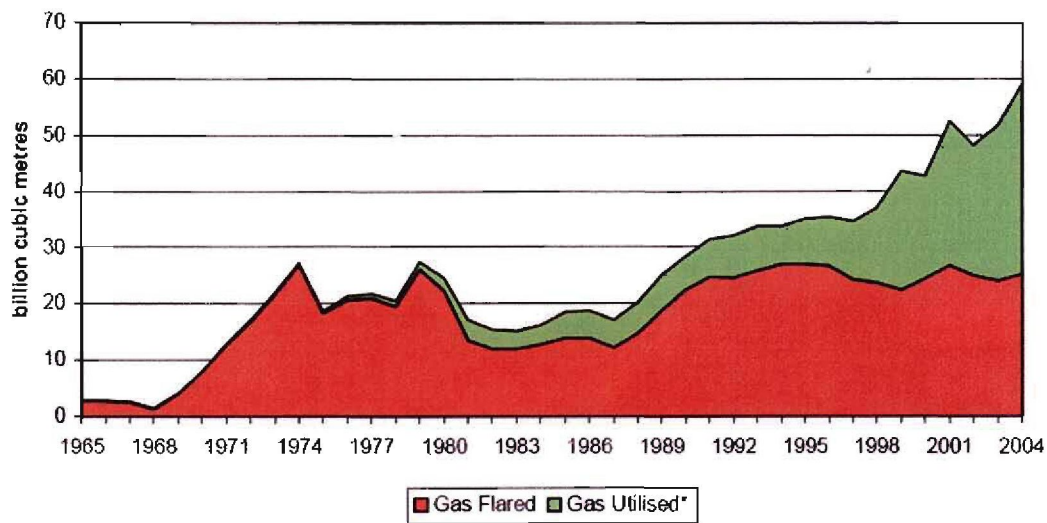


Figure 2.6 Chart: Gas Utilization in Nigeria, 1965 to 2004 (Statoil 2006).

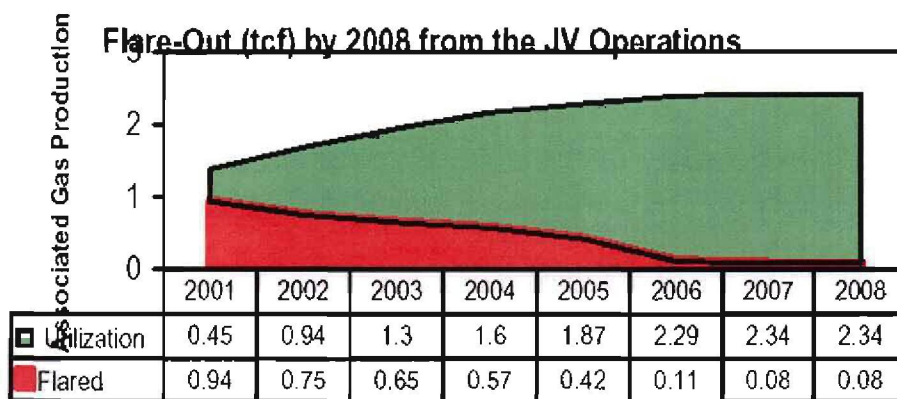


Figure 2.7 The Flare Out of Natural Gas by 2008 from JV Operations (Center for Energy Economics).

2.3.2.1 Impact of Gas flaring in Nigeria

Gas flaring is a significant waste of potential fuel that is simultaneously polluting water, air, and soil in the Niger Delta. Stated below are some of the impacts of natural gas to the Nigerian society.

1. Nigeria is vulnerable to the effects of global warming.
2. There is a great impact of rising sea levels, such as tidal waves and flooding.

3. The flame heat and soot has made surrounding vegetation to wither; this has made it impossible to farm (*Foe 2005*). There is much hunger and unemployment in the land.
4. The roofs of most homes and other local structures have corroded as a result of consistence acid rain (*Foe 2005*).
5. The health of the inhabitants has deteriorated. Humans exposed to such substances can suffer from a variety of respiratory problems, asthma, chronic bronchitis and leukaemia caused by benzene (*Foe 2005*).

2.4 Natural Gas Development Projects

Gas utilisation is a primary goal of Nigerian petroleum and energy policies. With a proven reserve of 185 trillion cubic feet of natural gas, Nigerian gas reserve is triple the nation's crude oil resources. Nigeria loses an estimated 18.2 million U.S. dollars daily (Alexander 2002) and US \$2.5 billion on a yearly basis (*Foe 2005 and ESMAP 2004, Pg 13*).

The main drivers of gas utilization projects in the Nigeria had been the government's desire to create more wealth and diversify the economy of the country. However, a combination of new government incentives and pressure from the environment ministry to end flaring, coupled with rising domestic industrial demand for gas have now encouraged operators to go into gas projects. These projects can be looked at from two perspectives; export oriented projects and domestic- oriented projects.

2.4.1 Export- Oriented Projects

2.4.1.1 Liquefied Natural Gas Projects.

A significant portion of Nigerian natural gas is processed into liquefied natural gas (LNG). LNG is the condensation of the natural gas to liquid form by cooling it to about -260°F at normal pressure (*NGSA 2006 b*). LNG takes up about one six hundredth the volume of gaseous natural gas. For this reason, LNG can easily be transported from on place to another. Due to its ease of transportation, LNG can serve to make economical those stranded natural gas deposits for which the construction of pipelines is uneconomical.

The Nigerian Liquefied Natural Gas Company was established in 1992. The execution of the project commenced in 1993. The \$3.8 billion NLNG facility on Bonny Island was completed in September 1999 (*Mbendi 2005*). It was expected to process 252.4 bcf of LNG annually (*Adegbulugbe .A.O. 2006*). The shipment of gas from the Bonny Plant to overseas buyers in Europe commenced late in 1999 with 2 trains. The Construction of a third LNG production train, with an annual capacity of 130.6 bcf, was completed and operational in December of 2002. The third LNG train increased NLNG's overall LNG processing capacity to 383 bcf per year (*EIA 2005C*).

Since then, the trains have been expanded to train 4 and 5 with Halliburton and KBR as joint venture. The train 4 and 5 project was also called "NLNGPlus Project. The NLNGPlus plant was expected to have an overall production capacity of 16.8 million tons per year (MMT/y) of LNG, 2 MMT/y of LPG, and 1 million tons of condensate by utilizing about 2,800 MMcf/d of gas (*EIA 2005C*). In January 2006, NLNG sent its first shipment of LNG exports to the United States from its newly commissioned fourth train. The company's fifth train began operation in January 2006 as well. Today, the additional two trains have increased annual production capacity to 17 million tons per year of LNG (*EIA 2005C*).

Plans have been approved for a sixth train to come online in 2007. It will have a capacity of 4.1 million metric tons per year of liquefied natural gas (LNG) (*Center for energy economics*), raising NLNG's total production capacity to 22 million metric tons per year of LNG and 4.6 million metric tons per year of liquefied petroleum gas (LPG) and condensate (*PIA2004, Pg 2*). In addition to the environmental benefits, the expansion is expected to generate large export earnings for Nigeria. This would make Nigeria the third largest exporter of LNG in the world. Currently, The NLNG facility is supplied from non-associated natural gas fields. However this would be changed to associated gas in few years time.

In February 2001, Nigeria and Chevron-Texaco, Conoco, Exxon-Mobil and Texaco signed a memorandum of understanding (MOU) to conduct feasibility studies for a second LNG facility that would be located in Nigeria's Western Delta. Other LNG projects that have been announced are the Agip/Phillips Brass GBS LNG, OK-LNG to mention but a few.

In December 2005, ConocoPhillips, Chevron and Agip met with NNPC to sign a shareholders agreement for the establishment of the \$3.5 billion Brass River LNG plant (*Center for energy economics*). If the project continues along the current timetable, its two LNG trains will be operational by late 2009.

Chevron proposed a \$7 billion LNG plant project, OK-LNG, at Olokola in western Nigeria in January 2006. The plant would have an initial capacity of 11 million tons per year and a maximum capacity of 33 million tons per year (*EIA 2005C*). Construction should have begun in 2006, with completion date of 2009.

2.4.1.2. Gas Gathering Projects.

These projects entail the installation of gas gathering and extraction facilities at the Escravos terminal. Chevron has embarked upon the Escravos Gas utilization project, which would process about 160 billion standard cubic feet (MSCF) of gas daily from the company's Mefa and Okan fields (*EIA 2005C*). About 130 MSCF of dry residue gas would also be available daily from this project to the Nigerian Gas Company for commercial and domestic use.

EGP 1, the first major gas project to gather and process associated natural gas in Nigeria, came on stream in 1997. It processes 165MMcfpd of associated natural gas supplied to the domestic market by pipeline (*Alexander 2004*). EGP 2, the project's second phase processes an additional 135MMcfpd of gas (*Alexander 2004*), extending capacity to 290 MMcf/d, began operations in late 2000. EGP 3, a planned Phase 3 would process up to 400 MMcf/d of natural gas from ChevronTexaco's offshore and onshore swarrp oil production facilities (*Alexander 2004*).

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2.4.1.3 Gas Injection Project.

SHELL JV Belema's gas Injection project is aimed at reducing flares in five flow stations by re-injecting some of the gas, some for gas lifting, and some for use as fuel by local industries and the excess for backing out non-associated gas that is currently used to meet various existing contractual obligations. The contracts for the execution of the engineering procurement construction and gathering pipelines are still in the early stages of execution. About 80 MMcf/d of gases would be utilized (*Center for energy economics*).

2.4.1.4 The West Africa Gas Project (WAGP)

This project would transport natural gas from Nigeria to Ghana, Benin and Togo. The \$590-million WAGP would traverse 420 miles (1,033 kilometers) (*Center for energy economics*) both on and offshore to its final planned terminus at Effasu in Ghana and would initially transport 120 MMcf/d(*Center for energy economics*) of gas to Ghana, Benin and Togo beginning in 2004. Gas deliveries are expected to increase to 150 MMcf/d in 2005, 210 MMcf/d in 2010 and be 400 MMcf/d by the end of 2020 (*EIA 2005C*).

In May 2005, the first shipload of pipes arrived at Port Tema for the construction of the pipeline. Operational start-up of the project was expected during 2006, with initial capacity of 200 MMcf/d of natural gas. The pipeline is expected to function at a full capacity of 450 MMcf/d within 15 years (*EIA 2005C*). Multilateral Investment Guarantee Agency (MIGA) and the International Development Association (IDA) are also helping to fund the WAGP by giving \$75 million and \$50 million, respectively (*EIA 2005C*).

2.4.1.5 Trans-Saharan Pipeline Project.

Nigeria underlined its determination to penetrate the European gas market when it signed preliminary agreements with Algeria in October 2001 on a planned Trans-Saharan Pipeline running through the North African country. The project would seek to connect the Nigerian gas field with that of Algeria, to the European market. The 2,500-mile pipeline would carry natural gas from oil fields in Nigeria's Delta region to Algeria's Beni Saf export terminal on the Mediterranean (*Center for energy economics*). It is estimated that construction of the \$7 billion project would take six years (*EIA 2005C*).

2.4.2 Domestic-Oriented Projects.

2.4.2.1 Power Projects

The generation of electricity has traditionally been a very polluting, inefficient process. However, with new fuel cell technology, the future of electricity generation is expected to change dramatically in the next ten to twenty years (*NGSA 2006 b*). However, major oil companies are planning or have already established gas fired Independent Power Plants (IPPs). Based on this fact, current power projections show that gas would be very prominent.

2.4.2.2 Liquefied Petroleum Gas.

Liquefied Petroleum Gas is currently produced from the four local refineries, the current total refinery capacity being about 200,000 tonnes yearly (*Alexander 2002*). Transportation is, however, a major handicap in LPG marketing. As part of gas conversion, the Nigerian Agip Oil Company has constructed two gas re-cycling plants at the Obiafu/Obrikorn and Kwale/Okpai oil fields. At Obiafu/Obrikorn, there are gas re-injection wells capable of injecting 200MMSCF per day, while Kwale/Okpai can handle 73MMSCF daily (*Alexander 2002*).

2.4.2.3 Gas to Liquid (GTL)

Natural gas can be used as the raw material for manufacturing GTL fuel, producing a final petroleum product (middle distillates, gasoline, or jet fuel) that has extremely clean properties, basically free of sulphur and nitrogen. In recent years, costs of gas-to-liquids conversion have been lowered to the point where commercial plant operations now seem feasible. It should be noted that all GTL projects are also very sensitive to both the base cost of gas and the tax regime for capital costs. Chevron Escravos gas-to-liquids (GTL) project is expected to have production capacity of 34 000 barrels per day (*Chevron 2005, Pg 2*).

The plant would utilize Johannesburg-based Sasol Ltd's proven synfuels conversion technology to produce premium-quality, ultra-low sulfur diesel fuel and naphtha. This would be sold in Europe and the United States. The proposed Completion of the GTL project was initially scheduled for 2005 but has been rescheduled for 2009 (*Chevron 2005, Pg 2*). This is a key element in Chevron-Texaco's initiative to reduce flaring of natural gas.

2.4.2.4 NGL Project.

MOBIL JV NGL plant located at its OSO field in the south-eastern part of Nigeria started production for export during the third quarter of 1998. The OSO Phase 2 Project is to provide additional gas make-up for the OSO NGL as well as maintain condensate production at the expected plateau (*Center for energy economics*).

2.4.2.5 Expansion of Domestic Gas Distribution Network.

Several distribution schemes are planned to help promote Nigerian consumption of natural gas. The proposed \$745-million Ajaokuta-Abuja-Kaduna pipeline would deliver gas to central and northern Nigeria. More so the proposed \$552-million, Aba-Enugu-Gboko pipeline would deliver natural gas to portions of eastern Nigeria (*Center for energy economics*). The Lagos State government and Gaslink Nigeria Limited (Gaslink), a local gas distribution company, are developing a pilot program to deliver natural gas to nine residential neighborhoods in the state.

Other announced projects, which are projected path to flare out by 2008, are as shown in table 2.4 below.

Table 2.4 Summary of Gas Projects in Nigeria (*Center for energy economics*)

Summary of Gas Projects in Nigeria

Project	Type	Company	Design Capacity MMcf/d	Gas Utilized MMcf/d	Cost \$Mm
Oso Phase II	NGL & LPG	MPN	600	600	800
Gas To Liquids	Synthetic Fuel	ChevronTexaco	300	300	1,200
Escravos Gas plant	NGL & LPG	ChevronTexaco	Phase 1 - 165 Phase 2- 135 Phase 3 - 400	700	550 - 1000
Belema Project	Gas Injection	Shell	80	80	N/A
NLNG	LNG	SHELL (25.6)/ ELF (15)/ AGIP (10.4), NNPC (49)	Train 3,4 & 5	3000	N/A
Lagos-Ikeja Gas lines	Distribution & Marketing	UNIPETROL, Gas link	20	20	35
Ota,/Agbara & Aba Gas lines	Distribution & Marketing	Shell Nig Gas (SNG)		N/A	35
West Africa Gas Project (WAGP)	Distribution & Marketing	ChevronTexaco, SHELL (SPDC), NNPC(NGC), TOGO(SoToGaz), GHANA(GNPC), BENIN(SoBeGaz)	180 620 miles of 18" diameter pipeline	180	400
Escravos-Lagos Gas pipeline phase 1,2&3	Distribution	NGC	Phase 1- 80, Total Phase 3 - 160	160	N/A
TNEP Phase 1-3	Dist., Mkt'g & power	ChevronTexaco, ABB		N/A	2,500
Elf Gas Comp	Gas gathering	Elf		N/A	400
Lagos Emer. Power Purchase	Power Generation	AES Corporation	Supply 270MW	N/A	800
ABB - IPP	Power Generation	ABB Group	Phase 1 2 & 3 300 MW	N/A	N/A

N/A - Not Available

2.5 Natural Gas Consumption

Natural gas is rapidly gaining in geopolitical importance. It has grown from a marginal fuel consumed in regionally disconnected markets to a fuel that is transported across great distances for consumption in many different economic sectors. It is increasingly becoming the fuel of choice for consumers seeking its relatively low environmental impact, especially

for electric power generation. The graphical representation of natural gas consumption is stated in figure 2.8.

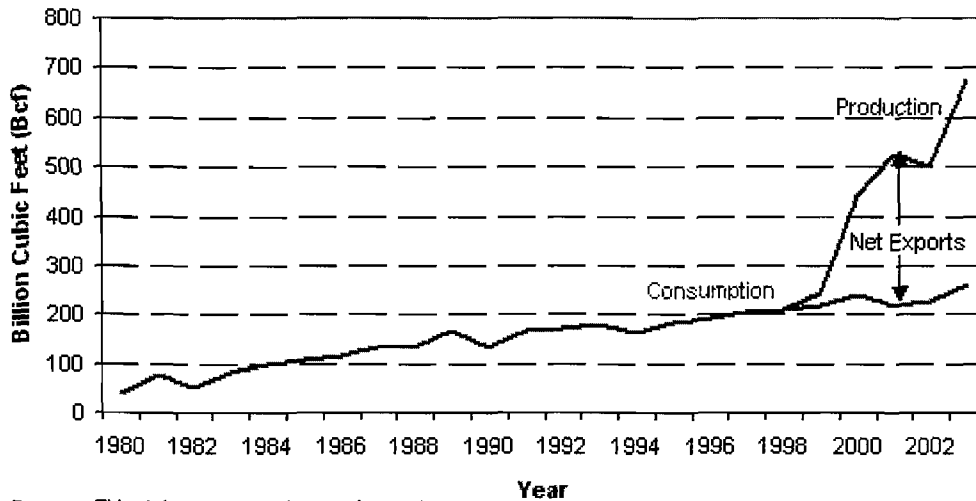


Figure 2.8 Nigeria's Natural Gas Production and Consumption, 1980-2003 (EIA 2005C).

2.5.1 Natural Gas World Consumption

World gas consumption is projected to more than double over the next three decades, rising from 23% to 28% of world total primary energy demand by 2030 (EIA 2006). It is surpassing coal as the world's number 'one' energy source and potentially overtaking oil's share in many large industrialized economies. Gas consumption is projected to grow in nearly all world regions, with the largest absolute increase in North America and Europe. There would likely be rapid growth in new markets such as China, South Asia and Latin America.

It is likely that rising gas consumption in many of these markets will force an increase in imported supplies as low-cost local resources are exhausted. Simultaneously, falling costs for transporting gas-both by pipeline and by ship as liquefied natural gas (LNG)-would continue to improve the viability for these distant suppliers to develop markets outside their borders.

2.5.2 Domestic Natural Gas Consumption and Market.

Apart from the export potential of the Nigerian gas, local demand opportunities are tremendous. Some of the demand centres are power generation, cement industry, fertilizer and iron and steel plants. Others are petrochemicals, aluminium smelting and distribution to industrial centres as source of energy supply. However, it must be noted that in spite of the abundant gas resources available as a source of energy, domestic gas demand is constrained by limited capacity utilization that currently exists in these plants.

2.5.2.1 Power Sector

The largest single consumer of natural gas in Nigeria was NEPA now Power Holding Company (PHC) and it accounts for about 70 % of the gas consumed domestically and 90% of gas sells (*Center for energy economics*). (PHC) currently operates power generating gas plants at three gas-turbine stations at Afam, Sapele and Ughelli (*Hart 1995, 199*). The combined daily requirement of these plants, at peak production, is about 1,500 mm cfpd (*Center for energy economics*). However, the plants are yet to meet that. Considering the average 425kWh/capita correlated to Gross Domestic Product (GDP) per capita for developing countries like Nigeria.

There is going to be a likely growth of gas demand for power generation. Using a growth factor of 2.5 % as the base estimate would result in increased gas consumption by the power sector in Nigeria from the 1999 level of 270 mm cfpd, to 1,350 mm cfpd in 2010, to over 3,800 mm cfpd by 2020 (*Alexander 2002*).

2.5.2.2 Industrial Sector

- Cement Industry

Liquid fuel fired cement is not cost competitive as it is expensive to produce. Gas fired cement is less expensive to produce due to the relative cheapness of gas over other sources of energy. Based on the development of the country, the growth rate of cement is expected to double potentially every 10years. The gas demand for this sector could increase to 85 mm cfpd by 2010 and 270 mm cfpd by 2020 (*Alexander 2002*). This could lead to plants expansion, new grassroots capacity additions, and conversion of

liquid fuelled kilns to the more efficient, gas-fired kilns. The major gas consumer for cement production in Nigeria is the West African Portland Cement Company.

- Steel Industry

The steel industry in Nigeria is at a stand still. This inactivity of the plant at Aladja and Ajaokuta has reduced the gas consumption to near zero. However, with improved performance in the industry and the other sectors, it is estimated that gas demand may double every 10 years. Restarting the existing steel plants and revamping them to meet the estimated demand of 2.0 mm tpy by 2020 would result in total gas demand increase of 70 mm cfpd by 2010 and 130 mm cfpd by 2020 for this sector (*Alexander 2002*).

- Aluminium Industry

Pots and building roof materials have advanced to the use of aluminum. Aluminium Smelter Company of Nigeria (ALSCON) with a capacity of 200,000 tpy, if re-activated is projected to consume 85 mm cfpd by about 2005 (*Alexander 2002*).

- Petrochemical Industry

Gas is a major feedstock of the petrochemical industry. The consumption of natural gas in the petrochemical industry is in direct proportion to production output. With an increase in demand of petroleum products and establishment of new plants in 2010 and 2020, gas demand is approximately 60 mm cfpd. This demand could reach almost 80 mm cfpd by 2010 and 100 mm cfpd by 2020 (*Alexander 2002*).

- Fertilizer Industry

Fertilizer demand is projected to increase by 6 to 7 % per year over the next 20 years. This increase in fertilizer demand would result from increased land cultivation, and the improved fertilizer application rate. As at 2002, fertilizer application rate was about 13 kg/hectare, which are lower than most African countries. Gas demand in this sector could reach 110 mm cfpd by 2010 and 170 mm cfpd by 2020 (*Alexander 2002*).

2.5.2.3 Residential Sector

Extending gas supply to residential consumers and small industrial concerns is problematic. Infrastructure and operating costs for supplying residential consumers are typically high hence leading to low volume. The total current average domestic gas demand in Nigeria is estimated at about 600 mm cfpd. Average domestic gas demand, from a recent study, has the potential to increase to 1,900 mm cfpd by 2010 and ultimately to over 4,800 mm cfpd by 2020 if the infrastructure is put in place to improve distribution network (*Alexander 2002*).

2.6 Regulations and Incentives on Gas

The government has put in place a number of regulation and incentives to encourage gas production, transmission and utilization.

2.6.1 Natural Gas Laws and Regulations:

The Petroleum Drilling and Production Regulation No.51 of 1969 Section 42 of the Decree stipulates that not later than five years after the commencement of production from the relevant area, the licensee shall submit to the commissioner (in this case, the Minister) any feasibility study, programme or proposal that they may have for the utilization of any natural gas; whether associated with oil or not, which has been discovered in the area.

- The Petroleum Amendment Decree of 1973 made provisions for the Federal Government to take natural gas produced with crude oil by the licensee or lessee free of cost at the flare or at an agreed cost and without payment of royalty (*Akeredolu and Sonibare 2006, pg 744*).
- The Associated Gas Re-Injection Decree 99 of 1979 requires producing companies to submit proposals for utilization of AG produced in their operating areas and to stop flaring of gas from 1st January 1984 except by express permission of the Minister of Petroleum Resources. The consequence for violating the Decree included forfeiture of the acreage concerned (*Alexander 2002*).
- The Associated Gas Re-Injection Amendment Decree 7 of 1985 introduced a charge of 2k/1000 cf of gas flared at the fields where authority to flare associated gas was not granted. In 1990, 50k/1000 cf, 1998, N 10/1000 cf. reflect the effective weight of the penalty in relation to the exchange rate at the time (*Alexander 2002*).

- DPR also has a policy of not allowing the development of non-associated gas where associated gas utilization is feasible, apart from the provision for back-up supply (*Alexander 2002*).
- Guarantees and Assurances Decree of 1990 (*Alexander 2002*).
- The 1991 and 1992 Associated Gas Framework Agreement (AGFA) (*Alexander 2002*).

2.6.2 Incentives on Gas

Existing incentives for gas in respect of domestic gas operations are:

- Equipment and machinery meant for gas project development are exempted from VAT and import duty (*Alexander 2002*).
- Applicable tax rate under the PPT Act to be at the same rate as Companies Income Tax Act (CITA) currently at 40 % (*Alexander 2002*).
- Investment Tax Credit (ITC) at the current PPT rate of 50 % that was the same rate of credit granted to oil producing companies (*Alexander 2002*).
- Royalty at the rate of 7 % on-shore and 5 % offshore (*Alexander 2002*).
- Pioneer status for companies engaged in gas production for a period of 5 years Gas Transmission and Distribution (*Alexander 2002*).
- Capital allowance at the present rate of 20 % per annum in the first four years, 19 % in the fifth year and 1 % in the books (*Alexander 2002*).
- Tax rate at the rate of Companies Income Tax Act (CITA), which is at present 40 %.
- Tax holiday under pioneer status, which shall be for a period five years (*Alexander 2002*).

Much has been written and discussed about natural gas in Nigeria, as reported in this chapter. Many natural gas utilization projects have been proposed. To date, the projects that have made significant use of the Nigeria's natural gas are WAGP and LNG. Other projects such as GTL, which were proposed to commerce in 2005, are yet to be completed as at 2007. Oil companies find it more economically expedient to flare the natural gas and pay the insignificant fine than to re-inject the gas back into the oil wells. The research question then remains – what economic potential could the gas resource have on Nigeria economy?

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

The research study required the evaluation of the economic impact of explored and produced natural gas utilization on Nigerian economy. During the research work, the evaluation and assessment of potential prospect in natural gas to meet future demand; Nigerian available international gas market, Nigerian competitiveness in the gas market as well as natural gas economic growth contribution were done. For the economic growth evaluation, GDP and GDP per capita were used as economic indicator in estimating natural gas potential on the Nigerian economy if fully utilized. The economic model used for the study was developed using Microsoft Excel.

Since the research topic is very sensitive, most data are hidden from the public eyes while others are not actually the precise values. Hence data obtained were gathered by surveying authoritative literature from reliable Internet sources as well as oil and gas companies' journals and reports. "BP 2006" was one of the major sources of data obtained for this study. The numerical data collected are measured under standardised conditions. Although there were likely errors of estimation, most of the data from one source corresponds with the data from other sources such as "Oil and Gas 2005 and IEA 2004".

In the evaluation of availability and reliability of natural gas as well as its competitiveness in the gas market, equation 1 and 2 below were used to calculate the percentage production of natural gas as compared to proven reserve and the lifespan of the gas before depletion respectively.

$$\% \text{Production} = \frac{\text{Production}}{\text{Proven Reserve}} \times 100 \dots\dots\dots 1$$

$$\text{Life Span} = \frac{\text{Proven reserve}}{\text{Production}} \dots\dots\dots 2$$

Natural gas production, consumption and proven reserved for 1980 to 2005 with 5 years interval were correlated. Countries were grouped into nations with natural gas but don't consume; those with natural gas but consume more as well as those with natural gas but

consume less. The volume of natural gas for countries with 0.1bcm of natural gas consumption or production was neglected in the compilation. Since natural gas consumption in Nigeria is less than 0.1bcm, her consumption data was not included in the data compilation shown in appendix C-V

The economic impact of natural gas exploration was investigated by using GDP as the economic indicator. Data on energy prices are often more difficult to obtain. Energy pricing depend upon outlet opportunities among other factors (*Graham & Trotman 1983, Pg 334*). More so, prices can be collected for typical consumers based on published price lists (*Graham & Trotman 1983, Pg 342*). The European Union is one of Nigerian gas outlet opportunities and a typical natural gas consumer. Therefore European Union’s natural gas price was used for the natural gas GDP calculation. It is assumed that the natural gas price comprises of production and transportation costs.

Natural gas produced from 1999 to 2005 was utilized for GDP calculation. To generate the GDP for each year, necessary dimensional analysis, which involves conversion from one standard unit to another, were made. The dimensional measures applied are shown in appendix B-I, B-II and B-III.

For a comparative analysis of the GDP between two different years, real GDP and current GDP calculation was made applying “*Nilotpal Das*” principle. In order to calculate the current GDP of natural gas, the formula stated in equation 3 was applied.

$$GDP_{Current} = P_t \times Q_t \dots\dots\dots 3$$

Where

$GDP_{current}$ = Current gross domestic product

P_t = Price level of time t

Q_t = Output level of time t

Equation 4 was used for real GDP calculation and the base year used is 1990. Equation 3 and 4 shown below were obtained from “*Rudiger .D and Stanley .F. 1991 as well as Shenk.H*”

$$GDP_{Real} = P_b \times Q_t \dots\dots\dots 4$$

Where

GDP_{Real} = Real gross domestic product

P_b = Price level of base year

Q_t = Output level of time t

GDP of natural gas per capita from year 1999 to 2005 was also calculated using the model stated below in equation 5:

$$GDP \text{ per capita} = \frac{GDP}{Population} \dots\dots\dots 5$$

Equation 5 can also be expressed as equation 6 (*Michael .C. and Sigrid .S. 2005, Pg 178*) below

$$y = Y/P$$

Where

Y = Annual national income(GDP) 6

P = Population size

y = per capital income(GDP per capita)

Considering the economic growth potential of Nigerian natural gas, the estimated contribution of natural gas GDP to Nigerian GDP and per capita real GDP from 1999 to 2005, if the gas produced was utilized, was calculated using the annual growth rate of per capita income model shown below in equation 7 (*Michael .C. and Sigrid .S. 2005 Pg 171*).

The calculation is reflected in appendix DIII.

$$y_t = (1+g)^t \times y_o \dots\dots\dots 7$$

Making g the subject formula;

$$g = \text{anti log} \left(\frac{\log \left(\frac{y_t}{y_o} \right)}{t} \right) - 1 \dots\dots\dots 8$$

Where

t = Time period

y_t = Income per capita level at time period

y_o = Income per capita level at base year

g = Annual growth rate

In order to obtain the population data that could be used to get the GDP per capita, Malthus population growth model of differential equation (*Wenner J.M*) shown in equation 9 was applied. The reason for population data computation was because the data obtained from different data sources seems not to correlate with each other. The last two population censuses held in Nigeria were in 1991 and 2006. The population for these two years is 88500000 and 140008418 respectively as shown in “*Akeredolu & Sonibare 2006, Pg 749; CIA 2005, NBS and Olori .T. 2007*”.

$$\frac{dN}{dt} = rN \dots\dots\dots 9$$

Where

r = The rate of natural increase and usually expressed in percentage

t = The interval of time

N = The number of individuals in the population at a given time.

Differentiating 9 with respect to the method stated in “*Weisstein E.W*”, equations below were obtained.

$$\int_{N_o}^N \frac{dN}{N} = \int_0^t r dt \dots\dots\dots 10$$

$$\ln \frac{N}{N_o} = rt \dots\dots\dots 11$$

$$N = N_o e^{rt} \dots\dots\dots 12$$

Where

$$N_o = N(t = 0)$$

N_o = Starting population

N = The population after certain time t has elapsed

r = The growth rate, termed Malthusian parameter

With the help of Microsoft excel package and the exponential function growth formula stated in equation 12, Population data were calculated. The values obtained were in-line with estimated data in “*Air Ninjab*”

An economic growth model was created to project economic impact of natural gas to the Nigerian economy over a period of 30years, taking 2005 as the base year. The projection was developed by applying the general proportional growth rate model obtained from “*Michael .C. and Sigrid .S. 2005*”. The expression of proportional growth rate model for per capita national income is expressed as shown in equation 13.

$$\dot{y}_t \equiv \frac{y_t - y_{t-1}}{y_{t-1}} \dots\dots\dots 13$$

Where

y_{t-1} = Income per capita level at at the start of one period

y_t = Income per capita level at the start of the next period

\dot{y}_t = proportional growth rate.

Learning curve model was also used to estimate Nigerian economy over the 30years as a result of natural gas utilization. The learning curve equation is as stated below in equation 14 (*Robert H.P and Don W.G 1998, Pg 9-21*). However the parameters in equation 14 are defined for the purpose of this study.

$$C_{ME} = K[X^{N+1} - (X - 1)^{N+1}] \dots\dots\dots 14$$

Where

C_{ME} = GDP or per capita GDP

K = Effective value of first GDP or per capita GDP

X = Period

N = Growth rate.

With the help of Microsoft excels spreadsheet; the economic growth model simulation was done. The Nigerian GDP and per capita income are presented in Appendix D

In carrying out the research work, the methodologies in this chapter were used to obtain the findings in the next chapter. This was to ensure that all data reviewed were sufficiently reliable for inclusion in this research work after acknowledging the limitations of the available data on natural gas in Nigeria. The next chapter would include the findings on Nigerian natural gas availability and reliability, natural gas potential market as well as the gas impact on Nigerian economy. The results obtained from the stated findings were also discussed in details in the next chapter. The next chapter will give a better understanding of all the results and analysis obtained by the investigation methods stated in this chapter.

CHAPTER FOUR

4.0 FINDINGS AND DISCUSSION OF RESULT.

The utilization of natural gas produced and explored in Nigeria is of paramount importance for the Nigerian economic development because of the related constraint by the Kyoto protocol. In the evaluation of gas potential to Nigerian economy; Findings on the availability, reliability, potential natural gas market, as well as its competitiveness, GDP, GDP per capita and economic growth were taken into consideration.

Results analysis were done with respect to currently available data on natural gas estimated proven reserve, production, consumption, as well as Nigerian GDP and population census obtained from IEA, BP2006 and CIA. The results were discussed in details to develop the potential of natural gas on Nigerian economy. The findings and discussion of results are presented below in the sections that follow.

4.1 Evaluation of Nigerian Gas Reserve and Production.

In order to predict the potential prospect in natural gas to meet future demand, Nigerian natural gas proven reserve was compared with its production. Nigerian natural gas proven reserve and production data and evaluated values, using equation 1 and 2, are presented in table 4.1. The graphical analysis presented in figure 4.1 and figures 4.2 are drawn from this table. The analysis of natural gas life is presented in figure 4.1 while figure 4.2 shows the trend of proven natural gas reserve discovery to that of production. The relationship of both can greatly affect the potential prospect of natural gas resource in any country over a unit of time.

The convention used for each column in table 4.1 is defined as follows:

NGPR	Natural gas proved reserved
NGP	Natural gas production
R/P	Reserve to production ratio.

Table 4.1 Comparison of Nigerian Proven Natural Gas Reserve with Production and Life Span

YEAR	NGPR(tcm) ¹	NGP(bcm) ²	NGPR(bcm)	%NGP*1000	R/P
1980	1.16	1.7	1160	147	682
1985	1.34	2.6	1340	194	515
1990	2.84	4.0	2840	141	710
1995	3.47	4.8	3470	138	723
2000	4.11	12.5	4110	304	329
2005	5.23	21.8	5230	417	240

¹ and ² are obtained from BP2006

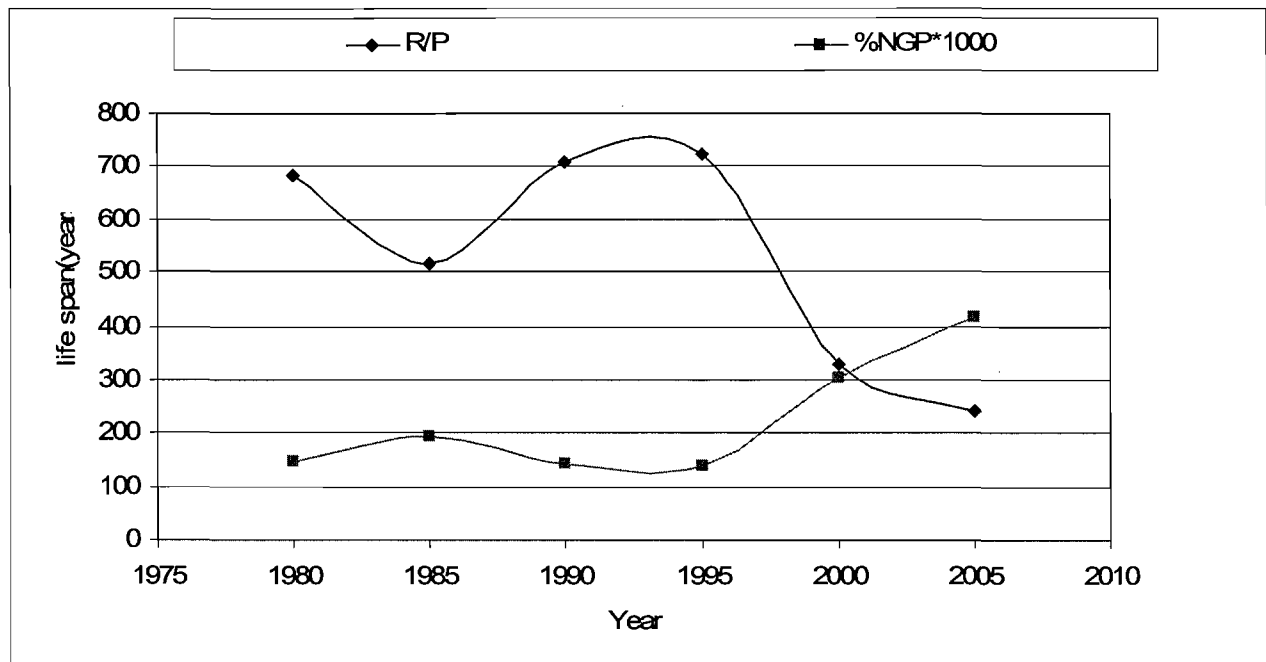


Figure 4.1 Nigerian Natural Gas Production verse Life Span

It can be seen in figure 4.1 above that the life span of natural gas reserve in Nigeria is inversely proportional to the percentage of gas reserve produced. The higher the percentage of gas reserve produced the smaller the life span of natural gas, hence the faster its rate of depletion. In order for natural gas to have a potential prospect to meet future demand, more gas wells have to be discovered, explored and utilized. However, table 4.1 shows that it would take 240 years for the gas to be exhausted, considering the

present production of natural gas. Hence it could be predicted that natural gas in Nigeria has a high possibility of meeting future demand.

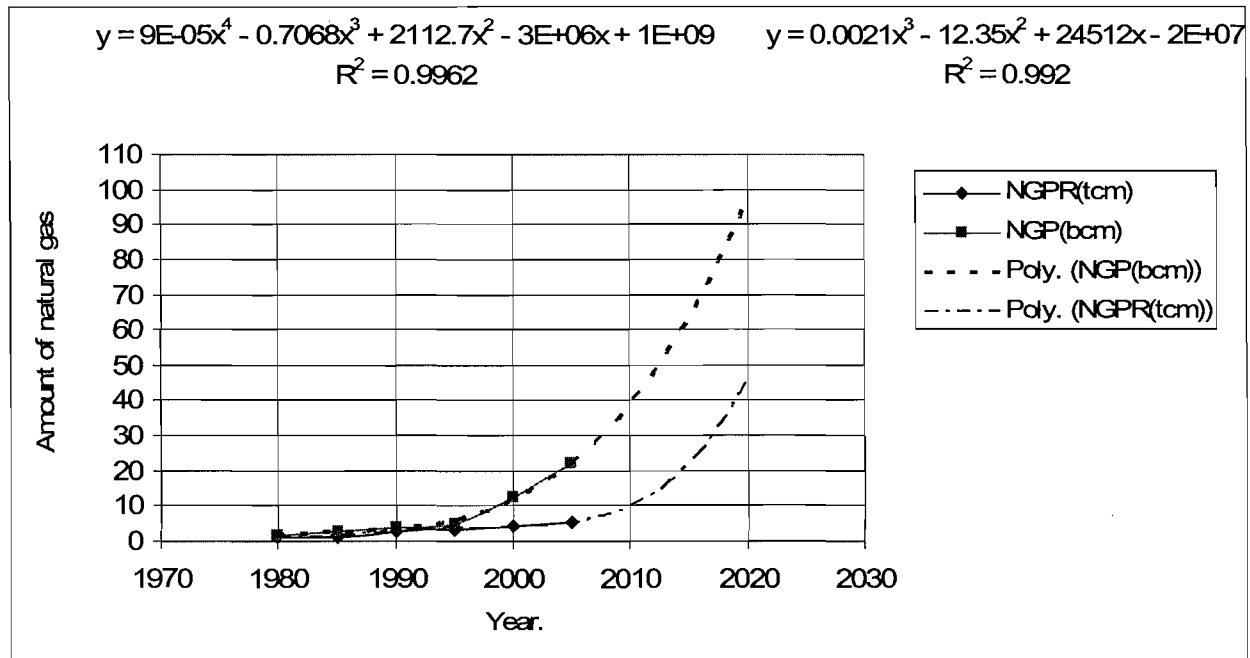


Figure 4.2 Nigerian Proven Natural Gas Reserve verse Production

Figure 4.2 showed that natural gas production is very low in billion cubic metres as compared to the proven Reserve, which is in trillion cubic metres. It also illustrated that Nigeria has a huge reserve of natural gas that has been slightly tapped. The upward movement of the graph showed that Nigerian proven reserve will not be exhausted by increasing the gas production as long as more reserves are discovered. The prediction from this figure further supported the prediction in figure 4.1.

4.2 Evaluation of Natural Gas Potential International Market Availability

In the evolution of the natural gas economic potential, besides the evaluation and assessment of potential natural gas resources availability, market development plays an important role. Hence, natural gas supply in relation to consumption is of great importance. In order to assess natural gas market, World production and consumption as well as Nigerian competitiveness as compared to other countries were put into consideration. In predicting possible market for Nigerian natural gas, various tables and graphs were drawn for easy evaluation as presented in this section.

The conventions used in tables 4.4 to 4.8, are defined below.

PRDT Production of natural gas

CSMPT Consumption of natural gas

DIFF The difference between natural gas production and consumption

R/P Ratio Reserve to production ratio (life span)

Table 4.2 Exportation and Importation of Natural Gas by Continent

Years	1995	2000	2005
Northern America (bcm)	-26.7	-16.6	-23.8
Southern America (bcm)	0.1	4.1	11.4
Middle East (bcm)	7.1	21.3	41.5
Europe (bcm)	-25.1	-53.2	-60.6
Africa (bcm)	33.7	58.8	70
Asia (bcm)	-4.6	-24.5	-46.8

Where - represents importation and + represent exportation

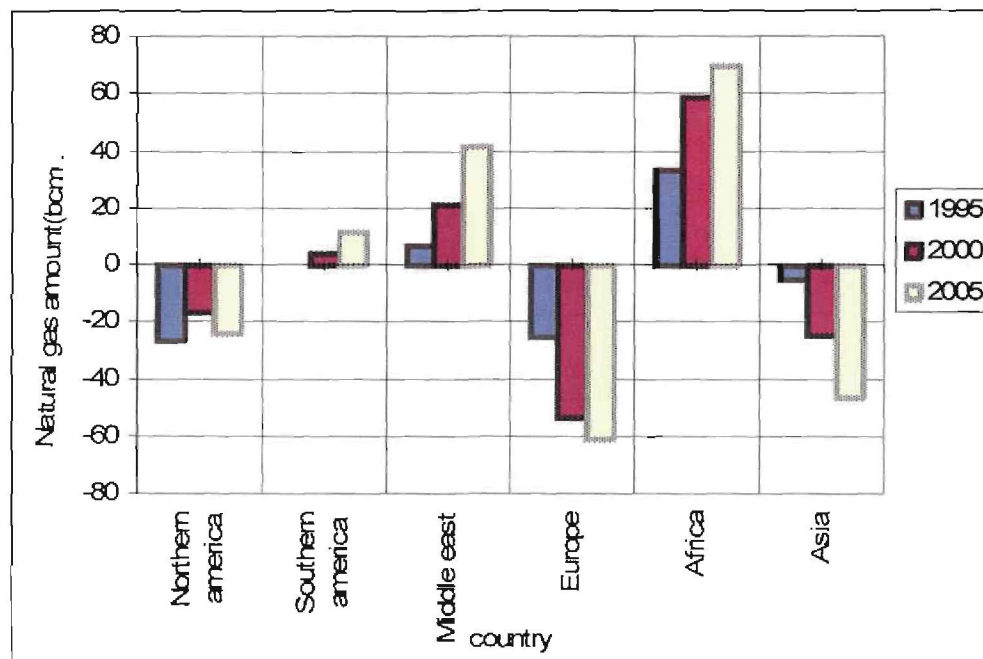


Figure 4.3 Continental Comparison of the Availability of Natural Gas

North America, Europe and Asia importation of natural gas greatly increased over the past 20 years as illustrated in figure 4.3. This is in accordance with "Gass, J, 2004" that there is a recent steady increase in gas production and demand in the Asia Pacific region. More so that Europe, natural gas demand is projected to grow 2 to 3 percent per year for the next 20 years.

However, the Middle East appeared to have a steep growth in her exportation. This showed that they are producing at a faster rate than any other continent. Although Africa increase in exportation from 1995 to 2000 was higher, the exportation of natural gas from 2000 to 2005 was higher for the Middle East.

Table 4.3 World's Production and Consumption of Natural Gas

Year	1995	2000	2005
Production (bcm)	2142	2437	2763
Consumption (bcm)	2153	2435	2750

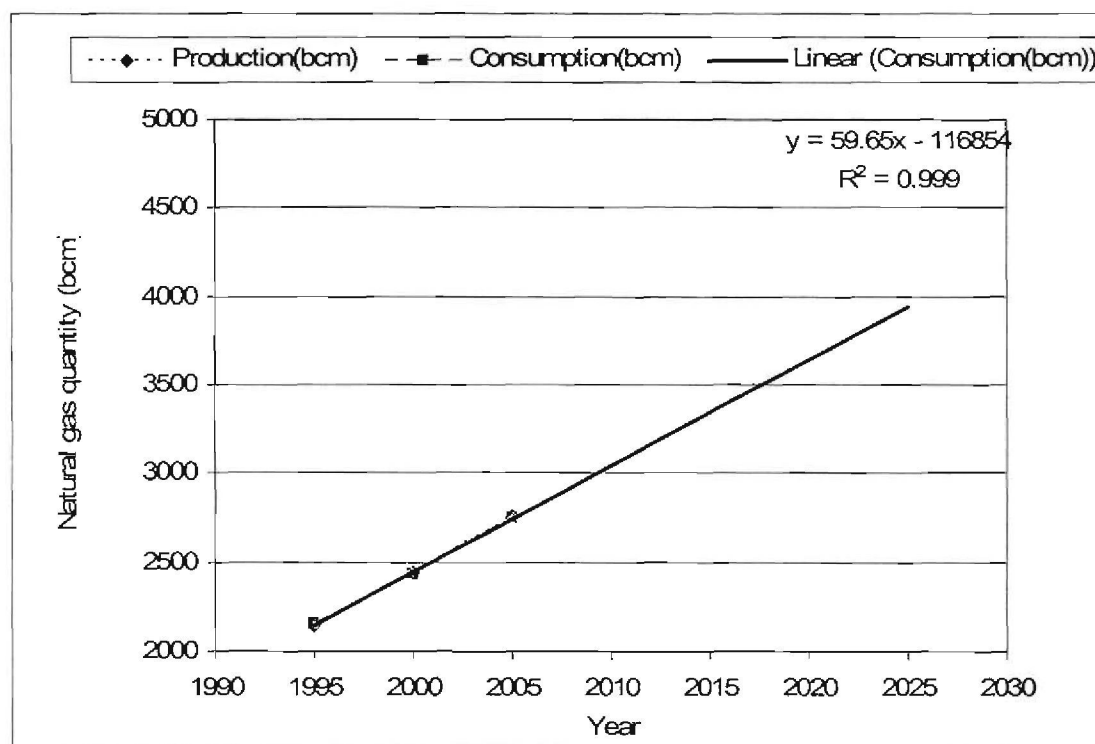


Figure 4.4 Comparison of World's Production and Consumption of Natural Gas

Table 4.3 presents the assessment of how natural gas is valued in the world. However it should be noted that countries with less than 0.1bcm of natural gas production and consumption were neglected in this analysis. In 1995, the amount of natural gas produced and consumed in most countries were not up to 0.1bcm. The consequence of the negligence is that consumption was greater than production.

The trend of the graph illustrated in figure 4.4 showed that the world's consumption and production of natural gas has been increasing at the same rate for the past 20years having

a slope of 59.65bcm/year. This is in accordance with "EIA 2006" that world's gas consumption is projected to more than double over the next three decades. Overtime, consumption rate would be higher than that of production since it is a non-renewable resource.

"EIA 2006" states that the rising gas consumption in many of these markets will force an increase in imported supplies as low-cost local resources are exhausted. The increase in demand and decrease in supply would cause an increase in natural gas prices based on economic law of demand and supply.

Table 4.4 to table 4.8 were drawn based on the evaluation done on appendix C-V. They involve the evaluation of the natural gas status of various countries in the world. This evaluation was made to predict probable market for Nigerian natural gas. It could also be used to predict Nigerian competitors in the market, hence the fate of her natural gas resource. The graphical representations are shown in figure 4.5 to 4.8 for easy evaluation.

Table 4.4 Countries with Consumption of Natural Gas Greater Than Production

Year	1995(bcm)			2000(bcm)			2005(bcm)			2005 Reserve	
	³ PRDT (bcm)	⁴ CSMPT (bcm)	DIFF (bcm)	⁵ PRDT (bcm)	⁶ CSMPT (bcm)	DIFF (bcm)	⁷ PRDT (bcm)	⁸ CSMPT (bcm)	DIFF (bcm)	⁹ bcm	R/P Ratio
USA	534.3	638.0	-103.7	555.6	669.7	-114.1	525.7	633.5	-107.8	5450	10
Mexico	26.6	28.1	-1.5	35.8	38.5	-2.7	39.5	49.6	-10.1	410	10
Brazil	4.8	4.8	0.0	7.2	9.3	-2.1	11.4	20.2	-8.8	310	27
Other S and C Americas	2.2	7.3	-5.1	2.2	11.9	-9.7	3.5	18.3	-14.8	170	49
Azerbaijan	6.2	8.0	-1.8	5.3	5.4	-0.1	5.3	8.8	-3.5	1370	258
Germany	16.1	74.4	-58.3	16.9	79.5	-62.6	15.8	85.9	-70.1	190	12
Italy	20.4	49.9	-29.5	16.2	64.9	-48.7	12.0	79.0	-67.0	170	14
Poland	3.5	9.9	-6.4	3.7	11.1	-7.4	4.3	13.6	-9.3	110	26
Romania	18.0	24.0	-6.0	13.8	17.1	-3.3	12.9	17.3	-4.4	630	49
Ukraine	17.0	76.2	-59.2	16.7	73.1	-56.4	18.8	72.9	-54.1	1110	59
U.K	70.8	70.5	0.3	108.4	96.9	11.5	88.0	94.6	-6.6	530	6
other Euro	15.9	13.8	2.1	11.3	13.5	-2.2	9.8	15.3	-5.5	460	47
Iran	35.3	35.2	0.1	60.2	62.9	-2.7	87.0	88.5	-1.5	26740	307
Other M.E	3.4	16.1	-12.7	3.4	22.1	-18.7	3.4	27.0	-23.6	50	15
Other Afirca	3.0	12.8	-9.8	5.9	17.0	-11.1	7.0	21.6	-14.6	1200	171
India	19.4	19.4	0.0	26.9	26.9	0.0	30.4	36.6	-6.2	1100	36
Thailand	10.4	9.8	0.6	18.6	19.2	-0.6	21.4	29.9	-8.5	350	16
Other A.P	3.5	3.5	0.0	3.7	5.1	-1.4	7.3	8.9	-1.6	370	51

^{3, 4, 5, 6, 7, 8& 9}were obtained from BP2006

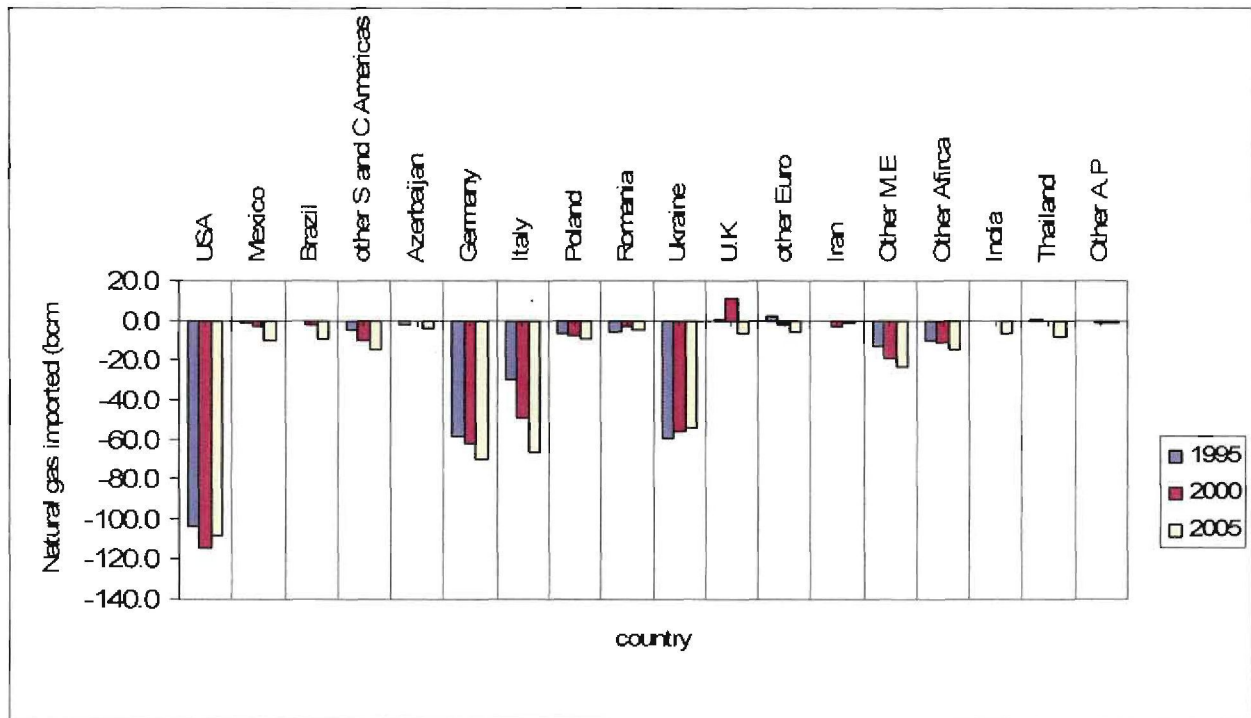


Figure 4.5 Status of Natural Gas Imported by Producing Countries

From the graph presented in figure 4.5, the quantity of natural gas imported especially by Germany and Italy increased from 1995 to 2005; although that of Ukraine reduced within the year range specified. USA's importation trend did not adhere to a particular sequence. However, she emerged as the greatest importer of natural gas of all the producing countries with consumption greater than production. This recognized USA, Germany, Italy and Ukraine as consumers rather than suppliers hence were predicted as Nigerian major natural gas market. "EIA 2006" supports the finding by stating that there will be rapid growth in new markets such as South Asia and Latin America. The countries proposed for Nigerian gas market also concord with the countries in "Adepetun.S. and Segun.K.1996, Pg 595 & 596".

Table 4.5 Countries Whose Production of Natural Gas is More Than Consumption

Year	1995			2000			2005			2005 Reserve	
	¹⁰ PRDT (bcm)	¹¹ CSMPT (bcm)	DIFF (bcm)	¹² PRDT (bcm)	¹³ CSMPT (bcm)	DIFF (bcm)	¹⁴ PRDT (bcm)	¹⁵ CSMPT (bcm)	DIFF (bcm)	¹⁶ bcm	R/P Ratio
Canada	158.7	80.2	78.5	183.2	83.0	100.2	185.5	91.4	94.1	1590	9
Argentina	25.0	27.0	-2.0	37.4	33.2	4.2	45.6	40.6	5.0	500	11
Denmark	5.3	3.5	1.8	8.1	4.9	3.2	10.4	5.0	5.4	70	7
Kazakhstan	5.5	10.8	-5.3	10.8	9.7	1.1	23.5	17.8	5.7	3000	128
Netherlands	67.0	37.8	29.2	57.3	39.2	18.1	62.9	39.5	23.4	1410	22
Norway	27.8	2.9	24.9	49.7	4.0	45.7	85.0	4.5	80.5	2410	28
Russian	555.4	377.8	177.6	545.0	377.2	167.8	598.0	405.1	192.9	47820	80
Turkmeni- stan	30.1	8.0	22.1	43.8	12.6	31.2	58.8	16.6	42.2	2900	49
Quatar	13.5	13.5	0.0	23.7	9.7	14.0	43.5	15.9	27.6	25780	593
Saudi Arabia	42.9	42.9	0.0	49.8	49.8	0.0	69.5	69.5	0.0	6900	99
United Arab Emirates	31.3	24.8	6.5	38.4	31.4	7.0	46.6	40.4	6.2	6040	130
Egypt	11.0	11.0	0.0	18.3	18.3	0.0	34.7	25.5	9.2	1890	54
Australia	29.8	20.4	9.4	31.2	23.9	7.3	37.1	25.7	11.4	2520	68
China	17.9	17.4	0.5	27.2	23.8	3.4	50.0	47.0	3.0	2350	47
Indonesia	63.4	30.1	33.3	68.5	32.3	36.2	76.0	39.4	36.6	2760	36
Malaysia	28.9	13.7	15.2	45.3	24.3	21.0	59.9	34.9	25.0	2480	41

¹⁰, ¹¹, ¹², ¹³, ¹⁴, ¹⁵ & ¹⁶ were obtained from BP2006

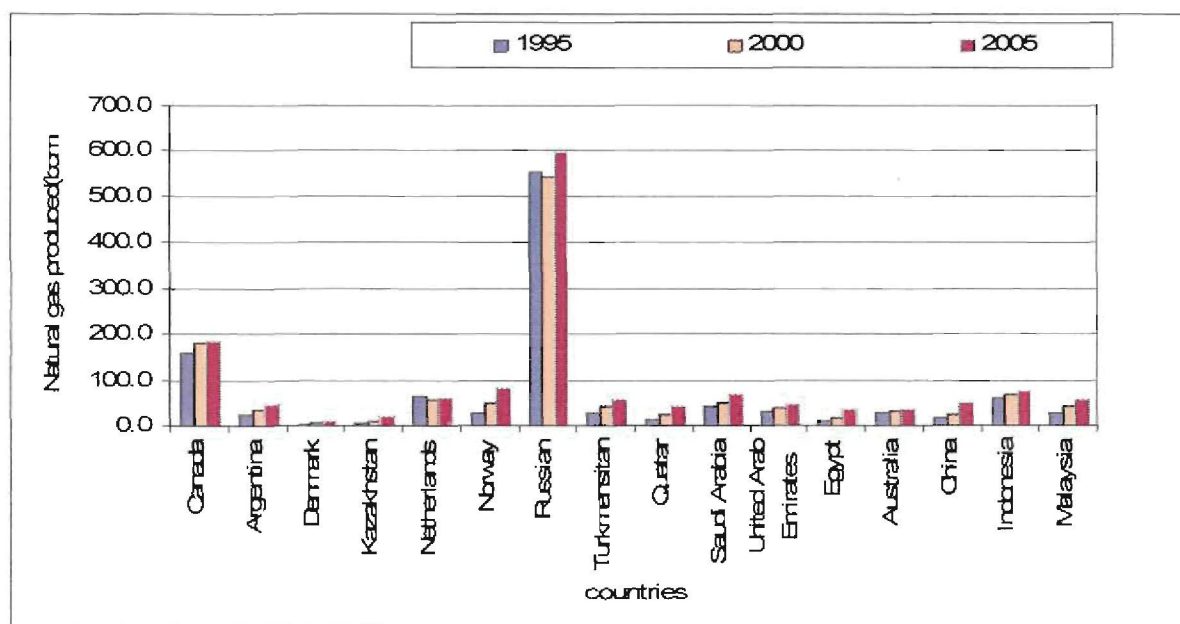


Figure 4.6 Countries with Increased Natural Gas Consumption but Enough Production

Figure 4.6 showed that these countries have excess natural gas for exportation after domestic consumption. The result presented these countries as suppliers and consumers

at the same time. However since they are self sustaining and still suppliers of nature gas, they are predicted to be Nigerian competitors in natural gas market

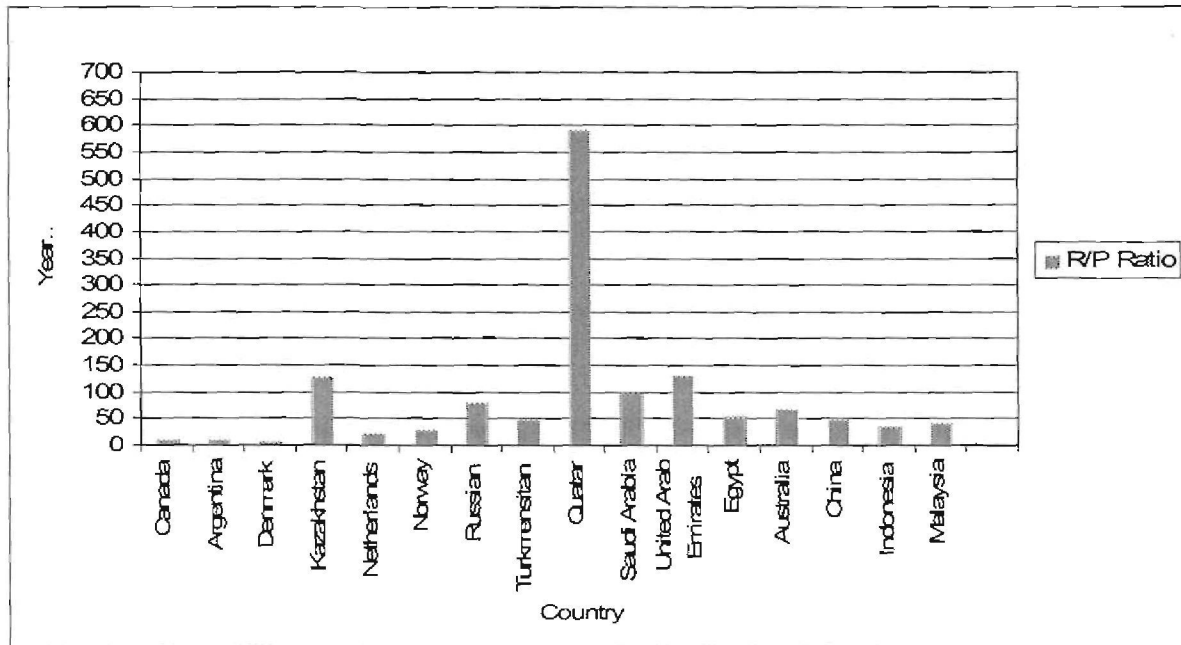


Figure 4.7 Life Span of Natural Gas for World’s Producers as at 2005.

The life span of natural gas in the countries listed in table 4.4 is far lower than that of Nigerian natural gas except Qatar. After an average of 130 years, the graph demonstrated that most of these countries would have to import natural gas from those counties who still have natural gas reserve like Nigeria with a life span of 240 years. The years could be further reduced if the rate of their consumption becomes higher than the rate of production as well as the rate of proven reserve discovery. Since Nigeria accounts for 80 % of the region’s natural gas and 3.5% of total world’s proven natural gas reserve (EIA1999), comparing figure 4.6 and 4.7 analysis, it could be predicted that the countries presented in figure 4.6 would become Nigerian natural gas market after 130 years.

Table 4.6 Countries with Natural Gas Consumption without Production or Proven Reserve

Year	1995			2000			2005			2005 Reserve	
	¹⁷ PRDT (bcm)	¹⁸ CSMPT (bcm)	DIFF (bcm)	¹⁹ PRDT (bcm)	²⁰ CSMPT (bcm)	DIFF (bcm)	²¹ PRDT (bcm)	²² CSMPT (bcm)	DIFF (bcm)	²³ bcm	R/P Ratio
Chile	0	1.6	-1.6	0	5.2	-5.2	0	7.6	-7.6	0	0
Ecuador	0	0.1	-0.1	0	0.1	-0.1	0	0.2	-0.2	0	0
Peru	0	0.4	-0.4	0	0.3	-0.3	0	1.6	-1.6	0	0
Austria	0	7.9	-7.9	0	8.1	-8.1	0	10.0	-10.0	0	0
Belarus	0	12.3	-12.3	0	16.2	-16.2	0	18.9	-18.9	0	0
Belgium& Luxemburg	0	11.8	-11.8	0	14.9	-14.9	0	16.8	-16.8	0	0
Bulgaria	0	5.0	-5.0	0	3.3	-3.3	0	3.2	-3.2	0	0
Czech Republic	0	7.3	-7.3	0	8.3	-8.3	0	8.5	-8.5	0	0
Finland	0	3.2	-3.2	0	3.7	-3.7	0	4.0	-4.0	0	0
France	0	32.9	-32.9	0	39.7	-39.7	0	45.0	-45.0	0	0
Greece	0	0.0	0.0	0	1.9	-1.9	0	2.5	-2.5	0	0
Hungary	0	10.2	-10.2	0	10.7	-10.7	0	13.4	-13.4	0	0
R.Ireland	0	2.6	-2.6	0	3.8	-3.8	0	3.9	-3.9	0	0
Lithuania	0	2.3	-2.3	0	2.7	-2.7	0	3.2	-3.2	0	0
Portugal	0	0.0	0.0	0	2.4	-2.4	0	3.0	-3.0	0	0
Slovakia	0	5.7	-5.7	0	6.5	-6.5	0	5.9	-5.9	0	0
Spain	0	8.3	-8.3	0	16.9	-16.9	0	32.3	-32.3	0	0
Sweden	0	0.8	-0.8	0	0.7	-0.7	0	0.8	-0.8	0	0
Switzerland	0	2.4	-2.4	0	2.7	-2.7	0	3.1	-3.1	0	0
Turkey	0	6.8	-6.8	0	14.1	-14.1	0	27.4	-27.4	0	0
Hong Kong	0	0.0	0.0	0	2.5	-2.5	0	2.2	-2.2	0	0
Japan	0	61.2	-61.2	0	74.9	-74.9	0	81.1	-81.1	0	0
Philippines	0	0.0	0.0	0	0.0	0.0	0	3.0	-3.0	0	0
Singapore	0	1.5	-1.5	0	1.7	-1.7	0	6.5	-6.5	0	0
South korea	0	10.2	-10.2	0	21.0	-21.0	0	33.3	-33.3	0	0
Taiwan	0	4.3	-4.3	0	6.7	-6.7	0	10.7	-10.7	0	0

¹⁷, ¹⁸, ¹⁹, ²⁰, ²¹, ²² & ²³ are obtained from BP2006

Table 4.7 Countries with Production of Natural Gas without Consumption

Year	1995			2000			2005			2005 Reserve	
Country	²⁴ PRDT (bcm)	²⁵ CSMPT (bcm)	DIFF (bcm)	²⁶ PRDT (bcm)	²⁷ CSMPT (bcm)	DIFF (bcm)	²⁸ PRDT (bcm)	²⁹ CSMPT (bcm)	DIFF (bcm)	³⁰ bcm	R/P Ratio
Bolivia	3.2	0	3.2	3.2	0	3.2	10.4	0	10.4	740	71
Trinidad and Tobago	6.1	0	6.1	14.1	0	14.1	29.0	0	29.0	550	19
Bahrain	7.2	0	7.2	8.8	0	8.8	9.9	0	9.9	90	9
Oman	4.1	0	4.1	8.7	0	8.7	17.5	0	17.5	1000	57
Syria	1.9	0	1.9	4.2	0	4.2	5.4	0	5.4	310	57
Brunei	11.8	0	11.8	11.3	0	11.3	12.0	0	12.0	340	28
Myanmar	1.6	0	1.6	3.4	0	3.4	13.0	0	13.0	500	38
Vietnam	0.1	0	0.1	1.6	0	1.6	5.2	0	5.2	240	46

^{24, 25, 26, 27, 28, 29 & 30} were obtained from BP2006

Table 4.8 Countries with Natural Gas Consumption Equal to Production

Year	1995			2000			2005			2005 Reserve	
Country	³¹ PRDT (bcm)	³² CSMPT (bcm)	DIFF (bcm)	³³ PRDT (bcm)	³⁴ CSMPT (bcm)	DIFF (bcm)	³⁵ PRDT (bcm)	³⁶ CSMPT (bcm)	DIFF (bcm)	³⁷ bcm	R/P Ratio
Colombia	4.4	4.4	0	5.9	5.9	0	6.8	6.8	0	110	16
Venezuela	27.5	27.5	0	27.9	27.9	0	28.9	28.9	0	4320	149
Uzbekistan	45.3	42.4	2.9	52.6	47.1	5.5	55.7	44.0	11.7	1850	33
Kuwait	9.3	9.3	0	9.6	9.6	0	9.7	9.7	0	1570	162
Algeria	58.7	21.0	37.7	84.4	19.8	64.6	87.8	24.1	63.7	4580	52
Bangladesh	7.4	7.4	0	10	10.0	0	14.2	14.2	0	440	31
New Zealand	4.3	4.2	0.1	5.6	5.5	0.1	3.7	3.6	0.1		0
Pakistan	14.6	14.6	0	18.8	18.8	0	29.9	29.9	0	960	32

^{31, 32, 33, 34, 35, 36 & 37} are obtained from BP2006

Table 4.6 shows the countries with consumption of natural gas without proven gas reserve. These countries are predicted as possible international markets for the natural gas in Nigeria. The same prediction applied to countries listed in table 4.8 since they are more of consumers than suppliers. However countries listed in table 4.7 are predicted to be Nigerian competitors. "WEC 2001" states that there is a challenge to the supply of energy in a way compatible with a wise use of the environment and earth resources. Hence it was predicted that these countries in table 4.7 would not be able to withstand the competition in the gas market over a period of time if more gas reserves are not discovered.

Table 4.9 Qatar's Natural Gas Consumption and Production

Year	³⁸ CSMPT (bcm)	³⁹ PRDT (bcm)
1995	13.5	13.5
2000	9.7	23.7
2005	15.9	43.5

³⁸ & ³⁹ were obtained from BP2005



Figure 4.8 Competitive State of Qatar's Natural Gas Trend

Figure 4.7 presents Qatar as the major competitor in term of production, proven natural gas reserve as well as life span. It was estimated that Qatar's consumption of natural gas is constantly increasing as shown in figure 4.8 unlike that of Nigeria which is termed to be negligible since she consumed less than 0.1bcm of natural gas (*Bp*). If the trend persists, the probability of Qatar's proven gas reserve being lower than that of Nigeria would be higher. The analysis further presents Nigeria as a future major supplier of natural gas in the world

4.3 Potential of Natural Gas on Nigerian Economy.

The evaluation of natural gas existence in Nigeria and the trend of its discovery and production were very important in determining the gas economic potential. More so the need to predict natural gas price trend, available market, market competitors and her strength to withstand competitors could not be ruled out. Having investigated these

fundamental concepts in section 4.1 and 4.2, natural gas potential on Nigeria economy would be evaluated

The total market value of Nigerian natural gas that could have been exchanged for money yearly, if the gas produced was fully utilized, was assessed to predict the gas contribution to Nigerian GDP, GDP per capita and her economic growth. For GDP measures the value of all economic activity within a country's borders (*Nilotpal Das*).

Table 4.10 obtained from appendix C-II, shows the relationship of relation of Nigerian natural gas GDP, per capita GDP and Population since one factor depend on the others. It is to establish a better understanding of the economic indicators used in Table 4.10 and how population without considering inflation affects them. Hence real GDP shown in equation 4 is used for the comparison.

The convention used for the columns in the first row of the table 4.10 is stated below.

- NGP Natural gas production
- C90GDP GDP of natural gas at constant 1990 price in USA dollar
- GDP/C.E Gross domestic product per capita based on population growth model
- PFE Population data from Population growth model

Table 4.10 Gross Domestic Product Value of Natural Gas verses Population

Year	NGP(mBTU)	C90GDP(m\$)	PFE(m)	GDP(\$)/capita.E
1999	218154000	615	113	5
2000	454487500	1282	117	11
2001	541749100	1528	120	13
2002	516297800	1456	124	12
2003	698092800	1969	128	15
2004	792626200	2235	132	17
2005	792626200	2235	136	16

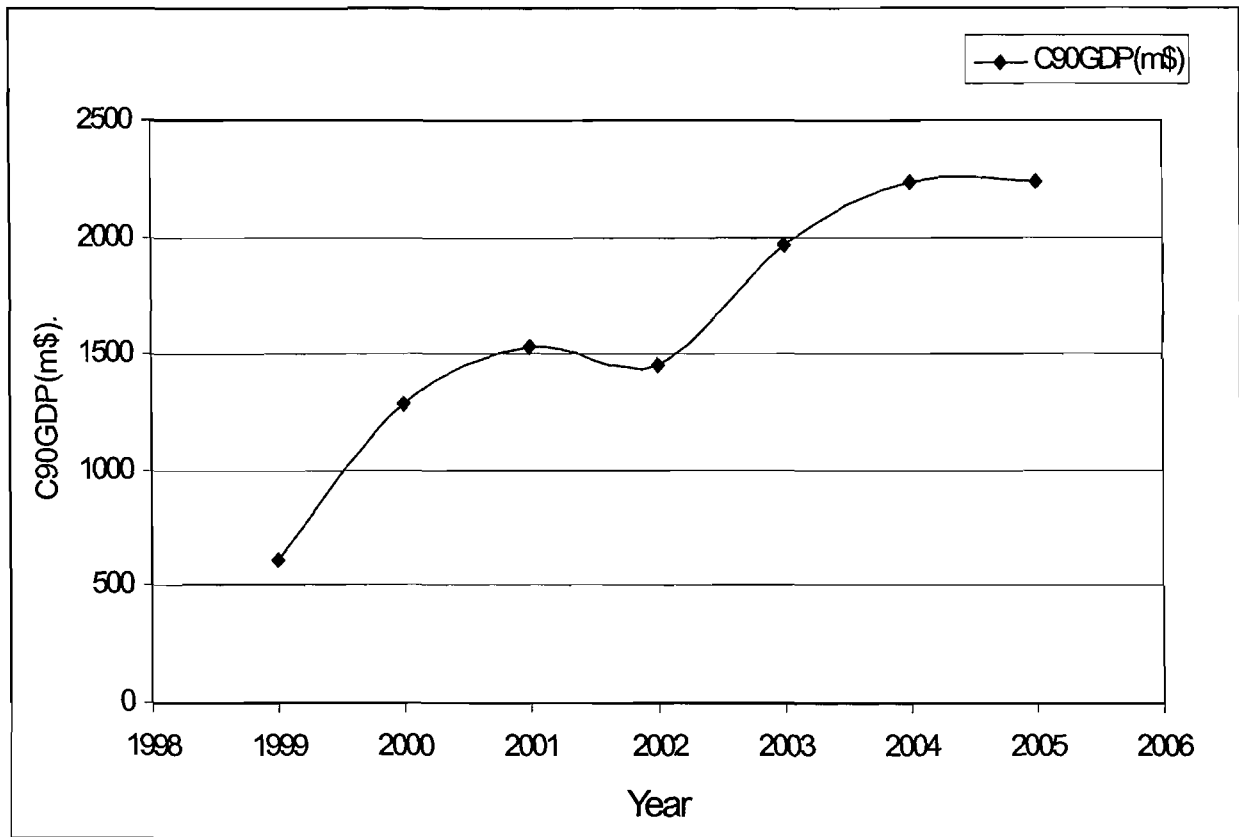


Figure 4.9 Natural Gas Gross domestic Product at 1990 base year

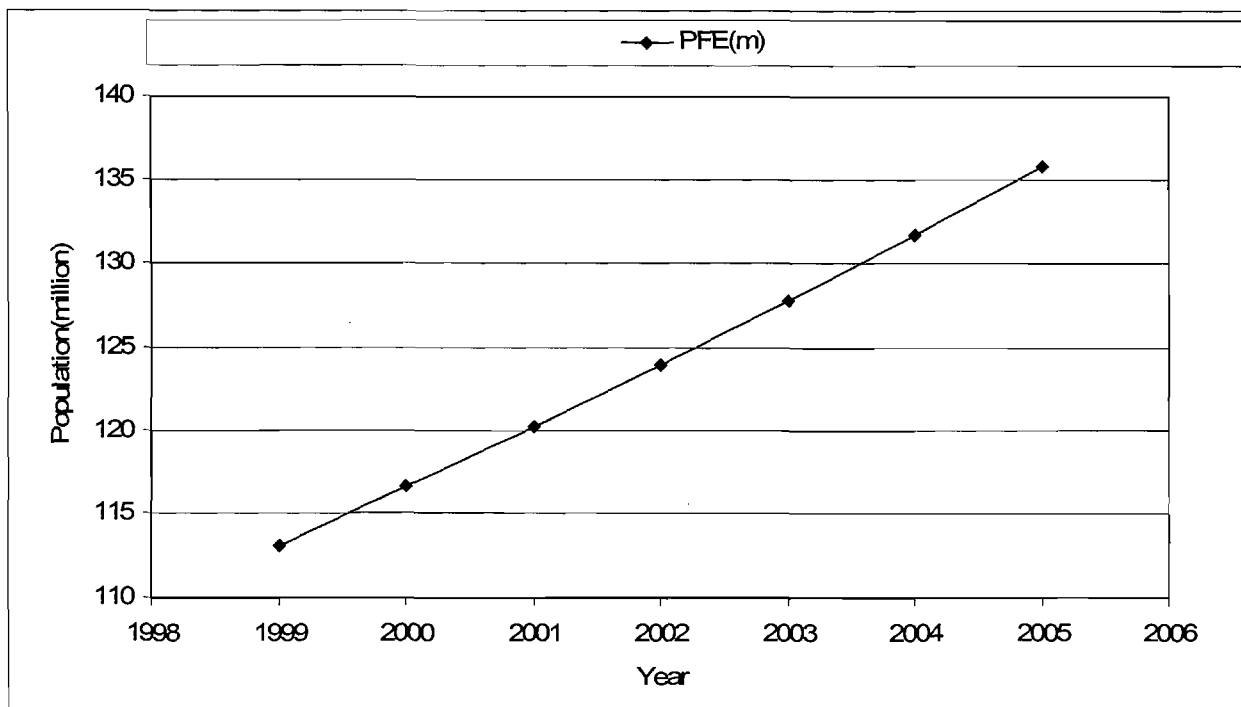


Figure 4.10 Interpolated 1990 to 2006 Nigerian Population Census

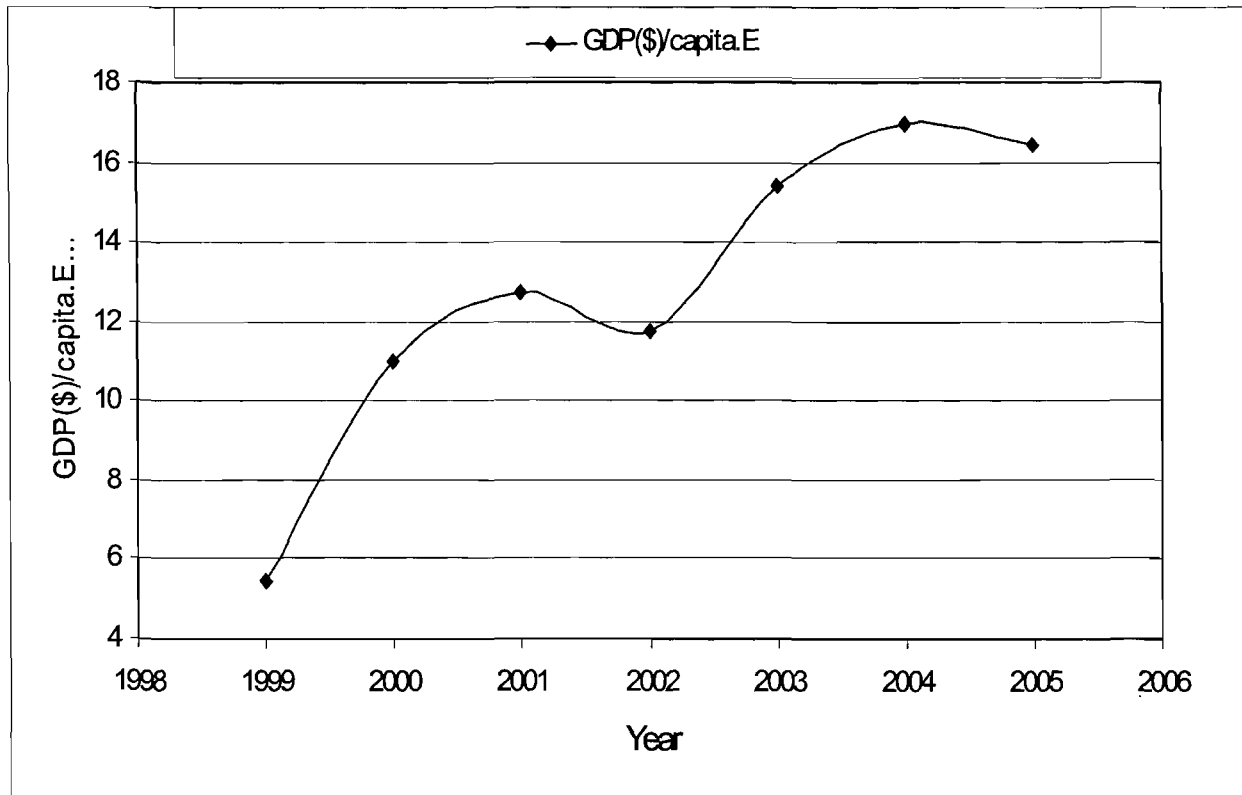


Figure 4.11 GDP per Capita of Natural gas.

The trend of the relationship between GDP, population and GDP per capita in figure 4.9, figure 4.10 and figure 4.11 respectively showed an increase if Nigeria's natural gas was fully utilised. The gas GDP and GDP per capita graph had similar curve unlike the population graph that had a linear graph. The two graphs demonstrates that the average distribution of wealth among a countries' population greatly depend on the GDP of the country rather than on her population. It could be predicted that an increase in GDP would increase per capita GDP of a country irrespective of her population at a point in time, hence improve her living standard.

The GDP and per capita GDP curve do have a dip as shown in figure 4.10 and 4.11. The first dip in the GDP and GDP per capita curve was as a result of decrease in the production of natural gas between 2000 and 2002. In the presentation of natural gas GDP per capita, there was a second dip that was as a result of constant production of gas between 2004 and 2005 while there was an increase in population. However these dips do not alter their use as economic indicators.

Considering the total utilization of Nigerian natural gas for the past seven years (1999 to 2005), the economic growth rate calculation in appendix C-III showed that total natural gas utilization would have accounted for an estimate of 0.577% annual growth rate of Nigerian GDP. Appendix C-IV also showed that the gas would have accounted for 0.558% annual growth rate of her per capita GDP. These economic growths would have contributed to the increase of the economy development of Nigeria if the gases produced were totally utilized.

Table 4.11 presents the assessment of how current GDP and per capita GDP of natural gas would have affected Nigerian GDP and her economic growth if the gas produced was totally utilized. The table was generated from appendix C-I. The result obtained from the assessment of table 4.11, was used in the economic growth model simulation shown in Appendix D-I and D-II for natural gas potential on Nigerian economy for a period of 30 years if gas produced is totally utilized. However the graphical model of the growth is presented in figure 4.13 and 4.14 using GDP and per Capita GDP as the economic indicators.

Current GDP was used because it measures the prices of output prevailing at the time of production and takes into account inflation. Hence the government in drawing out natural gas policy could use the knowledge acquired from the research study.

The convention used for the columns in the first row of table 4.11 is defined as follows:

GDPWNG	Current GDP of Nigeria with natural gas
NGDP	Nigerian GDP
PFDB	Population from Data Based
% Δ GDPWNG	Percentage growth rate of Current GDP of Nigeria with natural gas
% Δ NGDP,	Percentage growth rate of Nigerian GDP
GDPWNG (\$)/C	Current GDP of Nigeria with natural gas per capita
NGDP (\$)/C	Nigerian GDP per capita
% Δ GDPWNG/C	Percentage growth rate of Current GDP of Nigeria with natural gas per capita
% Δ NGDP (\$)/C	Percentage growth rate of Current GDP of Nigeria with natural gas per capita
Aver %g	Average percentage growth rate.

Table 4.11 Current GDP of Natural Gas versus Nigerian Current GDP

YEAR	⁴⁰ NGDP (t\$)	GDPWNG (t\$)	PFE	ΔGDPWNG (%)	ΔNGDP (%)	NGDP (\$)/C	GDPWNG (\$)/C	ΔGDPWNG (\$)/C	ΔNGDP (\$)/C
1999	110.5	110.9	113028789			977.6	981.1		
2000	117.0	118.5	116538600	6.9	5.9	1004.0	1016.6	3.6	2.7
2001	105.9	108.1	120157400	-8.8	-9.5	881.3	900.1	-11.5	-12.2
2002	112.5	114.3	123888572	5.7	6.2	908.1	922.5	2.5	3.0
2003	114.8	117.9	127735606	3.1	2.0	898.7	922.8	0.0	-1.0
2004	125.7	129.3	131702100	9.7	9.5	954.4	981.9	6.4	6.2
2005	132.1	137.1	135791762	6.0	5.1	972.8	1009.5	2.8	1.9
Aver %g				3.8	3.2	Aver%g		0.6	0.1

40 is sourced from Airinja a-CIA

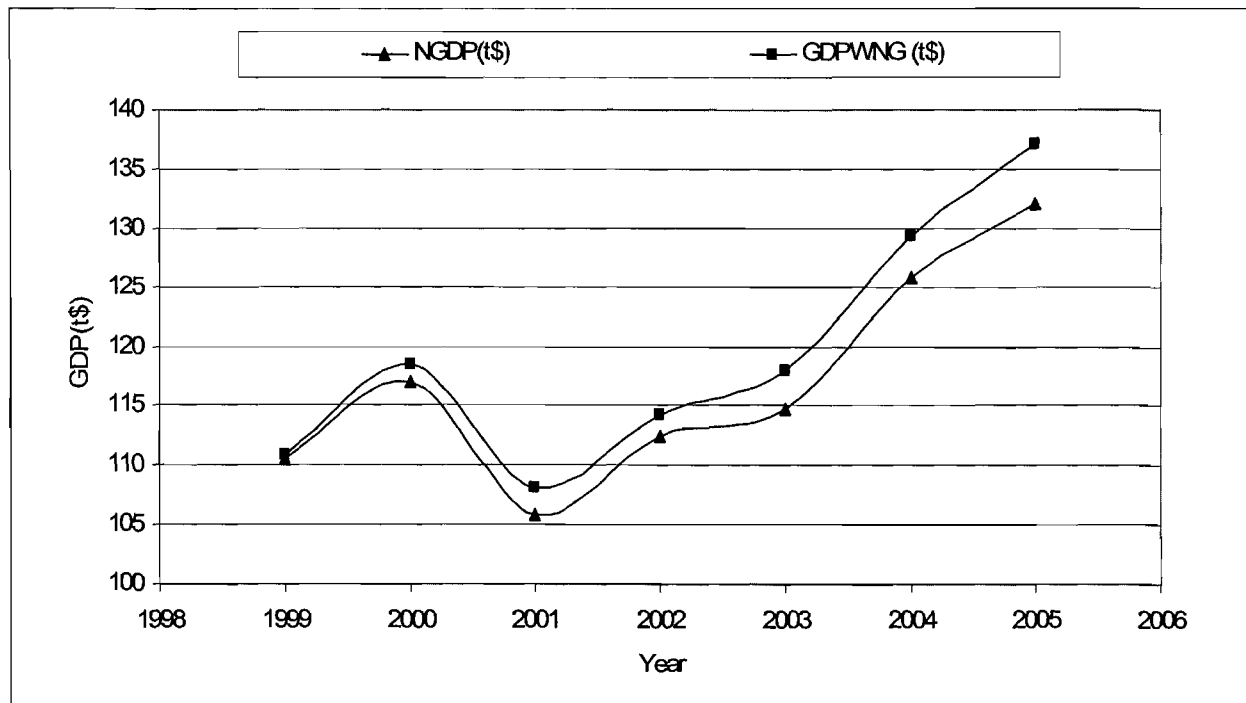


Figure 4.12 Comparison of Nigerian GDP with and without Natural Gas GDP Added

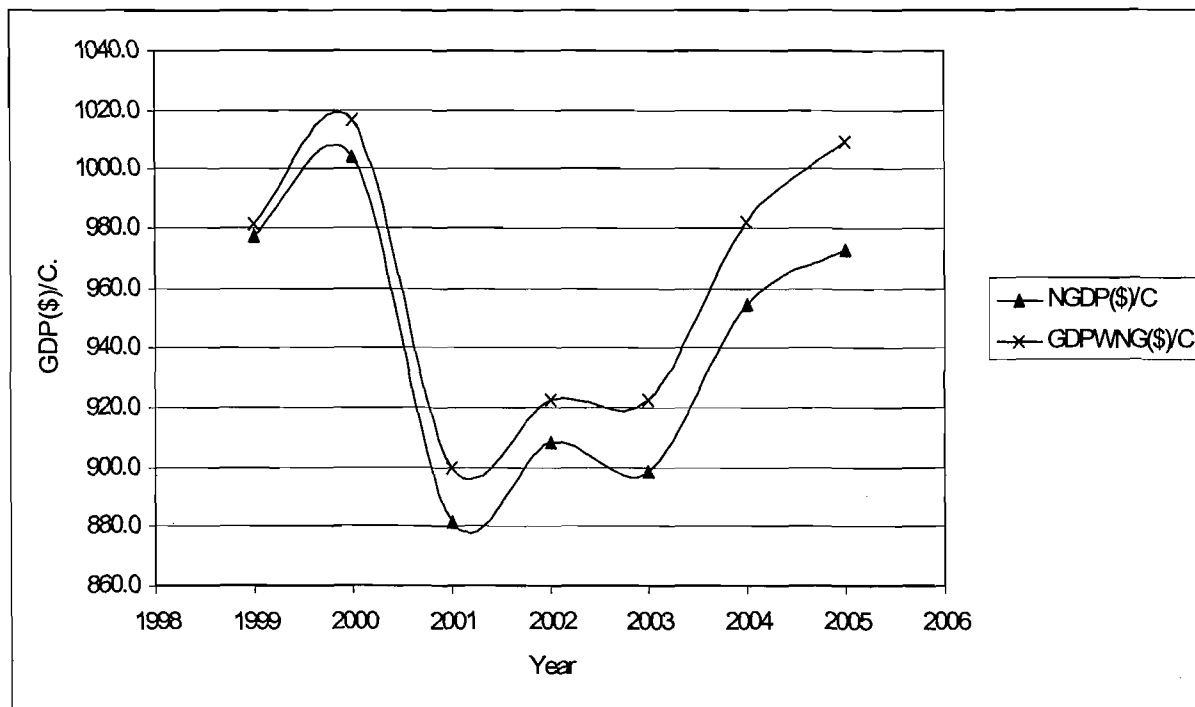


Figure 4.13 Comparison of Nigerian GDP per Capita with and without Natural Gas GDP Added

Figure 4.12 shows that GDP of Nigeria for each year increased when that of natural gas was added. This was based on the assumption that natural gas value was not included in the computation of Nigerian current GDP. If the gas produced were converted to market value, the value of natural gas in GDP would have increased over the years. This increase could have also increased Nigerian GDP as shown in figure 4.12. The value and trend in table 4.11, figure 4.12 and figure 4.13 respectively are closely in-line with the conclusion made in a report by Economides et al (2004), that Nigeria will make close to \$10 billion per year from sales of natural gas produced in the country in the next few years.

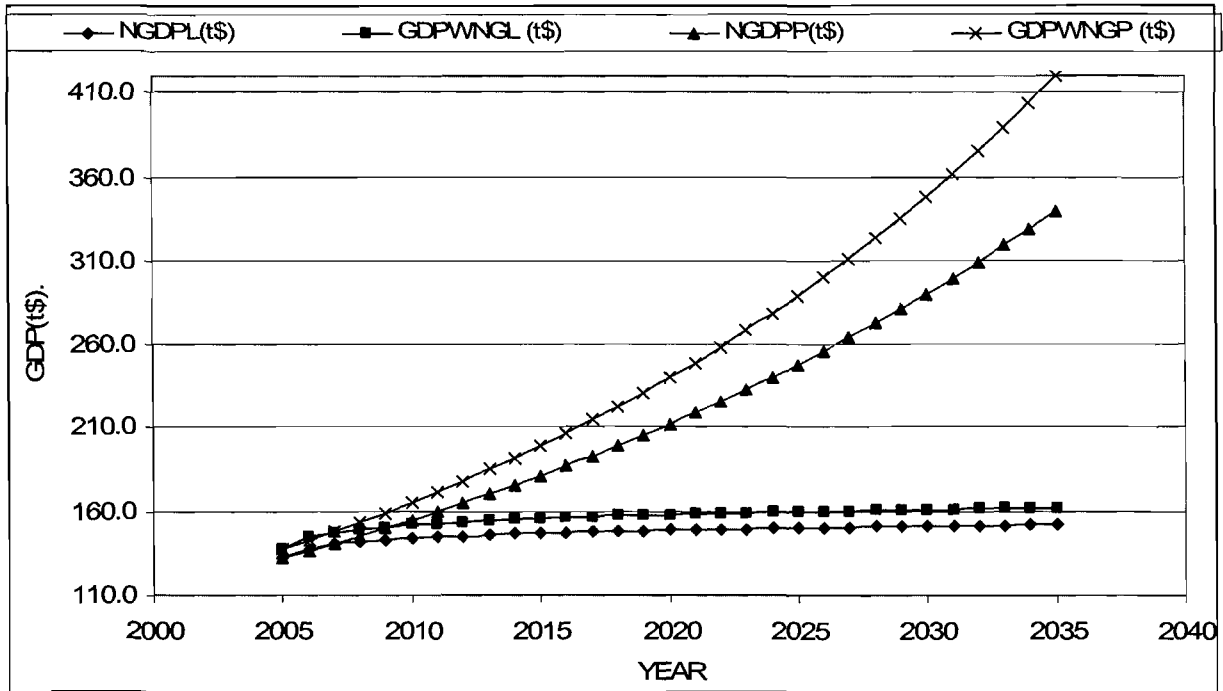


Figure 4.14 Economic Growth of Nigeria GDP due to Gas Utilization

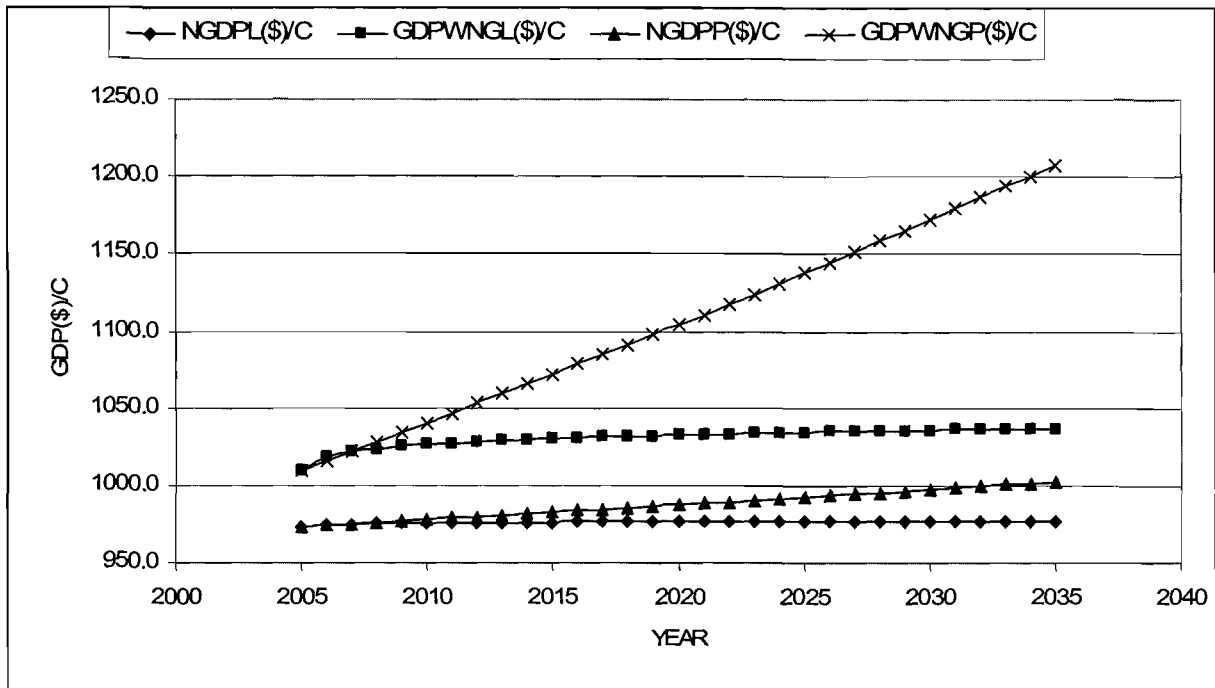


Figure 4.15 Economic Growth of Nigerian per capita GDP due to Gas Utilization

The forecast derived from the economic growth model of equation 13 and 14 are presented in figure 4.14 and 4.15. The estimated projections showed that there would be growth of in Nigerian GDP over the next 30 years if all the natural gas produced were also utilized. One indicator of living standard in a country is per capita GDP. In order to determine the potential of natural gas resource to the living standard of Nigerians, a forecast on Nigerian GDP per capita was also evaluated. The model is as presented in figure 4.15.

GDP/capita is a measure of the average wealth of a country, expressed as a ratio of its population size. Comparing figure 4.14 and 4.15, trend lines, it could be estimated that with a small growth in Nigerian GDP as a result of natural gas utilization, there could be a greater growth in the Nigerian per capita GDP with other economic factors being constant. Hence it can be predicted that the utilization of Nigerian natural gas would greatly increase the growth rate of Nigerian economy. This is according to "NNPC 2005" which predicts a continuous increase in natural gas GDP. It states that there is a predicted 25% annual growth rate of Nigeria's gas demand by 2010 which is expected to generate about 13 billion annually by 2012.

Having made a detailed discussion of all the results obtained for this research work, the next chapter gives a summary of the knowledge acquired during the interpretation and discussion of results. It also includes recommendation and further area of studies suggestions made, which is based on the unlocked potential of Nigerian natural gas.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Nigeria has a large estimated proven natural gas reserve that would take 240 years to deplete completely without the discovery of new reserves. Considering this time period before depletion, the gas would be able to meet international market demand. However, the major competitor was predicted to be Qatar in terms of her natural gas duration before depletion and proven natural gas reserve. However, the increasing trend of Nigeria's natural gas reserve discovery demonstrated that natural gas would be the future fuel of Nigeria.

Although it is said that natural gas is treated as a by-product of oil exploration due to the absence of sufficient market outlets. The research work done has been able to predict some available market for Nigeria's natural gas market. North America, Europe and Asia were the predicted major gas markets on continental level while USA, Germany, Italy and Ukraine were the predicted markets on country level. In the near future, the demand for natural gas would become very high and the supply low. More so in 130 years time, most countries would have exhausted their natural gas reserve. Considering the law of demand and supply, there would be increase in natural gas price in the near future.

The research work also demonstrated that the average distribution of wealth among a countries' population greatly depend on the GDP of the country rather than on her population. It could be predicted that an increase in GDP increases per capita GDP of a country in respective of her population, hence improve her living standard. The conversion of natural gas produced per year to market value increases natural gas GDP, hence Nigeria GDP.

Considering the economic growth contribution of Nigerian natural gas as a result of total utilization, the gas accounted for 0.577% annual growth rate of Nigerian GDP for the past six years (1999-2005). In addition to the GDP, it accounted for 0.558% annual growth rate of her per capita GDP for the same time period. This increase in the economic indicators could have contributed to the improvement of the living standard of Nigerians.

The research predicts that over the next 30 years (2005 to 2035), there would be a considerable increase in the growth of Nigerian GDP and GDP per capita if natural gas produced is totally utilized. Hence it could be presumed that the utilization of Nigeria's natural gas would greatly increase the growth rate of Nigerian economy and improve the average distribution of wealth in Nigeria.

Considering all the available international market and proven natural gas reserve, the natural gas produced can be traded globally, hence leading to globalization. Apart from the increase in the growth rate of Nigerian economy the improvement of the average distribution of wealth in Nigeria, it could offer a fresh opportunity for developing and developed nations to establish lasting relationships. This interrelation could result to the improvement of other sector of the economy.

5.2 Recommendation

The research work presented herein, has lead to the recommendation of the following

1. With the increasing trend of consumption, more major gas drilling companies should be established for the purpose of gas exploration rather than relying on the existing Oil drilling companies who will rather spend more money on crude oil exploration and production rather than gas exploration and production.
2. Although there are gas regulations and policies in place, most of them are not effective. The fine paid by oil companies for the flaring and venting of gas is very small. They rather pay the fines than utilize the gas. Hence Effective regulation and policies should be put in place to enforce oil multinationals to invest in gas-utilization infrastructures and Exploration. The fines on book should be that which will greatly cost the multinational companies a fortune.
3. Nigeria has adequate reserves of associated and non-associated natural gas for development; however, the constraint on oil production by OPEC could limit the amount of associated gas that can be produced daily. This limitation could affect the potential prospect of Nigerian natural gas to meet world demand of gas. Hence gas should be treated as a separate sector rather than a sub-sector in petroleum sector of Nigeria economy. By so doing

OPEC restriction effect on gas exploration would be eliminated and Nigeria would enjoy the full potential of gas on her economy.

5.3 Area of Further Study

The research work proposed the available international gas market for Nigerian natural gas for which the natural gas can be sold as final consumption product in order to determine its potential GDP. However it did not cover the evaluation of best market for which natural gas GDP can be optimized. Hence a further study should be carried out to evaluate and assess the proposed natural gas market route that would lead to the optimization of Nigerian gas GDP and hence Nigerian GDP.

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APPENDIX A DEFINITIONS

- Constant Dollar GDP: GDP calculated when the output of the economy in any given period is measured at the prices of the base year. It factors out the impact of inflation and allows for easy comparisons by converting the value of the dollar in other time periods to present-day dollars.
- Consumption: This involves natural gas consumed within the country, including imports.
- Crude oil: Oil found underground before refining.
- Current Dollar GDP: GDP calculated in present-day dollars. It makes time period comparisons difficult due to the effects of inflation.
- Fault: Structured traps where the rocks have been fractured and large sections have slipped past one another.
- Fossil fuel: Fuel that was created by the decomposition of organic matter. It usually contain oil and natural gas and are non renewable.
- Gross Domestic Product (GDP) of a country: The total value of goods and services produced within a country's geographic borders for a given period of time, either quarterly or yearly depending on the period of reporting. It determines the rate of growth of an economy GDP is calculated both in current dollars and in constant dollars.
- Her and She: These are words used to represent a country.
- Hydrocarbon: Chemical compound containing primarily carbon and hydrocarbon. Natural gas is composed of hydrocarbon.
- Liquefied Natural Gas: Natural gas that has been chilled to very cold temperatures, which liquefies it for storage or for use as fuel in heavy duty vehicles
- Liquefied Petroleum Gas: Consisting mainly of propane.
- Methane: The simplest hydrocarbon molecule, with a chemical formula CH_4 and the main component of natural gas.
- Natural gas Liquids: Heavier Hydrocarbons including condensate, butane, propane and ethane.
- Production: Where available, gross and net (marketed) volumes are given, together with the quantities re-injected, flared and lost in shrinkage (due to the extraction of natural gas liquids, etc.).

- Proved reserves: Those quantities of natural gas, which, by analysis of geological and engineering data, can be estimated with a high degree of confidence to be commercially recoverable from a given date forward, from known reservoirs and under current economic conditions.
- Purchasing Power Parity: Currency conversion rates that allow output in different currency units to be expressed in a common unit of value.
- R/P (reserves/production): The ratio calculated by dividing proved recoverable reserves at the end of a year by production (gross less re-injected) in that year. The resulting figure is the time in years that the proved recoverable reserves would last if production were to continue at the year level.

APPENDIX B. UNIT CONVERSIONS

Conversion I

Natural gas and LNG		To					
From		Billion cubic metres NG	billion cubic feet NG	Million tonnes Oil equivalent	million tonnes LNG	trillion British thermal units	Million barrels Oil equivalent
		Multiply by					
1 billion cubic metres NG		1	35.3	0.90	0.73	36	6.29
1 billion cubic feet NG		0.028	1	0.026	0.021	1.03	0.18
1 million tonnes LNG		1.38	48.7	1.23	1	52.0	8.68
1 trillion British thermal units		0.028	0.98	0.025	0.02	1	0.17

Conversion II

Units

1 kilolitre = 1 cubic metre

1 kilocalorie (kcal) = 4.187 kJ = 3.968 Btu

1 billion cubic metre = 1000 million cubic metre.

Conversion III

Calorific equivalents

One tonne of oil equivalent equals approximately:

Heat units	10 million kilocalories
	42 gigajoules
	40 million Btu
Electricity	12 megawatt-hours

APPENDIX C CALCULATIONS

I Natural Gas and Nigerian Current GDP and per capital GDP

YEAR	NGP(mBTU)	^a NGPr/mBTU	CNGGDP (\$)	^b NGDP (b\$)	GDPWNG (b\$)	NGCNGDP (%)
1999	218154000	1.80	392677200	110.5	110.9	0.4
2000	454487500	3.25	1477084375	117.0	118.5	1.2
2001	541749100	4.15	2248258765	105.9	108.1	2.1
2002	516297800	3.46	1786390388	112.5	114.3	1.6
2003	698092800	4.40	3071608320	114.8	117.9	2.6
2004	792626200	4.56	3614375472	125.7	129.3	2.8
2005	792626200	6.28	4977692536	132.1	137.1	3.6

a and b are sourced from BP2006 and AIRNINJA-CIA respectively

Note that Nigerian GDP is based on purchasing power parity

The convection used for the table above is shown below

CNGGDP Current natural gas GDP

GDPWNG Current GDP of Nigeria with natural gas

NGCNGDP Natural gas contribution to Nigerian GDP each year

NGPr Natural gas price

NGP Natural gas production

NGDP Nigerian GDP

II Calculated Population, Natural Gas Pricing, and GDP Calculations from 1980 to 2005.

YEAR	NGP(mBtu)	^c Natural Gas(\$/Mbtu)	CNGGDP(\$)	C90GDP(\$)	PFE
1980	61810300	European	-	174305046	63220117
1981	90897500	Union cif	-	256330950	65183251
1982	94533400	-	0	266584188	67207346
1983	105441100	-	0	297343902	69294293
1984	101805200	3.76	382903469	287090664	71446045
1985	94533400	3.83	361800849	266584188	73664614
1986	112712900	3.65	411708977	317850378	75952075
1987	109077000	2.59	282061242	307597140	78310567
1988	134528300	2.36	318106151	379369806	80742296
1989	152707800	2.09	319476813	430635996	83249536
1990	145436000	2.82	409704732	410129520	85834631
1991	141800100	3.18	450847100	399876282	88500000
1992	156343700	2.76	431028745	440889234	91248135
1993	178159100	2.53	451086494	502408662	94081606
1994	159979600	2.24	358354304	451142472	97003063
1995	174523200	2.37	413619984	492155424	100015238
1996	196338600	2.43	477102798	553674852	103120948

1997	185430900	2.65	491391885	522915138	106323098
1998	185430900	2.26	419073834	522915138	109624682
1999	218154000	1.80	392677200	615194280	113028789
2000	454487500	3.25	1477084375	1281654750	116538600
2001	541749100	4.15	2248258765	1527732462	120157400
2002	516297800	3.46	1786390388	1455959796	123888572
2003	698092800	4.40	3071608320	1968621696	127735606
2004	792626200	4.56	3614375472	2235205884	131702100
2005	792626200	6.28	4977692536	2235205884	135791762

C is sourced from BP

The convention used for the columns in the first row of table 4.11 is stated below.

NGP	Natural gas production
C90GDP	GDP of natural gas at constant 1990 price in USA dollar
CNGGDP	Current natural gas GDP
PFE	Population from evaluation

III Calculation of Natural Gas Economic Potential on Nigerian GDP

Calculation of annual economic growth rate of Nigerian GDP if gas produced was totally utilized, using equation 5.

$$g = \left(\text{antilog} \left[\frac{\log \left(\frac{(137.1 \times 10^9)}{(110.9 \times 10^9)} \right)}{(2005 - 1999)} \right] - 1 \right) \times 100$$

$$g = (1.03598 - 1) \times 100$$

$$g = 0.03598 \times 100$$

$$g \cong 3.598\%$$

Calculation of annual economic growth rate of Nigerian GDP without gas GDP added, using equation 5.

$$g = \left(\text{antilog} \left[\frac{\log \left(\frac{(132.1 \times 10^9)}{110.5 \times 10^9} \right)}{(2005 - 1999)} \right] - 1 \right) \times 100$$

$$g = (1.03021 - 1) \times 100$$

$$g = 0.03021 \times 100$$

$$g \cong 3.021\%$$

Calculation of economic potential of natural gas on Nigerian GDP

$$\begin{aligned}\text{Economic potential of natural gas} &= g_{GDPWNG} - g_{NGDP} \\ &= 3.598 - 3.021 \\ &= 0.577\%\end{aligned}$$

IV Calculation of Natural Gas Economic Potential on Nigerian per capita GDP

Calculation of annual economic growth rate of Nigerian per capita GDP if gas produced was totally utilized, using equation 5.

$$\begin{aligned}g &= \left(\text{antilog} \left(\frac{\log(972.8/977.6)}{(2005-1999)} \right) - 1 \right) \times 100 \\ g &= (0.99918 - 1) \times 100 \\ g &= -0.00082 \times 100 \\ g &\cong -0.082\%\end{aligned}$$

Calculation of annual economic growth rate of Nigerian per capita GDP without gas GDP added, using equation 5

$$\begin{aligned}g &= \left(\text{antilog} \left(\frac{\log(1009.5/981.1)}{(2005-1999)} \right) - 1 \right) \times 100 \\ g &= (1.00476 - 1) \times 100 \\ g &= 0.00476 \times 100 \\ g &\cong 0.476\%\end{aligned}$$

Calculation of economic potential of natural gas on Nigerian GDP

$$\begin{aligned}\text{Economic potential of natural gas} &= g_{GDPWNG/C} - g_{NGDP/C} \\ &= 0.476 - (-0.082) \\ &= 0.476 + 0.082 \\ &= 0.558\%\end{aligned}$$

V Natural Gas Production, Consumption and Life Span for 1995, 2000 and 2005

YEAR	1995		2000		2005		2005 Reserve	
Country	PRDT (bcm)	CSMPT (bcm)	PRDT (bcm)	CSMPT (bcm)	PRDT (bcm)	CSMPT (bcm)	bcm	R/P Ratio
USA	534.3	638	555.6	669.7	525.7	633.5	5450	10.36713
Canada	158.7	80.2	183.2	83	185.5	91.4	1590	8.571429
Mexico	26.6	28.1	35.8	38.5	39.5	49.6	410	10.37975
Argentina	25	27	37.4	33.2	45.6	40.6	500	10.96491
Bolivia	3.2	0	3.2	0	10.4	0	740	71.15385
Brazil	4.8	4.8	7.2	9.3	11.4	20.2	310	27.19298
Chile	0	1.6	0	5.2	0	7.6	0	-
Colombia	4.4	4.4	5.9	5.9	6.8	6.8	110	16.17647
Ecuador	0	0.1	0	0.1	0	0.2	0	-
Peru	0	0.4	0	0.3	0	1.6	330	-
Trinidad and Tobago	6.1	0	14.1	0	29	0	550	18.96552
Venezuela	27.5	27.5	27.9	27.9	28.9	28.9	4320	149.481
other S and C Americas	2.2	7.3	2.2	11.9	3.5	18.3	170	48.57143
Austria	0	7.9	0	8.1	0	10	0	-
Azerbaijan	6.2	8	5.3	5.4	5.3	8.8	1370	258.4906
Belarus	0	12.3	0	16.2	0	18.9	0	-
Belgium& Luxemburg	0	11.8	0	14.9	0	16.8	0	-
Bulgaria	0	5	0	3.3	0	3.2	0	-
Czech Republic	0	7.3	0	8.3	0	8.5	0	-
Denmark	5.3	3.5	8.1	4.9	10.4	5	70	6.730769
Finland	0	3.2	0	3.7	0	4	0	-
France	0	32.9	0	39.7	0	45	0	-
Germany	16.1	74.4	16.9	79.5	15.8	85.9	190	12.02532
Greece	0	0	0	1.9	0	2.5	0	-
Hungary	0	10.2	0	10.7	0	13.4	0	-
R.Ireland	0	2.6	0	3.8	0	3.9	0	-
Italy	20.4	49.9	16.2	64.9	12	79	170	14.16667
Kazakhstan	5.5	10.8	10.8	9.7	23.5	17.8	3000	127.6596
Lithuania	0	2.3	0	2.7	0	3.2	0	-
Netherlands	67	37.8	57.3	39.2	62.9	39.5	1410	22.41653
Norway	27.8	2.9	49.7	4	85	4.5	2410	28.35294
Poland	3.5	9.9	3.7	11.1	4.3	13.6	110	25.5814
Portugal	0	0	0	2.4	0	3	0	-
Romania	18	24	13.8	17.1	12.9	17.3	630	48.83721
Russian	555.4	377.8	545	377.2	598	405.1	47820	79.96656
Slovakia	0	5.7	0	6.5	0	5.9	0	-
Spain	0	8.3	0	16.9	0	32.3	0	-
Sweden	0	0.8	0	0.7	0	0.8	0	-
Switzerland	0	2.4	0	2.7	0	3.1	0	-
Turkey	0	6.8	0	14.1	0	27.4	0	-
Turkmensitan	30.1	8	43.8	12.6	58.8	16.6	2900	49.31973

Ukraine	17	76.2	16.7	73.1	18.8	72.9	1110	59.04255
U.K	70.8	70.5	108.4	96.9	88	94.6	530	6.022727
Uzbekistan	45.3	42.4	52.6	47.1	55.7	44	1850	33.21364
other Euro	15.9	13.8	11.3	13.5	9.8	15.3	460	46.93878
Bahrain	7.2	0	8.8	0	9.9	0	90	9.090909
Iran	35.3	35.2	60.2	62.9	87	88.5	26740	307.3563
Kuwait	9.3	9.3	9.6	9.6	9.7	9.7	1570	161.8557
Oman	4.1	0	8.7	0	17.5	0	1000	57.14286
Qatar	13.5	13.5	23.7	9.7	43.5	15.9	25780	592.6437
Saudi Arabia	42.9	42.9	49.8	49.8	69.5	69.5	6900	99.28058
Syria	1.9	0	4.2	0	5.4	0	310	57.40741
United Arab Emirates	31.3	24.8	38.4	31.4	46.6	40.4	6040	129.6137
Other M.E	3.4	16.1	3.4	22.1	3.4	27	50	14.70588
Algeria	58.7	21	84.4	19.8	87.8	24.1	4580	52.16401
Egypt	11	11	18.3	18.3	34.7	25.5	1890	54.46686
Libya	5.8	0	5.3	0	11.7	0	1490	127.3504
Other Africa	3	12.8	5.9	17	7	21.6	1200	171.4286
Australia	29.8	20.4	31.2	23.9	37.1	25.7	2520	67.92453
Bangladesh	7.4	7.4	10	10	14.2	14.2	440	30.98592
Brunei	11.8	0	11.3	0	12	0	340	28.33333
China	17.9	17.4	27.2	23.8	50	47	2350	47
Hong Kong	0	0	0	2.5	0	2.2	0	-
India	19.4	19.4	26.9	26.9	30.4	36.6	1100	36.18421
Indonesia	63.4	30.1	68.5	32.3	76	39.4	2760	36.31579
Japan	0	61.2	0	74.9	0	81.1	0	-
Malaysia	28.9	13.7	45.3	24.3	59.9	34.9	2480	41.40234
Myanmar	1.6	0	3.4	0	13	0	500	38.46154
New Zealand	4.3	4.2	5.6	5.5	3.7	3.6	0	0
Pakistan	14.6	14.6	18.8	18.8	29.9	29.9	960	32.10702
Philippines	0	0	0	0	0	3	0	-
Singapore	0	1.5	0	1.7	0	6.5	0	-
South Korea	0	10.2	0	21	0	33.3	0	-
Taiwan	0	4.3	0	6.7	0	10.7	0	-
Thailand	10.4	9.8	18.6	19.2	21.4	29.9	350	16.35514
Vietnam	0.1	0	1.6	0	5.2	0	240	46.15385
Other A.P	3.5	3.5	3.7	5.1	7.3	8.9	370	50.68493

Data sourced from BP

APPENDIX D ECONOMIC GROWTH SIMULATION FOR THIRTY YEARS

I Nigerian GDP and GDP per Capita Projection of Thirty Years (2005 to 2035) using Proportional Growth Model

YEAR	NGDP(t\$)	GDPWNG (t\$)	NGDP(\$)/C	GDPWNG(\$)/C
rate	3.2%	3.8%	1.3%	1.8%
2005	132.1	137.1	1025.8	1064.5
2006	136.3	142.3	1039.2	1083.7
2007	140.7	147.7	1052.7	1103.2
2008	145.2	153.3	1066.4	1123.0
2009	149.8	159.2	1080.2	1143.2
2010	154.6	165.2	1094.3	1163.8
2011	159.6	171.5	1108.5	1184.8
2012	164.7	178.0	1122.9	1206.1
2013	170.0	184.8	1137.5	1227.8
2014	175.4	191.8	1152.3	1249.9
2015	181.0	199.1	1167.3	1272.4
2016	186.8	206.6	1182.5	1295.3
2017	192.8	214.5	1197.8	1318.6
2018	198.9	222.6	1213.4	1342.4
2019	205.3	231.1	1229.2	1366.5
2020	211.9	239.9	1245.2	1391.1
2021	218.7	249.0	1261.3	1416.2
2022	225.7	258.5	1277.7	1441.6
2023	232.9	268.3	1294.3	1467.6
2024	240.3	278.5	1311.2	1494.0
2025	248.0	289.1	1328.2	1520.9
2026	256.0	300.0	1345.5	1548.3
2027	264.2	311.4	1363.0	1576.1
2028	272.6	323.3	1380.7	1604.5
2029	281.3	335.6	1398.6	1633.4
2030	290.3	348.3	1416.8	1662.8
2031	299.6	361.6	1435.2	1692.7
2032	309.2	375.3	1453.9	1723.2
2033	319.1	389.6	1472.8	1754.2
2034	329.3	404.4	1492.0	1785.8
2035	339.9	419.7	1511.3	1817.9

II Nigerian GDP and GDP per Capita Projection of Thirty Years (2005 to 2035) using Learning Curve Model

YEAR	NGDP(t\$)	GDPWNG (t\$)	NGDP(\$)/C	GDPWNG(\$)/C
2005	132.1	137.1	972.8	1009.5
2006	138.0	144.4	974.1	1017.9
2007	140.4	147.3	974.7	1021.1
2008	141.9	149.2	975.0	1023.2
2009	143.0	150.7	975.2	1024.8
2010	144.0	151.8	975.4	1026.0
2011	144.7	152.8	975.6	1027.0
2012	145.4	153.6	975.7	1027.9
2013	146.0	154.4	975.9	1028.7
2014	146.5	155.0	976.0	1029.4
2015	147.0	155.6	976.1	1030.0
2016	147.4	156.1	976.2	1030.5
2017	147.8	156.6	976.2	1031.1
2018	148.2	157.1	976.3	1031.5
2019	148.5	157.5	976.4	1032.0
2020	148.8	157.9	976.4	1032.4
2021	149.1	158.3	976.5	1032.8
2022	149.4	158.7	976.6	1033.1
2023	149.7	159.0	976.6	1033.5
2024	149.9	159.3	976.7	1033.8
2025	150.2	159.6	976.7	1034.1
2026	150.4	159.9	976.8	1034.4
2027	150.6	160.2	976.8	1034.7
2028	150.8	160.4	976.9	1035.0
2029	151.0	160.7	976.9	1035.2
2030	151.2	160.9	976.9	1035.5
2031	151.4	161.2	977.0	1035.7
2032	151.6	161.4	977.0	1036.0
2033	151.8	161.6	977.0	1036.2
2034	151.9	161.8	977.1	1036.4
2035	152.1	162.0	977.1	1036.6

