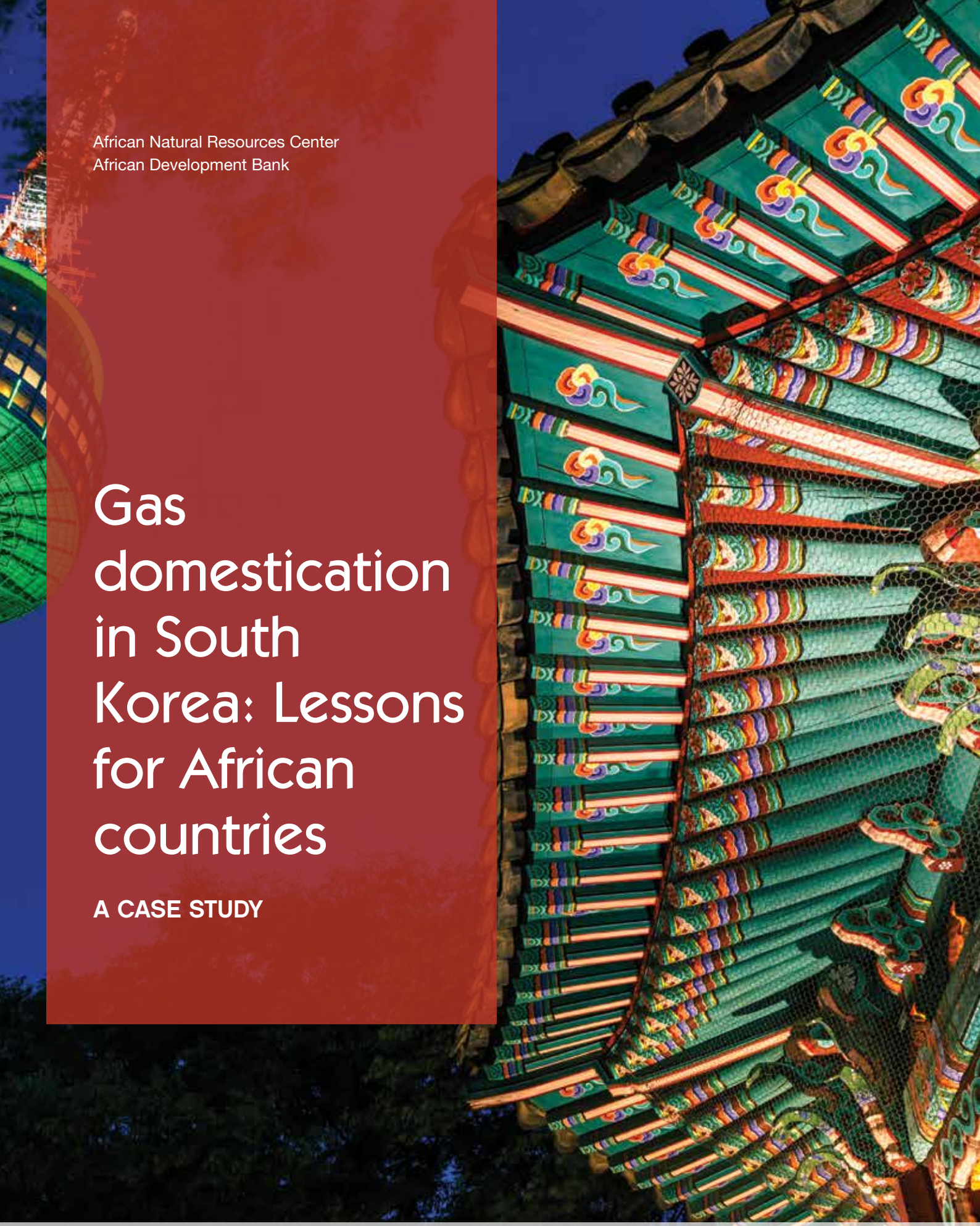
African Natural Resources Center
African Development Bank

Gas domestication in South Korea: Lessons for African countries

A CASE STUDY



AFRICAN DEVELOPMENT BANK GROUP

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Executive summary

Introduction

Since importing its first cargo of liquefied natural gas (LNG) in 1986, Korea has developed a gas industry based on LNG imports and is continuing to promote gas use for transport and as a clean fuel in city areas.

This study identifies and describes the issues encountered by Korea during the successful development of its gas industry. Korea's experience provides relevant lessons for those African governments that are considering options for the development of their own gas industries.

AfDB program context

In 2015, the AfDB unveiled its landmark "High Fives" initiative to accelerate Africa's development over the subsequent ten years within the context of the Bank's Ten-Year Strategy. Under the initiative, the first High-Five priority is to "Light up and Power Africa" in association with the "New Deal on Energy for Africa" that aims at achieving universal access to energy in Africa by 2025. Development partners are encouraged to scale up their efforts, and regional member countries are asked to expand their share of financing going into the energy sector, demonstrating the stronger political will that will ensure the success of the Deal.

Benefits of gas development

An adequate supply of reliable energy is essential for economic development. In sub-Saharan Africa, the static demand for energy is essentially for electricity; thus the primary focus of gas-industry development is to provide for gas-fired power generation.

The AfDB's New Deal on Energy for Africa notes that over 645 million Africans have no access to electricity. Energy-sector bottlenecks and power shortages are estimated to cost African economies some 2–4% of GDP annually, undermining economic growth, stifling employment creation and discouraging investment. Over 90% of Africa's primary schools lack electricity, while potentially life-saving equipment lies unused in African hospitals because of the lack of power. An estimated 600,000 Africans (mostly women and children) die annually due to indoor air pollution associated with the use of biomass for cooking; the use of electricity or LPG for cooking would significantly reduce this number. The potential economic and social benefits of local involvement in the development of indigenous gas resources have been well documented and a number of African countries have introduced successful programs.

Korea: The decision to import LNG

In 1981, the Republic of Korea was the world's fourth largest debtor country and in the midst of an economic crisis. Against this background, the second oil shock from 1979 took crude oil prices to USD 38/bbl (nearly USD 120/bbl in 2016 terms) at a time when some 58% of Korea's primary energy was imported oil. Some imported oil products were used to produce manufactured gas, which was distributed to smaller consumers via established city gas networks. During the latter part of the 20th century, natural gas was the fuel of choice for space heating in any cold-climate region. For Korea, as a country with a significant winter heating requirement, the decision to import LNG was entirely rational.

Korea: Policy implementation

Against the above background, the Korean government introduced a policy to increase

the size and extent of the gas industry based on LNG imports. The policy was substantially implemented through the Korea Gas Corporation (KOGAS) Act of 31 December 1982, which established KOGAS as the single buyer – with responsibility for construction of LNG import terminals and a national transmission pipeline system – and manager of gas supply. Korea signed a 20-year contract with Indonesia to import 2 million tons of LNG every year, largely for power generation, with the first cargo arriving in 1986. Distribution of natural gas from LNG imports commenced in 1987 via the city gas network in the Seoul metropolitan area.

Korea: Gas-industry development

The government has developed a "Long-term natural gas supply and demand plan" every two years since 1992, the latest being end-2015. Through KOGAS, the government pursued a policy of continuing to develop a national gas transmission system until around 2015, when it was deemed uneconomic to continue to connect smaller and smaller communities. Gas-distribution planning is decentralized to city gas companies but, since gas is the preferred fuel for space heating, the government has supported the development of city gas networks to deliver gas to the majority of households.

Of the five operating and one under-construction LNG import terminals, two are owned by private companies and came about because of lack of competition in the gas market and other price distortions seen to be increasing costs for consumers. There are some 33 privately operated city gas companies, of which 29 supply natural gas purchased from KOGAS, with the others based on LPG.

Korea: Energy policy

The Ministry of Trade, Industry & Energy (MOTIE) is responsible for energy policy planning, supervision of the sector, climate-change policy, resource development and energy savings and other matters relating to energy policy. Every 2 years, MOTIE publishes a 15-year forward plan for the primary energy balance, the electricity balance and the gas balance.

Korea is a relatively densely populated country and in the 1990s concerns about air pollution increased. Vehicles were identified as a major source of pollution, and measures to promote the use of compressed natural gas (CNG) were put in place. The use of LPG as a transport fuel was also promoted. The policy to expand city gas networks facilitated the end of the polluting and hazardous "yeontan" coal briquettes as fuel.

Korea: Gas pricing policy

With one exception, tariffs charged for gas supply to all categories of consumer have covered variable costs but during the initial development of the industry, KOGAS was not required to deliver a return on the government's investment.

Between 2008 and 2013, the government only allowed some of KOGAS' increased LNG costs to be recovered in the wholesale price charged to city gas companies – and hence to household and other smaller consumers – in contrast to the wholesale price of gas to electricity generators, which remained connected to the imported cost of LNG. The accumulated deficit in KOGAS' accounts peaked at USD 5 billion before the policy was changed.

The international gas market and the development environment

The starting point for many African countries, as they make policy decisions relating to gas-industry development in 2017, is different from that of Korea when it committed to long-term contracts for the import of LNG in the mid-1980s when the LNG market was seen as a "chain", typically characterized as:

Gas reserve development › liquefaction/export › LNG shipping › onshore LNG import/ storage/re-gasification › gas transmission › power generation/other gas-use › gas/ electricity consumption.

For the last two decades, increasing volumes of LNG have been traded on a spot basis. As of early 2017, the international LNG market is close to having sufficient liquidity to publish trading-hub price data that can be used as a reference price for contracts and for the development of risk-management instruments.

Also since around 2000, increased gas production by the United States (as a result of the development of "fracking" technologies) has resulted in short- and medium-term cargoes of US LNG becoming available free on board (FOB) or delivered at terminal (DAT)[1] on the basis of the Henry Hub gas price plus a fixed liquefaction charge. US LNG exports and the development of new LNG export projects, such as those in East Africa, may serve to keep international prices at a level that makes LNG imports a competitive energy option for many countries.

The development of floating storage and regasification unit (FSRU) technology has removed the requirement for a large up-front investment in onshore LNG storage tanks. The availability of relatively short-duration leasing contracts and the ability to "sail away" the FSRU in the event of default have served to reduce risks for importers, investors and lenders, alike. A number of companies have established aggregator businesses, which acquire a portfolio of LNG from a number of projects and commit to supply LNG to a number of buyers.

The basis for gas-industry development in Africa

In the same way that the international LNG market is different from that faced by Korea in the 1980s, the current basis for gas development is different in most African countries. In 1981, Korea's GDP per capita was around USD 2,000, which is not markedly different from many African countries in 2016, however, whereas Korea was able to borrow on international financial markets, many African countries find it difficult to raise capital. As a consequence, most gas-industry development in sub-Saharan Africa is project-financed. Where indigenous production is part of gas-industry development, financing contracts are based on production-sharing contracts (PSCs). The PSC may not adequately address all the issues from a gas-field development encompassing liquefaction facilities and the delivery of gas to export and domestic markets. Hence, what is required is likely to be a comprehensive framework of contracts, which provide for finance, field development, infrastructure development and pricing arrangements that, in effect, define the regulatory basis for future gas and electricity prices in the host country.

In cold-climate Korea, fuel for space heating was an important requirement that drove the development of the city gas networks. For African countries, electricity distribution is the key energy requirement, while solar power is the preferred option for water heating. As a consequence, many doubt there is a case for large-scale development of gas distribution networks if it is based on the provision of energy for cooking only.

Policy leadership

Every country needs to develop an effective "National Energy Plan" that includes all other energy forms, including renewables and gas, to meet projected energy requirements. The difficult task for any government is to turn what has previously too often been a high-level and aspirational energy plan into defined projects which, together, implement the plan and deliver the identified benefits. It is for the government to define and award projects on a transparent and competitive basis that maximizes the potential for bidders to minimize the cost to consumers by drawing on a range of traditional and innovative financing solutions.

Conclusion

Korea provides an example of gas-industry development based on imported LNG that was driven and financed by the government. Few sub-Saharan African governments are in a position to finance the development of a gas industry by themselves and they must, therefore, attract international finance.

Whether a country is a gas producer or importer – or both a producer and importer – potential investors in gas-industry development and any associated gas-fired power generation will look to the same energy fundamentals as were considered in Korea: can gas and electricity returns from tariffs recover the cost of gas supply?

1. Introduction

This report for the Study on Domestication of Gas Consumption in the Republic of Korea: Lessons for African Countries was undertaken for the African Natural Resources Center (ANRC) of the African Development Bank (AfDB). The report tells the story of gas-market development in Korea and identifies prerequisites and experiences relevant to African countries. It is based on a short mission to Korea in October 2016 and subsequent correspondence with Korean institutions. It necessarily reflects the international environment and development objectives of its time.

The African Natural Resources Center (ANRC) is a non-lending entity of the African Development Bank (AfDB). The Center delivers tools for policy advice, technical assistance, advocacy and knowledge development. This report is intended to be such a tool. The ANRC enters into strategic partnerships with regional, bilateral and multilateral organizations to assist the Bank's regional member countries.

Korea's experience during the successful development of its gas industry provides lessons for those African governments that are considering options for the development of their own gas industries.

The gas industry is international with recent and evolving changes in the nature of its commodity markets. Many analysts consider that US liquefied natural gas (LNG) exports and the development of new LNG export projects, such as those in East Africa, will serve to keep international prices at a level that makes LNG imports a competitive energy option for many countries. The number of opportunities for developing gas reserves far exceeds the availability of capital for their realization. Hence, investment decisions will be highly project-specific. For gas-importing countries however, competitive prices and the availability of LNG tankers is good news and presents opportunities for including gas in their energy policies.

As the experience of Korea illustrates, the gas industry operates in an ever-changing environment to which it must continuously adapt if it is to meet the economic, social and environmental objectives of consumers.

The report identifies and draws on material from within the AfDB and from other institutions. It seeks to present current thinking on the benefits of gas-industry development and the requirements for realizing those benefits. It does not however pretend to provide a comprehensive literature review.

1.1. Why the Republic of Korea?

Korea has a population of 50 million and is slightly more densely populated than Africa's most densely populated country, Rwanda[2].

Since importing its first cargo of LNG in 1986, Korea has developed a gas industry based on LNG imports and is continuing to promote gas use for transport and as a clean fuel in city areas. In the 1980s when its government made the policy decision to commit to long-term imports of LNG, Korea was described as a "third world debtor country"[3]. Since then, the country has become a member of the OECD (1996) and by 2016, after 30 years

of export-led economic growth, had become the world's 11th largest economy[4]. Since the mid-1980s, exports have grown from around USD 3 billion/year to over USD 50 billion in 2014, the main exports being steel, vehicles, ships, equipment and electronics[5]. The Korean gas industry is now mature but continuing to evolve in response to changing market conditions – as consumers who are now able to buy competitively-priced gas seek access to natural monopoly infrastructure.

Korea provides a number of policy lessons for African countries, particularly in the current environment of relatively low oil/LNG prices, the availability of leased FSRUs[6], an evolving LNG spot market and the prospect of LNG imports to sub-Saharan countries.

1.2. Relevance to African countries

The Korean experience of developing its gas industry has similarities and differences with the situation faced by African countries seeking to develop their gas industries today, according to the category into which they fall:

- Existing or projected production is/or may not be sufficient to meet projected gas requirements, notably for power generation, and imports are planned or proposed (this category includes Ghana, Côte d'Ivoire, South Africa, Morocco and others);
- Major reserves have been discovered and developed but internal gas prices are held below international levels and payment risk and institutional obstacles mean there is little incentive to increase production to meet projected gas requirements (notably Nigeria);
- Reserves have been discovered, sometimes major, and there is either a local or export market requirement but policy commitments are required to facilitate gas developments (Mozambique, Tanzania …); or
- There is a need to eliminate flaring of gas produced in association with oil production, with investment support under the Global Gas Flaring Reduction partnership and other programs available to transform this zero- or even negative-cost gas into a marketable commodity (Angola is the prime example, with Congo and others needing to follow).

2. Rationale for gas-industry development

2.1. Aims of the study

The initial aims of the study were three-fold:

1. To examine the institutional experiences of the Korean public and private sectors and to familiarize African countries that are considering options for domestic use of regional gas with lessons from the successful experience of Korea. Korea has long and successfully pursued policies to encourage domestication (generalized domestic use) of natural gas;
2. To create a high-level policy tool that maps policy options and trade-offs to permit the use of the Korean gas sector as a guide; and
3. To identify and generate interest among potential private-sector investment partners who can join with entrepreneurs in the new gas-producing countries and lay the foundations for developing the technical and commercial skills needed for the new industry.

As the results of the study indicate, while the economic situation of many sub-Saharan African countries today is not so different from that of Korea in the 1980s, they are much less able to finance gas-industry development. However, conditions in the international gas market are very different today from 30 years ago when Korea took the decision to develop its gas industry and it is now easier to import LNG – notably as the basis for gas-fired power generation – than ever before. Nonetheless, the study has identified a number of policy prerequisites.

2.2. Program context

In 2015, the AfDB unveiled its landmark initiative “The High Fives” to accelerate Africa’s development over the next ten years and within the context of the Bank’s Ten-Year Strategy. Under this initiative, the High-Five priorities are:

- Light up and power Africa;
- Feed Africa;
- Industrialize Africa;
- Integrate Africa; and
- Improve the quality of life for the people of Africa[7].

The 2015 “New Deal on Energy for Africa” has the goal of achieving universal access to energy in Africa by 2025[8]. The Deal focuses on mobilizing support and funding, with the Bank significantly expanding its support to energy. The AfDB provides investment loans, advice on reforms and transactions and guarantees.

Development partners were encouraged to scale up their efforts, while countries should also expand the share of financing going into the energy sector, at the same time demonstrating stronger political will to ensure the success of the Deal. They were encouraged to coordinate their efforts to drive critical policy and regulatory reforms in the energy sector. This study is part of the AfDB’s contribution to the policy-development process.

"Power Africa" is the presidential initiative launched by then US President Barack Obama during his Africa Tour in July 2013[9]. The initiative aims at supporting economic growth and development by increasing access to reliable, affordable and sustainable power in Africa. The AfDB was a key partner in the design of the initiative.

Methodologies for achieving Power Africa goals across sub-Saharan Africa include improving policy environments and the legal and regulatory frameworks related to the electricity and natural gas industries and improving electricity industry planning, including integrated resource planning.

In many ways, the World Bank's Africa Gas Initiative[10] had already led the way with its 2001 main report and country reports for the producing countries of Angola, Cameroon, Congo, Côte d'Ivoire and Gabon. The study aimed to end gas flaring by developing indigenous gas resources for local markets or export, achieving economic benefits through substitution of petroleum products and improving environmental conditions. Institutional and regulatory frameworks and petroleum fiscal legislation were analyzed, resulting in a number of recommendations to governments. Further recommendations included incentives for industry development through rational price structures with the removal of subsidies and ensuring market access.

The initiative has been carried forward and extended by country-specific programs, such as the Global Gas Flaring Partnership assistance to its flagship Angola project and to Congo, guarantees to support gas-field development in Côte d'Ivoire and Ghana and by the Mozambique MAGTAP[11] loan.

The January 2014 Report Harnessing African Natural Gas[12] provided a comprehensive snapshot of natural gas projects and prospects in sub-Saharan Africa. Towards the end of 2016, some of the projects have progressed, while some have stood still and others have receded.

For many countries, the major benefits of natural-gas industry development are achieved through gas use as a fuel for electricity generation. The key to realizing these benefits has remained unchanged since Korea took the first steps to develop its gas industry: consumers pay a price for electricity that reflects the cost of gas supply and the resulting electricity production and delivery. This primarily relates to electricity supplied from the grid, and is addressed in detail in the October 2016 publication Making Power Affordable for Africa and Viable for its Utilities[13].

However, a number of sub-Saharan African countries are in the apparently paradoxical situation of being rich in natural resources but lacking the necessary local or national infrastructure to deliver electricity to its broader population. The World Bank has highlighted[14] the importance of promoting off-grid electrification, particularly from renewable energy sources, for rapidly increasing access to electricity.

Non-renewable resources (minerals, gas and oil) account for the AfDB's (and, therefore, the ANRC's) regional member countries' largest investments. Related projects constitute

the continent's largest contribution to GDP and to national budgets. The aim of the ANRC is therefore to maximize economic value through domestic linkages, cross-boundary infrastructure projects, revenue management and sound investment policy design and implementation.

2.3. Benefits of energy development

Bacon and Kojima, in Energy, Economic Growth and Poverty Reduction"[15], note that, "It is generally believed that an adequate supply of reliable energy is considered essential for economic development." In sub-Saharan Africa, the static demand for energy is essentially for electricity. There is generally a low to negligible household space-heating load with some demand for cooking and water-heating. Thus, with limited residential and commercial demand for gas, the primary focus of any gas-industry development in sub-Saharan Africa is to provide electricity generation.

Income and consumption increase with connection to electricity supplies. The effects on employment can be measured in a number of ways (effects on men and women for hours worked, wage rates, participation) and they appear to be country- and situation-specific[16].

The New Deal on Energy for Africa notes that over 645 million Africans have no access to electricity. Power consumption per capita in sub-Saharan Africa is the lowest of all continents, estimated at 181 kWh per annum, compared with 6,500 kWh in Europe and 13,000 kWh in the United States. Energy-sector bottlenecks and power shortages are estimated to cost African economies about 2-4% of GDP annually, undermining economic growth, employment creation and investment. Children under-perform for lack of electricity, since over 90% of Africa's primary schools lack electricity. Lives are at risk in African hospitals, as potentially life-saving equipment and services remain unused because of power shortages.

A related issue is that of household air pollution. An estimated 600,000 Africans (mostly women and children) die annually due to indoor air pollution associated with the use of fuel wood and other solid fuels for cooking. Fine particulate matter (smaller than 2.5 microns in diameter) is especially harmful to the health of those in close proximity to the cooking source. Policies to reduce household air pollution are being pursued, but it is difficult to evaluate the benefits. Nonetheless, in 2008 Hanna, Duflo & Greenstone[17] undertook a review of the potential benefits. The review covered the use of kerosene for cooking. Reduced use of kerosene (which is sometimes subsidized) reduces the potential for it to be "spiked" into diesel (the same phenomenon that produces sooty discharge from buses and trucks).

The potential economic and social benefits of local content involvement in the exploitation of indigenous gas resources have been well documented, including by the AfDB[18] the World Bank[19] and others. Ovadia provides detailed insight into how petroleum development impacts an economy and society[20]. Of course, in order to develop indigenous reserves, they must be discovered in the first place.

Bacon & Kojima[21] note that, "The establishment of a link between increased energy use and the growth of an economy is relevant for many energy-sector projects. Projects designed to increase capacity, whether of generation, transmission, or distribution of electricity (including increasing access), or that develop oil or gas deposits, are intended to have as one consequence the facilitation of increased energy production and consumption. If increased energy use leads to increased output (growth) of an economy, then to the extent that increased economic output leads to poverty reduction, there is a link between these energy projects and poverty reduction."

3. Korea – the decision to develop a gas industry

3.1. The policy context of the decision to import liquefied natural gas

In 1981, Korea was the world's fourth-largest debtor country and in the midst of an economic crisis. Output had halved and the year before inflation had been 28.7%[22]. Against this background, the second oil shock from 1979 took crude oil prices to USD 38/bbl (nearly USD 120/bbl in 2016 terms)[23]. This happened at a time when some 58% of Korea's primary energy was derived from imported oil[24], much of which originated in the Middle East. In 1980 and 1981, some 80% of Korea's electricity was generated from heavy fuel oil (HFO) and diesel. However, by 1985, and before the arrival of the first shipment of LNG, the percentage generated from oil was already down to around 34%. Nuclear power stations were commissioned and HFO was displaced by coal, even though electricity production increased by some 44% during the same period.

At this time, oil products were being used to manufacture gas for distribution to consumers via established city gas networks. By 1985, Korea was producing some 77 million m3 of such gas through LPG/air and naphtha cracking plants – equivalent to some 55,000 tons of LNG. During the latter part of the 20th century and into the 21st century, natural gas was regarded as the fuel of choice for space and water heating in cold-climate regions. The technology was typically household-based boilers, on the basis of both cost and convenience, and, with a few exceptions, district heating schemes were considered expensive to install and inefficient. It is only since the beginning of the 21st century that heat-pump technology has provided an economic and sustainable alternative to distributed gas-fired boilers for space heating, and solar water-heating has been adopted on a large-scale.

Indonesia started producing and exporting LNG to Japan in 1977 and had proved to be a reliable supplier, selling LNG at a price guaranteed to be lower than oil on a delivered energy unit basis. Under the 'S' curve oil price indexation formula applied in Indonesian contracts, the seller was protected from the impact of low oil prices and the buyer was protected from the impact of high oil prices.

This was also a time of political change in Korea. The new government continued to borrow on international markets in order to invest in export-oriented industries which, in turn, facilitated repayment of the debt. Korea's international trade was growing in the mid-1980s and by 1986 the economy was booming, inflationary difficulties had been resolved and there was a substantial trade surplus. In contrast to many of the other large indebted developing countries negotiating rescheduling arrangements with their creditors, Korea not only met all debt-service obligations, but was in a position actually to reduce its debt

stock by USD 2.25 billion[25]. It is noteworthy that the debt had been carefully monitored by the Ministry of Finance since the borrowing began in the early 1960s, with approval required for all loans[26].

Against this background, an economically strong Republic of Korea made the policy decision to commit to the long-term importation of LNG as a reliable and relatively cheap component of its energy mix.

3.2. Exploration & production history

In the search for hydrocarbon reserves, oil companies such as Gulf and the Shell Corporation explored Korea's shallow waters between 1970 and 1982, after which the Korea National Oil Corporation (KNOC) began working in the area alone, acquiring 2D and 3D seismic data and drilling 45 wells[27].

In 1998 KNOC finally discovered a commercially viable gas field in Block 6-1, named Donghae-1, in the East Sea. The discovery, about 60 km southeast of Ulsan, had total proven reserves of around 250 bcf of natural gas. Although not huge, the gas field was the first commercial hydrocarbon development in Korea.

The development of deep-water exploration and production techniques attracted interest in previously unconsidered offshore areas as, indeed, it has in some African countries. Since 2007, KNOC, together with various international oil company (IOC) partners, has explored the offshore area, including the Ulleung, Yellow and Jeju sedimentary basins. It is considered that the Ulleung basin contains commercially viable gas hydrate deposits[28] but, by the end of 2016, no commercial developments had been publicly announced.

Korea has become the second largest LNG importer in the world, second only to Japan (and KOGAS is the world's largest LNG importing entity). In 2015, it imported some 33.4 million tons of LNG (equivalent to some 46 billion m3 of natural gas) representing some 13.4% of the global LNG market[29].

3.3. Policy implementation

The Korean gas-industry policy was implemented through:

- The Korea Gas Corporation Act of 31 December 1982[30], which established the Korea Gas Corporation (KOGAS) under a "single-buyer" market model, as a state-owned entity with responsibilities including the construction of natural-gas receiving terminals and supply networks, as well as the supply of natural gas and LNG;
- The City Gas Business Act of 31 December 1983[31], which provided for the extension and development of urban gas businesses of economic scale appropriate for the public interest and general demand;
- The signature of a 20-year contract with Indonesia to import 2 million tons of LNG every year, largely for power generation, with the first delivery in 1986; and
- The start, in 1987, of natural gas (from LNG) distribution and supply via the city gas network in the Seoul metropolitan area.

4. Korea – gas industry development & ownership

4.1. Gas infrastructure development

4.1.1. Introduction

Korea's gas infrastructure development was substantially driven by the "Natural Gas National Supply Program Master Plan", which was adopted in 1990. The effective implementation of this plan resulted in the development of Korea's national gas infrastructure, comprising importation and regasification terminals, high-pressure gas-transmission pipelines delivering large volumes of gas to power stations and other bulk gas consumers, and the major expansion of low-pressure city gas networks, which resulted in the supply of natural gas to 10 million households by the end of 2003.

4.1.2. LNG import & re-gasification terminals

KOGAS' website[32] sets out the history of the initial development of Korea's LNG import terminals and high-pressure gas transmission system.

Korea's first LNG import/regasification terminal at Pyeongtaek became operational in 1986. In 2016, Korea had five operating LNG import/regasification terminals with a sixth due to be commissioned in 2017 and a major expansion of KOGAS's terminal at Incheon underway.

4.1.3. Gas transmission

Through KOGAS, the government has pursued a policy of continuing to develop a high-pressure, national gas transportation system until around 2015, when it was deemed uneconomic to extend the system to smaller communities. At that point, the high-pressure gas transmission system amounted to some 4,065 km[33].

Those communities that were deemed too remote for economic connection to the national transmission system would be supplied using LPG but, as elsewhere, are of interest to those offering renewable energy solutions.

4.1.4. City gas distribution

The decision of the government to commit to long-term LNG imports was made easier by the existence of city gas networks distributing manufactured gas to households, commercial and smaller industrial consumers.

During the last quarter of the 20th century, gas-fired, household-based boilers were regarded as the preferred solution for space and water heating in cold-climate regions. As with many other countries, the key for Korea, therefore, was to make gas available at the household level. In order to scale up city gas distribution, the government provided loans for the installation of city gas facilities with the "Oil Project Fund" from 1987. This fund became the "Energy and Resources Project Special Accounting" initiative in 1995 with a stronger focus on support for gas pipeline construction.

The City Gas Business Act of 1983 requires city gas companies to submit a non-binding 5-year supply plan every year to its relevant regional government. It is considered that the design and implementation of the tariff structure (discussed below) provides the incentives necessary for the continuing development of city gas networks.

4.2. Gas consumption growth

The data in Appendix A shows that Korea's primary energy consumption in the mid-2010s is around five times that of the mid-1980s. Natural-gas consumption has increased from zero in 1985 to around 16% of total primary energy supply today.

Nearly 50% of imported LNG is used in power stations, with over 20% of Korea's electricity now generated from gas. Meanwhile, the policy of extending the coverage of city gas networks, essentially in order to deliver gas for space heating[34], has driven the growth in gas consumption by household and commercial/public-sector consumers. Around 40% of gas currently delivered via city gas networks is used by manufacturing businesses.

4.3. Gas supply

In order to achieve effective natural-gas supply, the government has developed a "Long-term natural-gas supply and demand plan" every two years since 1992. The most recent plan was announced end-2015 and included a projection of gas demand by sector to 2029.

Incremental volumes of LNG have been procured from an international mix of new gas developments, including Qatar, Oman, Malaysia and Australia, with Korean industry benefiting from contracts under the development projects.

4.4. Gas industry ownership

4.4.1. Introduction

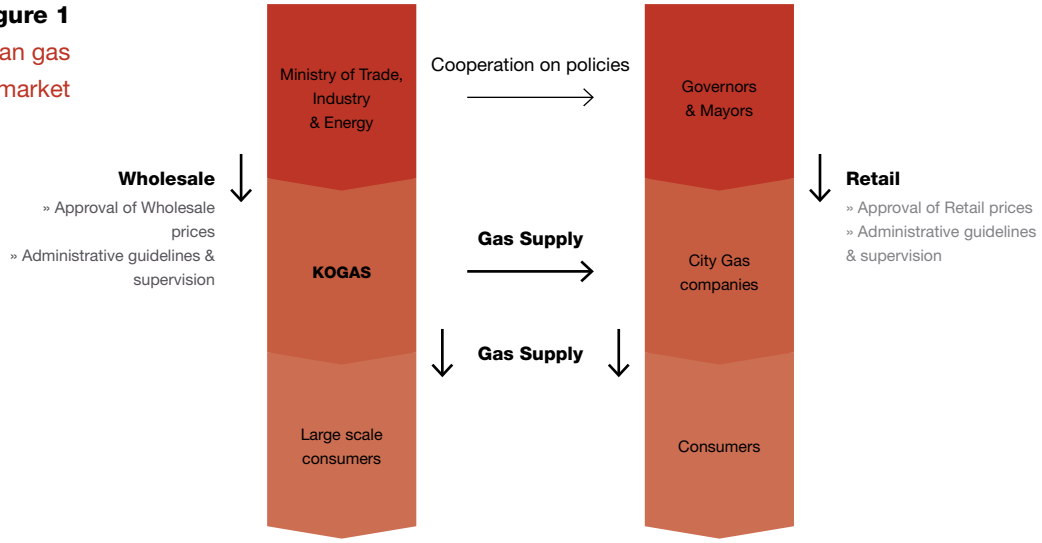
Four of the six LNG import terminals are owned and operated by KOGAS. The Gwangyang terminal is owned and operated by the private company POSCO (originally Pohang Iron & Steel Company), while the Boryeong terminal, due to be fully operational in July 2019, is owned by a joint venture of SK E&S Co and GS Energy. The main motive for the construction of the two private terminals is to generate competition in the gas market and reduce other price distortions that were seen to be increasing costs in the supply chain.

Figure 4.1 describes KOGAS' role in the Korean gas market in 2016. However, the government plans to start introducing competition to the wholesale gas market from 2025 when some 9 mtpa of LNG import contracts will have expired and not necessarily renewed by KOGAS. Regulated tariffs for LNG terminal and transmission-pipeline services will be introduced, while KOGAS is likely to be unbundled into separate trading and infrastructure companies.

4.4.2. Korea Gas Corporation

KOGAS was established in August 1983 under the 1982 Korea Gas Corporation Act with the purpose of "…promoting convenience in the lives of citizens and improving public welfare by...the stable long-term supply of gas."[35] The Corporation has been listed on the Korea stock exchange since 1999 but the government controls the majority of its shares. The gas industry was essentially developed during the period when KOGAS was wholly-owned by the Government of Korea.

Figure 1
KOGAS' role in the Korean gas market



When KOGAS was established, many of its initial commercial staff came from the existing electricity company KEPCO, bringing their experience of procuring coal and oil products. Additional technical expertise for the development of its LNG terminals and transmission system came from France.

KOGAS holds the LNG Sales & Purchase Agreements (SPAs) under which Korea imports the bulk of its LNG. At the end of 2016, KOGAS owned and operated its 4 LNG import/regasification terminals (Pyeongtaek, Incheon, Tongyeong, Samcheok) and was expanding storage capacity at the Incheon terminal. It also owns and operates the 4,440 km nationwide gas transmission network and sells gas to city gas companies and bulk consumers, including power generators, on the basis of a regulated wholesale price.

Following a policy decision by the then government, intended as a "hedge" for the internal market, KOGAS made a series of overseas investments between 2008 and 2012. In Africa, KOGAS has a 10% interest in the Eni-led Area 4 concession in Mozambique's Rovuma Basin.

In addition to its investments, KOGAS is also providing technical services to the development of LNG regasification terminals in Mexico, Thailand, Singapore, China and the Middle East.

4.4.3. KEPCO

The Korea Electric Power Corporation (KEPCO), as with KOGAS, is listed on the Korea stock exchange but the government controlls the majority of its shares. KEPCO carries out power generation, electricity transmission and distribution, electricity-related research and research related to the industry.

4.4.4. KNOC

Korea National Oil Corporation (KNOC) is the state-owned oil company established (as Petroleum Development Corporation) in 1989 to undertake petroleum exploration and

provide secure oil supplies. It has exploration and production interests in numerous countries, including Libya and Nigeria.

4.4.5. Private-sector operators

POSCO owns and operates the Gwangyang onshore LNG terminal, originally built to supply gas to its own generating plant and a plant belonging to K-Power (now part of SK E&S Co).

SK E&S Co. was established in 1999 as a joint venture between the Korean SK Group and Enron Corporation. By 2016, it had a number of LNG interests through investment and offtake contracts and was active in the LNG market. Its Boryeong LNG import and regasification terminal is jointly being constructed with GS Energy. SK E&S operates seven city gas subsidiaries.

GS Energy is a Korean electricity-generation company that also has international exploration and production interests. It operates two city gas companies.

4.4.6. City gas companies

There are some 33 privately operated city gas companies, of which 29 supply natural gas purchased from KOGAS and the remainder are LPG-based. They distribute and supply gas to the residential and commercial sectors, as well as to smaller units not connected directly to KOGAS' transmission system.

4.5. Gas-use development

The development of Korea's primary energy-supply mix and gas consumption since 1985 is shown in Appendix A alongside projected future consumption. In 1990, five years after the first import of LNG, some 75% of gas was being used for electricity generation, with most of the remainder's being distributed via city gas networks. By 2014, only 47% of imported gas was used for electricity generation, whereas over 30% was distributed via city gas networks and nearly 3% was used for transport.

The decline in the amount of gas used for electricity generation[36] is expected to continue as new nuclear plants are commissioned[37] and renewable-energy solutions are adopted. However, gas distributed via city gas networks is projected to grow at around 2% per year to 2029.

5. Gas policy & regulation in Korea

5.1. Policy-making institutions[38]

The Ministry of Trade, Industry & Energy (MOTIE), previously the Ministry of Knowledge Economy, is responsible for energy policy planning, supervision of the sector, climate-change policy, resource development, energy savings and other matters relating to energy policy.

The Ministry of Environment (MOE) oversees energy-related environmental policy, including the implementation of measures related to climate change.

The Korea Energy Economics Institute (KEEI) was established in 1986[39] and in 1999 joined the government-funded Korea Council of Economic & Social Research Institutes (KCESRI). KEEI analyses overall energy policy and provides sector-specific advice for oil, gas, electricity and renewables – as well as strategies for green growth and climate change. KEEI also provides statistics, outlooks for energy supply and demand, and develops strategies for international energy co-operation.

5.2. Other institutions

5.2.1. Korea Electricity Commission (KOREC)

KOREC is the regulator for the electricity industry and was established in April 2001 under the 2000 Electricity Business Act to ensure a smooth transition to a competitive and well-functioning electricity market. The Commission consists of up to nine members appointed by the President of Korea who also appoints the Chair on the nomination of the Minister of Trade, Industry & Energy. KOREC is affiliated to MOTIE and receives no independent funding. It oversees matters related to the licensing of market participants, the market structure and approves electricity tariffs. KOREC may act as an arbitrator between electricity companies and consumers.

5.2.2. Korea Institute for Energy Research (KIER)

KIER was founded in 1977 and focuses on energy-technology research and development (R&D) related to living standards and the security of supply to resource-poor Korea[40]. Its R&D areas include improving efficiency and the environmentally friendly use of fossil fuels, as well renewable-resource development. KIER seeks to commercialize its research through the marketing of intellectual property rights, onward development by Korean industry and technology transfer.

5.2.3. Korea Association for Natural Gas Vehicles (KANGV)

KANGV is an incorporated not-for-profit association founded in 1998 under the control of the Korean Ministry of Environment. The association promotes the use of natural gas as a clean alternative fuel for transportation in order to improve air quality[41]. It acts on behalf of its nearly 50 public- and private-sector members in international cooperation and joint ventures.

5.3. The policy-making process

The Government of Korea has traditionally taken a firm “hands-on” approach to managing the economy and to determining and implementing energy-sector policy. This has been achieved through a strong forecasting and planning capability, followed by close monitoring and evaluation.

Korean legislation provides for the establishment of a national basic plan for energy every five years, to be implemented over a period of 20 years. The law provides that the plan shall be decided after consultation has been made with the head of a relevant central administrative agency and the national energy committee has examined it.

The purpose of each plan is to propose the direction of future-oriented energy policies and determine mid- and long-term strategies for security of energy, infrastructure development and the efficient use of energy required for economic development. The plan should also include policies to minimize the environmental impact of energy use and propose policies to promote the development of energy-related technologies.

Every 2 years, MOTIE develops a 15-year forward plan for energy supply and demand for Korea. The plan is presented at 3 levels:

1. Primary Energy Balance
2. Electricity Balance
3. Gas Balance

Of these, the first two are presented to the National Assembly but do not require its formal approval. The Gas Balance only requires the approval of the Minister of Trade, Industry & Energy. All plans are published.

5.4. Current policy

The January 2014 Second Korea Energy Master Plan[42] provided a frank assessment of the drawbacks of Korea's energy policies at the time, including:

- A low-price policy motivated by social and economic concerns has reinforced energy overconsumption and accelerated the trend toward disproportionate use of certain types of energy including electricity. This is particularly relevant to the pricing of electricity produced from nuclear plants;
- Low electricity prices reduce incentives for the creation of new markets in less economical areas such as renewable energy and development of a smart grid;
- The current energy mix is based on economic feasibility without giving sufficient consideration to external effects. There should be a reassessment of external effects, such as environmental pollution caused by nuclear and coal-fired plants, public safety concerns and opposition from local residents; and
- In place of determined measures to curb demand, the large-scale, centralized supply infrastructure (the unified power grid) was expanded.

In response, the government identified six major tasks.

Task 1 – Transition to energy policies focused on demand management

Objective: Reduce electricity demand by 15% by 2035;

Main actions: Adjust energy tax rates, improve the electricity-tariff system, establish a demand-management system based on information and control technologies.

Task 2 – Build a distributed generation system

- Objective: Supply more than 15% of power from distributed generation by 2035.
- Main actions: Detect transmission constraints in advance, expand distributed generation, etc.

Task 3 – Strike a balance with environmental and safety concerns

- Objective: Apply the latest greenhouse-gas-reduction technology to new power plants;
- Main actions: Strengthen climate-change response, enhance nuclear safety, etc.

Task 4 – Enhance energy security and energy-supply stability

- Objective: Build overseas-resource development capacity and achieve a renewable-energy deployment rate of 11%;
- Main actions: Reinforce public resource-development enterprises, expand renewable-energy deployment, enhance international cooperation, etc.

Task 5 – Establish a stable supply system for each energy source

- Objective: Secure a stable supply of conventional energy sources, such as oil and gas;
- Main actions: Diversify supply routes, expand domestic stockpiling capacity, etc.

Task 6 – Shape energy policy to reflect public opinion

- Objective: Introduce an “Energy Voucher System” in 2015
- Main actions: Improve energy welfare, respond pro-actively to energy-related controversies, etc.

5.5. Environmental and social objectives

Korea is a relatively densely-populated country. In the 1990s, with the economy growing and people living in close proximity to industry, concerns about air pollution increased. Vehicles were identified as a major source of pollution and measures to promote the use of compressed natural gas (CNG) were introduced. The 1993 High-Pressure Gas Safety Control Act (amended in 2016) instituted technical standards for establishing CNG fuelling stations, fuel containers and fuel systems[43]. The 1998 Clean Air Conservation Act established permissible emission standards for newly manufactured vehicles.

The 2003 Special Act on the Improvement of Air Quality in Seoul Metropolitan Area came into force in 2005. Measures under this law included projects to lower exhaust gases from vehicles, administration of emission facilities and controls over energy utilities, as well as the introduction of a pollutant cap-and-trade system.

The government introduced a number of fiscal measures to promote the use of CNG, targeting fueling-station owners and bus and garbage-truck operators. By 2014 there were some 200 CNG fuelling stations and over 40,000 natural gas vehicles, mostly buses[44].

The use of LPG as a transport fuel was also promoted through legislation, that obliged all taxis to use LPG as fuel (although passenger cars were prevented from using LPG). There are over 200 LPG cylinder-filling stations and over 1,000 vehicle-filling stations, as well as a number of bulk suppliers.

Government policies and the promotion of natural gas vehicles by KANGV meant that by 2012, air-particulate (PM10) levels in Seoul were two-thirds those of 2000. However, concern over the volumes of LPG imports for taxis led to consideration of a return to the use of diesel-fuelled taxis in 2015. The ministry reasoned that, since all diesel taxis will be required to meet Euro-6 standards, there should be no adverse environmental impact as a result of the switch back from LPG[45].

Korean safety legislation prohibits the installation of CNG storage tanks in vehicle passenger compartments, which means that microbuses continue to be fuelled with diesel. CNG has, however, successfully been introduced for taxis and smaller vehicles in Egypt, China and Iran.

There are no plans for the generalized introduction of LNG as a transport fuel, other than as fuel for ships (the government has declared its interest in creating an LNG bunkering hub as the demand for LNG domestically declines and the world glut of the fuel continues)[46].

The development of city gas distribution networks brought health and social benefits through the elimination of coal “yeontan” (briquettes) as fuel for cooking and heating. Yeontan were polluting homes and were a source of potential carbon-monoxide poisoning.

5.6. Gas industry legislation and regulation

The Korean legal system is based the Japanese one but since 1945 a number of aspects of the US system have been adopted. In particular, while the legal codes (civil, commercial and criminal) form the basis for most decisions, the rulings of the Supreme Court of Korea have strong precedent value[47].

In contrast to electricity, there is currently no regulator for the gas industry. With the planned introduction of wholesale competition in the gas market from 2025, it is likely that some formal process for dispute resolution will be introduced, possibly through extending KOREC’s remit. It is considered unlikely that government will allow any regulatory decision to be tested in the courts.

5.7. Legislation and regulation: best international practice

The development of the gas industry in Korea began in the 1980s as a result of policy decisions and direct implementation by the government. Security of competitively-priced energy imports was a key driver of the policy and the government provided sovereign guarantees to underwrite long-term LNG import contracts.

The 1980s state-owned gas-industry model is still in operation in 2016. However, the nature of gas markets in other countries and regions (notably the US and EU) has evolved. Elsewhere, competitive markets operate through the separation of gas trading from national monopoly infrastructure activities, overseen by independent regulation.

The reliance on gas imports and the historical need to enter into long-term LNG contracts has meant that the process of industry restructuring and regulation familiar to North American and European markets is only now being introduced into Korea and Japan. According to the IEA in 2012, the 2008-2013 subsidies to city gas consumers and the

cross-subsidy of household gas consumers by industrial consumers meant that "gas prices for the industrial sector in Korea tend(ed) to be higher than elsewhere in the OECD[48]."

It is likely that that market-based prices in Korea will be introduced for large customers in the first instance starting in 2025 when some of KOGAS's important contracts will have expired. Regulated tariffs for LNG terminal and transmission pipeline services will replace the current system of negotiated access and, according to the government plan, KOGAS should be unbundled into trading and infrastructure companies.

Failure to adopt best international practice in the structure and regulation of the gas industry will lead to further basically uneconomic private-sector investments in gas infrastructure supported by subsidized prices that will only introduce artificial competition. This is hardly a sustainable policy in the long term.

5.8. Wholesale tariffs[49]

In 2016, the regulated wholesale gas tariff was composed of the commodity cost plus a supply margin based on the operating costs of KOGAS. The commodity costs include the price of LNG, transport expenses, insurance premiums, taxes and import duties. The supply margins are made up of KOGAS's supply costs plus guaranteed returns divided by target volumes, which are decided by MOTIE after consultation with KOGAS and the Ministry of Strategy and Finance (MOSF). It is not clear to what extent minority shareholders are able to influence this process.

The final tariff is subject to approval by the Minister of Trade, Industry & Energy, following discussion by the natural gas wholesale pricing committee and arrangements with MOSF. The wholesale pricing system allows KOGAS to pass its LNG costs onto consumers while the supply margin provides a guaranteed operating income to the company.

The cost of gas used in the power industry is adjusted monthly according to gas tariff policy by adding together the weighted average cost of gas (WACOG), including import costs and any related cost based on the planned volume of LNG procurement.

5.9. Korea's experience of intervening in wholesale tariffs

Between March 2008 and February 2013, the government disconnected the direct link between the LNG import price and the city gas price. It only allowed some of KOGAS's increased LNG costs to be recovered in the wholesale price charged to city gas companies – and therefore in the gas price to final consumers. This "disconnection" was made under the Minister of Trade, Industry & Energy's authority to soften the impact of international market conditions on consumers.

However, the wholesale price of gas to electricity generators (and other bulk industrial consumers) remained connected to the imported cost of LNG and passed through to electricity consumers. This was in contrast to the low price set for electricity produced by nuclear generation and raised the concerns of policy makers.

During the delinking period, crude oil went to over USD 100/bbl before falling as a result of the 2008 financial crisis. Prices then grew again averaging over USD 85/bbl in 2011, 2012 and 2013. Indexed to oil, but smoothed and lagged, LNG import prices to the Asia-Pacific market mirrored these price trends, reaching over USD 15/MMBtu in late 2008 before falling to well below USD 10/MMBtu in 2009 and averaging above USD 6/MMBtu in 2011, 2012 and 2013[50]. During this period of government intervention the deficit accumulated in KOGAS's accounts peaked at slightly more than 5.7 trillion KRW (around USD 5 billion) in October 2012.

Such subsidies were unsustainable, particularly as they had the unintended consequence of increasing city gas consumption as small and medium industries switched to cheaper gas from petroleum products. When international LNG prices finally fell, KOGAS's wholesale price to city gas companies failed to reflect it because the company was recovering its accrued losses. This increased calls to open the Korean gas market to greater competition.

5.10. Retail gas tariffs[51]

City gas prices are generally adjusted every two months, but the range of adjustment must be within 3% of the previous price. The tariff, based on KOGAS's wholesale price plus local distribution costs, is subject to approval by the mayor or governor through a local price-level consultation committee. In practice, it is considered that there is some cross-subsidy of household gas consumers by industry, although the level of the cross-subsidy varies between different city gas companies.

Best regulatory practice requires cost-based tariffs to be charged, which means that tariffs in less-densely populated areas are typically higher than in more populated areas (as unit infrastructure costs are greater) and that all gas delivered from the same pressure level of the network is charged at the same price, irrespective of its subsequent use. In Korea, however, every MJ of city gas is sold at the same price within the same usage category, e.g. households, commercial, industrial or transportation. This requires each meter to be "categorized" and means that two adjacent buildings with identical supply costs can pay different tariffs.

This has the potential to distort decisions regarding network extension. It is understood that the rate of return on investment and operating costs city gas companies are allowed by the provincial governments to recover through revenue is sufficient to encourage continuing network investment and greater gas volumes to be delivered. Where there is already a sizeable mature gas distribution network, it is usual for extensions to be made without increasing (and sometimes even decreasing) existing tariffs. If the cost of extending a distribution network would require a tariff increase for existing consumers, then this usually implies that some expensive high pressure pipe is required, which is better charged as a transmission, rather than a distribution tariff.

Korea does not have a system of "lifeline" tariffs under which a basic volume of gas to provide heat and cooking sufficient to maintain life is charged at zero or low cost. Instead, city gas companies are required to offer significant discounts to specific customers, such as low-income households, households that include people who are disabled or

of national merit and social-welfare facilities. Details of all city gas tariffs in Korea are published by the Korea City Gas Association[52].

Best modern billing practice includes the installation of smart meters that can be read remotely, electronic billing and direct bank-account debit payments. Smart meters can be used in conjunction with pre-payment systems where credit risk is an issue.

6. The international gas market & the bases for gas-industry development in Africa

6.1. Introduction

While there are some similarities between Korea in the mid-1980s and African countries' economic circumstances today, as they consider initial gas-industry development, the nature of the 2017 international LNG market is very different.

6.2. International LNG market

In the 1980s, the LNG market was seen as a "chain", typically characterized as:

Gas reserve development › liquefaction/export › LNG shipping › onshore LNG import/ storage/re-gasification › gas transmission › power generation/other gas-use › gas/ electricity consumption.

Project finance was introduced at each link in the chain, so the main concern of developers and lenders was the fundamental economic integrity of the entire chain, ultimately depending on electricity consumers' ability to pay prices that reflected the costs of the entire process. The result was long-term (often 25 years) and, therefore, predictable LNG contracts that committed buyers to importing LNG on the basis of oil-indexed prices, often tempered by a price "collar" that limited risk.

However, as initial contracts expired and certainly since around 2000, increasing volumes of LNG have been traded on a spot basis, such that by around 2010 over 20%[53] of all LNG trades were on a spot or short-term contract basis. The 2013 commissioning of the Angolan LNG liquefaction plant as a "merchant plant" selling LNG produced from previously flared oil-field natural gas on a cargo-by-cargo basis continued this trend. The ability of LNG buyers to re-direct and re-sell cargoes, as a result of competition regulation or commercial negotiation has led to the development of the international LNG market.

The Asia-Pacific region is the largest LNG-import market and Korea, Japan, China and Taiwan accounted for some 61% of the 2016 trade. LNG spot-price indices are now being published, one of which is the ICIS EAX based on average delivery prices to these four countries[54]. The FOB Singapore SGX LNG Index Group (SLNG) publishes spot-price indices for the region and gas/LNG trading platforms have been established in Shanghai and Tokyo[55].

The emergence of gas-trading hubs (physical or virtual) has the potential to transform Asian natural-gas markets from the traditional long-term SPAs at an oil-indexed price. If trading hubs develop sufficient liquidity, they will have the potential to establish a reference price for LNG and provide a basis for the development of hedging and other risk-management instruments.

The development of "fracking" technologies and the ability of the United States to produce gas from unconventional sources is considered to have been the "game changer" for the LNG supply and demand balance and, hence, market prices. Prior to 1998 shale-gas production did not exist but, by 2012, production in the United States of almost 8 trillion cubic feet/year (226 billion cubic meters/year) of shale gas amounted to one-third of US total gas production and more than 7% of global production, turning the country from an importer to an exporter[56].

The impact was a drop in prices on the key Henry Hub gas-trading center. US export liquefaction plants, such as Cheniere[57], have received regulatory approval and are under construction. Short- and medium-term LNG cargoes are now available FOB or DAT[58] on the basis of Henry Hub gas price plus fixed liquefaction and shipping charges.

In early 2017, the international LNG market was very close to providing published trading hub price data, which can be used as a reference for both Africa's existing and potentially gas-exporting countries (Mozambique and Tanzania), as well as for its potentially gas-importing countries.

Many analysts consider that US LNG exports and the development of new LNG export projects such as those in East Africa will serve to keep international prices at a level that makes LNG imports a competitive energy option for many countries. The number of opportunities for the development of gas reserves far exceeds the availability of capital for their realization, so that investment decisions will be highly project-specific. For gas-importing countries, however, competitive prices, the availability of LNG tankers and falling prices for FSUs/FRSUs (see below) is good news that brings the concept of cheap, flexible, gas-fired electricity generation ("LNG-to-power") closer to feasibility.

6.3. Floating storage and re-gasification units (FSRUs)

The development of floating storage and regasification unit (FSRU) and floating storage unit (FSU) technology has also meant that importing countries now have policy options not available to Korea in the mid-1980s. The ability to convert disused LNG carriers to FSUs and FSRUs and make them available for lease on daily terms has eliminated the need for a large up-front investment in onshore storage facilities. The availability of relatively short-duration leasing contracts and the ability to "sail away" the FSRU in the event of default or excess storage capacity has served to reduce risks for importers, investors and lenders, alike. An onshore LNG terminal has a capital cost of around USD 1 billion, whereas the capital cost of an FSRU may only amount to some USD 150 million for jetty and connection infrastructure. The floating unit will incur an additional daily leasing fee reflecting international market conditions that could rise to USD 120,000/day[59].

However, the use of an FSRU imposes significant operational constraints, as the capacity of the FSRU's storage is usually not much more than that of the delivering LNG tanker. As a result, the window "for delivering an LNG cargo may be quite narrow. Delivering a part-cargo may well increase costs. The key is predictability. Where re-gasified LNG is used for base-load power generation, the delivery window can reasonably be predicted. However, as the level of renewable generation increases, so gas-fired generation is being used in more of a mid-merit role – and the delivery window more difficult to predict. Flexibility on

the supply side has therefore become more important and served to strengthen the role of aggregators.

In the longer term, the operational constraints imposed by the use of an FSRU are likely to reduce the potential for competition in the wholesale gas market, unless a market has more than one entry point, as is the case with Korea. In 2016, the Toscana facility, offshore Livorno in Italy, is believed to be the only FSRU offering third party access, and that is because it is significantly under-utilized. Where an FSRU supplies financed gas-fired generation, fuel-holding requirements may narrow the LNG delivery window further, and interested parties have noted the requirement of the South African Department of Energy to provide for third party access (TPA) to the FSRU in its LNG-to-Power procurement program announced in October 2016.[60]"

6.4. The role of aggregators

A number of companies, including Shell/BG, BP, Total, Gazprom, GDF Suez and Gas Natural Fenosa, have established aggregator businesses under which they acquire LNG from a number of projects – usually on a long-term basis – and commit to the supply of LNG from this portfolio to a number of buyers. The advantage for the buyers is that the aggregator has access to a number of supply sources which reduces the delivery risk. An aggregator can also be more flexible on the timing of the start of deliveries, since it is not dependent on the completion of construction of a new project where there is a risk of a delay in start-up. An aggregator may be able to offer buyers a more flexible contract in terms of the volume of LNG to be delivered and the timing of deliveries, since it can manage such contractual issues within its overall portfolio. Aggregators generally want to expand the number of buyers in their portfolios. They have been active bidders when new buyers have tendered for supply.

6.5. The basis for gas-industry development in Africa

While the price and availability of LNG makes it a competitive energy option for countries without sufficient indigenous production, it needs to be viewed in the context of the overall national energy requirement. The primary requirement in African countres is to deliver electricity to as much of the population as possible. The development of a gas industry as can be part of satisfying this requirement but it needs to be seen in the context of a number of other factors including the location of demand centers, existing infrastructure, alternative generation options (including hydro), renewable generation technologies (solar, wind …), environmental factors, national budget and balance-of-payments issues and current energy prices/tariffs.

A number of African countries are endowed with significant gas reserves, which have yet to be developed or to be developed to their full potential. In many cases, this is "wet" gas containing butane and propane (LPG), which can be produced and distributed to off-grid locations in order to improve energy access and bring health and environmental benefits by displacing the burning of biomass. LPG can represent a "bridging" fuel between the use of biomass and the reliable supply of natural gas or electricity. However, for countries without their own reserves and where LPG is imported, it is subject to international oil price movements, plus shipping and handling costs, making it a potentially expensive fuel. The World Bank's USD 1.5 billion Egypt Household Natural Gas Connection Project,

has the objective of distributing piped natural gas to poor households for cooking in order to displace imported LPG.

In 1981, Korea's GDP per capita was around USD 2,000, which is not markedly different from many African countries in 2017, especially when climate differences and the lack of a need to pay for heating is considered. However, unlike today's African countries, in the early 1980s Korea was in the process of developing its heavy industrial base.

Another major difference is that, whereas Korea was able to continue borrowing on international financial markets, many African countries find it difficult to raise capital, including for gas reserves and gas-infrastructure development. As a consequence, most gas-industry development in sub-Saharan Africa is project-financed and undertaken on the basis of a contractual legal framework and not a legislative one as in Korea.

6.6. Significant proposed gas-reserve developments

The high production cost of Africa's deep-water gas typically renders uneconomic the development of capital- and energy-intensive gas-use technologies, such as gas-to-liquids (GTL) and methanol and fertilizer production, where international prices are typically set by low-cost Middle Eastern gas production. However, there is potential for gas exports and the development of domestic gas markets.

6.6.1. Egypt

Egypt became a major gas producer and exporter in the early 2000s and three LNG liquefaction plants were commissioned in 2005. However, policies of supplying gas to the internal market at below international price levels, together with low end-user electricity prices, stimulated demand for gas for both electricity generation and use in energy-intensive industries. Rapidly increasing internal demand for gas has led to the suspension of LNG exports and, in October 2016, Egypt announced a record tender for 96 cargoes of LNG to be imported in 2017 and 2018. However, it is hoped that the development of gas discoveries – especially the super-giant Zohr field – will eliminate the need for gas imports by the early 2020s.

A program of gas-market reform is currently being implemented by the government accompanied by a significant reduction in the level of energy subsidies. This is part of the economic reform supported by the IMF's November 2016[61] approval of a three-year USD 12 billion loan. Reducing energy subsidies will lead to higher wholesale and end-user prices for gas, facilitating development and helping to secure the financial viability of the gas industry.

6.6.2. Mozambique

On 1st June 2017 contracts were signed for development of the Eni-operated Area 4 Coral gas reserve (in which KOGAS has a 10% interest) using floating-liquefaction technology[62]. A joint Plan of Development (POD) with the neighboring Anadarko-led Area 1 concession was agreed in early 2017 providing for development of a common onshore liquefaction and LNG export facility. Delivery of natural gas to shore could encourage development of a domestic gas market.

Detailed studies of the opportunities for Rovuma Basin gas to support regional employment-generating industrial, commercial and agricultural development, based on the availability of natural gas and gas-fired electricity generation, have been delayed by the 2016 emergence of undeclared loans obtained by the government.

In the south of Mozambique, however, KOGAS is investing in gas transmission and distribution infrastructures in the Maputo/Matola area. KANGV has promoted the use of natural gas vehicles in the area, but Mozambique has limited administrative resources and other major priorities, so gas-fuelled transport remains a future option.

6.6.3. Tanzania

Development plans for Tanzania's major offshore gas reserves are reported[63] to be progressing, with 2017 expected to be a key year for negotiations between the government and IOCs over the proposed development of an LNG-export facility of up to 20 mtpa, development of the domestic gas market and the potential for gas exports to neighboring countries. Whether agreements can be concluded for the pipeline export of Tanzanian gas to neighboring countries could be a test of the feasibility of sustainable intra-Africa gas trade.

6.6.4. Nigeria

Not to be overlooked, the energy-sector reforms currently being formulated and implemented by President Buhari's administration may yet lead to the development of the country's discovered but neglected gas reserves, with a very significant increase in both gas and electricity production the result.

6.7. Significant proposed gas import developments

The ability to buy LNG on a cargo-by-cargo basis, to lease an FSRU and to have an aggregator manage the whole process have resulted in a number of LNG import proposals by African countries.

6.7.1. Ghana

Ghana is reported[64] to have an FSRU on lease but has yet to receive an LNG delivery. It is not yet clear whether the FSRU is only an interim measure until more indigenous gas production is delivered to the market or whether the FSRU will become part of a longer-term, possibly regional energy solution.

6.7.2. Côte d'Ivoire

Côte d'Ivoire is reported[65] to have committed to build an FSRU-based LNG import terminal to meet the demand for gas for electricity generation, with the objective of starting operations by mid-2018.

6.7.3. South Africa

In October 2016, the Department of Energy of South Africa set out[66] its gas policy rationale and the scope of its LNG-to-Power IPP Procurement program. This included details of the process under which it proposes to award the development, finance, construction and operation of a gas-fired power station, together with the gas supply chain to fuel the station from imported LNG.

7. Lessons from Korea and policy guidelines for african countries

7.1. Introduction

Many African countries will be relying on project finance for the development of their gas industries and therefore will be subject to the conditions that project finance necessarily imposes. On the plus side, conditions in the international gas market today are very different from those faced by Korea in the 1980s. It is no longer necessary to commit to a long-term (20 years or more) contract to import LNG. Nonetheless, a number of lessons for African countries emerge from the Korean experience.

7.2. Manage the macro-economy

When Korea made the policy decision to develop a gas industry based on imported natural gas in the form of LNG, it was described as a "third world debtor" and was the world's fourth largest debtor country[67]. However, it was seen to be managing its economy responsibly and to be able to service and repay its debt. Korea was, therefore, able to continue to borrow internationally, as well as domestically, in order to finance the development of its export-oriented industries and the development of the supporting gas infrastructure. It was also able to use sovereign guarantees to underwrite 20-year LNG import contracts. With LNG being purchased in USD at a price indexed to oil prices, changes to the KRW/USD exchange rate would have a direct impact on the price of gas to Korean consumers. However, the Government of Korea succeeded in maintaining a relatively stable exchange rate from the early 1980s through to the Asian financial crisis of 1998.

The first major requirement for African countries, therefore, is to manage their economies responsibly in order to minimize the cost of borrowing and the exchange-rate risk to end-consumers of gas and electricity. The development of export-oriented industries in association with that of the gas industry is discussed below.

7.3. Institutional capacity and policy leadership

The Korean government had the institutional capacity and financial flexibility to take a "hands on" approach to gas-industry development through the state-owned enterprise, KOGAS. However, the establishment of the Korea Energy Economics Institute (KEEI) in 1986 ensured that there was a non-ministerial organization – in theory less subject to political interference – with the analytical capability to forecast and monitor the implementation of energy policy, including gas-industry development.

While some sub-Saharan African countries have developed significant energy-sector planning and analytical capability, this has not always been matched by the political will to make difficult but necessary decisions. It is important to develop a strong forecasting and planning capacity with transparent, realistic statements regarding future prospects and timetables and decisions followed by close monitoring and evaluation.

Universities and institutes represent a potential resource of support to ministries in developing modeling and other analytical tools to evaluate the financial, budgetary, environmental, social, safety, employment-creation, human-resource requirements, community development and other impacts of alternative energy policies. They can also draw on the experience of their counterparts in other countries.

Any gas-industry development must be viewed in the context of the overall energy strategy. The priority should be to develop a national energy plan that includes gas-industry development alongside other energy forms, including renewables, to meet projected energy requirements. The plan needs to move from existing infrastructure to the future requirements nationally and regionally of households, agriculture, industry and transport.

The difficult task for government is to turn what has hitherto been a high-level, aspirational energy plan into defined projects to implement it. Elements of a national energy plan could include an LNG-import facility, an associated gas-fired power station, gas transmission lines to other bulk consumers, distribution to commercial and public-sector consumers and to CNG stations, CNG station development, CNG vehicle conversion, electricity transmission, power distribution extension and reinforcement, renewable generation development and off-grid energy solutions.

The government is responsible for defining and awarding project contracts on a transparent and competitive basis to maximize the potential for bidders to minimize the cost to consumers through traditional and innovative financing options.

7.4. The legal, contractual and regulatory framework

The government underwrote and financed KOGAS, so the legal and contractual basis for the development of the gas industry was in many ways already in place. KOGAS matched their LNG purchase contracts with back-to-back contracts under Korean law to supply defined gas volumes at regulated prices to the privately-operated city gas companies and to KEPCO. Prior to the part-privatization of both KOGAS and KEPCO, the government carried all the risk inherent in these contracts but minority shareholders now share this risk.

While other financing mechanisms may be available for smaller gas-industry developments, in general, any major gas projects in sub-Saharan African countries are likely to be project-financed. When seeking investment in gas-import facilities or gas-production development, it is important for countries to understand that they are competing in a worldwide market, which has more investment opportunities than available capital. The policy choices for African countries are likely to be limited. The challenge is to get the best deal possible, which requires an open and competitive procurement process.

Where the extraction of indigenous resources forms part of the development, the contracts for finance will operate with and in support of any production sharing contract (PSC), which itself will be subject to international arbitration. Also, the PSC may not adequately address all the issues that arise from a gas-field development that may encompass liquids production, significant processing facilities and delivery of gas to both export and domestic markets.

A successful result is likely to be a comprehensive framework of contracts that, together, may provide for finance, field development, infrastructure development and the pricing arrangements for the supply of natural gas and any associated liquids, which in effect

defines the regulatory basis for future gas and electricity prices in the host country. The net present value of the contract framework may easily amount to tens of billions of US dollars. The availability of local capital can reduce exchange-rate risks, but sophisticated equipment will need to be imported. Where there is associated power-generation development, "project-on-project" risks are the result. As a consequence, contracts for the provision of finance are typically subject to international arbitration and construed under English or New York law.

Given the complexity and value involved, the international oil companies negotiating with the host government use able commercial negotiators and hire expensive legal, commercial and technical advisers, the costs for whom will be recovered under the terms of the PSC. It is important, therefore, that a host government seeks to engage a similarly competent team including international expert advisers, where necessary. The key requirement is that government is not diverted from its fundamental objective of maximizing the economic, social and environmental benefits of the development.

7.5. Economic benefits

While not relevant in the Korean context, petroleum-production taxes are a key source of budget revenue for many current and prospective gas-producing countries in Africa.

Most petroleum exploration and production in sub-Saharan Africa is conducted under some form of PSC[68] whereby the host government typically receives a fixed percentage of "royalty" production and then an increasing share of "profits" after costs. Both the royalty percentage and the rate of increase in the government share may be bidding parameters in the initial award of the concession.

For many countries, an important question is: what price should be charged for royalty or profit-share gas, which is delivered to the internal market but is potentially exportable?

A full answer to this question would itself require a completely separate report. However, as discussed elsewhere in this report, the gas-use generally considered to deliver the greatest and most immediate economic and social benefits is to ensure electricity supply to the population. If the electricity can be used to support the economic development of employment-generating export or import-substitution industries, the benefits are amplified.

In general, Africa's offshore (particularly deep-water) gas is expensive to produce and it is not economic to use such gas in gas-to-liquid or fertilizer plants to produce internationally traded commodities whose price is typically set by low-cost Middle East gas production. The exception is where the gas is available as a result of flaring-reduction and therefore has a very low or even negative cost.

In order to undertake an effective evaluation of gas-use options, it is important that the authorities have sufficient institutional capacity to enable them to:

- Analyze the economic, social and environmental impact, at different price levels, of delivering gas into the internal market;

- Project the revenue from selling gas on international markets under alternative economic (notably price and exchange-rate) scenarios;
- Identify and undertake cost-benefit analysis of any energy-sector uses for gas-export revenue, including financing off-grid electricity solutions for the broader population.

The development of the gas industry has the potential to have a significant impact on the local economy through construction, operation and maintenance activities, the facilitation of technical transfer and the development of international-marketing skills.This was certainly the case with Korea which, although it brought in assistance from France for the initial LNG terminal and transmission pipeline development, was able to secure the involvement of Korean industrial manufacturing (notably shipbuilding) in the LNG supply chain. Korea now provides assistance to other countries for the development of their LNG terminals.

For those countries endowed with gas reserves, local involvement can lead to the development of a comprehensive indigenous petroleum industry, as in Nigeria.

7.6. Environmental benefits

The Korean environmentally beneficial gas policies are of increasing relevance to African countries. Traffic-induced air pollution is worsening in many African cities and biomass burning is contributing to deforestation and in-home air pollution. For those countries with their own gas reserves, the domestic marketing of LPG for cooking at the international reference price, less freight (as opposed to importing at reference price plus freight) can potentially bring health and environmental benefits.

The development of city gas distribution networks in Korea was fundamentally driven by the winter space-heating requirement. In sub-Saharan Africa, solar is now the preferred option for water heating, while the economic case for large-scale development of gas distribution networks for cooking is only sound as long as the electricity supply remains unreliable because people would prefer to cook with electricity when it is available and reliable. This raises issues such as investment in electricity generation, distribution and maintenance, as well as distributed generation, including through renewables.

KOGAS's natural-gas distribution project in Mozambique represents an African example of a mixed transmission and distribution development, with gas supplied to a power plant, industry, commercial consumers and households.

The Korean experience of the urban-pollution benefits of introducing CNG to buses and urban trucks is of relevance to a number of African cities. However, for CNG use in smaller vehicles the experience of Egypt, China, Indonesia, Iran, India and others may be more relevant.

7.7. Exploration can lead to production

Before committing to the long-term importation of LNG, Korea had undertaken petroleum exploration efforts for at least 10 years without success. The existence of a gas market and the fiscal terms offered by government had attracted Shell, Gulf Oil and other IOCs

to undertake exploration activities, even though the likelihood of a discovery in this pre-deep-water era were known to be limited.

The development of deep-water exploration and production technologies, generally considered to have been born in Brazil and advanced in the Gulf of Mexico, changed the outlook for indigenous gas development for Africa and for East Africa, in particular. With deep-water exploration wells typically costing US$100 million each, in order to attract international investment in the field, it is important to offer potential returns commensurate with such costs in the form of internationally competitive fiscal terms and access to an appropriate gas market.

7.8. Charge cost-based tariffs for gas and for electricity

Apart from the 2008-2013 period, Korea is understood to have charged tariffs for gas that recovered the revenue required to cover the total cost of gas supply and transportation, including a return on sunk capital. There remain some cross subsidies from industry to households to be "unwound" at the local city gas level to enhance the competitiveness of Korean industry. Even during the 2008-2013 period, the wholesale tariff for gas for power generation continued to be based on cost recovery.

The attenuation of distortions in the Korean gas market was an unexpected fringe benefit of the fall in oil prices that began in December 2014. It effectively saved the finances of KOGAS and the Government of Korea, as, indeed, it did of many oil-importing countries. While it is understood that Korean power companies have been able to recover the costs of gas-fired electricity generation, the consequences of underpricing nuclear-generated electricity include removing incentives for energy conservation and adopting renewable energy solutions, with apparently unconstrained demand growth requiring ever-more infrastructure investment.

In their August 2016 paper, Trimble, Kojima et al[69] found that only two sub-Saharan Africa countries had a financially viable electricity industry (Seychelles and Uganda), defined as charging tariffs that recover the revenue required to fund operating costs and full capital expenditure (CapEx) on the replacement value of existing assets. Their data was gathered during what proved to be a period of high oil prices, but their conclusion is, notwithstanding the specificity of their timeframe, that existing utilities in Africa may not be able to maintain existing asset bases without government subsidies, much less consider capacity expansion.

Whatever a country's natural-gas resource endowment, ensuring a financially viable electricity industry represents the first step towards securing the economic and social benefits of gas-industry development. Countries seeking finance for the development of their gas and/or electricity industries will have little option but to pass the full costs of energy supply on to consumers, which is why competitive procurement processes are important.

The fundamental lesson from the Korean experience with a gas-based energy sub-sector, and arguably that which brings the biggest social and economic benefits, is to extend reliable electricity supplies to the population in the first place.

A further key policy lesson is that energy prices and tariffs must reflect the full costs of supply, including the return of and on capital, in order to ensure long-term security of energy supply through a maintained and extendable asset base.

7.9. Conclusion

Korea provides an example of gas-industry development, based on imported LNG, that was driven and financed by the government. Few sub-Saharan African governments are in a position to finance the development of a gas industry by themselves and will, therefore, need to attract international finance.

Those African countries endowed with gas reserves will either be familiar with or rapidly learning about the issues to be addressed when financing gas production and gas-industry development. For those countries looking to develop a gas industry based on imported LNG, international market conditions are very different from those faced by Korea in the 1980s. In 2016, the availability of leased FSRU import facilities, the availability of short-term and spot cargoes of LNG and the ability of aggregators to provide a total gas supply service all served to avoid the large up-front capital expenditure and commitment to a 20-year LNG import contracts that Korea was obliged to enter into.

Whether a country is a gas producer or gas importer, or both, the providers of finance for gas industry development and any associated gas-fired power generation will look to the same energy fundamentals as they considered in respect of Korea's LNG supply chain: can gas and electricity tariffs recover the cost of supply?

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annexes

Annex 1. KOREA ENERGY SUPPLY AND GAS CONSUMPTION

ANNEX 1 KOREA ENERGY SUPPLY AND GAS CONSUMPTION

TABLE 1

Historical energy supply & gas consumption

	1985	1990	1995	2000	2005	2010	2014
Primary energy suply - ktoe							
Coal	22.022	25.383	26.610	41.949	49.657	73.454	81.699
Oil	27.142	49.735	91.126	99.039	92.490	95.115	96.336
Natural gas	-	2.724	8.321	17.005	27.368	38.625	43.125
Nuclear	4.186	13.783	17.468	28.397	38.251	38.725	40.761
Hydro	915	547	237	345	316	317	237
Other renewables etc	2.031	741	991	1.423	2.206	3.789	6.255
TOTAL	**56.296**	**92.913**	**144.753**	**188.158**	**210.288**	**250.025**	**268.413**
Primary energy suply - %							
Coal	39.1%	27.3%	18.4%	22.3%	23.6%	29.4%	30.4%
Oil	48.2%	53.5%	63.0%	52.6%	44.0%	38.0%	35.9%
Natural gas	0.0%	2.9%	5.7%	9.0%	13.0%	15.4%	16.1%
Nuclear	7.4%	14.8%	12.1%	15.1%	18.2%	15.5%	15.2%
Hydro	1.6%	0.6%	0.2%	0.2%	0.2%	0.1%	0.1%
Other renewables etc	3.6%	0.8%	0.7%	0.8%	1.0%	1.5%	2.3%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

	1985	1990	1995	2000	2005	2010	2014
Natural gas consumption - ktoe							
Electricity / Heat generation	-	2.037	4.167	5.755	11.072	18.001	20.134
Industry	-	73	533	2.880	4.167	7.090	8.824
Transport	-	-	-	-	324	1.023	1.212
Residential	-	464	2..685	6.228	8.371	8.938	8.318
Commercial / Public Services	-	136	778	1.805	3.095	3.525	3.855
Agriculture / Forestry	-	-	-	11	25	4	3
Own-use / Non-specified / Rounding	-	14	158	326	314	44	779
TOTAL	**-**	**2.724**	**8.321**	**17.005**	**27.368**	**38.625**	**43.125**
Electricity % generated from gas	**0.0%**	**8.9%**	**11.5%**	**10.6%**	**15.9%**	**20.4%**	**22.0%**

NOTES. 1 ktoe thousand tonnes oil equivalent (10.000 kcal/kg) **2** statistical issues arising from the production of gas from LPG / Air and from naphtha cracking would seem to be captured in the Own-use / Non-specified / Rounding data
Source. *IEA, KKEI*

TABLE 2
Projected Gas Consumption

Actual

	2014	2015	2022	2029
Projected natural gas consumption - ktoe				
Electricity / Heat generation	21.224	18.995	13.141	11.203
Industry	9.941	8.971	12.552	14.076
Residential	8.478	8.420	9.772	10.265
Commercial / Public services	3.483	3.435	4.701	5.406
TOTAL	**43.125**	**39.821**	**40.135**	**40.949**

Source. *12th Long Term Gas Plan, MOTIE, 2015*

End notes

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[66] https://gaslng.ipp-gas.co.za .
[67] Collins & Park, 1989.
[68] Also variously known as Production Sharing Agreement (PSA), Exploration & Production Concession Contract (EPC).
[69] Trimble et al, 2016.

Abbreviations, terminology and conversion factors

ABBREVIATIONS	
AfDB	African Development Bank
ANRC	African Natural Resources Center
BBL	Barrel (of oil)
BCF	Billion cubic feet (of gas)
DAT or DAP	Delivered at terminal or delivered at place
Distribution	Lower pressure transportation of natural gas, typically from a pressure let-down station to smaller consumers
FOB	Free on board – i.e. delivered into a ship
FSRU	Floating storage & regasification unit
GDP	Gross domestic product
GGFR	Global gas flaring reduction
GTL	Gas to liquids
IOCs	International oil companies
KANGV	Korea Association for Natural Gas Vehicles
KEEI	Korea energy economics institute
KEPCO	Korea electric power corporation
KIER	Korea Institute for Energy Research
KOGAS	Korea Gas Corporation
KOREC	Korea electricity commission
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MAGTAP	Mozambique - Mining and Gas Technical Assistance Project
MMBtu	Million British thermal units
MOE	Ministry of Environment of Korea
MOTIE	Ministry of Trade, Industry & Energy of Korea
MTPA	Million tons per annum (of LNG)
National gas transportation system	The interconnected gas transmission and distribution pipelines and networks

ABBREVIATIONS

OECD	Organisation for Economic Cooperation and Development
PE	Poly ethylene
POD	Plan of development
PSC	Production sharing contract
PSA	Purchase and sale agreement (for gas supply)
TPA	Third party access
Transmission	High pressure transportation of large volumes of natural gas

CONVERSIONS USED

LNG standard cubic feet/ton (scf/t LNG)	**48,734.6**
Standard cubic meters natural gas/tone LNG (scm/t LNG)	**1,380**
LNG calorific value	**Barrel (of oil)**
MMBtu/ton	**50.00**

NOTES.

In order to avoid the sometimes unclear reference to “sub-sectors”, this report adopts the convention of referring to the “energy *sector*”, the “gas *industry*” and the “electricity *industry*”.

In this report, the term “Korea” is synonymous with The Republic of Korea (RoK), also commonly known as “South Korea”.

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