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Comparative Analysis of Selected African Natural Gas Markets and Related Policies

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Abstract: The discovery of natural gas resources across the African continent has inspired debate on how such resources should be developed and best utilized. In several African countries, the discovery of commercial quantities of natural gas reserves has led governments to explore a number of strategies, investments, and policy directions. Two contrasting cases are that of Nigeria, which has pursued policies promoting domestic natural gas consumption and export, and Ghana, which has focused on encouraging sectoral-level domestic consumption. These divergent approaches have had immensely different impacts on the sector. This paper uses a case study methodology to identify and assess existing national approaches toward governance and market development. We consider the complex landscape for natural gas in Nigeria, Egypt, and Ghana. The results provide a comparative framework to aid understanding of natural gas development globally. We conclude by highlighting areas of further work.

Keywords: Natural gas; African energy; Energy policy and investment

1. Introduction

The global natural gas map has changed dramatically over the last 15 years. On the demand side, massive growth in various large emerging economies, such as China, Nigeria, and India, are reshaping international gas flows[1]–[3]. From Ghana to Tanzania, prospective gas markets are developing and growing as economies grow. Hidden under these mega-trends, gas markets are undergoing an important evolution in a number of developing countries. These developments have significant implications for human and economic development, as well as the global gas sector more broadly[3]–[5][6].

Just 15 years ago, few gas developers looked to these countries only as potential customers[7], [8]. Today, there is a proliferation of potential markets, as numerous countries reap the benefits of successive years of continued economic growth and expansion. Various factors are affecting this market growth potential, notably 1) the increasing global efforts to transition to gas as a fuel input [9],[10], [11], and 2) the technological innovations and improved economics of small-scale floating storage and regasification units (FSRUs). These FSRUs provide an avenue to deliver Liquefied Natural Gas (LNG) to smaller markets by avoiding massive investments associated with traditional land-based regasification facilities. Despite these notable evolutions, little analysis has explored lessons for the optimal utilization of gas resources for developing countries. While early discoveries led to the production of natural gas as an export commodity[12], [13], natural gas discoveries in Egypt, Tanzania, Mozambique, Libya, Ghana, and Nigeria among others have encouraged a shift from production solely for export to gas harvesting for domestic or regional use [14]. In practice, these policy directions have resulted in different outcomes worth analyzing for future investment decision purposes.

Improving the understanding of potential gas demand is not only relevant for analyzing domestic gas consumption-related policies but is also important for preparing a more complete risk assessment and strategy for export projects. Competing domestic needs have not historically been adequately evaluated. Failure to consider domestic demand dynamics in developing countries with export projects has contributed to challenges with gas projects. That is, the amount of gas available for export may be threatened not by production constraints, but by the allocation of gas for use within a country's borders—as experienced in Egypt in 2015[5]. In addition to competing domestic needs, nearby rival suppliers—particularly those with more resources—may pose competition to the profitability of export infrastructure and therefore the viability of gas supply expansion.

This paper aims to provide insight on potential policy directions to countries that may have just discovered natural gas or are still in the phase of natural gas policy formulation by eliciting insights from other countries that have enacted differing gas policies. It does not provide definitive recommendations, but rather explores elements of the literature to synthesize some of the existing gas policies in often under-analyzed and overlooked developing country markets in the areas of governance and market development. Understanding these policy dynamics is vital as the world—

particularly countries and international organizations—commits to ending energy poverty and moving toward a clean energy future[9], [15].

The remainder of this paper is structured as follows: Section 2 presents an illustration of some of the relevant LNG developments in Africa. Section 3 presents a review of natural gas demand dynamics and how they can inform policy. Section 4 presents an analysis/discussion of the various policies pursued by Nigeria, Egypt and Ghana in the areas of governance and market development. Section 5 concludes.

2. Background: LNG projects and policies in Africa

This section provides background on three related regional LNG projects being undertaken in Africa: 1) Egyptian LNG markets and infrastructure, 2) LNG projects in East Africa, and 3) Emerging developments in West Africa.

2.1 Unexpected domestic demand growth and uncertainty in Egypt

In the early 2000s, as the first Egyptian LNG trains moved to closure, domestic demand was limited. Over the next decade, demand grew dramatically, and in response, petroleum sponsors built increasing numbers of LNG trains[16]. Eventually, the competing demands for export LNG and for domestic use came to a head. Declining production during the unforeseen Arab Spring in 2011 combined with rising domestic consumption forced Egypt to cease exports and even begin importing gas to compensate for its irregular and unreliable production[17], [18]. Having previously exported to Israel, Egypt now relied on its trade partner—as well as Cyprus—to supply its domestic market, while Cyprus and Israel used Egypt's LNG infrastructure to supply gas to Europe.

In Egypt's case, domestic use crowded out competition from nearby import markets, as it often does. Recent gas field discoveries may mean that Egypt can both supply its domestic demand and fill its LNG plants' capacity, reclaiming gas export capacity from its own facilities. Yet this evolution creates uncertainty around stranded gas assets in the region due to Egypt's liberalization of its gas market—leaving private companies with the entitlement to engage in gas transactions on the open market—and the complex and evolving geopolitics of the region. With the breakdown of a recent agreement to re-open its Damietta LNG plant for exports, the future of Egypt's gas surplus remains to be determined.

2.2 Developments, prospects, and demand in East Africa

As recently as a decade ago, East African countries were not on the global natural gas map. Major resource discoveries off the coast of Mozambique and Tanzania have opened new opportunities for natural gas production in the region. Initially, analysts, investors, and policymakers focused specifically on the potential of these resources for exports[19]. However, the massive investment wave in new

liquefaction capacity in response to the Fukushima crisis, combined with local institutional challenges, have significantly cooled the idea that East African countries are going to be major exporters of natural gas in the short term[19]. Yet, the first project off the coast of Mozambique reached its Final Investment Decision (FID) in 2017, and recently Anadarko Petroleum – a US based hydrocarbon exploration company – agreed to a 15-year purchase agreement with Electricité de France and may well reach FID in the near future[20].

Considerably, less attention has been directed toward the possibility to use this sizable resource potential domestically or regionally, likely due to the absence of supporting infrastructure or a developed market[21]. However, there are possibilities to use a part of the discovered resource to build up industrial activity, and perhaps also utilize it within major urban areas, for instance in transport or for residential demand. As the means to transport natural gas in the form of LNG continues to mature, a supply chain along East Africa's coastline supplying major urban areas may not be inconceivable in the long term.

Previous analysis has suggested that, in the case of Tanzania, proven reserves are not substantial enough to allow for both exports and allocation of a significant share of the resource base for domestic usage, as the government intends[1]. On the other hand, Mozambique could support several major export projects and still have resources available for domestic usage[22]. Throughout the region, transporting natural gas to rural areas and into neighboring countries is likely to be economically challenging, depending on transportation costs and the costs of competing fuels. Other analysis highlights major power shortages throughout Africa and suggests that natural gas from the region could play a prominent role, up to 40 percent of the region's demand, to fulfill current and future electricity needs[23]. Of course, decisions to develop this resource are taking place in a context with variable renewable energy sources like solar and wind rapidly approaching grid parity and storage technologies maturing.

2.3 Emerging trends and development in West Africa

Countries in the western part of the continent, such as Senegal and Ivory Coast, are also key developing markets for natural gas. The demand intensity for primary energy has historically been low for the Senegalese and the Mauritanian populations. However, prospects of economic growth have stressed the importance of hydrocarbon resources in both countries, particularly natural gas, to fuel development. Major exploration successes in the shared deep waters by Cairn Energy in 2014 and Kosmos Energy in 2016 changed the energy landscape, and also highlighted regulatory and infrastructural issues in both countries. The government of Senegal adopted the Emerging Senegal Plan (PSE) in 2012 to serve as the strategic outline for economic growth until 2035. PSE highlights the importance of developing oil and LNG projects to create a competitive energy market and reduce electricity costs.

Through Public Private Partnerships, the government of Senegal and international oil operators are aiming to commence production from the Grand Tortue Ahmeyim and Yakaar-Teranga gas projects by 2023-24. This is expected to introduce a significant supply of natural gas that can be exported and

still meet domestic demand, contingent on investments in infrastructure and market regulation policies. Primarily, LNG project development in this context is to consider exports through long-term contracts that will allow investments into the country. This is supported by positive differential in the gas production (9.5 - 12 bcm) and demand (2.4 - 4.1 bcm) by 2040 under different scenarios as analyzed by the International Energy Agency (IEA) [24]. As Senegal aims for universal electricity access by 2025, power sector expansion and a shift from heavy fuel oil to gas will be key focus areas as highlighted in the PSE. Currently, the country relies on coal and expensive diesel for power generation, which results in high generation costs and tariff. Gas-to-power projects have thus, understandably, received much attention from the state-owned utility Senelec in recent years.

3. Natural gas demand dynamics

The demand for Natural Gas (NG) continues to grow because NG is relatively cheap, comparatively clean, or simply available. For some of these reasons, Brennard characterizes natural gas a preferred fuel in countries such as China.[25] Part of this increasing demand, in the developing world, has been satisfied by domestic sector requirements; that is, some countries such as Nigeria are not only producers/exporters but also consumers of NG. Other countries such as Angola and Equatorial Guinea export their NG to countries outside of Africa[2]. Ghana has resorted to using the NG from the Sankofa gas project for domestic consumption, primarily in the area of electricity generation. Since NG is chiefly used in the electricity sectors of developing countries as shown in Figure 1 below, this section will focus greatly on the demand for NG in the electricity sector.[1]

Growing projected demand for NG conforms with global efforts not only to connect most households to the electricity grid but also to ensure connected entities receive reliable electricity[26], [27]. Countries are therefore increasingly using NG as a storable and dispatchable input for power generation, as is the case in Ghana and Egypt where more gas-fired or dual-fuel plants are being constructed[28]. For instance, in 2011, Ghana experienced the beginning of an unexpected surge in electricity demand, which continues to this day [29], [30]. The country's inability to meet the unexpected increase in demand—attributable to electricity capacity constraints, high input (crude) cost for thermal generation, and population growth—led to long durations of unreliable power supply affecting economic growth[31], [32],[33]. This negative consequence influenced Ghana's decision to pursue a domestic utilization strategy for its gas resource.

[1] While SDG7 focuses on the electricity sector, the implementation of effective gas-related policies will also help developing countries satisfy other economic needs. As shown in Figure 1, about half of the projected increase in NG demand will come from the industrial, transportation, and building sectors.

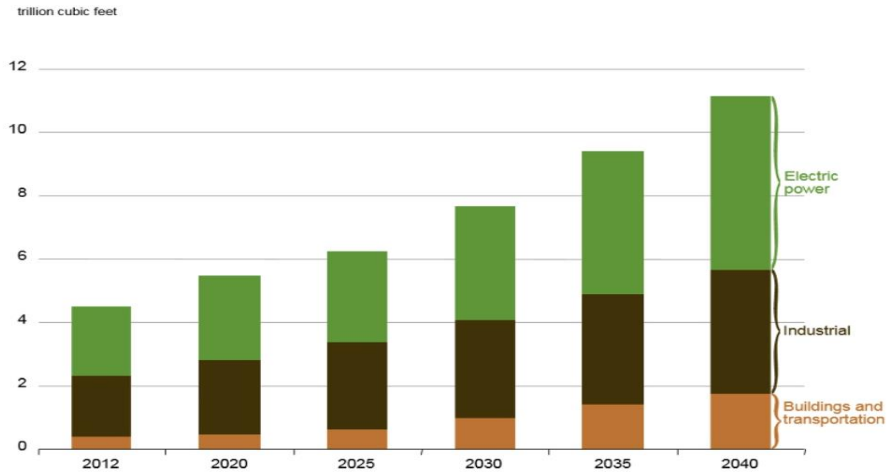

Figure 1[2]: Projected NG consumption (trillion cubic feet) in Africa by sector[34][35]

Given significant efforts to increase the share of natural gas for electricity production in the developing world[9], the shifting roles of natural gas in some African countries, and the growing need to consider comprehensive gas strategies in nascent and latent African markets, it is useful to draw lessons from the experiences of early movers in the region.

The global gas industry has shown strong growth potential over the past three years. Highlighted in the International Gas Union Global Gas Report, global gas demand, and gas trade increased in the past year (2020) [36]. Supply increases placed downward pressure on gas prices making gas a competitive fuel. Such factors as 1) the commissioning of pipeline routes connecting Russia, China and Europe, and 2) the increase in the number of approved LNG export projects played a role in the 2020 gas supply increase. On the demand side, the increases in infrastructural investments and the creation of trade hubs, and market deregulation in India and Spain have been critical [36]. Lower gas prices enabled demand as already exiting gas importers, as well as first-time importers, increased their demand for gas. While the increase in the customer base is beneficial to gas producers, it also aids the energy transition in the long run due to coal-to-gas switching. Although international gas trade flow grew in 2019, pipeline trade contracted, with Africa and Europe experiencing the largest contraction. Cheaper LNG prices derailed the competitiveness of pipeline gas from such countries as Algeria. Considering the huge growth potential of the global gas market, it would be beneficial for nascent African gas markets to learn from the experiences of other gas traders. This would enable nascent markets to take advantage of the projected global market growth.

[2] We acknowledge that these trends may largely be driven by a few markets.

4. Methodology

The most-different case study analytic technique allows for the examination of cases that are different on specified outcome variables. This study employs the most-different case study analytic tool to understand the divergent natural gas related polices pursued in emerging economies. The selected cases provide causal leverage as they demonstrate variation in pursued policies by such African countries as Nigeria, Egypt and Ghana. For each country, two facets of natural gas development are discussed: 1) governance, and 2) markets. Governance pertains to the contractual agreements of the extraction and sale of the resource. Market analysis examines the potential areas where the resource will be utilized/used.

4.1. Natural Gas Governance

4.1.1. Nigeria

With approximately 5.1 trillion cubic meters of proven natural gas reserves, Nigeria has been ranked as the largest natural gas producer in West Africa making Nigeria a major player in the gas market both regionally and internationally[4]. Nigeria supplies gas to other regional countries through the West Africa Gas Pipeline project, which enables countries such as Ghana, Togo, and Benin to receive natural gas. While the country may have large proven gas reserves, a large fraction of the produced gas – since the early 2000s – is flared because of insufficient LNG transport infrastructure. In 2018, Nigeria flared about 262 Bcf of natural gas, close to 15% of the annual gas production in the year [37].

To reduce this resource wastage, the government of Nigeria partnered with the World Bank in 2002 to develop innovative ways to utilize and harness natural gas across its value chain. This partnership yielded the Nigeria Gas Master Plan, a plan not just to curb flaring but to pinpoint how the country can optimally benefit from its gas resources[38]. With the demand dynamics discussed in section 3, the rapid inclusion of NG in countries' energy mixes warrants efficient resource utilization as countries seek ways to reduce gas flaring.

As such, the government of Nigeria has pursued two key policies worth highlighting. First, the 2003 National Energy Policy enacted to facilitate the incorporation of NG in the nation's economy and to reduce gas flaring. This policy aimed to increase the country's attractiveness for investment in gas exploration in a bid to increase available reserves. Additionally, the policy prioritized the establishment of transmission and distribution networks to ensure a smooth operation of the domestic gas market. Nelson [39] highlights implementation as a major challenge of 2003 National Energy Policy.

This gave rise to the second policy, the 2007 National Oil and Gas Policy, which laid out the institutional and the legal frameworks to govern the day-to-day activities of the country's oil and gas industry. In 2008 the government of Nigeria passed the Gas Master Plan, a plan to make Nigeria a regional energy hub. The plan was based on three pillars: 1) domestic reserve obligation/requirement, 2) pricing policy and 3) infrastructure blueprint. The domestic reserve obligation ensured that adequate gas is available for domestic consumption in order to spur economic growth. The pricing policy aimed

for a fair minimum price for gas buyers. The infrastructure blueprint laid out the plan to develop three central gas gathering and processing facilities and three pipeline transmission networks to help position Nigeria as a regional gas hub. This plan has gone through several phases of implementation, and while Nigeria may still be a large market in Africa, the country has not been able to fully reap the benefits of the natural gas resource as highlighted in the Master Plan. Its shortcomings have mostly stemmed from changes in governments with different views on which sectors to prioritize under their tenure.

4.1.2. Egypt

Egypt is one of the biggest economies in Africa with an extensive energy market. The country is often regarded as one of the biggest players in the African LNG market because of its two prominent LNG infrastructural assets, the Suez Canal transit point and the Suez-Mediterranean pipeline. The NG industry in Egypt is managed by the government through the Ministry of Petroleum and Mineral Resources and through the state-owned Egyptian Natural Gas Company (EGAS). These two agencies are charged with the concession of production agreements and leading new explorations in the bid to be the next energy hub[40]. While the country resorted to exports following its initial discovery of gas, it was unexpectedly struck by the increased domestic demand for electricity[17]. This inevitably led Egypt to prioritize domestic gas allocation.

To unlock the potential of gas resources in Egypt, the government enacted policies to restore the country's gas profile in 2013, in part through stimulation of upstream gas development [17], [41]. In the last six years, these policies have led to the discovery of new gas fields in the country (Zohr field, West Nile Delta field, and Greater Nooros and Atoll fields). These discoveries have the potential to augment Egypt's gas profile by increasing the potential domestic supply. Modifications in Egypt's gas profile in the last six years enabled the country to meet its domestic needs through rationing significant portions of the gas for domestic purposes.

Additionally, there have been conscious efforts—such as laws and regulations to pay arrears owed to international oil companies and the introduction of the Egyptian Petroleum Show/exhibition (EGYPS)—geared toward attracting investors as discussed in the Energy Resource Guide[40]. Such efforts have attracted energy giants such as ExxonMobil and Chevron to invest in the upstream sector of the petroleum industry in Egypt. The government also created the East Mediterranean Gas Forum to foster cooperation with Israel, Italy, Cyprus, Greece, Jordan and Palestine.

The various gas related polices enacted by the Government of Egypt resulted in an increase in investments in upstream development. Upstream development is critical to the discovery of more gas fields but accurately forecasting domestic natural gas demand could help Egypt maintain its energy balance.

4.1.3. Ghana

Ghana is yet another country in Africa to have discovered large reserves of natural gas. The initial discovery of oil off the coast of Ghana in 2007 gave rise to several projects intended to harness the resource for domestic use. Natural gas in Ghana is produced from two of its major fields, the Off Cape Three Points (OCTP) and the TEN oilfields. Prior to the discovery and development of oil and gas fields, Ghana relied heavily on irregular imported NG from Nigeria via the West African Gas Pipeline (WAGP). The irregularity of Nigeria's gas supply along with domestic gas discovery led the government of Ghana to pursue policies to develop its resource. As opposed to Nigeria and Egypt—which have allocated their gas resources for both domestic uses and exportation—the government of Ghana actively pursued policies to develop its gas fields specifically for domestic consumption.

The necessary transportation infrastructure is currently being put in place to allow for movement of gas supplies to the domestic market, mainly the power sector. Golar Tundra Ltd and Quantum Power Ltd are private firms developing floating storage and regasification units at the port of Ghana to aid gas evacuation for domestic power production. These developments have been challenged by lack of funds, by incomplete onshore infrastructure , and by conflicting interests of parties involved in the contract [42]. Although a clear gas pricing policy is critical to the performance of gas markets, gas pricing issues in Ghana are still not resolved as discussed by Abudu et. al [43].

In summary, all countries considered have pursued varied policies surrounding their NG resource. Egypt began by prioritizing exports, as Nigeria did, and later domestic demand crowded out the export market. Ghana pursued domestic production from the outset in its efforts to supplement imported gas from the WAGP. Despite these dynamics, all countries are continually investing in upstream development, such as exploration, and in the needed infrastructure to facilitate the supply of gas. Challenges mostly stem from inaccurate demand forecast, changes in governments and polices, lack of transparent pricing, delays in contract payments and poor gas infrastructural developments. Other countries in policy formulation stages could tap into to the successes and the likely challenges faced by Nigeria, Egypt and Ghana.

4.2. Markets

Broadly, NG markets are usually subdivided into domestic and export (international or regional) markets depending on how a country utilizes its resources. In addition to policies, available infrastructure also determines the market structure in which a country operates. For instance, based on its policies and infrastructure, Ghana is classified as a domestic gas market where the resource is intended for use in the country. Egypt and Nigeria, however, are classified as domestic as well as regional and international export markets. Domestic consumption/demand for natural gas in Nigeria, Egypt and Ghana is illustrated in Figure 2. Starting from 2015-2016, domestic consumption of natural gas in each country has been on an upward trend, with the power generation sector acting as the primary consumer [44][45] (see Figures 1 & 2).

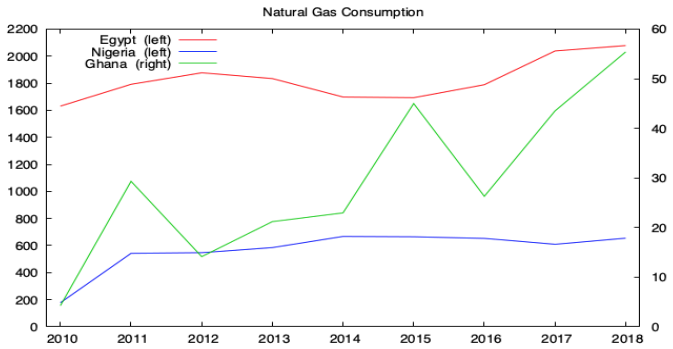

Figure 2: NG consumption 2010 -2018. Data sourced from[46][3]

4.2.1. Nigeria

Natural gas-related activities in Nigeria are controlled and managed by the government through the Department of Petroleum Resources. In the late 1990s, Nigeria started as a NG export market, exporting gas to mostly regional markets. As a result, the WAGP and the Trans-Saharan Gas Pipeline were put in place to facilitate regional gas trade between Nigeria, as the supplier, and other countries in the continent. The Economic Community of West African States (ECOWAS) spearheaded the WAGP while Trans-Saharan Gas Pipeline borne from an agreement between the governments of Nigeria and Algeria. These pipelines have proved useful to all parties involved.

Although the Gas Master Plan of 2015 set policy targets to ensure development of a robust domestic gas market by the same year, the implementation has been slow, and the market remains underdeveloped. The government retains an involvement in all segments of the value chain, whether as a regulator or policymaker. Delays from the government have resulted in a lack of clear regulatory and fiscal structure for the gas sector. The domestic wholesale gas market is operated by the Nigerian Gas Company which manages Gas Sales and Purchase Agreements with gas producers; the pricing methodology in place for these contracts is critical to the performance of the domestic market vis-a-vis the export market though pricing still remains an issue [47].

Market related policies in Nigeria yielded the creation of two of the pipeline networks to boost domestic and regional trade. The WAGP provides gas to Benin, Togo and Ghana and over the years, Ghana has benefitted from natural gas supply from the pipeline in the areas of electricity generation. This WAGP policy has fostered the inter-regional relationship among Nigeria, Benin, Togo and Ghana.

The domestic wholesale gas market has been threatened by arrears owed by buyers and the lack of a transparent pricing mechanism. This also gives an insight as to the relatively high share of flared gas (~11%) as compared to domestic market (~13.6%) in total gas utilization for 2018 [48]. Nigeria reported a gas utilization rate of 89% in 2018, with a domestic supply share (power and other industrial segments) of nearly 13.7%. The government constituted the National Gas Policy and the Nigerian Gas Flare Commercialization Programme (NGFCP) to accelerate the growth of gas market and reduce gas flaring. The latter outlines a framework for auction of flared gas (primarily associated gas) by the

[3] Data for this graph was sourced from the US Energy Information Administration Database.

government to third parties for commercial use. These policies are aimed to boost utilization in power plants, LNG, fertilizer and gas-to-liquid (GTL) plants. However, as the power sector remains the largest domestic offtake segment for gas, stimulating growth in this sector is critical to developing the local gas market. Also, as gas policies in Nigeria have resulted in the creation of domestic and regional pipelines trade networks, more robust policies are required to boost the performance of these markets. Such efforts will make nascent African gas markets competitive in the international space.

4.2.2. Egypt

Egypt has continually operated in both domestic and export markets. Unexpected growth in the domestic gas market post-2000 as well as falling domestic gas production forced the country to re-evaluate its gas priorities. By 2012, natural gas had assumed a majority share (~50%) in the nation's primary energy mix, as compared to only 35% at the turn of the century. Falling domestic production implied that in the long run demand would far outstrip domestic supply, forcing the government to reduce exports and lower the subsidy on gas delivery to the industrial sector.

Egypt began imports of LNG in early 2015 after it commissioned two FSRUs at Port of Sokhna. However, the discovery and fast-track development of the Zohr offshore gas field after 2015 has set Egypt on the path to reducing imports. Policymakers are increasingly looking to transform Egypt into an energy hub in the region, owing in part to the already existing maritime trade routes and pipeline infrastructure in the country[49]. The focus is on upstream value chain development.

By September 2018, the state gas company, EGAS, had reported self-sufficiency in natural gas. The government is also looking to boost foreign investment in the country's energy sector; Egypt has secured investment commitments to the tune of $400 million from the US-IFDC for insurance of the gas security in the region by rehabilitation of a subsea trunk line from Israel[50]. EGAS also retains one FSRU (BW Singapore) as a strategic measure to secure gas supply in case production deficiencies arise, while the other has been released from contract since 2018 to cut expenses after the country stopped importing LNG[51]. The country is also expanding its gas distribution and transmission network to increase access to the industrial sector. Alami [18] shows that nearly 63 percent of electricity generation is from domestic natural gas, making it the biggest consumer of Egypt's NG.

4.2.3. Ghana

The market for natural gas in Ghana is mainly driven by the demand for the resource from the electricity sector despite ongoing structural economic issues[52]. While the country previously relied on gas supply from Nigeria via the WAGP, which became erratic over time, Ghana has opted to use its gas to augment domestic demand. To fulfill the goal of switching to natural gas-based power productions, Ghana currently has 14 power plants with an approximate installed capacity of 3,140 MW that run on either dual fuel or natural gas[28], [53]. The goal conforms with efforts by international organizations to ensure countries have access to reliable and affordable electricity. Policymakers have argued that NG is a cheaper, abundant, and less polluting fuel input for electric power generation than other fossil fuel alternatives such as coal or heavy fuel oil. However, structural issues affecting the domestic market for natural gas have restricted its development and contribution

to the economy. Gas prices are expected to be low due to contracted supplies from Tema and Takoradi LNG port projects and domestic supply through Sankofa project outstripping the expected domestic demand to 2023[52]. In the medium to long term, natural gas demand from industrial sectors such as cement and steel can marginally improve utilization in the domestic market. However, the most important contribution to the nation's energy goals will likely come from investments in expanding the power generation fleet that uses natural gas as fuel.

The market analysis undertaken in this section provide insights as most African countries mainly exported gas for revenue generation in the past. Starting in the early 2000s, economic growth and increase in energy needs resulted in an increase in domestic and regional demand for NG. This shifted the focus more on developing domestic/regional markets, as well as developing infrastructure to facilitate distribution to these markets[54]. Such infrastructure developments included 1) the development of domestic and regional pipeline networks to facilitate gas flows and 2) the inclusion of NG in the electricity generation mix. While the inclusion of NG in the generation mix is progressing, the regional trade markets/pools have been lagging. Notably, the viability of the West African Gas Pipeline (WAGP) has been threatened by 1) the lack of transparent competitive prices, 2) the delays in payments of debts owed to suppliers and 3) the ongoing security issues regarding the pipeline [55].

5. Future Outlook & Conclusion

This paper presents a most-different case study overview of the various natural gas-related policies enacted by Nigeria, Egypt and Ghana, with particular attention to the governance structure and market development.

More African countries are discovering significant quantities of natural gas and understanding the framework to optimally benefit from the resource is vital for both energy efficiency and economic growth purposes. Governments across Nigeria, Egypt and Ghana have prioritized the use of NG in the areas of domestic consumption and/or regional/international exports. Ghana has allocated its NG for domestic purposes only, on the other hand countries such Nigeria and Egypt have focused on both domestic and export purposes.[3],[17],[43] The key takeaways from this comparative analysis include: 1) significant effort should be dedicated to accurately forecast energy demand to enable allocation of NG to the domestic market, 2) investment in upstream development to increase domestic reserve as buffers, 3) prioritizing infrastructure developments for a smooth domestic and regional NG transmission and distribution, 4) reduce the frequent gas related policy changes following changes in governments, 5) transparent pricing and finding innovative ways to defray contractual debts and 6) consider potential use of gas in industrial and other upcoming demand sectors in policy formulation. These takeaways provide the framework for optimally exploring the discovered reserves in nascent African markets and draw on insights from these case studies for future policy directions. Therefore, future governments should explore current demand along with future expansions to develop a comprehensive natural gas policy strategy.

Egypt's initial focus on exportation and lack of accurate forecasting resulted in policy shifts when domestic demand crowded out the market, derailing policy expectations. Egypt could have avoided the high cost of importing gas and followed a sounder strategy for development of both the export and the domestic markets by understanding its own needs from the outset. However, once the country recognized the extent of its own needs, it made reforms and actively pursued outside investment. Additionally, gas policies in Nigeria faced numerous challenges that hindered the realization of the policy goals. Policy implementation challenges and frequent changes in policies due to changes in governments are but some of the numerous challenges which hindered Nigeria from realizing its gas goals. These experiences provide lessons for countries in the early stages of formulating natural gas policies to pay close attention to prospective domestic demand as well as other policy related challenges. Aside demand from the power sector, other sectors are becoming prominent consumers of natural gas and should be considered in policy formulation. For instance, it has been shown that, the fertilizer industry is yet another large natural gas consumer in such developing countries as Bangladesh. The same applies to gas as a clean cooking fuel alternative. While there maybe numerous factors accounting for the low adoption of clean cooking fuels in the developing world, governments could incentivize citizens to adopt such fuels.[56], [57] As developing countries grow, NG is expected to become critical for industrial use, fertilizers and cooking gas of which comprehensive gas resource policies will matter.

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