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**Working Paper**

## Filling the Power Supply Gap in Africa: Is Natural Gas the Answer?

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# A G D I Working Paper

WP/16/049

## **Filling the Power Supply Gap in Africa: Is Natural Gas the Answer?**

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## **Filling the Power Supply Gap in Africa: Is Natural Gas the Answer?**

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### **Abstract**

**Purpose:** The purpose of this paper is to review the reserves and production of natural gas in Africa and evaluate how it can help solve the power challenges of the continent.

**Design/Methodology:** This paper develops from a descriptive analysis and literature on natural gas and power.

**Findings:** The key finding is that despite increased discovery of natural gas in Africa, it has had minimal impact on power production.

**Limitations:** This study provides a descriptive overview and is limited to only natural gas. It does not consider how other energy sources can contribute to solving Africa's power challenges.

**Policy implications:** This paper will draw the attention of both policy makers and the investment community to the opportunities in the 'natural gas- power' value chain and the need to invest in gas infrastructure.

**Originality:** An overview of the power challenges and natural gas potential of Africa is provided.

*Key words:* Natural Gas; Power Generation; Africa

*JEL Classification:* Q32; Q35; Q41; Q48; Q49

### **1. Introduction**

The world seeks energy resources that is available, clean and relatively cheaper. This is because, the consumption of energy has been found to be a major determinant of CO<sub>2</sub> emissions (Bhattacharya, 2010; Asongu et al., 2016). This makes natural gas the ideal fuel choice. Natural gas has been referred to as the bridge between non-renewable and renewable

energy sources due to its relatively low carbon emissions. In addition, the discovery of natural gas has been increasing over the last two decades. Natural gas is therefore considered the ultimate choice. Apergis and Payne (2010) note that most economies are using natural gas as a major source of energy and cite reduction in carbon emissions as the reason. Another reason for the increase in natural gas consumption is the role in reducing capital cost (Shahbaz et al., 2013). Natural gas is an alternative energy source that has cleanliness, burning easiness, high thermal value and resource availability (Aras and Aras, 2004).

In a report in 2011, the International Energy Agency predicts that natural gas demand will be growing in the coming decades due to five main factors. First, there is increasing use of natural gas in emerging and developing countries like China, Bangladesh and Turkey. Second, the use of natural gas in the transport sector has been increasing in both developed and developing countries. Third, due to the Fukushima Daiichi nuclear disaster, slower growth in nuclear power is anticipated (Asongu, 2012). The fourth factor has been the discovery of conventional natural gas such as Tanzania, Mozambique and Ghana and the productivity of old gas fields. Lastly, there has been rapid expansion of global supply capacity for Liquefied Natural Gas (LNG). For instance, Nigeria which hitherto flared its gas, became the 4<sup>th</sup> largest LNG exporter in 2012 (Nwaoha and Wood, 2014).

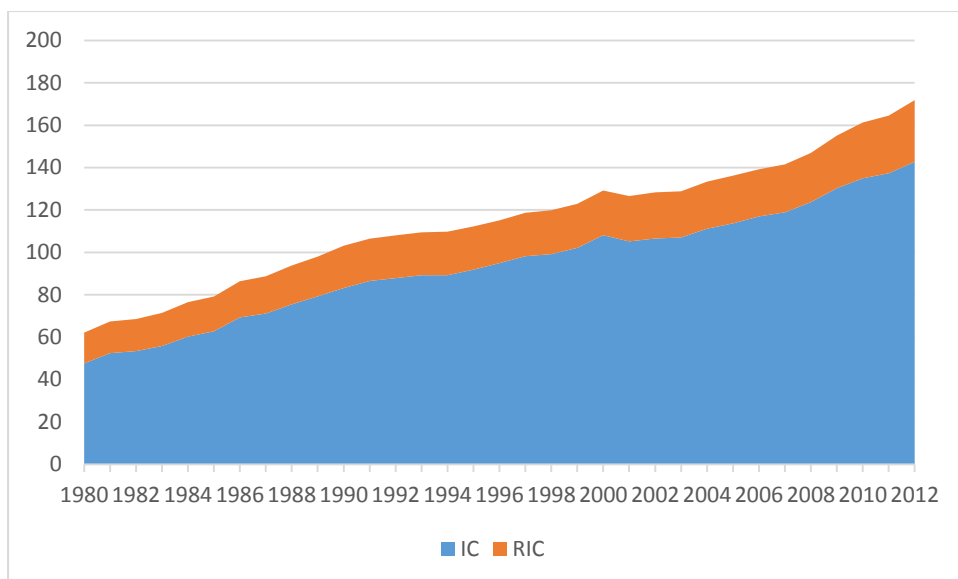
Total (2011) estimates that the demand for natural gas will grow at 2.5% annually over the next two decades. This implies that natural gas will become the second most important fossil fuel apart from oil considering the growth rate of coal at 0.2% and crude oil at 1.1% over the same period. The IEA (2011) posits that the growth in natural gas consumption will be driven by four main factors. Firstly, the need for a bridge fuel towards sustainable carbon economy. Secondly, new natural gas discovery in Africa and other parts of the World. The third factor is the regionalization and globalization of the natural gas market. Lastly, natural gas demand due to energy security concerns since natural gas is seen as a viable alternative to both renewable and other fossil fuels. Natural gas is generally considered a bridge between non-renewable and renewable energy due to its attractive environmental qualities. Unlike crude, which is traded on the World market, natural gas is traded regionally so there are the North American, European and Asia-Pacific gas markets, Africa has no gas market (Ackah, 2014, Adom et al.2012).

Shabbaz et al. (2013) review the literature on natural gas demand highlights three important points. First, the results are not unanimous as some studies report bidirectional, unidirectional or no relation between natural gas demand and economic growth. Second, the estimation methods are less appropriate in some studies especially those using bivariate model is subjected to omitted variable biasness. Third, the sample periods of study are not current without taking into account the current development. For instance, the global economic crisis and the recent development in climate change agenda have drastically changed the fuel mix policy. Therefore, without the inclusion of this time period, results of the previous studies may have little use for current natural gas policy making.

According to the BP Statistical World Energy Review (2010), Africa accounted for 8% of the global natural reserve. Natural gas is an ideal source for Africa for several reasons. First, natural gas is cheaper than petroleum and cleaner than both coal and crude oil. In addition, due to its efficiency and attractive qualities, natural gas is suitable for power generation to enhance energy access and security. This study provides an overview of the power challenges of Africa and the role of natural gas to solve these challenges to enhance access to and reliability of supply.

## **2. Africa's Power Situation**

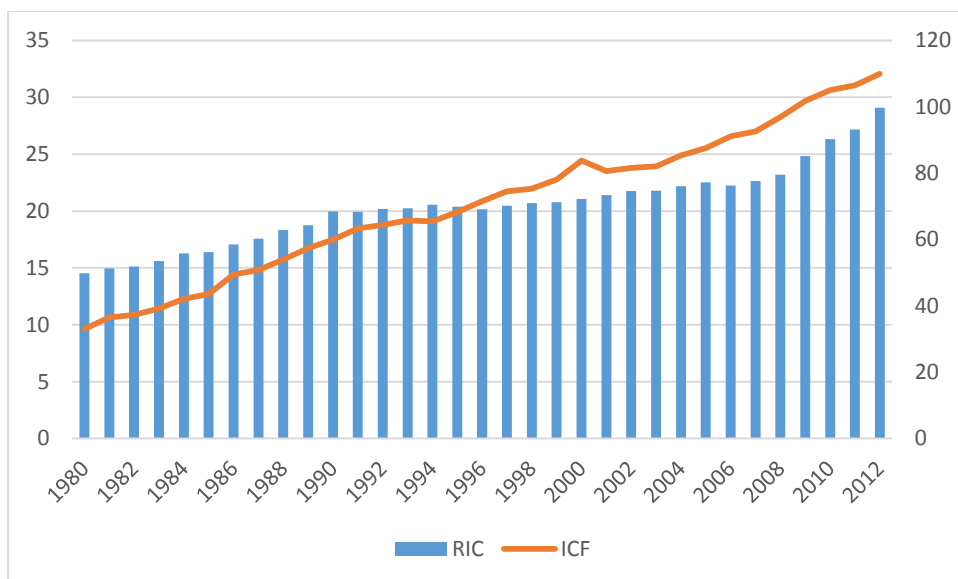
Africa's average Gross Domestic Product (GDP) growth rates reached 5% during the 2000's, more than twice that of the 1980s and 1990s, making Africa one of the fastest growing continents (Lynd et al. 2015; Asongu and Nwachukwu, 2016ab). According to the World Bank (2013), about 1.2 billion people do not have access to electricity. The International Energy Agency (2011) calculates that 43% of population of Africa and 80% of the rural population in Africa do not have access. More than half of these people live in Africa. Estimates of the Africa Development Bank indicate that lack of access and unreliable power supply cost Africa about 2% of its GDP annually.



\*\*Where IC is installed capacity and ‘RIC’ is renewable installed capacity  
 Figure 1. Installed power capacity in Africa in million kilowatts

Figure 1 presents the total installed capacity of Africa. According to the figure, a higher percentage of the installed capacity is non-renewable. The installed renewable energy capacity has been growing at 2.12% from 1980 to 2012. Overall, installed capacity has been growing at 3% per annum over the estimated period.

Even though, Africa is endowed with huge energy resources, yet most countries in the continent are still in the dark after nightfall. It is no wonder that Africa’s underdeveloped power sector affects its GDP. Countries with electrification rates of less than 80% of the population consistently suffer from reduced GDP per capita. The only countries that have electrification rates of less than 80% with GDP per capita greater than \$3,500 are those with significant wealth in natural resources, such as Angola, Botswana, and Gabon(Castellano et al.2015). Africa’s power supply is unreliable. African manufacturing enterprises experience power outages on average 56 days per year. As a result, firms lose 6% of sales revenues in the informal sector. Where back-up generation is limited, losses can be as high as 20 percent. Additionally, power tariffs in most parts of the developing world fall in the range of US\$0.04 to US\$0.08 per kilowatt-hour. However, in Sub-Saharan Africa, the average tariff is US\$0.13 per kilowatt-hour. In countries dependent on diesel-based systems, tariffs are higher still. Given poor reliability, many firms operate their own diesel generators at two to three times the cost with attendant environmental costs (World Bank, 2013).



\*\*ICF is installed fossil fuel capacity

Figure 2. Installed renewable and fossil fuel capacity

According to figure 2, fossil fuel capacity overtook renewable energy after 1996. This is as a result of increased construction of thermal plants in Africa. However, constant breakdown of thermal plants and the unavailability of fuel have led to intermittent power supply in most African countries. Apart from South Africa, electricity generation in Africa is based significantly on hydroelectricity and diesel generators. Installed renewable energy capacity grew by 2.2% annually from 1980 to 2012. However, installed fossil fuel capacity grew by 3.7% annually over the estimated period.

## 2.1 Power Access

Sub-Saharan Africa alone accounts for 13% of the world’s population and 48% of the share of the global population without access to electricity (Ackah and Kizys, 2015). Africa in general faces low access and insufficient capacity – About 24% of the population of sub-Saharan Africa has access to electricity versus 40% in other low income countries. Excluding South Africa, the entire installed generation capacity of sub-Saharan Africa is only 28 Gigawatts, equivalent to that of Argentina (World Bank, 2013)

## 2.2 Electricity Demand

Observing energy consumption patterns across various countries at different stages of economic development reveals that in general, as a country prospers, per capita consumption of energy increases as well. For example, Roland Berger Strategy Consultants (2013)

estimated that per capita energy consumption in the United States was nearly 13 times greater than in India in 2012.

Despite increased effort in increasing Africa’s generation capacity, electricity consumption has been growing faster. Whereas power generation is increasing at 4.4% annually, consumption has been increasing at 2% according to figure 3.

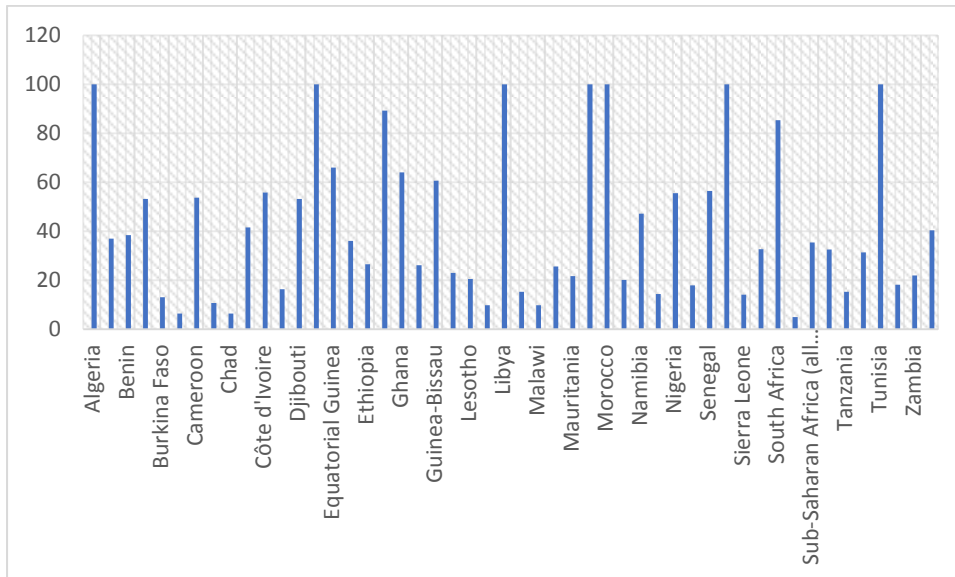


Figure 3: Electricity Access rate of selected African countries

Africa’s consumption rate is far below other continents. Average electricity consumption in sub-Saharan Africa, excluding South Africa, is only about 150 kilowatt-hours per capita. This is a fraction of consumption rates in Brazil, India, and South Africa(Castellano et al. 2015). According to the International Energy Agency, the world electricity consumption was 18,608 TWh in 2012. Out of this, Africa consumed only about 3%(IEA, 2014).

### 2.3 Forecast

A forecast by Castellano et al. (2015) shows that sub-Saharan Africa’s energy consumption is expected to increase to nearly 1,600 terawatt hours by 2040, which is four times what was consumed in 2010. This projection was based on a number of important factors, including a fivefold increase in GDP, a doubling of population, electricity-access levels reaching more than 70 percent by 2040, and increased urbanization.

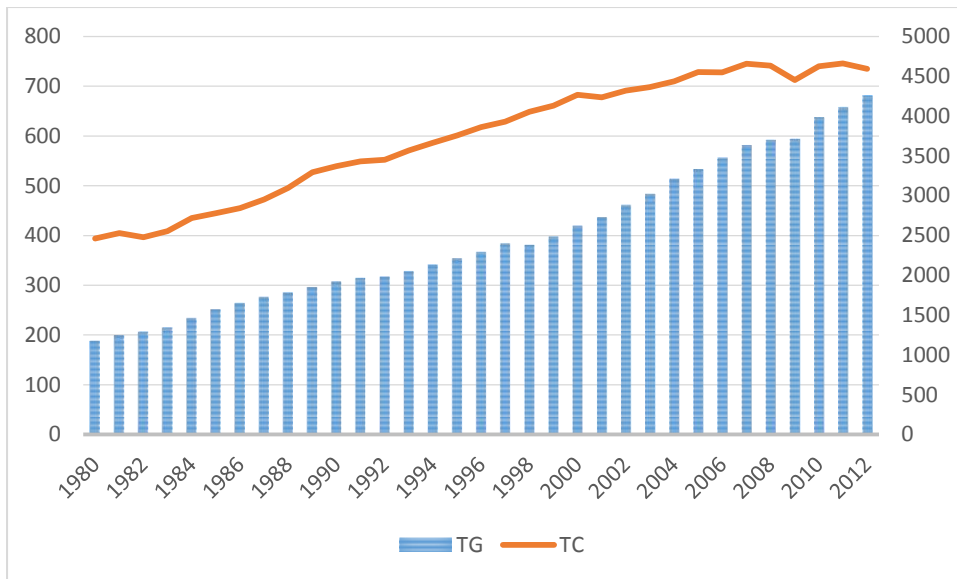


Since the mid-1990s, external finance to Africa's power sector has averaged only around US\$600 million per year of public assistance, plus a similar volume of private finance. More recently, Chinese, Indian and Arab sources have also emerged as significant energy financiers. Nonetheless, it is estimated that doubling current levels of energy access by the year 2030 will require sustained investment at much higher levels (World Bank, 2013).

### **3. Natural Gas in Africa**

The Oil and Gas Journal (2011) estimates that Africa has 14 trillion cubic meters (bcm) of proved natural gas reserve as of December, 2011. However, according to the IEA (2012) technical recoverable reserve stands at 74 bcm accounting for about 10% of global technically recoverable reserve. This represents about 7.5% of global gas reserve with Algeria, Nigeria, Egypt and Libya accounting for about 92% of proved reserves. Total gas production was 203 billion cubic meters with Nigeria, Algeria and Egypt accounting for 88%. Natural gas production in Africa grew by an average of 4% annually between 2000 and 2011 (BP, 2012). Nigeria accounted for 66% of natural gas production in Africa in 2011 and was followed by Equatorial Guinea at 14.6% (EIA, 2013). Figure 4 provides an overview of natural gas production in Africa.

Africa produced 4485 million metric meters of natural gas in 1971. This increased to 204298 million metric tonnes in 2012. The major natural gas producers in Africa over this period are Algeria, Angola, Cameroon, Congo, Cote D'ivoire, Egypt, Equatorial Guinea, Gabon, Libya, Mozambique, Morocco, Nigeria, South Africa, and Tunisia. At the supply side, new natural gas field discoveries such as in Mozambique, technological improvements like hydraulic fracturing, LNG technologies, and new uses of gas in Africa such as for power generation and construction of pipelines to aid transportation have increase production.



\*TG is total generation. TC is total consumption

Figure 4. Total power generation and consumption in Africa

On the demand side however, the increasing use of natural gas for electricity generation, increased use of natural gas in households where it is seen as a perfect substitute for charcoal, increase in income, and natural gas subsidies seem to be major drivers of demand. It is estimated that gas consumption in Africa has been growing at 6% per annum since 2000 and reached 210 bcm in 2011 (BP, 2012). In terms of consumption, Egypt and Algeria accounting for more than 70% of total gas consumption in Africa for 2011.

### 3.1 Natural Gas Pricing

Natural gas pricing could either be market-based price or regulated price. The International Gas Union (2012) identifies three market based approaches prevalent in both developed and developing countries. These are oil or product indexation where gas prices are linked to the prices of oil or coal or other refined fuel. The second is the gas-to-gas competition reflects the demand and supply of a natural gas spot market or market. The final pricing scheme is the netback from final product which is usually used in natural gas contracts where the price of gas is linked to the price of ammonia.

In Africa however, the regulated natural gas price is widely used. This happens when the government set prices at the wellhead, wholesale or city gate based on the government's domestic policy. This policy could be social, political, economic or environmental. For

instance, in order to discourage households from using fuel wood from cooking, the government of Ghana started subsidizing natural gas in the early 1990's as an alternative cleaner cooking fuel. The price regulations are in the form of below-cost price consumer prices which leads to inefficient consumption and robs the country of export revenue through excessive domestic consumption of gas producers and increase the import expenditure of non-producers (OECD/IEA, 2013). There are five major means by which the government regulates natural gas prices (International Gas Union, 2006). These are:

1. Regulation cost of service (RCS): The aim of this pricing scheme is to allow investors to recover the wellhead price. The price set covers the price of the service which includes cost of investment and allows for fair return. The price is published by the regulator.
2. Social and political regulation (SPR): This is where the price of natural gas increases or decreases depending on perceived, demand and supply imbalances and government revenue needs. In the case of SPR, prices can change quickly and price setting is ad-hoc in nature.
3. Regulation below cost (RBC): This occurs when the gas company is state-owned and especially when the country produces oil such a Nigeria. The price charge is below the production and transmission cost. The difference between the production cost and the price is subsidized with oil revenues.
4. Bilateral monopoly (BM): With BM, prices are agreed between two countries especially when one is the producer and the other is the consuming country.
5. No Price (NP): With this pricing scheme, prices are charged for gas consumption. This happens when prices are subsidized 100% by the regulator.

### **3.2 Transportation**

Natural gas can be put to different uses. For instance, natural gas can be used power generation, chemical production especially in the fertilizer industry and in the residential sector such as for heating and cooking. Natural gas can be transported in two main ways. That is either through pipelines or as a Liquefied Natural Gas. In the case of pipelines, the gas is transported from the place production to the place of consumption possibly through other countries. In the case of LNG, the natural gas is cooled to  $-160^{\circ}\text{C}$ , creating a clear, colourless and non-toxic liquid, 600 times smaller than natural gas. The answer to that question can be found in the specific advantages of LNG. Because it makes transporting gas over long distances both technically and economically feasible, the LNG value chain creates many opportunities for gas-producing and gas-consuming nations alike. In addition, exporting LNG through methane carrier means that abundant gas reserves located far from major gas-

consuming regions can be delivered to those markets, opening up new outlets for producing countries. Further, gas liquefaction offers an alternative to the flaring of oilfield associated gas, helping to curb greenhouse gas emissions;

A major challenge to the establishment of a gas market has been the use of long term contracts. According to Newbery (2002), a market loses its competitiveness when most transactions occur in long term contracts. Stern (2002) posits that long-term contracts are going to dominate the natural gas market over the next two decades. The preference of long term contracts by suppliers' depends on the difference between short run and long run price elasticities of demand (Neuhoff and von Hirschhausen 2005). According to them, if the long-run elasticity is significantly higher than the short run elasticity, the suppliers prefer long-term contracts. It has also been argued that longer-term contracts may be socially beneficial since they promote the investment in and the development of infrastructure that appear to be much riskier with spot transactions and price volatility (Dilaver et al, 2011, Oren, 2003). These reasons imply that long- and short-run elasticities are important in developing natural gas market.

The process of transporting natural gas from the producer to the consumer requires huge investment in the form of LNG or long distance pipelines which requires long term contracts. An example is the West African Gas Pipeline which transports natural gas from Nigeria through Benin and Togo to Ghana. Due to such huge investments, knowledge of the factors that influence natural gas demand will be valuable for both policy making and investment decisions. Again, understanding issues that influence natural gas demand will help design policies that deal with issues like climate change, energy access and energy security.

### **3.3 Environmental Considerations**

Natural gas is considered the cleanest fossil fuel in terms of carbon, nitrogen and sulphur content. Therefore, in order to meet the target of Kyoto Protocol and other environmental commitments, natural gas and renewable energy become the ideal choice of fuel. However, due to intermittent supply of renewable energy such as wind and solar, there is the need to encourage the investment in gas.

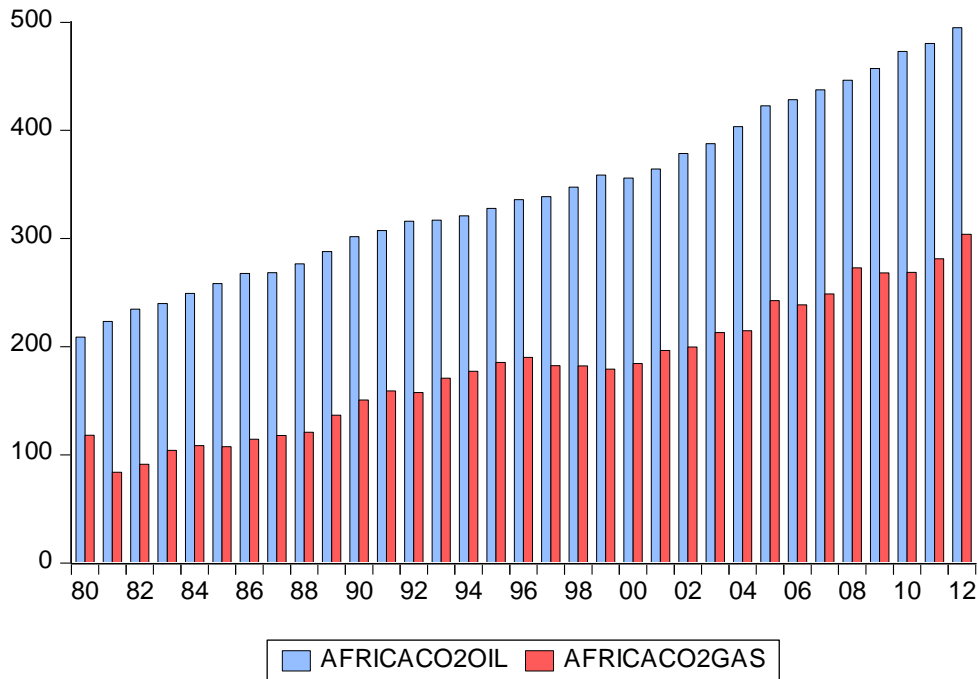


Figure 5. CO<sub>2</sub> emissions from oil consumption and natural gas consumption (including natural gas flaring)

Natural gas is environmentally friendly relative to other fossil fuels according to figure 5. Bhattacharyya (2011) posits that natural gas emits 30% less CO<sub>2</sub> as compared to oil and about 70% less as compared to coal. In addition to these advantages, natural gas is widely abundant in Africa. Therefore as countries yearn to reduce the environmental impact of energy consumption, natural gas comes only second to renewable energy in terms of emissions. According to figure 5, natural gas emits less than half of the emission from oil consumption even if flaring is added. This affirms the environmentally friendly attributes of natural gas.

The IEA (2011) forecasts that the share of natural gas in global energy mix will increase from 21% in 2010 to 25% in 2035. This increase is principally driven by increased use of natural gas in transportation, low growth in nuclear energy and discovery of conventional and unconventional gas. In Africa, there have been a series of natural gas investments that encourage demand. Notable among them are the West African Gas Pipeline which stretches from Nigeria through Benin and Togo to Ghana and huge gas discoveries in Mozambique, Nigeria, Angola and Tanzania. In terms of natural gas reserves, the African Development Bank estimates that Algeria, Egypt, Libya and Nigeria possess about 91% of Africa’s gas reserves. Ernst and Young in a report in 2012 describes natural gas as a ‘prime mover’ for

broader economic development in Africa. According to the BP statistical review (2012), natural gas consumption in Africa has been growing at an annual rate of 6% since 2010. BP Outlook (2012) estimates that Egypt and Algeria accounted for 70% of Africa's total gas consumption in 2011.

#### **4. Natural Gas as the solution**

With high economic growth, urbanization and population growth, the power consumption in sub-Saharan countries is expected to increase significantly. Meeting this growing demand in a sustainable and affordable manner is an important challenge. Gas-fired generation can be a good complement to intermittent renewable sources (like solar and wind power), where on-demand renewable resources (like hydropower and geothermal energy) are limited. The gas-fired combined cycle power plant is the most efficient (in terms of energy and emissions) technology to convert a fossil fuel into electricity.

According to a report by the International Energy Agency in 2011, the world is entering a "golden age" of natural gas. The report stipulates that the major drivers of this resurgence of natural gas include the trend toward higher energy consumption in non-OECD regions of the world such as China and India. Further, the global environmental imperative to move toward lower-carbon energy systems, particularly in the energy and transport sectors is a factor driving increased natural gas demand. In addition, the report finds that increased recovery of unconventional natural gas resources in places such as Mozambique, Nigeria, Ghana, and Cote D'ivoire provides an opportunity for increased natural gas consumption. Since natural gas has been widely discovered in many African countries, there is the need to invest in LNG plants, pipelines and gas powered thermal plants to boost power production. Maisonnier (1999) identifies technology, economics and environmental considerations as the main factors that are driving natural gas consumption in the power sector. Globally, natural gas consumption has been increasing due to the following factors: First, gas is cleaner than coal to burn and cheaper than crude oil (Ackah, 2014). For instance, natural gas possesses some attractive characteristics like the limited carbon emissions, operational flexibility and efficiency (Akkurt *et al.*, 2010). Second, natural gas is the cleanest and most hydrogen-rich of all the hydrocarbon energy sources, and it has high energy conversion efficiencies for power generation (Economides and Wood, 2009). Natural gas consumption has grown substantially in recent years in Africa, stimulated by increased economic activity, large investments in new infrastructure and domestic price subsidies (Eggoh *et al.*, 2011). Since natural gas is abundant

in, Africa, environmentally friendly, relatively cheaper to oil and has high conversion rate in terms of power generation, it represents the ideal fuel for Africa's power challenges.

## 5. Conclusion and Recommendations

With less than 30% of the population of Sub-Saharan Africa having access to modern forms of energy, there is the need to invest in energy sources that is affordable, available and environmentally clean. Natural gas is therefore the ultimate choice of energy since it is carbon-neutral and relatively affordable. Even though electricity production is increasing, there is a need for more investments to enhance access and reliability. It is recommended that Africa economies should invest in natural gas infrastructure such as regasification and thermal plants to take advantage of the booming gas industry.

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