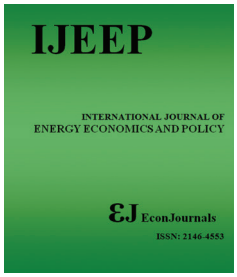

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2016, 6(3), 442-448.

Natural Gas Distribution Infrastructure and the Quest for Environmental Sustainability in the Niger Delta: The Prospect of Natural Gas Utilization in Nigeria

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ABSTRACT

Natural gas distribution infrastructure is critical to socioeconomic development and environmental sustainability in Nigeria. Environmental degradation has benefited largely from inadequate natural gas utilization and infrastructural development in the domestic and regional networks to gather, transmit and distribute the associated gas produced. Thus, this paper explores the concept of gas development to promote sustainable development and to tackle the problem of environmental degradation in Nigeria. It identified the various natural gas utilization projects in the domestic, regional and international networks to stimulate economic growth as well as the quest for environmental sustainability across the gamut of Nigeria. These projects enable captured gas to be harnessed for socioeconomic and environmental benefit, eliminate routine gas flaring and create the much needed gas infrastructure for development. Quite remarkably, natural gas distribution infrastructure creates undisputed domestic and regional hub gas based opportunities for industries in the domestic network. It also acts as industrial feedstock to consolidate the market share in high value export market through the liquefied natural gas, Escravos gas project and the West Africa Gas Pipeline in the West African sub region.

Keywords: Natural Gas Utilization, Environmental Sustainability, Environmental Preservation
JEL Classifications: O13, Q55

1. INTRODUCTION

With clear insights into the natural gas infrastructural development in Nigeria, it is technically feasible to harness natural gas for social and economic development, like most developed countries of the world. Christiansen and Haugland (2001) noted that it is a common knowledge that to find outlets for some of the gas in the domestic and regional networks, there should be a deliberate policy on gas development to eliminate routine gas flaring that is synonymous with the oil and gas industry in Nigeria. Thus, natural gas gathering, transmission and distribution infrastructure in the domestic, regional and international networks is critical to gas utilization. The captured and use of natural gas represent the last real opportunity to plan and implement environmental preservation and sustainable development in the Niger Delta region. Undoubtedly, domestic, regional and international gas development projects promote gas utilization and export, energy efficient and sustainable management of non-renewable resources.

The expansion of the domestic gas market, development of the regional and international gas networks steered the low carbon direction and significantly halt the pollution of the domestic environment as well as regional and global environment from a multiplicity of environmental degradation. Studies carried out by Onwukwe (2009) identified key gas projects such as the liquefied natural gas (LNG), the West African gas pipeline (WAGP), OSO natural gas liquid (NGL), Escravos gas project (EGP) and gas to liquid (GTL) as the bedrock of environmental sustainability in Nigeria. In addition, domestic gas utilization consists of gas supplies for power generation, industrial utilization, cement, fertilizer, steel and aluminium industries as well as small scale industries, petrochemical plants and liquefied petroleum gas (LPG), while the export market consists the LNG and the WAGP. Natural gas gathering, transmission and distribution infrastructure in the domestic, regional and international networks is critical to environmental management for the socioeconomic benefits of the local population (Odumugbo, 2010).

Similarly, Sonibare and Akeredolu (2004) argued that the domestic gas utilization projects comprise the power, cement, fertilizer, aluminium industries, petrochemical plants, steel industries and LPG. These projects constitute the backbone to Nigeria quest to eliminate gas flaring and to tackle the lingering environmental degradation that is a threat to the well-being of the subsistent peasant economy and the survival of the people of the Niger Delta region.

Christiansen and Haugland (2001), Sambo (2008) noted that despite Nigeria being a major player in the global oil and gas industry, however, it faces a serious energy crisis, particularly in the power sector with persistent shortages of generation capacity and frequent power outages caused by deteriorating infrastructure with consequences on economic losses and human hardship. It is worthy to note that the Nigeria gas market is in its embryonic state and yet to be fully developed as a result of poor gas pipeline infrastructure to support and promote commercialized gas utilization (Sonibare and Akeredolu, 2004). Until the last decades or thereabout, natural gas utilization in Nigeria was targeted at specific projects such as the National Electric Power Authority (NEPA), steel companies, aluminium smelting company, industrial companies, cement companies, petrochemical plants and fertilizer plants, and to keep with government social responsibilities rather than for economic reality.

The emerging trend of gas development in the domestic context since 2000 focuses on industries in Lagos industrial areas of Ikeja, Illupeju, Agbara, Orile Iganmu and other commercial hub cities within the main gas pipeline routes to meet domestic needs for long term utilization dictated by commercial reality of the market. Natural gas utilization for industries in Nigeria is now a reality, with about 100 industrial companies such as Cadbury, Guinness, PZ, Textile Mills, and Steel Mills located within the industrial zones in the Lagos area alone have switched from electricity as an energy source to natural gas which is cleaner burning and environmental friendly (Odumugbo, 2010). Commercial utilization of natural gas for industrial usage is now being extended to other cities in the South Eastern States of Cross Rivers, Akwa Ibiom and Rivers and other commercial centers across Nigeria.

The WAGP promote the regional export of natural gas within the West Africa sub region while the LNG promotes international export of natural gas with a clear intent to promote sustainable development in Nigeria. Thus, Onwukwe (2009) argued that there is compelling evidence that the introduction of gas distribution projects in the domestic, regional and international network represents a giant leap towards the realization of Nigeria's goal of promoting socioeconomic development and environmental preservation through the provision of gas infrastructure to halt the colossal waste of natural resources.

2. NATURAL GAS EXPORT DEVELOPMENT WITHIN THE CONTEXT OF ENVIRONMENTAL SUSTAINABILITY IN NIGERIA

Export of natural gas commenced in 1999 when the LNG started operations, and several gas export infrastructural development projects in the international and regional networks has since then been initiated. Gas export has increased dramatically, which have been pivotal to socioeconomic and sustainable development in the Niger Delta region. The development of the vast natural gas resources also aimed at driving the needed growth in the energy sector. Odumugbo (2010) asserted that Nigeria is a leading country and a major player in the worldwide LNG continuously pushing for a sizeable share of the market. Thus, government earnings from its 49% shareholding in the LNG to date stood at $14.7 billion and corporate income tax of about N1.1 billion in 2014 (LNG, 2015), although the project was accorded a pioneering status with tax freedom as an incentive to trigger and encourage investment in the early stage.

On environmental sustainability and socioeconomic benefit of natural gas, Diugwu et al., (2013) aptly indicated that Nigeria is on course, growing LNG rapidly and is now the second fastest LNG holder in the world with a capacity of 22 million tons per annum of LNG and 4 million tons per annum of LPG, adding significantly to the global gas market. This is one of the boldest and most ambitious steps in Nigeria's quest to stem the tide of gas flaring, promote environmental preservation and sustainable development. More specifically, Christiansen and Haugland (2001) noted that the volume of gas Shell flared in 1998 prior to the establishment of the LNG was about 57 million standard cubic feet a day or about the size of the Nigeria LNG project. With the LNG fully operational, the benefit of environmental improvements by reducing gas flaring, which has been a major environmental pollution in the Niger Delta is being fully realized.

The environmental benefit of the LNG is stupendously enormous, with a strong policy on environmental conservation and continuously developing a workable environmental management plan to minimize environmental consequences of its operations to the immediate communities (Agbonifo, 2015). The LNG has continued to maintain its position as a major and reliable supplier and converted about 4.68 trillion cubic feet of previously flared gas to exports as LNG and NGLs to deliver about 7% of global supply (Andeobu et al., 2015). Quite evidently, it is the commitment to exploit the extensive gas reserves, combines with the promise of economic growth and a growing respect for the environment that is the bedrock of the LNG. It is somewhat remarkable that the LNG is spearheading the growth for economic growth, environmental preservation, and a hallmark to sustainable development.

Another important milestone that is particularly significant towards gas development for infrastructural development and environmental preservation is the WAGP, a regional gas development to transport Nigerian produced natural gas to commercially viable markets in Benin Republic, Togo and Ghana, and a gateway to gas market in Equatorial Guinea (Odumugbo, 2010). The WAGP is connected to the Chevron/Nigerian National Petroleum Corporation (NNPC) joint venture in the Escravos area of the Niger Delta, Nigeria, which is the first large scale project that is focusing on enhancing regional utilization of associated gas across the borders of West Africa.

This WAGP project is in pursuant to Nigeria's commitment to Article 48 of the ECOWAS Treaty, which encourages member

Nations to co-operate, consult and coordinate their policies regarding energy and mineral resources. Quite evidently, Christiansen and Haugland (2001) argued that WAGP is probably more important for regional cooperation and developments than for mopping up associated gas, although there exist opportunities for environmental sustainability through the WAGP. However, given the alarming security situation in the gas supply source, the Niger Delta region, illegal maritime navigation activities and current underdeveloped gas markets in the region, the uncertainties involved are much higher than for projects aimed predominantly at export markets. The region is noted for violent crime, armed struggle, hostage taking, kidnapping and other social conflict arising from prolonged neglect, environmental pollution, underdevelopment and marginalization. These contentious issues need to be resolved to guarantee the future gas supply of the project.

The main goal of WAGP is to harness Nigeria economic benefit from natural gas, reduce and possibly eliminate environmental degradation, create the needed gas infrastructure for the economic benefit of the entire region for sustainable development. Regional energy security is essential to securing sustained gas supply into the broader global market and curtails the wasteful and harmful practice of flaring associated gas (Goodland, 2005). Consequently WAGP is regarded as a catalyst for economic growth, tool for environmental sustainability, cornerstone for regional integration and sub-regional backbone for gas distribution. However, it is not very likely that the discovery and exploration of oil and gas in Ghana can alter the WAGP project in a foreseeable future because of the problem of low base oil and gas infrastructure in Ghana. WAGP is a game changer for the Ghanaian economy, providing cheap Nigerian gas to the thermal plants, particularly in Takoradi and Tema (Odumugbo, 2010).

There are several socioeconomic development and environmental benefits arising from the creation of gas infrastructure. The WAGP serves as a source of cost-effective, clean and reliable energy that provide a foundation to facilitate regional economic growth and sustainable development. It also provides economic integration and infrastructure to stimulate foreign investment and contribute to the reduction of environmental degradation. The major positive environmental impact of WAGP is the gathering, distribution and utilization of flared gas for industrial production to curtail the wasteful and harmful practice of flaring associated gas. This project creates a platform for the provision of basic infrastructure that could alleviate the energy crisis and additional economic benefits in the sub region. Quite bluntly, Goodland (2005) argued that an increase in natural gas utilization is a hallmark to economic development goals and carries with it environmental preservation and sustainable development.

On the domestic context, Sonibare and Akeredolu (2004) noted that the current state of gas pipeline infrastructure is poor, resulting in low capacity utilization. The potential consumer base projects involve power generation, cement industry, fertilizer plants, iron and steel industry, petrochemical plant, glass manufacturing industries, food and beverage manufacturing industries within the domestic context**.** Consequently, gas pipelines in the domestic network supply chain have increased dramatically from 2000 km in the 1990s to about 9,265 km in 2005 (Goodland, 2005). Natural gas is a major source of fuel for electricity generation to various gas turbines located in Egbin, Afam, Delta, Ughelli and Onne power stations, and NEPA alone accounts for about 70% of total gas demand in the domestic network which is fundamental to environmental sustainability in Nigeria (Sonibare and Akeredolu, 2004).

2.1. EGP

Chevron started processing NGL, LPG and condensate at its Escravos gas plant in the Niger Delta 1997. This project is known as the Chevron Nigeria Ltd/NNPC joint venture which is operated by Chevron that also owned 40% stake in the project. It processed previously flared natural gas to generate a capacity of about 230 million standard cubic feet a day of associated gas from its offshore fields in the Niger Delta, resulting in daily export gas sales to the domestic market of 180 million cubic feet, as well as export sales of 8,000 barrels of LPG and condensate (Chevron Corporation, 2011). The project has been expanded from processing capacity of 285 million to 680 million cubic feet of natural gas. Daily export of LPG and condensate capacity has been increased from 15,000 to 58,000 barrels. According to Chevron Corporation (2011), the project's EGP Phase 3B which began operations in 2013 is designed to install a 120 million cubic feet per day of natural gas gathering and compression platform in continuation of Chevron's Western Delta Gas Development Programme. Offshore natural gas gathering, compression and processing facility are also part of the infrastructure expansion. The project is to ensure sufficient gas supply for the Escravos GTL (EGTL), and eventually to sell condensate gas to regional markets through the West WAGP.

With the conclusion of these projects, the EGP will have the capacity to process more than 19 million Sm^3/d of associated gas or 7 billion Sm^3 per year. This project is a roadmap to eliminate routine flaring of natural gas associated with crude oil production, and the most ambition steps towards commercializing natural gas resources in Nigeria.

2.2. EGTL Project

This project is jointly owned and funded by Chevron and the NNPC which holds 75% and 25% shares respectively. The project entails an initial construction capacity of 34,000 barrels per day (bpd) of EGTL plant in Escravos in Western Niger Delta. It is projected to expand to a 120,000 capacity within 10 years of completion (Chevron Corporation, 2011). The project forms an integral part of the gas utilization strategy, which includes domestic gas sales, regional market of natural gas through the WAGP and international sales of GTL product.

With a projected cost of US$8.4 billion, the EGTL project construction commenced operations in 2005. As a result of delay and cost, the plant is nearly 70% completed, but full plant operations commence in 2013. The proposed GTL plant is designed to process rich gas sourced from Chevron Escravos field operations and is capable of converting over 300 mcf/d of natural gas like low-sulphur GTL diesel, GTL naphtha and LPG into premium environmentally friendly fuel, thus eliminate the

high incidence of gas flaring in the oil producing communities of Niger Delta. In September 2000 Sasol, a South African Energy and Chemical Company and Chevron signed the final agreements on the GTL projects, using leading technologies and technical expertise of Salso Chevron (Salso's proprietary Fischer-Tropsch Technology and Chevron's Proprietary Isocracking Technology), to provide management, operating and technical services to the project owner. Salso and Chevron will also market products from EGTL to primary market in Europe and USA. Despite the relatively high costs compared to those of other alternatives for utilizing natural gas, Chevron considers GTL a viable long-term solution to Nigeria's quest to resolve the lingering socioeconomic impact of gas flaring.

2.3. OSO NGL Project

The OSO NGL project located in Bonny Island, Southern Niger Delta and is a joint venture between Mobil (ExxonMobil) and the NNPC. Mobil holds 51% shares, while the NNPC holds 49% shares. The project commenced production of 30,000 barrels a day in 1998, and production is anticipated to rise at a peak of 50,000 bpd of mixed propane/butane for export. The project will recover a total of 350 million barrels of NGL over its lifetime. This represents about 30% of the associated gas being flared in 1998. Feed gas for the NGL plant is sourced from some 600 million standard cubic feet a day of the OSO condensate field and other associated gas production in the Niger Delta region. NGLs are liquids derived from the processing of natural gas by means of subjecting the gas stream to very low temperatures or pressure reduction. The OSO NGL project involves two locations, the offshore site at the OSO field and the Bonny River Terminal.

The OSO NGL project is a significant development for natural gas production in Nigeria, while it also allows Mobil to continue its goal of profitably growing production. The most significant landmark is the contribution of the project to the overall socioeconomic and environmental sustainability of Nigeria.

3. DOMESTIC GAS INFRASTRUCTURE AND UTILISATION IN NIGERIA

Domestic gas consumption and utilization within the context of environmental preservation is relatively small compared to the quantum of natural gas production in Nigeria. Commercial utilization of natural gas in Nigeria dates back to 1963 through gas supplies to NEPA at Afam Power Station, NEPA Delta Power Station, Ughelli, 5 private industries in Aba and the Port Harcourt Refinery (Omiyi, 2001). Another important landmark towards gas utilisation include the gas supply to NEPA Sapele in 1978, Aladja Systems and Oben-Ajaokuta pipeline in 1981 and 1983 respectively, and the Escravos-Lagos Gas Pipeline (ELP) project commissioned in 1989 which is the biggest gas pipeline project executed to date in Nigeria which also serve as a hub center to Lagos and gas corridor to the WAGP project (Agbonifo, 2015).

The domestic gas market in Nigeria is dominated by the Nigeria Gas Company (NGC) a subsidiary of the state owned NNPC. The NGC retained the government main responsibilities to provide gas pipeline infrastructure to power plants, cement industries, fertilizer plants, iron and steel plants, petrochemical, glass manufacturing industries, food and beverage manufacturing industries within the domestic context. Other companies in the domestic gas supplies chain are Shell Nigeria gas (SNG) and Gaslink Ltd., that supplies gas to mainly industrial customers in the Lagos industrial area and its environs in the westerner part of Nigeria and Port Harcourt and Aba axis in the southern part of Nigeria. According to Shell (2011), in 2010 SNG distributed an average of 121 million standard cubic feet a day of natural gas to industrial customers in its area of operations. The Aba distribution system supplies gas to industrial customers in and around Aba city, while the Agbara - Ota axis supplies industrial customers in the Lagos environs of Agbara, Ota and Igbessa cities with customers are GlaxoSmithKline, Unilever and Nestle.

It should be noted that there is potential for large market for investors in the domestic market as more awareness on gas utilization is being created. Due to some aggressive investment in domestic gas development projects, total gas utilization has increased from a mere 197 million standard cubic feet a day in 1999, about 573 million standard cubic feet a day in 2004, and 1.71 in 2014, with a projection of about 5.4 billion standard cubic a day in 2019 (Yakubu, 2014). Consequently, domestic gas pipelines also increased dramatically from about 2,000 in the 1990s to about 9,265 km (Goodland, 2005). The NGC alone account for more than 1,205 km of pipeline, seven gas systems and fourteen compressor stations (NNPC, 2015). Supplies of natural gas for industrial usage are being extended to the South Eastern States of Cross Rivers, Akwa Ibiom and Rivers through the East Horizon Gas Company and other commercial centers in Nigeria.

The first phase of the domestic integrated urban network of gas pipeline infrastructure for power generation and industrial processes started in Lagos in 2001. The project commenced with the construction of 11.2 km gas pipeline network capacity to deliver 15 million metric standard cubic feet of gas a day (mmscf/d) from the NGC City Gate, Ikeja mainline to transverse Oba Akran, Lateef Jakande and ACME Road, within the Ikeja industrial scheme. The project pioneered by Gaslink Nigeria Ltd., an indigenous company established in 1988, has its main responsibility to promote natural gas distribution to industrial, residential and commercial consumers in Nigeria. Since the completion of the first phase, there have been further developments by Gaslink to integrate companies in other industrial areas within the Lagos metropolis into the gas distribution pipeline scheme. With this development, Gaslink has broken the monopoly of NEPA as the only source of power supply in Nigeria. The use of natural gas results in reduction in energy cost, maintenance cost as well as environmental pollution.

Gaslink has completed work on the 5 mmscf/d Ikeja phase 1 B, 4.6 km gas distribution pipeline with a capacity to deliver 20 mmscf/d, and this development lends credence to gas utilization in Lagos metropolis. This pipeline is to deliver gas to companies located within the Oregun industrial area via Mobolaji Bank Anthony Way, in Lagos.

The second phase tagged "Greater Lagos Phase II" was completed in 2004. It is a 65 mmscf/d of gas covering 99 km distribution network, added to cover industrial areas such as Ojota, Oshodi, Matori, Iganmu, Amuwo Odofin, Illupeju, Isolo, Apapa and Tin Can Island. The introduction of a gas distribution project represents a giant leap towards the realization of the country's goal of promoting economic development and environmental preservation through the provision of gas pipelines to halt the colossal waste of gas resources through flaring (Tinubu, 2008). Natural gas utilization for industries in Nigeria is a reality, and over 100 industrial companies have switched from NEPA to natural gas in Lagos area covering over 99 km gas distribution network and a capacity to deliver 38 million standard cubic feet of gas per day. The development of gas utilization projects for cottage industries within the Lagos metropolis is already steering the low carbon direction and significantly addressing the socioeconomic and environmental impact.

Natural gas by its nature is globally renowned as cleaner energy, more environmentally friendly, clean burning and cheaper compared to other fossil fuels such as petrol, diesel and low pour fuel oil. Above all, natural gas guarantee pollution free environment that increases socioeconomic activities and industrial development. Companies such as Cadbury, Guinness, Textile Mills, and Steel Mills located within the industrial zones of Ikeja, Illupeju, Apapa, Iganmu, Matori, Isolo and Tin Can Island is enjoying the benefit of running their plants and machines on natural gas. The use of natural gas by industries has potential for saving of the energy bill of more than N480 billion or US$4.6 billion for the first 20 years at the present energy cost, and generate more than N360 billion or US$3 billion in foreign exchange from the displaced low pour fuel oil.

From the perspective of sustainable development, natural gas development creates the much-needed environmental and socioeconomic benefit for the interest of all stakeholders. Some consumer base projects in the domestic context include power generation, iron and steel plants, aluminium smelting plant, cement industry, petrochemical and industrial usage have benefited from natural gas development.

3.1. Power/Electricity Generation

In Nigeria, natural gas is used as a major source of fuel to power electricity generation to various gas turbines in various locations at Egbin, Afam, Delta, Ughelli and Onne power stations. NEPA accounts for about 70% of total gas demand in the domestic network. Natural gas as an energy source is more efficient because it is cleaner than other fossil fuels such as coal, diesel oil, and produces less carbon dioxide per unit of energy released. The use of natural gas for power generation is mostly necessary where gas can be obtained at competitive prices. The pricing structure in Nigeria is favourable to NEPA operations. The activities of NEPA have become increasingly strategic with significant multiplier effect to the rest of the Nigerian economy. In addition, the earlier stage of gas development was in keeping with the social responsibility of government rather than being dictated by the commercial or economic reality of the market. NEPA enjoyed some preferential treatment because it is a government monopoly entrusted with the responsibilities to provide electricity to the whole of Nigeria. It has, however, been unable to live up to the expectation.

Despite Nigeria huge natural gas resources, electricity supply is in a deep crisis. With a total installed generation capacity of 5,900 MW, it is only able to generate a meagre 1,600 MW, compared to the United Kingdom with about 145,000 MW, South Africa 39,154 MW and Algeria about 11,000 MW. This indicates that only 40% of the entire 150 million people and <10% of rural household have access to electric power on a partial basis. According to Christiansen and Haugland (2001), Nigeria is facing serious energy crisis, particularly in the power sector with persistent shortages of generation capacity and frequent power shutdowns caused by deteriorating infrastructure with consequences on economic losses and human hardship. Owing to frequent shutdown on the transmission and distribution networks, so many residential and commercial establishments are left with no option than to run their own power generators, producing electricity at a high cost to themselves and to the Nigerian economy. Small scale industries, particularly in the industrial areas are now switching to gas as an alternative energy source.

3.2. LPG

The LPG is generally known as cooking gas. Nigeria is the largest producer of LPG in Africa with annual production capacity of 4 million metric tons; ironically, among the lowest consumers of LPG because it is barely available to local consumers, or where it is available, the price is hardly affordable. Nigeria's LPG production for export is about one million tons of ExxonMobil Oso plant, about 800,000 tons of the LNG plant and about 300,000 tons of the Chevron Escravos facilities. About 95% of LPG from these production facilities is exported abroad despite the growing demand and potential for domestic consumption. Consequently, prices of LPG locally has soared beyond the reach of average Nigerians to as much as N3, 000 (US$18.00) for a 12.5 kg about the highest in the World. The level of LPG consumption is further compounded by the dearth of refinery capacity in Nigeria to produce gas for the domestic market, occasionally resulted in net import from abroad. Nigerians are compelled to pay the international cost in the domestic market in addition to the cost of logistics, all of which discourage domestic consumption of cooking gas.

Unlike kerosene and firewood, LPG is clean burning, safe and environmentally friendly form of energy. The initial cost outlay is a major obstacle for potential consumers comparable to kerosene stove and firewood. To join the league of LPG users, consumer requires between N15,000-N20,000 (equivalent US$78-$105) for a gas cylinder, hose and regulator, whereas it costs so much less to start using kerosene stove and firewood. Notwithstanding the initial cost, in the long run LPG is by far conveniently cheaper, reliable and more efficient and environmentally friendly fuel for cooking. Thus, it must be reiterated that utilization of LPG has many socioeconomic and environmental benefits with a significant reduction in gas flaring, mitigate deforestation and provide a nonpolluting source of energy for cooking.

3.3. Residential Application

In the meantime, there is little or no opportunity for growth potential in this sector because urban centre configuration in Nigeria hampers the installation of economic distribution network

for gas. Due to the tropical location of the region, the climatic condition makes the need for space heating almost irrelevant. This is in most cases the largest consumer base load of natural gas in Europe and America. It is possible to supply gas to homes where it is used for such purposes as cooking food, space heating, refrigeration, preservation needs, washing and ironing, and water heating, but the demand of individual consumers in Nigeria is likely to be too meagre to justify the huge financial investments for gas distribution and network infrastructure.

3.4. Industrial Customers

The early stage of gas utilisation in Nigeria witnessed a modest commercially oriented gas pipeline constructed to the West African Portland Cement Company (WAPCO) plants at Shagamu and Ewekoro cement factories from the ELP Project supply spur lines commissioned in 1993 and 1994 respectively. The aluminium industry represents another potential area for major gas demand, which is centered on the Aluminium Smelter Company of Nigeria (ALSCON) facility at Ikot Abasi. These facilities were built primarily for export purposes, (made up of 140,000 metric for export and 40,000 metric tons domestic) and requires very low cost fuel for industrial processes and power generation.

Furthermore, natural gas is a predominant feedstock worldwide for the production of ammonia, which forms the basis of nitrogen based fertilizers. NAFCON (Rusal Industries) is Nigeria's main fertilizer plant located in Onne, and uses gas as feedstock for the production of nitrogenous fertilizer. The plant which has a capacity to produce 1,000 tons of ammonia, 1,500 tons of urea and 2,000 tons of bulk blend NPK per day was established in 1980. It should be noted that the manufacturing process for ammonia is very sensitive to the price of natural gas, which is the feedstock of nitrogen based fertilizers.

In addition, natural gas requirement in the steel industry is for firing large furnaces for melting iron ores, iron billets and as direct fuel. The two steel plants owned by the government (Aladja and Ajaokuta) have the capacity to produce 1.8 million tons of steel per annum, but they are operating at very low capacity and are only able to produce a paltry 0.4 million tons (Economides et al., 2014). Gas demand in this sector has been largely low because many steel companies were operating far less their installed capacity, however there is potential for future growth. Unlike Nigeria, Algeria, Mexico and Venezuela are good examples of countries that used oil and gas business to kick start their steel sectors. The impact of these sectors on the Nigeria economy and environmental preservation cannot be underestimated considering the amount of natural gas utilization.

Increase utilization of gas in Nigeria by manufacturing industries is pivotal to environmental preservation and economic development with a clear contribution to the millennium development goal and overcome the serious threat of climate change phenomenon generated by a multiplicity of gas flaring activities in the Niger Delta region.

3.5. Small Industry

There are many small scale industries scattered across Nigeria, which require gas as a source of energy because of the dismal power generating capacity from the NEPA. Natural gas is a cleaner burning fuel, environmentally friendly and by far more economical compare to fuel diesel.

Unfortunately, natural gas infrastructure is in its embryonic stage and lots of domestic industries do not have access to gas infrastructure networks. Some cottage industries within the industrial area that has close proximity to the already existing gas pipelines are more likely to be connected to natural gas than industries in isolated locations. Gas development infrastructure is deliberately targeted at large base load customers like industrial companies that have the capacity to mop up a substantial amount of natural gas that is more cost effective and economical to investors.

Table 1: Some gas utilization thermal projects in Nigeria

Project name	Year of construction	Location	Installed capacity (MW)	Available capacity (MW)
Egbin	1986	Egbin, Lagos state	1320	110
Sapele	1978, 1983	Sapele, Delta state	1020	90
Delta	1966	Ughelli, Delta state	900	300
Geregu	2007	Geregu, Kogi state	414	276
Omotosho	2007	Omotosho, Ondo state	304	76
Olorunsogo	2008	Olorunsogo, Ogun state	304	76
Afam (V)	1963	Afam, Rivers state	726	60

Source: BPE (2011a)

Table 2: Major domestic gas supply pipelines in Nigeria

Gas pipeline systems	Design capacity (MMSCFD)	Line diameter (inches)	Pipeline length (km)
Aladja gas pipeline system	70	6, 8, 14 and 16	130
Oben-Ajaokuta gas pipeline system	200	24	198
Sapele gas pipeline system	200	10 and 18	44
Obigbo North/Afam pipeline system	90	14	19
Imo river aba gas pipeline system	35	12	28
Alscon gas pipeline system	160	14, 16, 7, 24	117
Alakiri-Onne gas pipeline system	138	14	17
ELP system	1100	30 and 36	514
Ibafo-Ikeja city gas system	50	24	48
Ajaokuta-bajana gas pipeline			90
Total			1205

Source: NNPC (2015). ELP: Escravos-lagos gas pipeline

4. CONCLUSION AND RECOMMENDATIONS

The link between gas development and natural resource management within the context of sustainable development and environmental preservation has been well established in this article. Natural gas development and gas pipeline infrastructure to promote socioeconomic and environmental sustainability is a reality in Nigeria as evidence in the various gas projects and pipeline infrastructure across the gamut of the country. The socioeconomic and environmental benefit created by gas development is enormous. More fundamentally, this article makes a notable contribution to the conceptualization of climate change and green economic phenomena, with a better understanding of and commitment to non-renewable energy development, energy efficiency and environmental sustainability. Notwithstanding the level of gas infrastructure to fast track natural gas utilization and environmental protection, there appear some serious gap and a broken link in the chain such as the state of conflict and security situation in the Niger Delta region, the main supply source which has resulted in distortion.

Consequently, there is a need for serious consideration to the question of standardization to the domestic pricing in the gas value chain to eliminate distortion in the supply system and encourage investment and competition in gas development. It is also imperative to eliminate any form of complexity in the production, distribution and utilization of natural gas. There is also the problem of ownership structure of gas to eliminate the monopoly and price distortions.

Furthermore, as part of the development process, the use of modern technologies such as gas re-injection that is synonymous with oil and gas production activities in other oil producing countries such as Angola, Brazil and Kazakhstan should be pursued with all vigour. What is of utmost priority is the leverage to develop a framework to expand the existing infrastructure focusing principally on commercial models through aggressive investment in gas gathering, transmission and distribution infrastructure to encourage gas utilization.

Develop appropriate methodology to translate and convert the abundant flared natural gas to provide energy efficiency that is rarely available in homes in Nigeria as this constitutes the bulk of natural gas consumption in Europe, America and Asia, which send shock waves and hiccup to families' budget particularly during the winter season. Curbing economic wastage that is synonymous with the oil and gas industry in Nigeria through gas development promotes resource utilization and environmental sustainability.

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