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A Comparison between Korean Gas Market and Oil Market in the Consideration of South Korean Gas Market Reform

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A Comparison between Korean Gas Market and Oil Market in the Consideration of South Korean Gas Market Reform

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Abstract

A Comparison between Korean Gas Market and Oil Market in the Consideration of South Korean Gas Market Reform

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South Korea established a non-competitive natural gas market in order to have a stable and economical supply of natural gas. The allegation has been raised about the inefficiency of this non-competitive market structure, but reform attempts have failed because of protests. Proponents of this incumbent system argue that gas needs to be supplied by the public sector in a monopolized structure so as to have a stable supply of this essential good, natural gas, and to prevent market failures like exorbitant gas prices and a deficit in supply due to a natural monopoly. They also argue that the unified gas purchase endows purchasing power. However, the gas industry does not exactly meet the categorical characteristics of an essential good or a natural monopoly and the concept of purchasing power is hardly accepted. Moreover, according to agent theory and property theory, the current market and firms are likely to be inefficient; several events are proving this inefficiency to be true. However, people remain unsure about the necessity of gas market reform. Ironically, South Korea has a different policy and market approach to the oil market despite the similarity of these two fuels. The oil market in South Korea constitutes an effective competitive market via a liberalized market, and is supplying the fuel stably and economically, contrary to people's expectations. This thesis contrasts different approaches in South Korea toward similar hydrocarbon fuels, oil and gas. The competitiveness of the oil market is examined through statistics, Lerner index, analyzing of the profit trend in the market, and price comparison by countries. Results support the validity of South Korean gas market reform if the oil market is effectively competitive through liberalization.

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1. Introduction

Despite passions for green and renewable energy, a new wave of energy has come from an unexpected sector. As U.S. President Barack Obama declared that the U.S. has a 100-year supply of natural gas (Snyder & Klimasinska, 2012), the shale revolution, which is the extraction of natural gas from shale layer, an unconventional reserve, brought about a paradigm shift in energy dynamics. Natural gas is important because of its abundance, economics, and cleanness. Meanwhile, South Korea, a country with few indigenous hydrocarbon resources, has been vulnerable regarding energy security despite its impressive economic development. The country's import dependence of this primary energy source is 96.4%; fossil fuels dominate the energy supply and gas comprises 16% of its energy mix (KEEI, 2012). Different from other areas benefitting from the recent low price of gas after shale revolution, this Far East country still pays the highest gas price. Because of weak market power and transportation restrictions due to the country's isolated geographic location, South Korea has been left behind in this big change. The South Korean gas market is monopolized through all sectors; the gas import and transmission is monopolized by a state controlling enterprise (SCE), Korean Gas Corporation (KOGAS), and the final distribution and sales are monopolized locally by small local distribution companies (LDCs). Contrary to the general idea that competition makes for efficiency, this industry is non-competitive to prevent market failures like inefficient resource allocations in the infrastructure and excessively expensive prices. However, situational changes are casting doubts about if the current system is still efficient; requests for gas market reform are substantial. A bill allowing the private sector to import natural gas was proposed but failed to pass last year due to protests.

Given this situation, this thesis aims to verify if South Korea's gas market reform is valid. In order to do this, I first provide overview of natural gas to understand why physical characteristics have constricted the transaction practice and influenced supply and demand. Next, I provide background knowledge about the current status of the South Korean gas market.

Conflicting rationales exist with regard to the maintenance of the status quo for non-competitive market and reforms of the competitive market. The non-competitive market is appropriate for three reasons: when an item is essential to people's lives and needs an universal service; if the industry has a high probability of a natural monopoly due to high capital investment as with the network industry; and if the unified import by a single monopoly company endows purchasing power to the company. However, the gas industry falls short of the qualification to be an essential good or a network industry. Rather, the public sector can be inefficient and purchasing power does not make sense considering the events showing the inefficient KOGAS transaction.

The severe controversy required an empirical benchmark and many attempts have been made to compare South Korea's market with those of foreign countries. However, this paper draws from another energy industry within South Korea's borders. The oil industry in Korea provides a complementary baseline for comparison to the country's gas industry. This thesis identifies the similarity of gas and oil, and proves that the oil market is effectively competitive through liberalization. Results assert that there is no reason to reject gas market reform. Consequently, this paper contrasts and examines the validity of arguments supporting reform and the maintenance of the status quo within the South Korean natural gas market. It also offers the case study of the oil industry in South Korea, an effectively competitive market due to liberalization, as supporting evidence of gas market reform.

2. Background

This thesis discusses the matter of supplying natural gas (referred to hereafter as just "gas" sometimes) to South Korea (referred to hereafter as Korea for convenience). Before the discussion about the main topic, this chapter overviews the basic knowledge about Natural gas and provides a brief introduction to the Korean natural gas market.

2.1 Overview of Natural Gas

Natural gas is one of the main energy sources in modern society. Understanding the physical characteristics of natural gas is important because they influence on the fuel's supply chain and market structure. The following sections will explain the various aspects of natural gas. Please note that this chapter provides information about commonly salable quality gas despite a variety of forms of natural gas, since this thesis is about the marketed natural gas as a fuel.

2.1.1 Basic properties of natural gas (hydrocarbon)

Natural gas is the group of the simplest and lightest form of organic hydrocarbons, which are compounds of hydrogen and carbon. This gas shows various combinations such as methane (CH_4), ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}). The smaller its number of carbon molecules, the lighter it is. Additionally, it is more likely to be gaseous under the cold temperature and high pressure. Methane is the main component of the commercial natural gas; other light hydrocarbons, from ethane to butane, are called "natural gas liquids" (NGL). These light hydrocarbons that are gaseous at the temperature of 20 ℃ under atmospheric pressure are categorized as natural gas according to a strict definition. However, natural gas in real reservoirs includes a little portion of low density liquid hydrocarbons heavier than pentane (C_5H_{12}) so called "condensate." Hydrocarbons heavier than hexadecane ($C_{16}H_{34}$) are categorized as petroleum when liquid, or coal when solid. This variance of the compositions comes from the temperature and pressure at the place where the hydrocarbons formed, which will be discussed later. Gas containing more than 95% methane is called "dry gas" or "lean gas", and gas containing less than 95% of methane and more than 5% of other hydrocarbons is called "wet gas" or "rich gas". When the gas contains a significant amount of NGL or condensate, it is better to sell the hydrocarbons separately because prices of the non-methane hydrocarbons are more expensive than that of pure methane. In a natural state, natural gas includes a significant amount of impurities like water, carbon dioxide (CO_2), hydrogen sulfide (H_2S), oxygen, nitrogen, and helium as well as heavier hydrocarbons, which are refined before they are marketed. Removal of these impurities is important in dealing with natural gas because CO_2 and H_2S can corrode the pipelines and produce undesirable byproducts like sulfur oxide (SO_X) and greenhouse gases (GHG). Gas with a high composition of H_2S is called "sour gas"; gas with low composition is called "sweet gas". Both sour and sweet types of gas need removal of H_2S to prevent air pollution, though sweet gas is easier to refine. Other impurities like helium or argon are neither toxic nor corrosive, but they lower the energy density of gas. Thus, typical natural gas in the market is mainly methane with a small amount of other components.

Heavier hydrocarbons have higher heating value, higher boiling point, higher viscosity, and more impurities than lighter hydrocarbons. Therefore, the light hydrocarbon like methane has relatively low energy; the heating value of natural gas is 35,400 – 42,800 kilo Joule per square meter (kJ/m^2). However, natural gas emits lower levels of pollution than oil or coal, since heavier hydrocarbons are more likely to combust incompletely and contain more impurities. Natural gas is odorless and lighter than the air. The boiling point of pure methane is -162℃; propane at -42℃. These properties make natural gas difficult to store and transport; gas was abandoned or flared in the early stages of the oil and gas industry (Kidnay & Parrish, 2006).

2.1.2 Gas Formation and Reserves

Since natural gas is a kind of fossil fuel, the basic principal of its formation is similar to that of petroleum; but is unique regarding the temperature and pressure at the location where it formed. There are a few theories regarding the hydrocarbons origin, but the most accepted and applicable theory to the marketed hydrocarbons so far is the organic theory: the dead marine lives accumulated on the bottom of the ocean; these organic matters decayed and decomposed through the heat and pressure over an accumulation of millions of years, turning into kerogen, the precursor for hydrocarbons; the heat and pressure reaction called diagenesis, catagenesis, and metagenesis (distinguished by the level of temperature and pressure that causes the hydrogen/carbon ratio increase to transform the kerogen into hydrocarbon sources). As depth increases, more gas than oil forms; below 6,000 meters, only gas forms and at between 1,500 to 6,000 meters, oil and gas form together. (Coal and coal bed methane form when this process occurs in an onshore area with land-based living creatures.) The formation occurs first in a muddy sedimentary rock like shale, source rock, but increasing accumulations add more pressure and squeeze the droplets of hydrocarbon, forcing them to migrate upward to more porous layers like sandstone, reservoir rocks. They stop to migrate when they meet a capping impermeable layer, sealing rock. This reservoir can include gas only or oil only, but mostly have both of them. When a reservoir contains mainly petroleum, gas found in the reservoir is called “associated gas”; gas without oil is called “nonassociated gas”. This type of common reservoir comprised of source rock, reservoir rock, and sealing rock is called a conventional resource. Unconventional sources refer to coal bed methane, gas hydrate, and gas at other difficult conditions with low permeability, like shale gas. These unconventional resources have been considered to be not feasible due to the technical and economic constraints in the past. However, technological advances like directional drilling and hydraulic fracturing finally enabled economically feasible natural gas extraction from the low permeable shale formation (Craig, Vaughan, & Skinner, 2011).

Unit: tcm

Region	tcm	Region	tcm
World Total	187.3		
Middle East	80.5	North America	10.8
Iran	33.6	US	8.5
Qatar	25.1	Canada	2.0
Saudi Arabia	8.2	Mexico	0.3
UAE	6.1	Africa	14.5
Others	7.5	Algeria	4.5
Europe & Eurasia	58.4	Nigeria	5.2
Russian Federation	32.9	Others	4.8
Turkmenistan	17.5	Asia Pacific	15.5
Others	8	Australia	3.8
Central & South America	7.6	China	3.1
Venezuela	5.6	Indonesia	2.9
Others	2	Others	5.7

Table 1: World proved natural gas reserves by country (drawn from BP data)

The measurement of the existing gas amount varies based on the standard. The possible resource amount including all conventional and unconventional sources is enormous, but statistics agencies usually include only the “proved reserves”, which are considered to be extractable under the current economic and technical base. The current estimation of the proved reserve is 187.3 trillion cubic meter (tcm). Distribution of the reserves is sparse, similar to that of petroleum. Iran is the richest country with 33.6 tcm of natural gas followed by Russia with 32.9 tcm. Middle Eastern countries have 43% and the former USSR region has 29% of the world's reserve. The world's proved reserve amount has increased by 59% from 117.6 tcm in 1992, including unconventional resources into proved reserves (BP, 2013). This trend will continue, since many countries in South America and China have large unconventional gas resources.

2.1.3 Supply Chain

The natural gas supply chain can be drilled down into three main stages: upstream, midstream, and downstream. Upstream usually refers to exploration and production activities; midstream means the refining and transformation of gas, and transportation activities by pipelines or vessels; downstream indicates the commercial activities distributing the gas to the end-users. However, in an economy without its own reserves, the importing activity is considered to be upstream since it is bringing gas into the economy; the intra transmission line is considered to be midstream; lastly the small local distribution is the downstream. This section will deal only with upstream and midstream; downstream will be discussed later in the market structure part, since its sector closely aligns with commercial activity.

2.1.3.1 Upstream Sector

Regarding the production activity, there are two ways to produce more hydrocarbons; one is to produce more from the existing well and the other is produce from wells that were previously not producible. First, we can produce hydrocarbon from conventional wells that have good porosity and permeability. Those wells used to be explored and produced by vertical drilling. At the early stage of production of a conventional well, the well's natural pressure incurred by internal water drive, gas expansion, and evolution of dissolved gases can push the fossil fuel out. 20-30% of petroleum or gas can be recovered with this natural pressure and this method is called "primary recovery." When the natural pressure cannot push the hydrocarbons anymore, artificial pressure is introduced by inserting water, steam, or chemicals; this additional recovery is called "secondary recovery." Naturally, the secondary recovery is expensive but the maximum rate of hydrocarbon production is known to be at most 50% after all these efforts. Thus, people want to find more reserves. Drilling deeper into the underground is a definite way to find and produce more hydrocarbons. Rotary drills can operate to the depth of more than 10,000 meters. The evolution of the offshore platforms has enabled the production at the depth of 3,000 meters under the ocean.

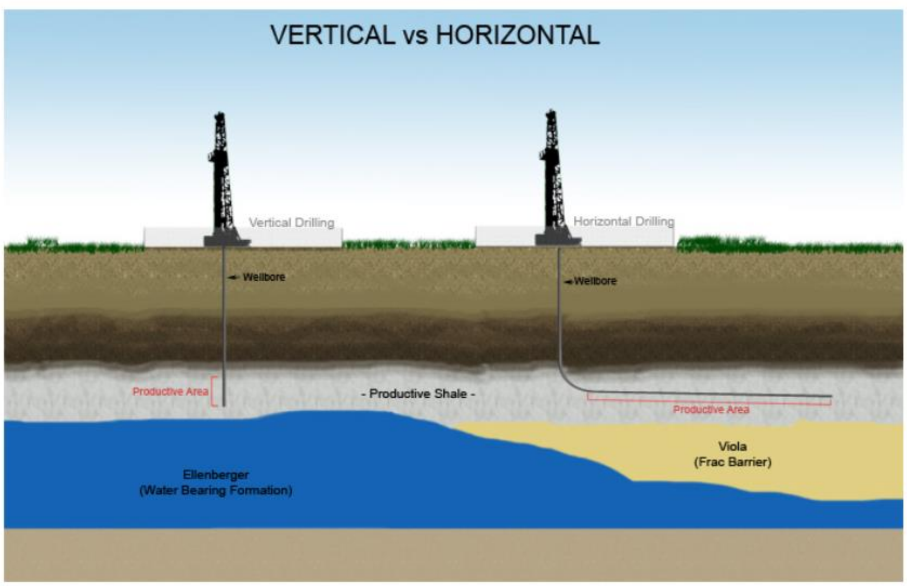


Figure 1: Vertical drilling and horizontal drilling (Keystone Exploration, 2014)

However, the more dramatic technological breakthroughs were directional drilling and hydraulic fracturing. These advances enabled the production from unconventional wells and increased the amount of proved reserves. After reaching a certain depth by the vertical drilling, the drilling is converted to horizontal and keeps changing the direction to dig the existing reserve efficiently. As a result, directional drilling can produce petroleum from a 10 kilo meter (km) wide zone with one wellhead and reduced drilling sites and wells. This change reduced cost and enhanced productivity.

Hydraulic fracturing also opened up the tight constricted pores by pumping down the water and coarse sand with high pressure and injecting strong acid chemical solutions into the impermeable layer, like shale (Craig, Vaughan, & Skinner, 2011). Hydraulic fracturing rendered an immediate commercial production increase in the U.S. Now the U.S. is competing with Russia as to which country is the largest natural gas producer.

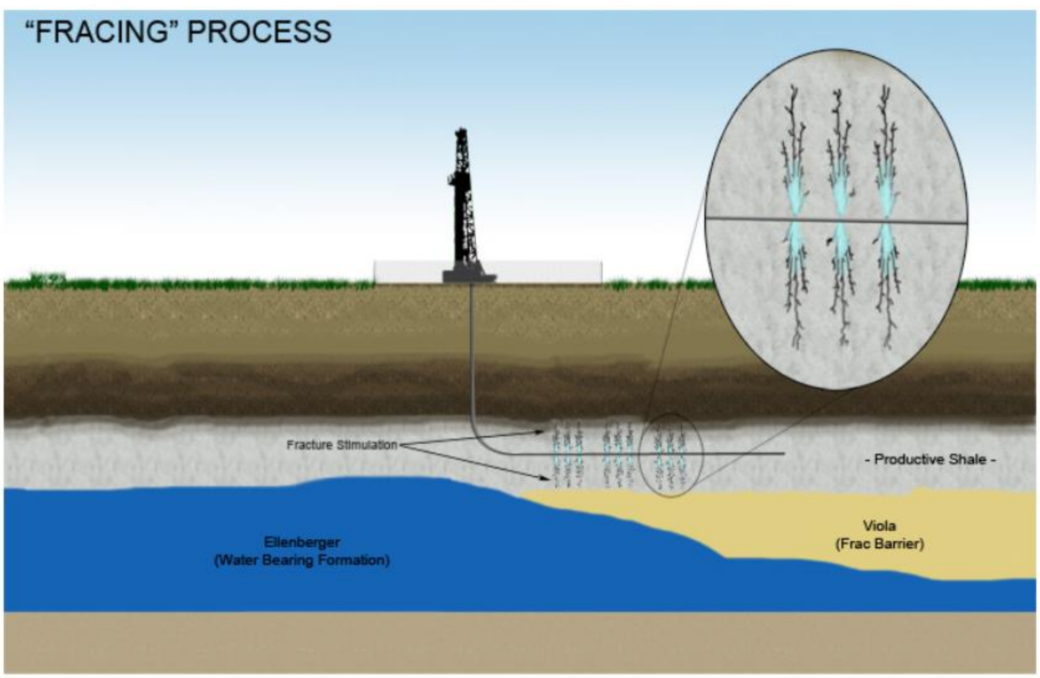


Figure 2: Illustration of hydraulic fracturing (Keystone Exploration, 2014)

The world's natural gas production volume in 2012 was 3,364 billion cubic meter (bcm); the U.S. produced 681 bcm and Russia produced 592 bcm. The production rate is not exactly proportional to the reserve amount. A country like Norway produces more compared to its reserve amount, but a country like Venezuela produces less than its reserve amount (BP, 2013). The difference comes from the infrastructure and commercial production development varying by countries. Moreover, hydraulic fracturing has not been executed commercially outside the US so far, but the diffusion of the technology will likely lead to future changes in production volume.

Unit: bcm

Region	bcm	Region	bcm
World Total	3363.9		
Middle East	548.4	North America	896.4
Iran	160.5	US	681.4
Qatar	157.0	Canada	156.5
Saudi Arabia	102.8	Mexico	58.5
UAE	51.7	Africa	216.2
Others	76.4	Algeria	81.5
Europe & Eurasia	1035.4	Egypt	60.9
Russian Federation	592.3	Nigeria	43.2
Norway	114.9	Others	30.6
Turkmenistan	64.4	Asia Pacific	490.2
United Kingdom	41.0	China	107.2
Others	222.8	Indonesia	71.1
Central & South America	177.3	Australia	49.0
Trinidad & Tobago	42.2	Parkistan	41.5
Argentina	37.7	Thailand	41.4
Venezuela	32.8	India	40.2
Others	64.6	Others	139.8

Table 2: World natural gas production by country in 2012 (drawn from BP data)

2.1.3.2 Midstream Sector: Pipelined Natural Gas

Supplying natural gas is not just about production, since consuming areas and producing areas are different as other fossil fuels. Transportation plays an important role in supplying natural gas because natural gas is trickier to transport--it is too light and bulky at the normal surface condition, excepting the NGLs sold separately to industrial users. Transportation costs, via onshore pipeline per one energy unit of natural gas, are three to five times higher than the energy equivalent amount of oil transportation. Intercontinental natural gas transportation via pipeline or liquefied natural gas (LNG) tanker can cost about 20 times more than that of oil transportation. The pipeline for long distance transportation is called the "transmission pipeline," which is distinct from the small pipeline for the local distribution. The diameter of the transmission pipeline ranges from 16 to 48 inches and it is comprised mostly of steel and alloys. The point of primary importance in the pipeline operation is to maintain a proper pressure for gas to flow. The operation pressure in onshore pipeline networks ranges from 60 to 125 bar, and offshore pipelines need as high as 150 bar. To endure the pressure, the high-quality steel pipelines are coated to prevent corrosion. When a pipeline is submerged in water, the cathodic protection method is used to protect corrosion by applying a direct current to offset the corrosion current. Moreover, to prevent the internal corrosion, various measures are employed, including dewatering, inhibition, cleaning (pigging), and using internal pipeline coatings. To maintain the pressure of the gas flow during the transportation, periodical compression is required. Thus, compression stations are located at every 40 to 100 mile intervals. Metering stations monitor any loss of gas and the flow is controlled by numerous valves in cases of maintenance or an event necessitating the closure of some parts of pipelines (Chandra, 2006).

The construction cost of pipeline is roughly estimated by the unique unit of inch-mile, which means the average cost per combined unit of each inch in diameter and each mile in length. The construction cost of pipelines increased from around $30,000 per inch-mile in 1993 to $100,000 per inch-mile in 2008. Despite the technological advances, the rising steel price has impacted the cost, since this material cost comprises about 35% of the total cost (Tubb, 2009).

(Unit: $1,000 per inch-mile)

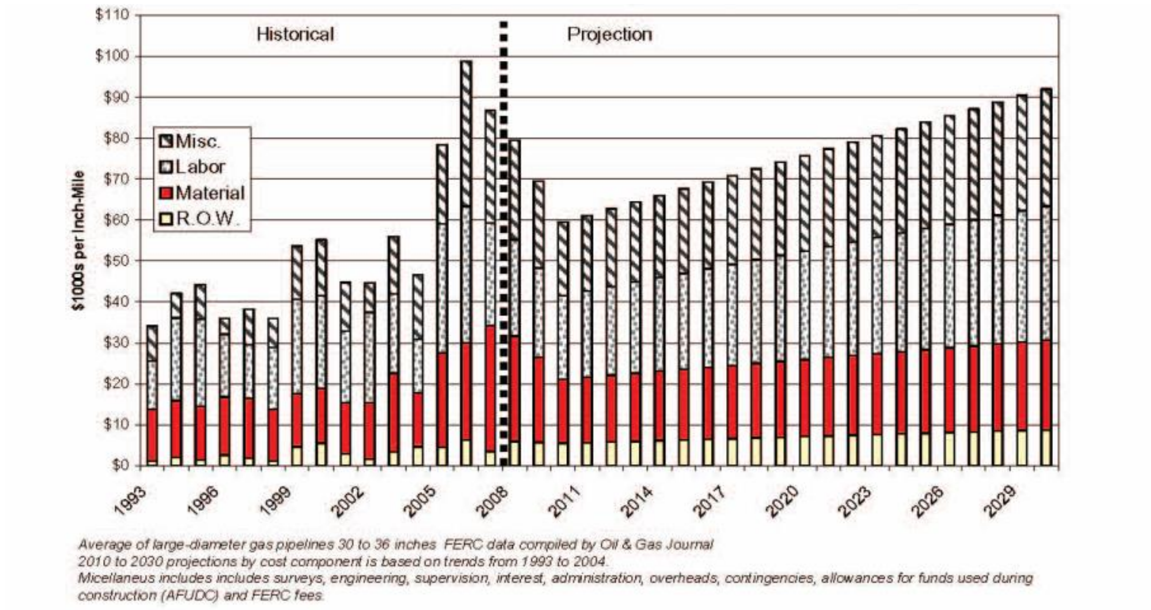


Figure 3: Natural gas pipeline construction costs (Tubb, 2009)

2.1.3.3 Midstream Sector: Liquefied Natural Gas

In onshore natural gas transportation, pipeline networks are absolutely advantageous, but in offshore transportation, the LNG can be a good alternative. Because of the proportional cost of pipeline construction and the surging cost in the case of submarine pipelines, there is a break-even point at the distance of 3,000 km between pipeline transportation and LNG tanker transportation; for distances longer than 3,000 km, LNG is more favorable than pipelines, as shown in figure 2 (Schwimmbeck, 2008). Therefore, 31 percent of total natural gas production is traded internationally, and about 29 percent of the international trade amount is transported in the LNG form (IEA, 2013).

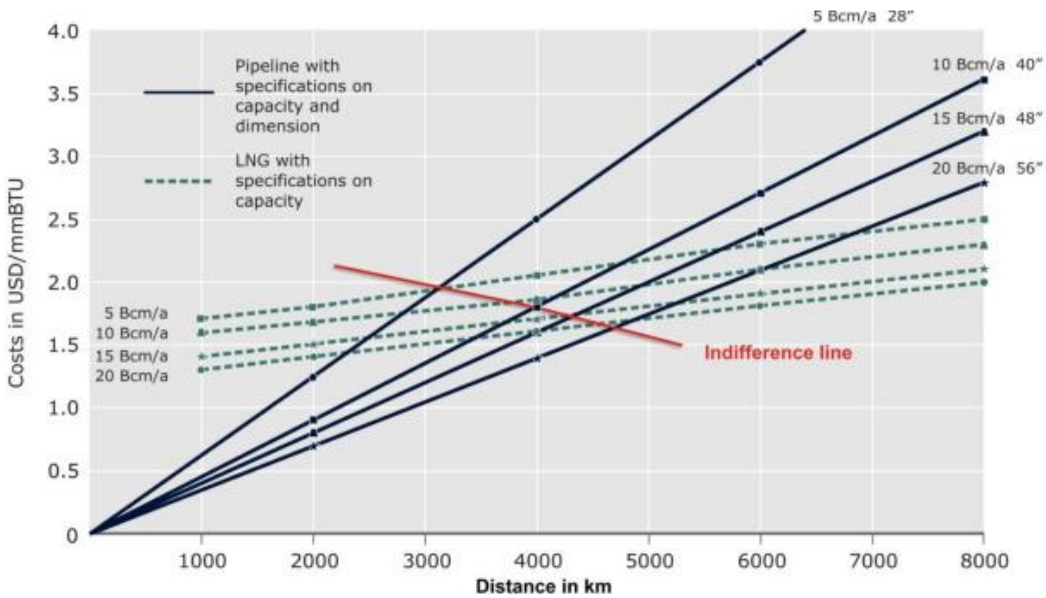


Figure 4: Transportation costs for natural gas via pipeline and as LNG as a function of the capacity (Schwimmbeck, 2008)

The LNG value chain is composed of three main parts: liquefaction, marine tanker, and regasification. Natural gas is liquefied at -162℃ and its volume contracts to 1/600 times when liquefied. In order to acquire this freezing temperature, an expensive refrigerating facility is required. The principal of natural gas liquefaction is the same as the refrigeration cycle used in an air conditioner or a refrigerator. However, the real application in a natural gas liquefaction plant is complex and its size is gigantic. The main factors that characterize the plant are refrigerant and the numbers of cycles. Natural gas cools down via the heat exchanges with the refrigerant. The refrigerant, once heated, is pressurized by compressors and cooled down by air or cooling water; then achieves the freezing temperature required for liquefaction by depressurizing. The efficiency of this cycle, which is the ratio between the output of the LNG and input energy of the feed gas, is measured by the proximity of the cooling curves of the refrigerant and the feed gas. The gap between the two curves is related to energy consumed by the compressors. Different kinds of refrigerants and different numbers of cycles can create infinite combinations, but only a few combinations are actually applied in real projects. The companies specialized in process designs have proprietary rights on their development. In a pre-cooled cycle system, mixed refrigerant is preferred, although a pure component refrigerant can be used in the pre-cooling stage. In a cascade system, pure refrigerants are used for each exchanger; the refrigerant ingredient is different at each level. The former combination is called a mixed component pre-cooled refrigeration (MPR) and the latter is called a pure component cascade (PCC). These are the main distinctions of the LNG liquefaction, though variations continue even within each distinction. Various factors are considered when deciding which process to install in real LNG plants, not just efficiency because efficiency of the process varies according to the capacity of the plant. The capacity of a train has increased from 0.5 MMtpa to 8 MMtpa. A larger capacity train provides economy of scale, which lowers the capital cost, but multiple smaller capacity trains allow operational flexibility. Until 2000, 90% of LNG plants worldwide selected propane pre-cooled mixed refrigerant process (C3MR); after 2000, the cascade system expanded its share to 18% but C3MR has 74% share including AP-X process. In a typical cost allocation, a liquefaction facility takes up the highest portion of 30-40% in the whole LNG value chain. The historical unit construction cost of an LNG export terminal was about $300 per tonne per annum (tpa), but the costs of recent projects doubled (Mokhatab, Mak, Valappil, & Wood, 2014). For example, the total cost of the Sabine Pass LNG terminal, which is equipped with two 4 MMtpa LNG plants, is known to be $5.6 billion, about $700/tpa (hydrocarbons-technology.com, 2014).

After the liquefaction, LNG is loaded into the LNG tanker, a specially designed ship for LNG transportation. It is necessary to maintain the cryogenic temperature during the LNG transportation, since the LNG will evaporate and expand to its original volume at a normal surface state. To prevent this phenomenon, LNG tankers have insulated storage;

spherical tanks are made of a special alloy of steel with aluminum and nickel; rectangular membrane tanks are made of steel and PVC or polystyrene. Despite this insulation, the gas boils off and the typical loss of gas is estimated to be 0.1-.0.25% daily. The total loss rate of the total LNG chain ends up being 2-6%. An LNG tanker uses this evaporated gas as its fuel. Sizes of LNG tankers vary from 30 cubic kilo meter (km^3) to 265 km^3. A 138 km^3 size tanker can load 65,115 tons of LNG and it can serve a 4 mta capacity LNG plant if it can complete 33 times trips in a year. Shipping cost is expressed as daily charter rates and it fluctuates according to the market situation. Before 2009, it was around $60,000~70,000/day and dropped to $30,000/day after the economic crises from 2009 to 2011, which was far below the break-even cost of $60,000/day. This postponed new ship orders and created a shortage of ship supply. As a result, in 2012, the rate soared to $150,000 and recently it stabilized at around $90,000/day (Odell, 2013).

After the LNG arrived at its destination, the gas need to be stored and re-gasified at import terminals to be supplied to retail markets. An import terminal mainly consists of an unloading berth, gas storage, and a regasification facility. Due to the seasonal variance of natural gas demand for heating, flexibility is required in supplying gas. The storages passively maintain the low temperature of LNG using insulation similar to the tanks on LNG tankers. Aboveground tanks, retired hydrocarbon reserves, and salt caverns can be used as storage. The gas gets re-gasified before it is sent to the retail distribution lines. Regasification is a simple heat exchanging process between the feed LNG and the heat transfer fluid. Utilizing sea water as the heat transfer fluid is the most popular method, since most LNG importing terminals are located close to the open ocean. Glycol-water, hydrocarbons, and even ambient air can be used as heat transfer fluids. However, these methods can reduce the throughput influenced by climate. For example, the seawater temperature drops during winter or in a cold climate. To cope with this fluctuation, a submerged combustion vaporizer system places the heat exchanging tubes in a heated water bath. This increases costs by 1.5-3% because it consumes natural gas to heat the bath, but it is advantageous considering that it maintains the regasification rate constant and is easy to start up and shut down. LNG import terminals' construction costs about 1/5 less than the construction of export terminals, but still requires a huge investment. For example, the Sempra terminal in Northern Mexico with 7.5 mta cost $0.8 billion (Chandra, 2006).

The total cost of LNG chain ranges from $2.8 to 4.6/MMbtu as shown in Table 3.

. (Unit: $/MMBtu)

components	Low-end Cost	High-end Cost
Gas Production	0.5	1
Liquefaction	1.5	2
Tanker transportation	0.5	1.2
Import Terminal	0.3	0.4
Total	2.8	4.6

Table 3: Typical Cost Allocation of the LNG project as of 2003 (Mokhatab, Mak, Valappil, & Wood, 2014)

2.1.3.4 Midstream Sector: Local distribution

LNG is delivered to the final customers via the local distribution pipeline networks, small fleets, and tank trucks. The residential/commercial sectors, the main focus of this thesis, are highly dependent on these local pipeline networks, called urban gas service. In a large city of a planned residential area with high population density, the urban gas service is a convenient and effective gas supply method, but is not favorable for the remote and sparse areas. Since local distribution is directly linked to the sales activity, this function can be included in the downstream sector. The technical aspects of this area are mostly similar to that of the transmission pipeline except for the length and diameter of the pipeline.

2.1.4 Demand and Consumption

It is obvious that the world's energy demand is exploding. Worldwide total energy consumption in 2000 was 400 quadrillion Btu (Quad), and increased to 524 Quad in 2010, a 30% increase over ten years. The U.S. Energy Information Administration (EIA), in its 2013 report, forecasted that the world's energy consumption will increase to 733 Quad by 2040. Developing countries' hunger for energy is well known as the reason of the exploding demand. Not one energy source can satisfy this soaring demand, and natural gas will fill some portion of the energy demand. The concern is regarding which source will be consumed more among those resources. Energy consumption is not decided by an individual's decision; rather, the decision-making is systematic and it involves three main criteria: accessibility, economics, and environmental concerns. Natural gas fits the criteria to a substantial level. Natural gas is an abundant source. As discussed above in the formation part, natural gas forms at wider range of temperatures and pressures than oil. Technological advances made it possible to extract the gas from unconventional reservoirs. Natural gas was considered to be difficult to deliver, but now transmission pipeline networks and LNG transportation have solved the problem. In terms of economics, the price of natural gas in the North American market is at a historic low. Considering energy equivalent, a six to one ratio of the price between one barrel of crude oil and one MMBtu of natural gas is reasonable, but it has reached to 20 to 1 since 2009 (Powers B. , 2011). This is a unique phenomenon in the North America market, since the natural gas price in this market is decided on a market base, while other markets are linking the natural gas price to the oil price. However, this difference is creating arbitrage opportunities, which will be discussed later.

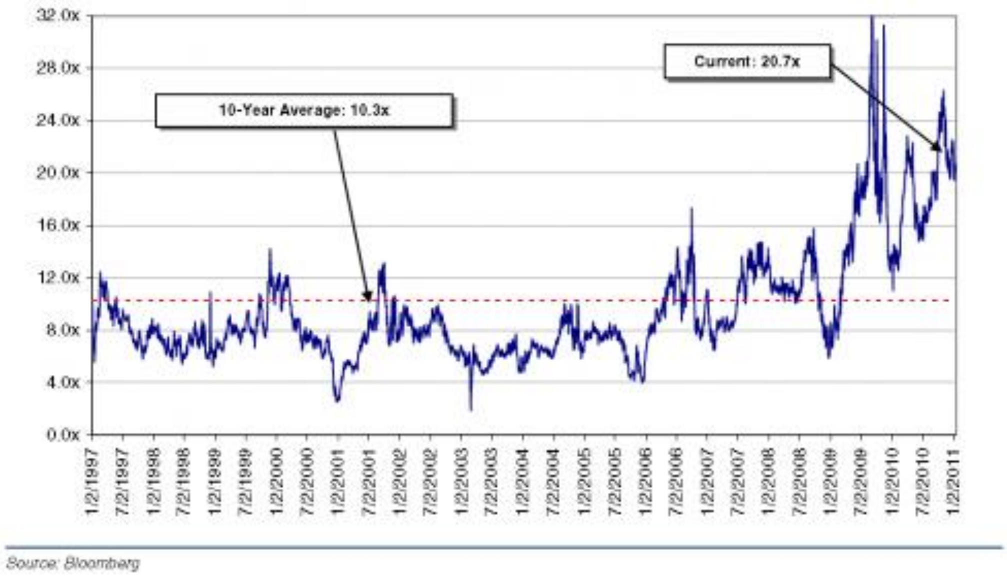


Figure 5: The price ratio between crude oil and natural gas in the US market (Powers B. , 2011)

Meantime, the production weighted price of coal in 2011 was \$2.57/MMBtu while that of natural gas was \$3.98/MMBtu (EIA, 2013b). However, this coals competitiveness reverses when it is compared to electricity generation cost. The levelized electricity generation cost entering service in 2018 by source presented that the cost of a gas turbine combined cycle (GTCC) plant is lower than that of a conventional coal-fired plant (EIA, 2013c). Moreover, the efficiency of GTCC reached 60%; GTCC requires less than 60 minutes for start-up after shut down (Gülen, 2013). The construction of GTCC plant takes three years, while coal-fired plants need five years (AEP, 2014). Thus, the gas's economics advantage is improving and attracts more demand.

(unit: $/MWh)

Plant type	Capital Cost	Operation Cost	Transmission Cost	Total Cost
Conventional Coal	65.7	33.2	1.2	100.1
Advanced Coal with CCS	88.4	45.9	1.2	135.5
GTCC	15.8	50.1	1.2	67.1
Advanced GTCC with CCS	34.0	58.2	1.2	93.4

Table 4: US levelized cost of new generation resources entering service in 2018 (EIA, 2013c)

Other concerns regarding the energy consumption are environmental impact and safety issues. Fossil fuels emit greenhouse gases (GHG) like carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_X), sulfur dioxides (SO_X), mercury, and other particulates when they are burned. Natural gas is the cleanest fuel among fossil fuels; it emits a half of CO_2, 1/5 of CO, 1/5 of NO_X,1/2,500 of SO_X , 1/400 of particulates, and no mercury compared to coal (Chandra, 2006). The international treaty to prevent climate change forces countries to reduce GHG emission; a shortcut to comply the agreement is replacing other fossil fuels with natural gas. Moreover, many countries are abandoning nuclear plants, another powerful competing energy source, and this energy source is likely to be substituted with natural gas.

(Unit: lbs/MMMBtu)

Plant type	Capital Cost	Operation Cost	Transmission Cost
CO_2	117,000	164,000	208,000
CO	40	33	208
NO_X	92	448	457
SO_2	1	1,122	2.591
Particulates	7	84	2.744
Mercury		0.007	0.016

Table 5: Comparative emissions levels of fossil fuels (Chandra, 2006)

With all these aspects considered, natural gas consumption is likely to increase and EIA estimated that the increasw will rise from 116.8 Quad in 2010 to 177.9 in 2040 with an average growth rate of 1.7%, the highest growth rate among fossil fuels.

(Unit: quadrillion Btu)

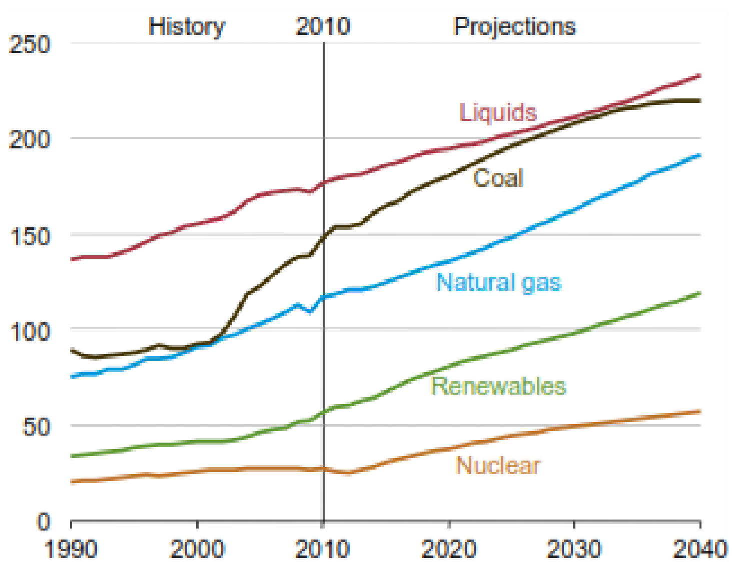


Figure 6: World energy consumption by fuel type, 1990-2040 (EIA, 2013a)

Like other hydrocarbon sources, natural gas is used in heating, lighting, electric generation, chemical feedstock, and transportation. EIA's 2010 data and forecast about world natural gas use by sectors from 2010 - 2040, indicates the following: Industrial users consumed, in 2010, 39% of natural gas for heating, lighting, combined heat and power, process heating, and the feedstock for petrochemical and fertilizer, etc. U.S. petrochemical companies are expanding the use of natural gas as process feedstock due to the low price, and are expected to enjoy the competitive advantage, since their competitors are using an expensive petroleum feedstock, naphtha. Residential users accounted for 17% of natural gas consumption in 2010 and this use will grow with expanding urban gas networks in developing countries. In electric generation, which consumed 33.6% of natural gas in 2011, natural gas will continue to expand its composition due to its relatively low price, substituting the old coal-fired utilities. The transportation sector is not growing substantially with only 3% share, but its feasibility will continue to be tested in the form of gas-to-liquid (GTL), compressed natural gas (CNG), and LNG.

(Unit: quadrillion Btu)

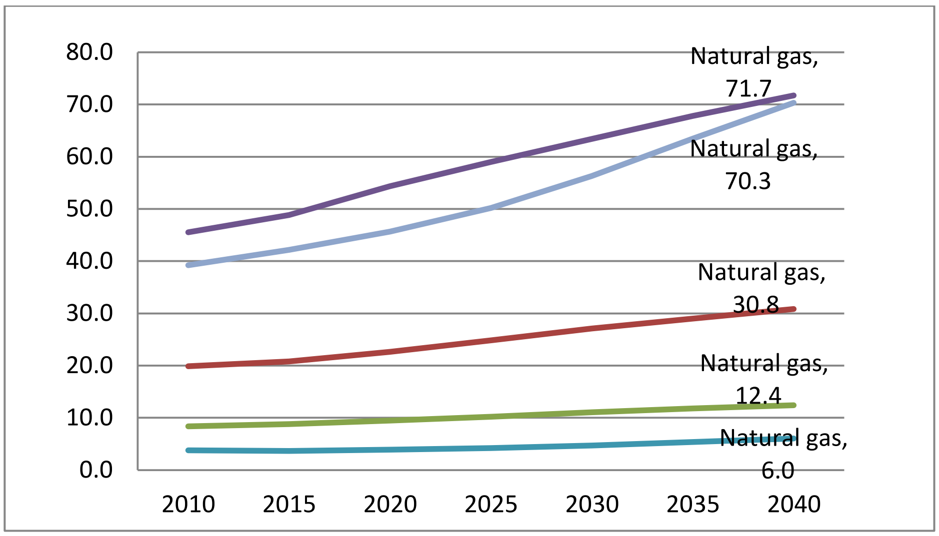


Figure 7: World natural gas consumption by end-use sector, 1990-2040 (EIA, 2013a)

2.1.5 Contracts and Price Determination

Transactions of natural gas can be divided into three main phases involve different entities and contracts: licensing, wholesale, and retail sales.

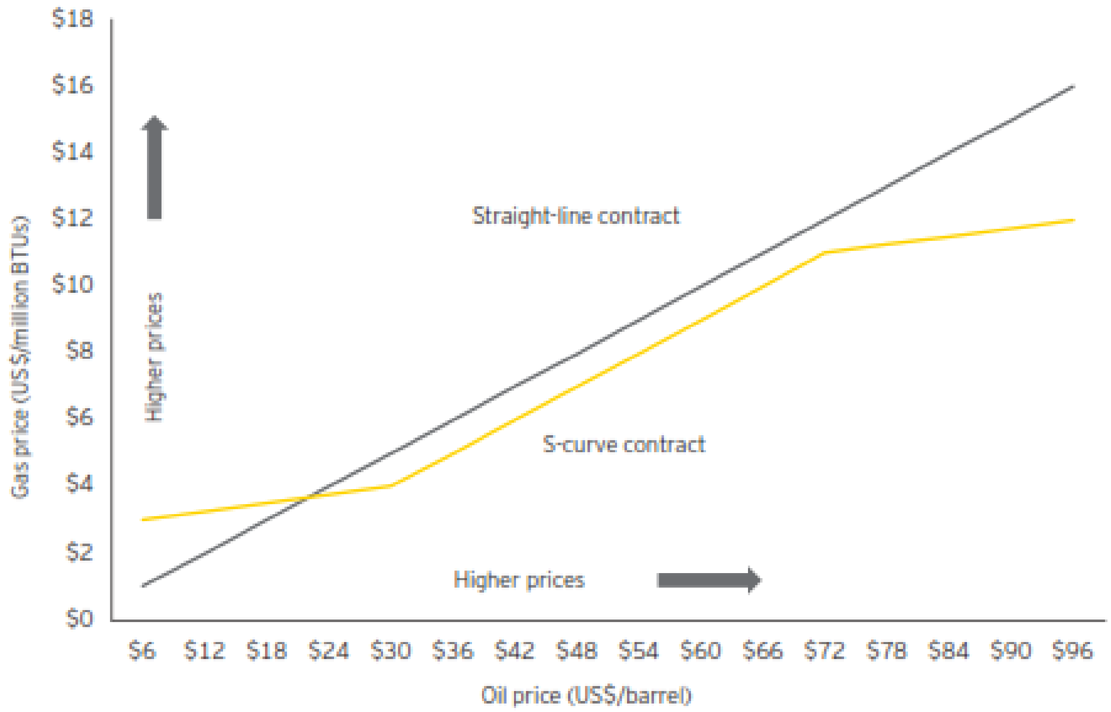
2.1.5.1 Licensing

At the licensing phase, an entity that wants to explore and produce needs to get a permit to do so from another entity that has the authority. In many countries, natural resources' rights belong to the nation or state except in North America, where private entities can own the resource right. In most cases, the producers are large international oil companies (IOC), because oil and gas exploration is very risky and requires experiences, technologies and huge capitals. Typically, the host, the hosting government (HG), or the national running oil company (NOC), or individuals in North America, endows the right to produce resources from the reservoir to a contractor, which is an IOC operating the production. Then, both parties need to sign contracts about sharing the output. This contract has a variety of forms, but its main distinctions are a concession and a profit sharing contract (PSC). In a concession contract, the IOC should pay a royalty proportional to the revenue from the well every year regardless of their profitability. In a PSC, the IOC is compensated for their expenses first and then shares the remained profit with the host. The concession guarantees the income for the host, but the windfall is shared with the host. PSC gives more income to the host during a boom, but smaller or zero stake during a recession. Today, to moderate these merits and demerits, hybrid contracts, combinations of the royalties and the profit sharing are common. The host is paid some portion of the royalty, next contractors cover their expenses, and then the remaining profit is shared between two parties. Additionally, the contractor should pay income tax on its profit separately according to the national tax law (Smith, et al., 2010).

2.1.5.2 Wholesale

The contractors, then, need to sell the gas to the wholesalers. In a market like North America's, contractors can sell gas directly to local distribution companies (LDC), but as in most cases of international transactions, a big intermediary dealer first imports gas to a country and then sells it to that country's LDCs. The critical decisions regarding the transaction condition are made in the sales and purchase agreement (SPA) between the producer and the importer. An SPA is a contract that includes terms, quantities, prices, and obligations. Terms vary from a one-time deal to tens of years. In the past, natural gas could only be purchased with a long-term contract that compensated for the risky investment. Long-term contracts still constitute a majority of the transactions, though spot markets are expanding. In the same light of this, some projects require a buyer to commit to buying all of the output; this is called a depletion contracts. Moreover, some projects requires a minimum or maximum quantity to be taken within specific periods such as daily, weekly, or monthly, when the production is subject to the continued operation. Even take or pay (TOP) obligation can be accepted to ensure the payout and continued operation, which forces buyers to take output gas or pay 60-95% of its price in case the buyers are not able to take them. Unfair provisions like fixed delivery points and transfer preventions prevailed in the past, because the market was seller-oriented (Chandra, 2006).

Price determination methods are also diverse. In the beginning stages of natural gas industry, natural gas exchange markets were not established. The first trade of natural gas on the New York Mercantile Exchange (NYMEX) was made only after 1988 (Cooper, 2006). Moreover, in the past natural gas transactions were mostly bilateral and veiled, so individual negotiation decided conditions. The most implemented method was linking the price of natural gas to the equivalent price of substitutes such as crude oil, gas oil, and fuel oil, which is called oil indexation. In the Asian market where most gas is imported as LNG and lacks indigenous gas resources, the natural gas price is linked to crude oil. For example, Japan's customs-cleared price (JCC) first calculates the average price of a basket of crude oil imported to Japan during the month. Then, the weight of 16.67%, the heat-equivalent of natural gas to crude oil, is multiplied to this crude oil basket price and this type of contract is called "straight-line contract." However, this parity can be adjusted by negotiation up or down. Some contracts add another modification that provides a ceiling to protect buyers at high oil prices and floor to protect sellers at low oil prices. This type of contract is called an "S-curve contract" (EY, 2013).



Source: EY adapted from Deutsche Bank Markets Research, *The Australian LNG Handbook*, 6 September 2011

Figure 8: LNG contract slopes of JCC (EY, 2013)

In the US market, which is regarded as the most competitive market, price is fully determined by supply and demand via exchange markets. Natural Gas Spot Prices at Henry Hub (HH spot) on the NYMEX is the most representative price index in the market. The spot and future exchanges are fully utilized by various financial tools like option, future and other derivatives. The European market is more diverse, since the market is composed of many countries that govern their market separately and the delivery forms are mixed with pipeline gas and LNG. This market has used the indexation of gas oil and fuel oil rather than crude oil. However, the region is establishing exchange hubs such as the National Balancing Point (NBP) in the UK and new or renewing contracts are changing the price term to spot price indexation (Melling, 2010). The reason why spot price indexation is preferred more than oil indexation is the current decoupling of gas spot prices from oil spot prices. Gas spot prices are cheaper than the oil indexed price, as shown in Figure 9.

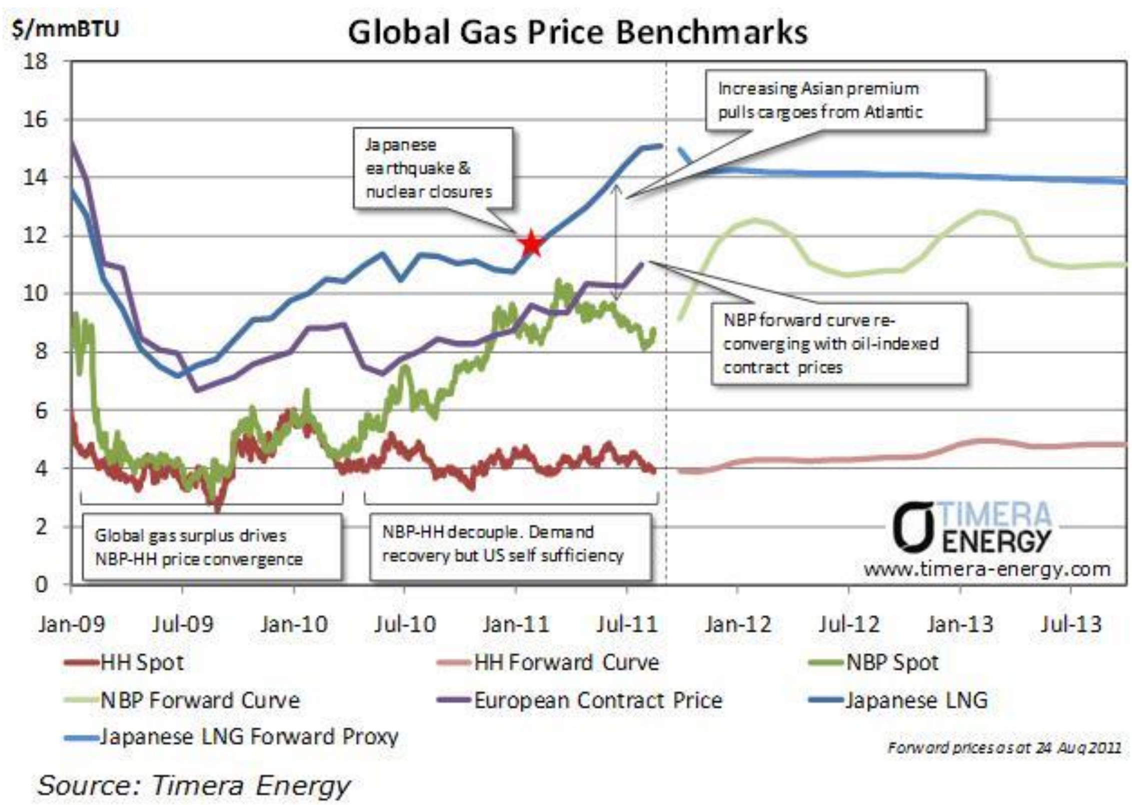


Figure 9: Historical movements of global gas price benchmarks (Timera Energy, 2011)

Due to this diversity, prices of natural gas differed by region, as shown in Figure 10.

(Unit: USD/mmbtu)

Figure 10: A July 2013 overview of global spot gas price benchmarks (Timera Energy, 2013)

2.1.5.3 Retail

Once natural gas is transmitted to the regional market, it is delivered to LDCs and then to the end-users. In some countries, the large customers can import natural gas directly for their own uses. Different from the prior steps where principals of global demand and supply dominates (though some countries are controlling the importing step), local distributions in most countries are subject to governments' regulations. The prices are calculated on a cost basis and the operations are controlled by national plans. LDCs are allowed to earn a reasonable profit and should not discriminate against consumers based on the service cost. However, places like the U.S. and the U.K. successfully liberalized their gas retail market and European countries are trying to make their retail market more competitive. Transaction practices vary by region and case, and it is impossible to deal with the all types of market structure and regulations. In the next chapter, this thesis provides detailed cases of the retail market as it pertains to the Korean natural gas market.

2.1.6 New Trends

Natural gas served as modern society's one of the main energy resources, but its importance is getting larger. Supply is increasing after shale revolution and the increasing supply is influencing on the trade practices. Many countries want a more competitive natural gas market and are establishing spot exchange floors and hubs. The trading system in the past natural gas market focused on securing the producer's return on investment. However, the changes in market balance and introduction of new systems will enable the diverse types of transaction practices and risk managements used in other commodities to the gas business. Thus, the new trends will cast questions regarding the incumbent market structures that are implemented in each regions and countries.

2.2 OVERVIEW OF KOREAN NATURAL GAS MARKET

Because it is a country with little fossil fuel resources, Korea has a high foreign dependence regarding its valuable energy security. The country's natural market allows monopoly and regulations preventing the abuse of the monopoly power. The following sections provide the basic features of the Korean natural gas market before discussing the effectiveness of the current market structure.

2.2.1 Brief overview of the energy structure of Korea

According to the 2013 annual report on Korea's energy status by the Korea Energy Economics Institute (KEEI), Korea's primary energy consumption has increased consistently by 4~12% of annual growth rates from about 46 million tonnes of oil equivalent (toe) in 1980 to 275 million toe in 2011. Since Korea's main economic development driving forces are highly energy intensive, such as petrochemical, steel-making, and other manufacturing industries, the industrial sector used 61.7% of its energy use in 2011. The major primary energy sources of Korea are fossil fuels such as oil, LNG, and Coal, which comprised 82.8 % of total energy sources, followed by nuclear power at 11.7% of the energy supply in 2011. The critical factor threatening Korea's energy supply stability is its high oversea dependency on import; it is importing 96.4% of its primary energy sources. This characterizes Korea's energy structure and practices.

First, the Korean government is actively regulating its energy sectors on both the supply and demand sides. State-owned companies are dominating in regard to supplying electricity and natural industry, while their retail prices are regulated by the state or the government to support people's lives. The petroleum industry is privatized but products are heavily taxed to maintain the fiscal income. Moreover, the Korean government pushes a strong policy to restrain energy consumption. For example, it regulates air conditioning or heating temperature inside commercial buildings, limits lighting hours for commercial uses, promotes the 5th-day-no-driving culture, and enforces corporations to decrease electricity consumption by 10%. All of these efforts are meant to secure energy stability, but they have a limited effect due to inconsistent energy price policy and a natural deficit of primary energy resources.[1]

Second, as the result of government intervention in energy prices through regulation and taxation, the electricity price became low and the petroleum products price became expensive compared to other countries; electricity price was about half of the OECD average and kerosene price was 20% higher than the OECD average (KEEI, 2013).

[1] The electricity price in Korea is relatively lower than other energy sources, which will be discussed later.

(Unit: $/liter)

	Regular unleaded gasoline	Automotive diesel	Light fuel oil for households	Automotive LPG
Korea	1.741	1.575	1.1977	0.972
Japan	1.826	1.579	1.1336	..
UK	x	2.222	1.0910	..
France	x	1.859	1.2345	1.187
Italy	x	2.013	1.8866	1.051
US	0.930	1.017	1.0319	..
OECD average	1.064	1.565	1.1661	..

Note: x = not applicable, .. = not available
Source: IEA, Energy Prices & Taxes, 4th Quarter 2012

Table 6: Consumer prices of oil products in Korea as of 2011 (KEEI, 2013)

Thus, Korean consumers use electricity rather than petroleum and the electricity composition in Korean final energy consumption increased from 17.3% in 1990 to 41.1% in 2012, while that of petroleum decreased from 52.4% to 14.9% during the same period.

(Unit: US$/toe, Net Calorific Value)

	Natural gas for industy	Natural gas for households	Electricity for industy	Electricity for households
Korea	778.0	839.7	672.1('09)	1,030.7
Japan	908.1	2,136.6	2,081.8	3,034.1
UK	458.9	869.9	1,481.3	2,455.6
France	665.7	1,121.2	1,413.2	2,175.5
Italy	536.7('10)	1,215.2('10)	3,247.8	3,242.8
US	219.1	464.5	808.9	1,370.2
OECD average	380.6	786.5	1,436.1	2,028.7

Source: IEA, Energy Prices &Taxes, 4th Quarter 2012

Table 7: Consumer prices of natural gas and electricity in Korea as of 2011 (KEEI, 2013)

In order to maintain the low electricity price, the Korean government has promoted the implementation of nuclear plants. Nuclear generation comprises 26.3% of Korea's electricity supply and the government announced its plan to build more nuclear plants to increase the composition of nuclear power in the energy mix to 29% (Mundy, 2014).

Third, Korea has a larger oil refinery capacity than its domestic petroleum product demand even though it has little indigenous hydrocarbon reserve. Korea's four main refinery companies have total refining capacity of 3.1 mil barrel per day (bpd) and they imported USD 100 billion of crude oil, but exported 51 billion dollars' worth of petroleum products in 2011 (Kang & Bae, 2012). This alleviates the country's burden to pay for domestic energy demands.

2.2.2 Overview of demand in Korean natural gas market

Fossil fuels comprise 86% of Korea's primary energy source with an LNG portion of 16.8%. In 1986, Natural gas was first included into Korea's energy mix and the primary energy consumption of natural gas reached 21 million toe (45.7 bcm) in 2011. The consumption as urban gas or LNG was 14 million toe; 6 million toe was used for electricity generation. In 2011, residential and commercial uses comprised 55.8% of the gas typed final consumption, followed by industrial usage of 38.9%, except the energy input for the electricity generation. Most final consumption, with the exception of the electricity, is supplied as urban gas regardless of end-use. The accessibility rate to the urban gas network, which indicates the ratio between the number of households accessible to pipeline networks and the number of total households, is 75% in average, 87% in metropolitan area and 63% in other area; this accessibility is considered to be saturated. The end use of natural gas devoted to heating purposes is not likely to increase substantially in the future because it is competing with combined heat and power (CHP) and cheap electric heaters (Kim & Yoo, 2013).

(Unit: 1,000 boe)

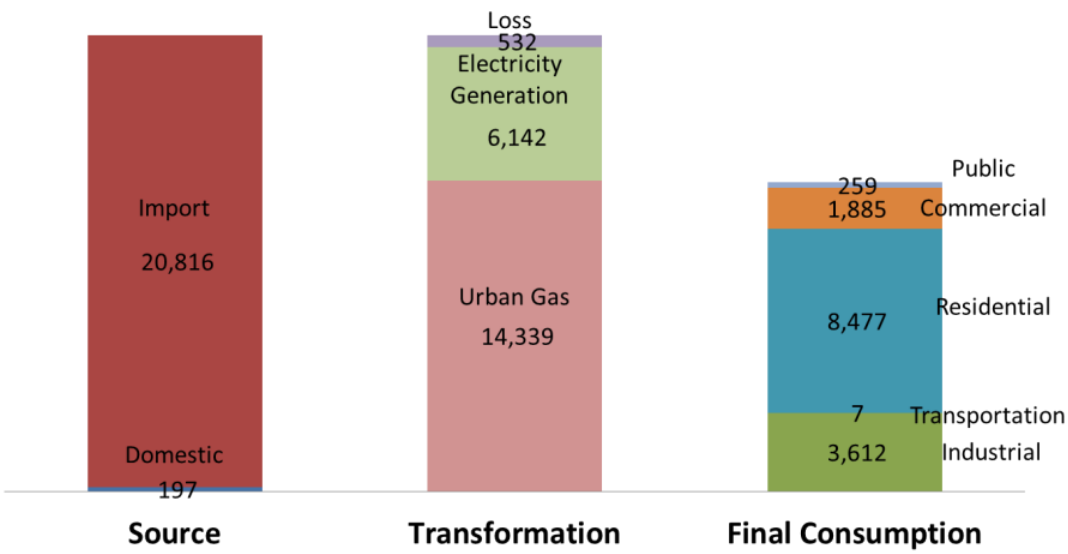


Figure 11: Natural gas supply and demand by sectors in Korea (drawn from KEEI data)

However, the top down ratio (TDR) of natural gas demand, the ratio of demand amount of peak month and bottom month, is high at 1.945 in 2012 (KOGAS, 2012); this swaying demand is caused by seasonal effect (demand is smaller in the summer and greater in the winter) and increases the gas purchase cost while deteriorating supply stability because of the high dependence on the spot market. Electricity generation, which improves demand stability with a low TDR, could increase considering the Korean government's new long-term energy plan approved this year; the government announced that it will promote decentralized generation, of which a most available decentralized generation method is small gas-fired power plants (Yoon H. , 2013).

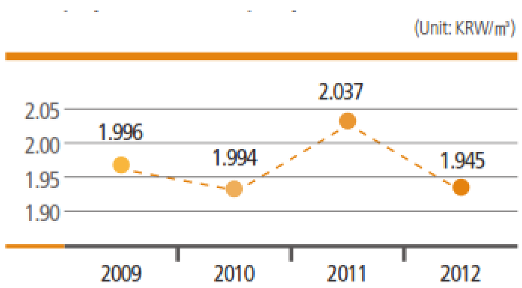


Figure 12: TDR of natural gas consumption in Korea (KOGAS, 2012)

2.2.3 Overview of supply in Korean natural gas industry

Korea had 1.0 bcm of proven reserves of natural gas at the end of 2011 and it produced 1.0 bcm that same year. The reservoir will deplete soon, after which it will be used as gas storage.

Export Country	Exporter	Export Facility	Importer	Import Country	Import Quantity (mtpa)	Duration	Effective
Indonesia	Badak LNG	Bontang	Kogas	South Korea	2	20	1994
Brunei	Brunei LNG	Lumut	Kogas	South Korea	1	21	1997
Indonesia	Badak LNG	Bontang	Kogas	South Korea	1	19	1998
Qatar	Rasgas	Rasgas 0	Kogas	South Korea	4.92	25	1999
Oman	Oman LNG	Oman LNG	Kogas	South Korea	4.06	24	2000
Qatar	Rasgas	Rasgas	Kogas	South Korea	7	20	2007
Qatar	Rasgas	Rasgas 3 T2	Kogas	South Korea	2.1	19	2007
Malaysia	MLNG Tiga	Bintulu	Kogas	South Korea	2	20	2008
Russia	Sakhalin Energy	Sakhalin-2	Kogas	South Korea	1.5	20	2008
Yemen	Yemen LNG	Yemen LNG T1	Kogas	South Korea	2	20	2009
Qatar	Rasgas	Rasgas 3 T3	Kogas	South Korea	2	20	2012
Indonesia	Donggi Senoro	Donggi Senoro	Kogas	South Korea	0.7		2014
Australia	Chevron	Gorgon LNG	GS Caltex	South Korea	0.25	20	2015
Australia	Gladstone LNG	Gladstone LNG	Kogas	South Korea	3.5	20	2015
Australia	Wheatstone LNG	Wheatstone LNG	Kogas	South Korea	1.5	20	2016
US	Cheniere Energy	Sabine Pass Train 3	Kogas	South Korea	3.5	20	2017
US	Freeport LNG	Freeport, Train 3	SK LTA (Tolling Agreement)	South Korea	2.2	20	2018

Source: BMI

Table 8: Major Korean LNG Supply Deals (BMI, 2013a)

Because the natural gas consumption in 2011 was 45.7 bcm, the rest of the country's total, 44.7 bcm, was imported. Qatar, Oman, Malaysia and Indonesia have been the major countries exporting to Korea; recently this list expanded to include Nigeria, Russia, Australia, and the US (BMI, 2013a).

The Korean Gas Corporation (KOGAS), a state-run company, is the only entity allowed to import natural gas into Korean market, though several utility companies are importing small amounts of natural gas for their own uses. Additionally, KOGAS and the Korea Oil National Corporation (KNOC) are investing or participating in the overseas projects to secure energy supply security.

Figure 13: The map of LNG pipeline network as of 2011 (KEEI, 2012)

There are four LNG regasification terminals, three owned by KOGAS with a 56.5 million (mn) tpa capacity and one owned by Pohang Iron and Steel Company (POSCO) with 1.7 mn tpa capacity. Two more terminals are under construction and will be completed by 2016, adding 9.5 mn tpa capacity. Total LNG storage capacity as of 2012 is 8.8 million cubic meter (mcm) and will increase to 15.3 mcm by 2017 (BMI, 2013a). The total length of pipeline networks as of 2013 is 4,065 kilo meter (km) and will expand to 4,312 km by 2016. Accumulated capital investment for the networks reached KRW 7.7 trillion (KOGAS, 2012).

Using this infrastructure, KOGAS supplies gas to its direct buyers like the Korea Electric Power Corporation (KEPCO) or to local distribution companies. Thirty-three urban gas companies monopolize split regions and distribute gas to end-users.

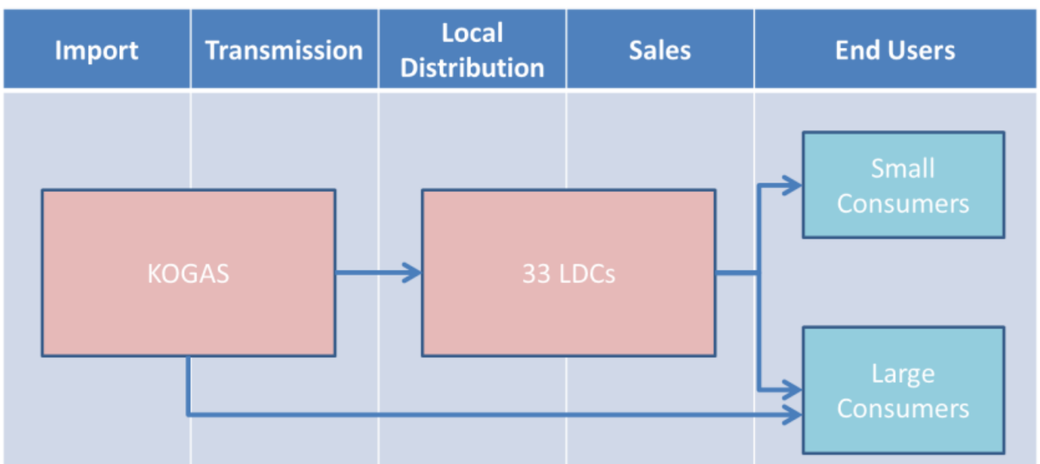


Figure 14: Diagram of Gas market structure in Korea

2.2.4 Regulations

The Korean Ministry of Knowledge and Economy (MKE) is the principle policy maker and supervises the execution of energy balance and climate change issues as well as the ruling statutes regarding the natural gas is urban gas business act. The import of natural gas is decided in accordance with the national energy master plan, which is revised every five years, and the long-term natural gas supply/demand plan, which is revised every two years. Balance is also adjusted during the operation at times of necessity. As mentioned above, KOGAS is the only agency authorized to deliver natural gas into the Korean domestic market except a small amount of own-use by permitted companies. Local distribution business is open to the private sector; all thirty-three LDCs are private companies. However, LDCs also need permission from local governments to open a business. Since the natural gas business is regarded as a public service in Korea, LDCs are required to provide universal and non-discriminative services regardless of cost and difficulty of service unless the condition falls under the criteria designated by law. Transmission lines are planned and constructed mainly by the Korean government and KOGAS; distribution lines are installed by LDCs when they have agreed to share the cost between the LDC and the benefited customer.

The most influential regulation on the business is regarding pricing. Prices have two steps: the wholesale price between KOGAS and LDCs and the retail price between LDCs and end-users. As a public good, cost-plus pricing methodology is accepted for natural gas in Korea, adding a reasonable return on infrastructure investment. First, the importing cost of natural gas provides the base for the pricing. The importing cost is consisted of LNG price, transportation costs like customs, sales tax, and importing dues. The price is adjusted every two months if the material price changes more than 3% during that time period.

Second, supplying costs will be added onto the importing cost. Supplying costs are the operating expenses of KOGAS and safety surcharges by law. After these charges, the reasonable return on the infrastructure investment is added; it is a similar concept to the weighted average cost of capital (WACC). Last, the loss from the previous term is added. Since the price is pre-determined by dividing the estimated price and sales volume before the sales term started, if there is an unexpected loss from the excessive cost rise, the loss is added and divided by the estimated sales volume for the new term. This adjustment is applied once in a year. The retail price formula is pretty same: operating expenses and WACCs of LDCs are added to the whole price where LDCs are buying the gas from KOGAS. At any rate, the material cost, gas import cost, is the most important factor in determining gas price, since it takes up 83% of the total cost (Lee S. , 2013).

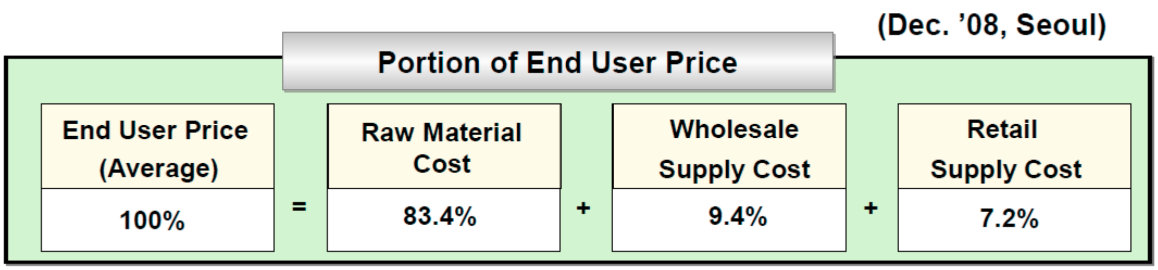


Figure 15: Cost structure of the retail urban gas in Seoul (Yoon N. , 2009)

2.2.5 Controversy on the Korean gas market structure

In short, the Korean government's policy goal regarding the natural gas industry structure is to supply natural gas stably and affordably. The government argues that its regulations are justified because: the importing price of natural gas into Korean market can be lowered by KOGAS' purchasing power and the supply stability can be enhanced by the monopolized import; the centralized infrastructure plan prevents redundancy and waste of national wealth; retail prices are regulated to prohibit the private companies' excess profit. However, opponents of the current system criticize it for its lack of competition. They are skeptical whether KOGAS did their best to purchase natural gas at the cheapest price; there is no comparable reference because KOGAS is the only importer. Moreover, there is no incentive for KOGAS and LDCs to reduce their operation expenses because all of the costs are transferable to end-users. All of the alleged inefficiencies are denied in the name of the stable supply, but the old wisdom that the absence of competition always brings out inefficiency causes consternation for the public. Moreover, the global natural gas industry is facing a paradigm shift as discussed above and question the relevancy and efficiency of the incumbent structure in the new environment.

In the light of this, an amended urban gas act was proposed last year, which aimed to permit private companies to import and sell gas in the domestic market (Yoon C. , 2013). However, parliament denied opening the market to private companies. The recently-passed act only permits the private companies to import and use gas for their own use or re-export (Seo, 2013). The pro-regulation perspective won the victory but the controversy remains unsolved. The latter part of this paper will explore the current controversy about the liberalization of Korean natural gas market and examine the validity of the arguments.

3. Debate on Korean Natural Gas Market Reform

Government policy and regulation have played an important role in forming the gas industries in many countries, including Korea. This chapter explores different types of market structures and regulatory systems. Then, it discusses the current status of the gas industry in South Korea and the controversy regarding its market structure. Finally, it examines the validity of the arguments presented in the chapter.

3.1 TYPES OF REGULATION AND MARKET STRUCTURE

The obvious distinctions of market structure are a government-controlled non-competitive market or a liberalized competitive market, though the degree of freedom and regulation varies. Some countries also have developed unique market structures according to their own situation. Regardless of the difference in structure, regulations are devised to enhance the industry's efficiency either by directly controlling the market or promoting the competition. This section compares different types of markets in order to provide a background for the discussion of market structure.

3.1.1 Government-controlled non-competitive market

Natural gas was an unwanted by-product during the oil production before the introduction of high tensile steel pipelines and electric welding. The pipeline network was critical for the gas industry as natural gas became available only after the pipeline network connected producers and customers. The onset of the natural gas industry in the U.S. started as privatized market and it soon experienced a natural monopoly. The natural monopoly refers to a monopoly formed in an industry with a high economy of scale, which requires a large amount of investment that acts as a natural entry barrier. In this case, a market failure occurs because of certain inefficiency. On the one hand, if the industry has competition with multiple players, redundancy in investment and expensive operational costs occur due to the low economy of scale, which is referred to as productive inefficiency. On the other hand, if a company succeeds in dominating the industry, the company has a monopoly status and will enjoy excessive profits. As a result, consumer benefits will be harmed; this is referred to as allocative inefficiency. Once this market structure is established, it has a strong entry barrier (Depoorter, 1999). Particularly in developing countries that lack capital and technology, the gas industry is initiated by the government or a state-controlled enterprise (SCE) to overcome investment difficulties. In this case, productive and allocative inefficiencies are believed to be removed since the whole industry is planned and established by a centralized scheme. Prices are also regulated to prohibit excessive profit seeking behavior by the monopolizing company. This is exactly what happened in South Korea, this paper's country of analysis. Taiwan, another main natural gas importing area in Asia, has the same market structure. These countries allow one monopolizing SCE import and transmit gas. Then, they split their areas into small distribution divisions and let LDCs serve each area by endowing local monopoly status.

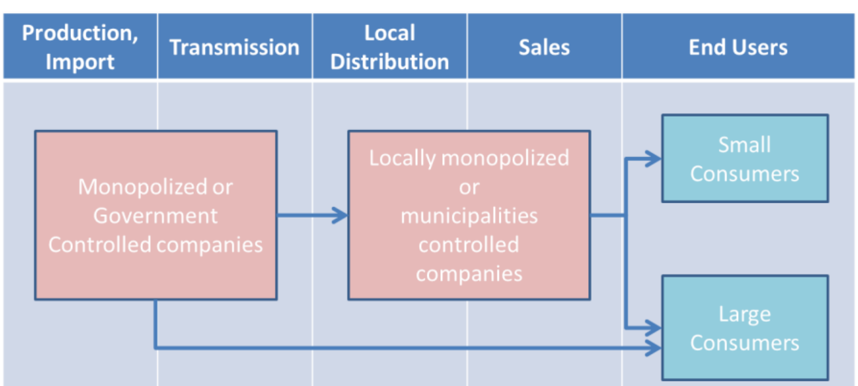


Figure 16: Diagram of Market structure in a non-competitive market

3.1.2 Liberalized market

Meanwhile, in the U.S., severe allegations were raised about natural monopoly and companies' abuses of their market power since private companies have comprised the industry from the start. Thus, regulatory efforts like a price cap and an entry limit to mitigate this market failure were implemented. However, those methods turned out to be a series of trial and error; the U.S. government finally realized that the absolute solution was to regard the pipelines as common carriers. Its diagnosis was that the monopoly power was endowed to neither producers nor customers but to pipeline service providers. Since they acted as the intermediary between producers and customers, they actually had the monopsony as well as monopoly; that is, they were paying less to producers and charging more to customers. The solution via U.S. regulation was functional unbundling and open access to the pipelines. The pipeline companies do not directly trade gas; rather, they only provide transportation services. If they established an affiliate to do intermediary business, they are forbidden to discriminate against other dealers in order to favor their own affiliate.

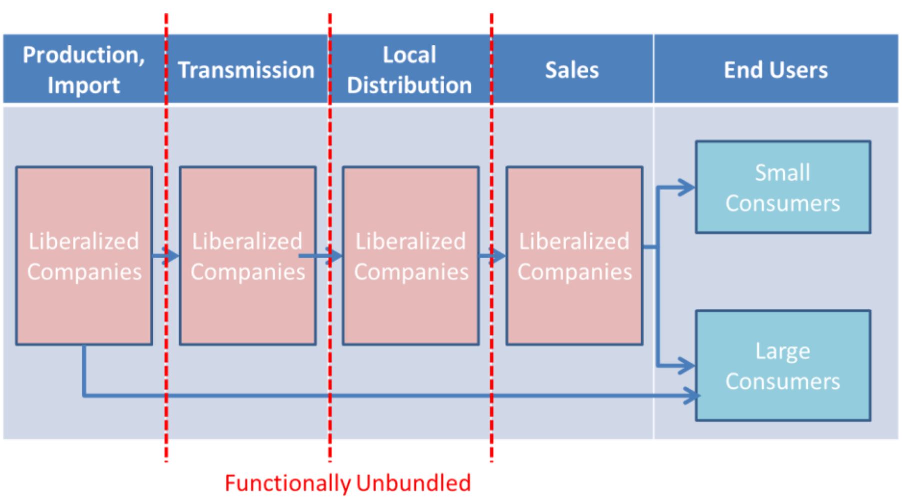


Figure 17: Diagram of Market structure in a competitive market

This equal status requirement applies to access to both physical infrastructure and information about tariffs and conditions. This change brought about a fully competitive market since shippers can deliver gas to any delivery depot and consumers can buy gas from any sellers without disadvantages. The United Kingdom also developed this kind of market structure. The exchange hub like Henry Hub and exchange market like NYMEX in the US can be highly developed because of the competitive environment; this exchange value acts as a benchmark price for physical transactions in the region. Thus, the industry is fully operated on market-base in this market (Bosselman, Eisen, Rossi, Spence, & Weaver, 2010).

3.1.3 Vertically integrated local monopoly

Another type of market structure is that of a vertically integrated company with local monopoly status. This monopoly can be a natural monopoly, like in the U.S. in the past, or a legally enforced monopoly, like in Japan. Natural gas producing countries used to have a local natural monopoly and each country introduced different remedies to cure the monopoly problem. As previously discussed, the U.S. solved this through competition; in contrast, Italy nationalized the industry in the 1950s. However, Japan opened this industry to private companies from the beginning. It endowed a local monopoly right as well as importing permission to LDCs. The large consumers like utility power companies (UPC) also received importing permission. Thus, the markets for general consumers and the large industrial consumers separated. Large industrial consumers import independently for their own use and LDCs establish individually vertically-integrated processes that include a wide range of duties, from importing to marketing. The monopolizing LDCs have built their own local networks and importing terminals, but they have not connected them into a nationwide network (Tokyo Gas Corporation, 2008). Consequentially, the local monopoly is very strong and the entry barrier is even higher than in other countries. The gas companies are importing only 35% of the nation's gas import amount and large industrial users 65% (BMI, 2013b); this results in the expensive and varying residential retail prices by local areas.

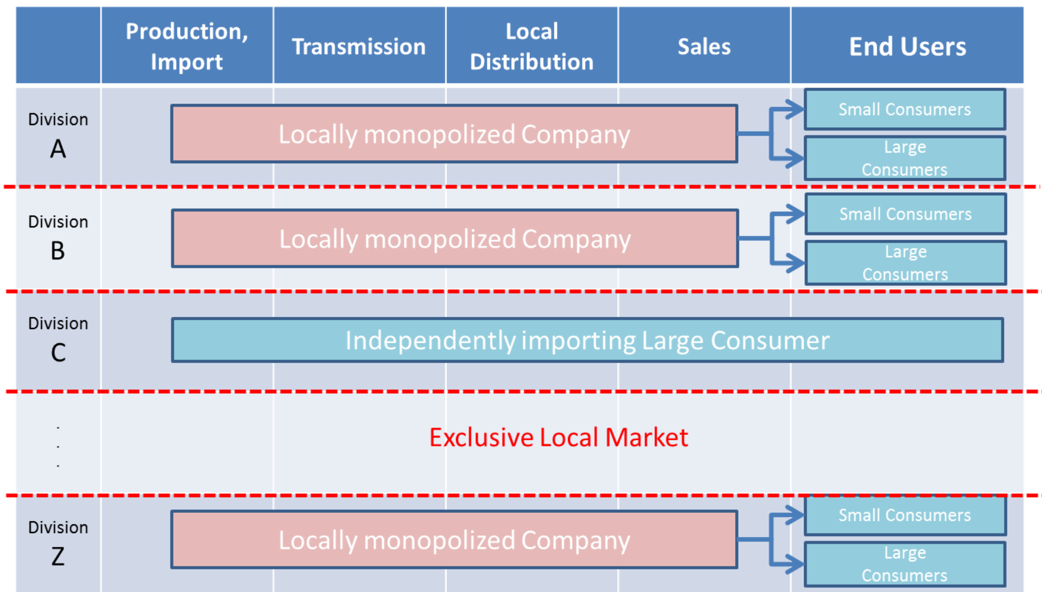


Figure 18: Diagram of Market structure of integrated local monopoly

Countries have chosen the market structure based on their own situation. Some countries liberalized; other countries are still controlling the market. The effectiveness of the structure is also up to the country's own situation. Most countries had monopolized and regulated market structure in the past to alleviate the market failure caused by natural monopoly. However, given the successful transition to the free open competitive markets of the U.S. and the U.K., many countries want to follow that trend. European countries have long attempted reforms on their natural gas market, but the Asian region, which is geopolitically short of negotiation power, lags behind the trend. Japan attempted the liberalization of natural gas market in 1995, but it was unsuccessful due to aforementioned strong local monopoly. Taiwan also attempted to open its gas market in 2003, but failed to induce investment from the private sector and obtain consensus on the reform. Since 1999, South Korea has discussed gas market reform, when the country suffered an economic crisis and was aided by the IMF, but there have been few changes so far.

3.2 KOREAN NATURAL GAS MARKET

Many countries developed and managed their gas industry as a public sector. In the beginning of industrialization in South Korea, the government drove the economic development and since the 1980s the gas industry was also established under the government leadership. The original structure still remains, but the voices demanding reform are also rising. This section examines the reasons for reform and related events.

3.2.1 Rationales for reform of the Korean natural gas market

An SCE like KOGAS is favored by the government as it executes governmental policy and has a good policy measure to cure the natural monopoly in terms of efficiency. These measures include supplying public goods, removing negative externality, and promoting positive externality. Moreover, the government can support the start-up of the industry with high investment cost and redistribute the wealth from the industry to society (Ahn, 2005). In light of this, the central government of Korea established KOGAS and municipalities established LDCs to develop the natural gas industry. KOGAS was given a monopoly right in import and transmission and LDCs local distribution by law. This structure was somewhat inevitable, though opinions vary, considering the economic capability of the country at the time--it lacked capital and technology. Later, governments privatized the matured industry and, in Korea, all of the LDCs were eventually sold to private companies. However, they still hold their local monopoly status and KOGAS maintains its public ownership and monopoly in import and transmission.

This incumbent market structure bears the possibility of inefficiency for two reasons: monopoly and moral hazard. A monopoly company's demand curve forms above its marginal revenue curve; the price is decided by the monopolizing company at a higher level where its marginal revenue equals marginal cost. Thus, the production quantity is smaller and the price is higher than those in a competitive market. The monopoly company takes consumer surplus since the consumers pay more than they want; the economy has a dead loss since the company reduces production to be smaller than the amount that the economy can consume if met by the supply (Posner, 1975).

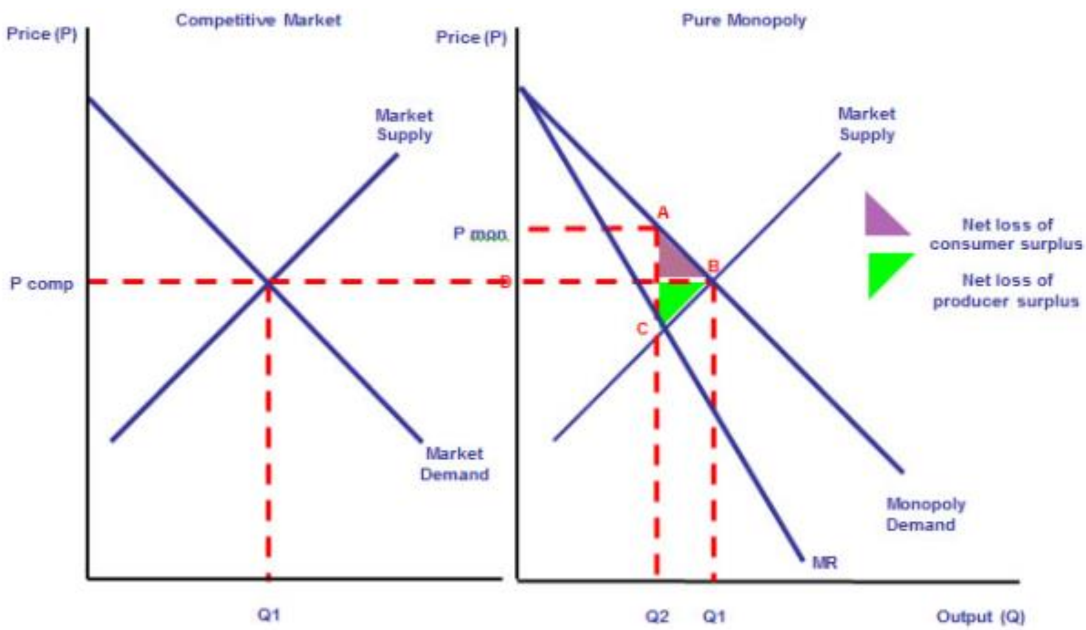


Figure 19: Comparison of equilibrium in competitive market and non-competitive market (Riley, 2012)

To prevent this loss and excessive profit, the government intervenes and regulates the price to be equal to marginal costs. However, the allocative inefficiency is unavoidable if the average cost is higher than this marginal cost since the price should be higher than the average cost to protect the supplier from loss. This can happen particularly in an industry with high economy of scale. Now, the wholesale and retail prices of natural gas in South Korea are in controlled by its central government and its municipalities. Regulated prices are decided based on cost and doubt cast on the genuineness of this cost. It is probable that consumers are paying more than they should, if the companies are inefficient and neglect effort to reduce the cost and many theories tried to explain this probability.

In *agent theory*, the inefficiency occurs because a *principal* fails to perfectly monitor its *agent*'s performance. The failure is unavoidable due to the informational asymmetries; the agent knows better than the task because it is in the middle of the task. Thus, there are motivations for the agent to pursue its own interests rather than the principal's interests and the principal will get a lower return than expected as a result. To prevent this moral hazard, the principal should devise and utilize incentives so that the agent's goal should be aligned with that of the principal (Gibbons, 1998). Applying this theory to the Korean gas market, a market is regulated and monopolized because it is regarded a public service irrespective of the ownership types of the participating companies. The consumers are the principal in this situation, but they are indirectly hiring the service providers. Even though consumers are paying the price for gas, the companies are more subject to governmental order than consumer's requests because the service providers are licensed by the government and municipalities; their profitability is up to the government or municipalities' approval. As a result, the companies fail to serve customers to their maximum satisfaction.

Some parties argue that the current structure is more inefficient because the main part of the industry is executed by an SCE, KOGAS. The *property theory* explains the inefficiency of SCE in terms of company's ownership. The theory argues that the privately owned company is more efficient because the owner is a residual claimant, which means that he or she receives extra earnings by his or her effort to perform better, while an SCE does not have that incentive (Kim & Mahoney, 2005). Moreover, in *pubic choice theory*, the SCE does not act to maximize public interest but to maximize labor interest in the public sector (Engelen, 2007). The government also pursues its own goal, like reelection, and utilizes the SCE as a reward for the politicians who contributed to the election. Since the gas industry in Korea consists of both SCE and private companies, *agent theory* more universally explains about the inefficiency problem than other theories. This argument then expands to the debate on reform of the Korean natural gas market.

3.2.2 Reform attempts in the Korean natural gas market

After the economic crisis in the 1990s, the concept that privatization equals efficiency improvement prevailed in Korea. The Korean government planned to divide KOGAS into three importing parts and a transmission component and then to sell the importing parts to the private sector. As a preliminary arrangement for the plan, KOGAS went public in 1999, and a 40% share was sold to private shareholders. However, further attempts to privatize KOGAS failed since the exporting parties denied transferring the SPA to the purchasers of the KOGAS business. Since then, the plan has diverted focus, changing the market into a competitive one rather than privatizing KOGAS. The plan is to open the importing function to the new entries and liberalize the local distribution market. However, this plan also has failed due to opposition from the labor union of KOGAS and LDCs (KFTC, 2009a). The plan to improve the efficiency of natural gas industry by a competitive market is still ongoing despite the failures, but there seems to be no consensus about liberalizing the gas market in Korea. The latest event regarding gas market reform was last year's proposed urban gas act. As discussed above, the proposed urban gas act originally included the decisive change to open the natural gas import function to 3rd party private companies, but ended up only allowing 3rd party companies to resell their imported gas to the foreign market and not to the domestic market.

The failure of the original bill's passage was influenced by the unique psyche in Korea and another event happened in the railroad sector last year. There is a unique negative sentiment about the competitive market and enterprise activities in South Korea. Even though South Korea's economy is established under capitalism, people regard private profit seeking behavior as undesirable. This sentiment formed in the rapid economic development period during military dictatorship in the late twentieth century, when entrepreneurs took advantage of partnership with corrupt political power (Powers C. M., 2010). The problem is that the introduction of competition and privatization are often taken in the same breath since people think that new entry companies to the liberalized market are likely to be private conglomerates. Thus, any attempt to induce competition in the public service sector faces severe opposition from left wing politicians and activists. As a recent example, the South Korean government approved a reform plan of Korail in 2013, the state owned railroad company, to spin off an affiliate to operate new lines and compete with Korail. The backlash was fierce; Korail's labor union went on strike and the public showed their negative opinion by staging demonstrations against this reform. This was apparently not a privatization since Korail was establishing an affiliate, but the potential possibility that the affiliate could be sold to a private company in the future was enough to bring out the opposition. Although Korail is notorious for its huge deficit and inefficiency, fears of a rising fare and the closure of the unprofitable line in profit seeking behavior dominated people's sentiment (Park E. , 2013). Backed by this sentiment, arguments arose that the government should cease to open the gas market due to the unique characteristic of South Korean gas market. This atmosphere acts as a strong obstacle in the reform of the gas market, but the assertion is irrational and biased in some aspects. The next section will introduce in detail and rebut the main opposition reasons about gas market liberalization.

3.3 Further Debate on Reform

There are three main reasons for the opposition to liberalize the South Korean natural gas market: the belief that natural gas should be a universal public service, the trust that the current regulation is the remedy for potential inefficiency due to natural monopoly, the faith that the unified purchase is an advantageous method of gas procurement due to purchasing power.

3.3.1 The discussion of public service

The first argument is that natural gas is a public good and so it is better to be supplied by public sectors because private sectors are pursuing profit maximization, which can cause a price surge and the exclusion of unprofitable customers. In this argument, the term "public good" has multiple meanings. It is used as a sociological term to indicate that natural gas is deeply related to people's lives mainly because gas is used as a fuel for residential heating and cooking. Thus, some people argue that gas is an essential good. However, in order to satisfy the strict economic definition of an essential good, the item should have low price elasticity and have hard-to-find substitutes (Benson, 2002). In these terms, energy is absolutely essential, but it does not necessarily mean that each fuel is essential. As discussed above, fossil fuels are competing with each other according to their efficiency and situational economics. Moreover, gas is not just used for residential heating but also for industrial use. A similar fault can be found in terms of public goods. The characteristics of a public good are that, once the good is produced, a consumer cannot be excluded from using it; there will be no additional cost or competition for additional users. In light of this, gas itself is not a public good, though urban gas networks can be a club good. Once the pipeline network is installed, people in the network are anchored to use it, and the connection cost is very low for each consumer within the accessible distance to the network. However, gas has a unit cost and is a limited good. Though the price elasticity of urban gas is low for a customer once he or she included into the network and he or she would not want to be excluded from the service, in reality, the customer fails to pay the fee is already being excluded or limited from the service. Moreover, supplying gas to a remote and sparse area via pipelines is questionable considering the high construction cost and safety risk. In modern life, electricity is becoming more essential since electric devices can be activated by electricity only, but heating or cooking has many substitutes like oil or coal, which are more appropriate for difficult circumstances. This is the matter of convenience, not of essentialness. Thus, the idea of "publicness" of natural gas does not compute.

In regards to the universal service of natural gas, service is already universal in cost-efficient areas. The accessibility rate to Korean's urban gas network is 77% on average, 88% in metropolitan areas, and 64% in other areas, and is considered to be saturated (Sung & Yoo, 2014). The extension of the pipeline networks should be decided case by case according to economics and the cost share between customers and suppliers. The pipeline installment fee is actually already paid by customers, though people think the existing network is free. The invested capital expense is being amortized as depreciation cost (NTS, 2010). Thus, there will be no practical difference between the service from the public sector or the private sector.

Another concern causing worry is the fear of price surge due to privatization. As explained above, in Japan, the retail gas price is much higher than in Korea. People think that the higher price is because of privatization but it is actually because of the economy of scale in supplying cost based on the one-time consumption amount. Large consumers have a simpler supply chain and require smaller cost with regards to gas procurement (Hong, 2010). The cross subsidizing from large consumers to general consumers looks favorable for general consumers and separating the market will raise prices for the general consumers. However, price distortion needs to be evaluated in light of the overall economy. The lowered gas cost for the large consumer will enhance their competitiveness and eventually benefit the economy and small consumers as a whole. As discussed above, distorted electricity price influences inefficient energy consumption in Korea. Therefore, a price reflecting the market situation is the best solution (Lee S. , 2011). The effect of the price can be alleviated through social security, such as subsidizing poor people.

3.3.2 The discussion of natural monopoly

Regarding the natural monopoly problem, it is uncertain if the gas industry really belongs in this category since the high capital expenditure problem that causes the natural monopoly does not continue in the gas industry once pipelines are installed. Some people think of gas transmission and distribution as a kind of network industry like the railroad or telecommunication, which is the representative example of an industry with natural monopoly. A network industry has interconnected nodes, which are components of its products, and establishing connections of those nodes constitutes the firm's product. However, the term "network" connotes the hasty prejudice with which people regard a "network industry" if the industry has a network-shaped facility. Some people just use the term "network industry" for the gas industry because of its gas pipeline networks. However, gas pipeline networks fall short of the two main qualifications needed to be a network industry: the presence of externality and the need for repeated investments due to radical technology advancement.

In a network industry, the value of the last node does not decrease unlike the law of demand, since the last node is creating another individual product (Gottinger, 2003). For example, in the telecommunication industry, the joining of the *n*th new customer creates 2*(n-1) number of new products, since he or she will be connected to the previous n-1 customers and those connections constitute individual products. In other words, the entry of the new customer *z* ,the 24^{th} customer, to the network with *a* to *y* customer previously increases the product number from 22*23 to 23*24 by adding 2*23 products, since new combination of connection from *a*-*y* to *z* and from *z* to *a*-*y* are added to the network. It is same for the railroad network: a new station in Austin will create a new product from the capital city to Houston or Dallas, assuming that the network only had Houston and Dallas. The network with two stations originally had two products, providing two one-way routes from Dallas to Houston or from Houston to Dallas; after adding one more station in Austin, it has six products with the combination of the three stations. This is because of the multi-directional connection of the nodes. In gas pipeline networks, the flow of gas is one-directional. Gas flows from the storage node to the consumer node, but does not flow in the opposite direction. Connecting between consumer nodes does not constitute a product different from the examples above. Thus, the addition of the pipeline node to the gas network is not as valuable as in the network industry.

Moreover, the network industry keeps requiring reinvestment of large amounts of money because technology development nullifies the previous networks and needs new networks to improve quality of service. Wireless telecommunication has improved the speed and amount of service from 2G to LTE, and at the each phase of protocol, telecommunication companies should renew their network with huge amounts of investment. This industry trait is highly likely to be the barrier for the new entry and acts as the cause of natural monopoly. However, gas pipeline networks do not need to renew the whole of system after installment is done, except for maintenance or partial replacement.

In the debate about the natural monopoly, an entry limit is defensible because it prevents inefficiency due to redundant investment. This argument about the distribution network in the gas industry is effective, but it is difficult to measure the redundancy regarding the other facilities like storages and terminals especially when considering export sectors in the open economy. When measured in terms of a closed economy, excessive capacity larger than domestic demand seems inefficient, but the extra capacity can be utilized to enlarge the pie through individual efforts to maximize the private interests in an open economy.

Additionally, opponents of the competitive market argue that competition will be limited despite the open market because the gas industry is a capital-intensive business and only a few conglomerates can participate in the market (Ahn, 2005). This is plausible considering the current demand and market size, but the competition does not necessarily mean competition with an infinite number of contenders. In an economics theory of *effective competition*, a market can be competitive despite a small number of the participants. If the product is homogeneous and it does not have an entry cost, market leadership can be replaced by any second firm that can produce the product with a lower cost. Thus, the leading firms have incentive to innovate and be efficient in maintaining their market power. Therefore, the oligopoly market can improve the social benefit as far as the market is effectively competitive (Bender, Götz , & Pakula, 2011). The effective competitive market is the common remedy for the network industry globally, but an assumption of the no entry cost is sometimes criticized. However, the gas industry does not require repeated investment in the pipeline network, companies can share the network, and there are many firms that want to participate in this industry, This indicates that the entry cost is effectively low. Moreover, the capital-intensive industry can virtually lower the entry cost through functional unbundling as in the U.S. gas market. Importing and delivering gas requires huge initial costs, but it does not mean that every company needs to be equipped with all the functions. The way in which the U.S. gas industry unbundled functions and increased participants illustrates this aspect, which is discussed in the chapter 4.

3.3.3 The discussion of purchasing power

Aside from those debates based on economics theory, purchasing power is said to be another advantage of having a single importing company for the country. Although South Korea is the second largest LNG importing country after Japan, KOGAS is the largest LNG importing company because multiple importers are importing gas separately in Japan. The proponents of a single importer for a country argue that this purchasing power helps KOGAS to purchase gas in a cheaper and stable way since the international natural gas market has been seller-oriented (Hong, 2010).

However, this argument has no empirical proof and there are many factors influencing importing price rather than purchasing power. Research on the comparison of the natural gas importing price between Japan and Korea in 2013 showed that the natural gas importing price of KOGAS was higher than Japan’s average natural gas importing price. KOGAS imported gas at $741.25/ton, while Japan imported gas at $647.29; this higher price was found through the period from 2006 to 2009 (Han, 2013). Moreover, the importing price of KOGAS was also found to be higher than K-Power and POSCO in 2003 (Yoon C. , 2013).

(Unit: $/ton)

Year	Korea	Japan	Gap
2006	478.91	367.54	111.37
2007	491.77	398.68	93.09
2008	741.25	647.29	93.96
2009	495.77	467.19	28.58

Table 9: Comparison of gas import prices between Korea and Japan from 2006 – 2009 (Han, 2013)

KOGAS rebutted this allegation, providing three explanations. First, because of the high TDR of Korean market, KOGAS can help but use more spot purchase during winter, which is typically more expensive than long-term contracts. Second, contract price is highly dependent on the market situation at the time of the contract. K-power and POSCO could buy natural gas in the early 2000s when the market situaltion was favorable for the buyers. However, KOGAS could not renew the expired long-term SPA because of political uncertainty. In the early 2000s, the discussion about KOGAS reform was underway and there was a possibility that KOGAS could be privatized. Since Korean government failed to execute the reform plan because the exporters denied a tranfer of the importing right to the merger upon the government's first try to privatize KOGAS, it hesitated to approve the contract renewal. As a result, KOGAS had to buy gas from spot market and could renew the contracts only after 2006, when the market situation changed to a seller's market (Choi H. , 2013).

However, another allegation arose about KOGAS's gas import misstep. KOGAS concluded a twenty-year term SPA with Sabine Pass Liquefaction (SPL) of Cheniere Energy partners at highest price compared with other companies that contracted with SPL. The contracted price was $ 11.75/ MMBtu with annual purchase of 3.5 Million ton. This price was higher than $11.24, Spanish Gas Natural cost and the same price (for the same amount of purchase) as Indian Gal. Even this SPA was supported by the Korea trade insurance corporation and the Export-Import Bank of Korea providing 1.5 billion dollars of project financing to the SPL project, while the Indian Gal had no other additional condition. KOGAS also offered the excuse that the Spanish Gas Natural's lower price was due to the duty to pay some portion of contracted amount without receiving gas in case of Force Majeure (Lee D. , 2013).

Ironically, KOGAS's excuses about these inefficient purchase activities illustrate that there is no such thing as purchasing power. Even if admitting the existence of purchasing power, it is not necessary to unify the whole purchase amount of natural gas into a single importing company. Purchasing power can be formed when a certain threshold is reached in an individual transaction. In fact, KOGAS is the largest LNG buying company as a whole, but it divides its procurement into multiple contracts. Thus, the purchase amount of a transaction is not overwhelmingly larger than other companies'. In the above example of the SPL account, the purchase amount was the same as those of Gas Natural and Gal, and BP's was much larger, 5.5 million tpa.

The ability to make an advantageous contract is more dependent upon other conditions than the amount itself, as KOGAS insisted. For example, every country has difficulty achieving cheaper and stable supplies of gas because of TDR. Korea is paying more because the TDR is much higher than other countries, 1.9 as shown in Figure 12. Japan alleviated this by restructuring its overall energy practice, reducing the TDR to 1.4. Restructuring ranged from pricing restructuring to the promotion and creation of a new gas refrigeration system to increase gas usage during the summer (Chung, 2010). These reforms were not driven by the government but by the private sector in efforts to be efficient and profitable.

Some people argue that KOGAS is advantageous in its global business because it is supported by the guarantee of Korean government. This was effective when the global supply was dependent on a few countries. However, the global supply and the number of suppliers are increasing after the shale revolution; the market is finding a power balance between buyer and seller. As mentioned above, Indian Gal could buy gas without any governmental support. Despite difficulties, there are many private companies doing business without governments' guarantees.

Another problem with the centralized gas import is that the responsibility is too heavily imposed on KOGAS and this responsibility forces KOGAS to make inefficient decisions. After the conclusion of the SPA with SPL, KOGAS added another SPA from Ras Gas 3 of Qatar, even though it had already secured an import amount to satisfy the expected demand from 2017-2024. The problem was that, to resolve the surplus of supply, KOGAS agreed to resell 20% of the shale gas from SPL to French Total. The price of the shale gas from SPL is $ 11.75/MMBtu, while that of the Qatari gas is $ 15.3/MMBtu, but Qatari gas is bound by TPA; thus, KOGAS had to resell the cheap shale gas rather than the expensive Qatari gas (Lee D. , 2013). As long as KOGAS is the single company to be responsible for the whole natural gas supply to South Korea, this nonsense can continue to happen, since

KOGAS has no flexibility. This inefficiency influence the downstream sector since the material cost takes up 83% of the retail price. Moreover, the supply cost of LDCs is highly likely to be inefficient considering their local monopoly status.

Even though people admit that the current non-competitive market structure is problematic after all of those above rebuttals, they are reluctant to agree that a competitive market is the right solution. Theoretical debate is not enough to convince people that a certain type of market is better so an empirical benchmark is required. The following chapter suggests a good benchmark for the competitive energy market.

4. Empirical Case of Competitive Energy Market in Korea

There has been a fierce debate to determine whether or not the competitive market for the energy sector is appropriate and viable. To support their arguments, people want a more directly comparable case for Korea and have usually tried to find a benchmark with an overseas example. However, ironically, an example of competitive energy market can be found within the Korean territory. There have been many cases comparing the gas market with the electricity market to analyze the effect of privatization, since both sectors are run by the public sector in Korea; yet currently there have been no attempts to compare the similarity of the oil and gas industries.

These two industries have three aspects in common: both are hydrocarbon fuels, are imported, and require a huge amount of capital investment. Petroleum products are critically related to people's lives as they are an energy fuel. Oil comprises the largest portion of the nation's primary energy consumption. To some degree, oil is more critical than gas because 99% of transportation fuel is comprised of oil. As discussed before, heating and cooking have substituting fuels, but transportation is dominated by oil; still there have been fewer calls to deem gasoline or diesel essential goods rather than natural gas. Moreover, since Korea has few hydrocarbon reserves within its boundaries, 100% of crude oil is imported. The industry is highly capital-intensive because of the expensive and massive infrastructure consist of refinery plants, storages and importing ports, distribution pipelines, and fuel stations. This causes a high probability of a monopoly or oligopoly. Thus, cheap and stable supply of oil is very important just like natural gas.

This similarity between gas and oil has been ignored, and policy approaches to these industries have been totally different in Korea. The gas industry is served by the public sector and the oil industry by the private sector. The oil industry experienced a sea change regarding the regulation and deregulation. Thus, the oil market provides an excellent analogy for the effectiveness of a competitive energy market. This chapter examines the validity of the allegation that the competitive natural gas market will deteriorate the social benefit through an analysis of Korea's competitive petroleum product market.

4.1 Overview of Korean petroleum products market

4.1.1 Overview of demand in the Korean petroleum market

In 2011, oil comprised 38.2% of Korean primary energy consumption, which takes up the largest portion of the country's energy mix. The portion has decreased from 50.6% in 2001 to 38.2% in 2011, but the absolute amount has not decreased; it has been around 2 million (MM) barrels per day (bpd) since 2000.

(Unit: Mbpd)

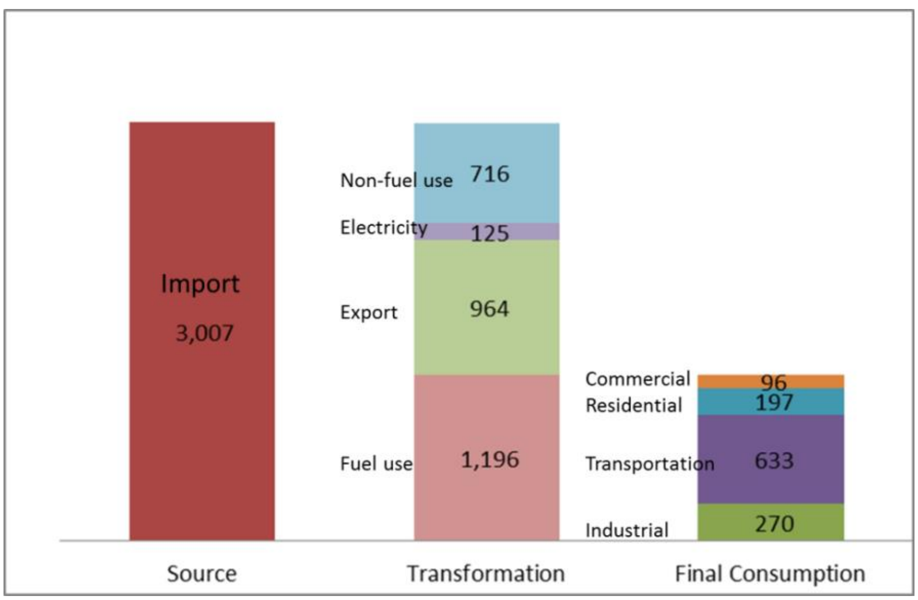


Figure 20: Supply and consumption balance in Korean oil industry (KEEI, 2012)

In final consumption, industrial use of oil has a high proportion because 716 Mbpd of oil is used as feedstock for the petrochemical industry, which does not use it as a fuel and this use will be excluded from the topic of this paper hereafter. Thus, as pure energy use, 1.3 MMbpd of oil is finally consumed. Transportation use comprises 31% of total oil consumption, supporting 99% of transportation use. Electricity generation uses 6% of the oil, and 13% is used for residential/commercial use (KEEI, 2012). As in most other countries, the transportation sector is locked in by oil, and this implicates that oil can be critical to people's life, because of the absence of substitutes.

4.1.2 Overview of supply of the Korean petroleum industry

The modern oil industry in Korea started with the establishment of Korean Oil Corporation (KOC) in 1966. Before this, major American oil companies like Standard, Caltex, and Shell supplied imported petroleum products. The Korean government needed a self-sufficient oil supply to support economic development and wanted to build an indigenous refinery plant. Due to the lack of capital and technology of the poor country, the first refinery plant with a capacity of 35 Mbpd was built with the help of foreign oil company, Gulf. The second plant, Honam refinery (currently GS Caltex) was built through a Joint venture between Korean Lucky (currently GS) and Caltex (currently Chevron); other refinery plant construction plans followed. Backed by surging demand, the total refinery capacity of the country increased to 840 Mbpd in 1993 when the market was liberalized (which will be explained in detail later). During the liberalization, KOC was privatized and merged by SK Innovation (SK). Today four major refinery companies operate in Korea: SK and its affiliate SK Incheon petrochemical (IC), GS Caltex (GSC), Hyundai (HD), and S-oil (SO) (Lee M. , 2013). The capacity expansion continued after market liberalization, and as of 2012 the current capacity is world's sixth largest with 3 MMbpd, one-third times larger than the country's domestic consumption. For a single plant, the capacity of Korean refineries is at a high rank worldwide, which illustrates the scale of economy. Korean refinery companies are world-renowned to be competitive in their operation and high quality of products. Petroleum products exported by those companies comprised 10% of the whole national export in 2012.

(Unit: Mbpd)

Company	CDU	HOU
SK Innovation*	1,115	212
GS Caltex	855	268
Hyundai Oilbank	390	148
S-oil	669	134
Total	**3,029**	**762**

Table 10: The status of refining capacity by companies in Korea

Those companies are operating their own marine transportation system and their inland pipeline transportation is served by Daehan Oil Pipeline Corporation (DOPC); distributing the products from plants to storage centers (DOPC is an independent pipeline service provider; it began as a SCE in 1990, but was privatized in 2000). Tank trucks deliver the products from storage centers to gas stations or final consumers.

There are 528 wholesale agents and 99 are exclusively franchised by the Korean refinery companies as of 2012. The number of gas stations totaled 3,882 before liberalization and increased to 13,495 by 2011. Refinery companies trade 40% of their products directly with gas stations and utilizing agents for 47.4% of their sales. 82.3% of the products are sold through gas stations and small stores occupy 5.4% of the market. The consumption by the large industrial users takes up 12.3%.

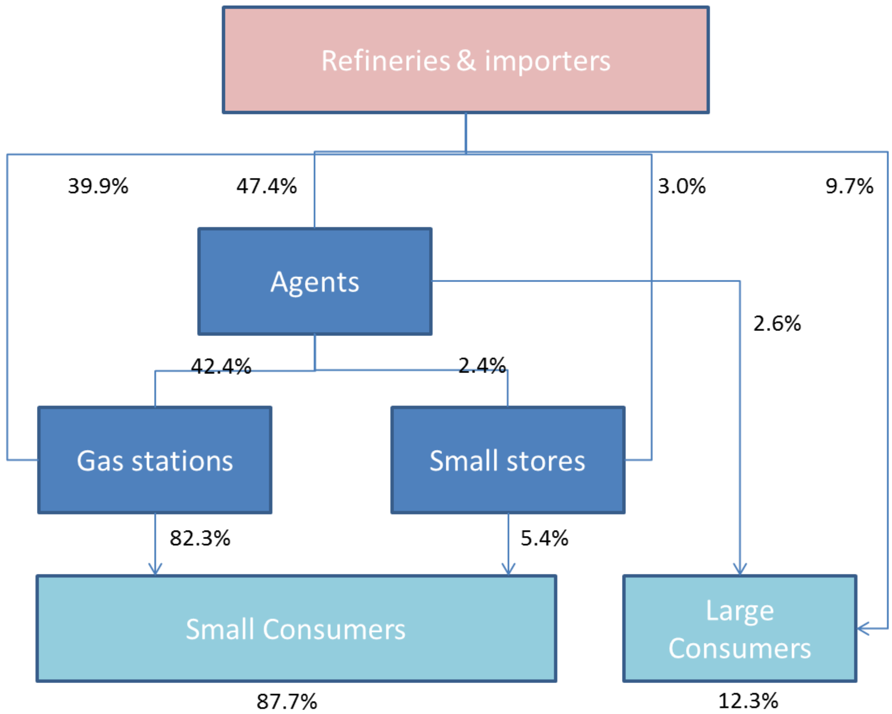


Figure 21: The diagram of the sales channel composition (Choi & Hwang, 2013)

The refinery companies are deeply engaged with the retail market; 91% of the stations are franchised with the refinery companies, including the refinery owned or operated stations (8.7%) and agent owned or operated stations (5.1%). Gas stations' average sales per month is around 1,000 barrels; Germany is, for example, over 2,000 barrels per month. Thus, industry experts argue that the supply side of the retail market is saturated in Korea and restructuring is required (Choi & Hwang, 2013).

4.1.3 Regulations

A timeline of the liberalization of Korean oil market can be categorized into three eras: pre-liberalization, liberalization, post-liberalization. The main exercises of liberalization policy were fulfilled starting in 1993, and the debate on the efficiency of the free market after the crude oil price reached $100/bbl brought out more radical methods to induce increased competition in the market after 2008.

4.1.3.1 Pre-liberalization

Since government plan drove the development of the petroleum industry in Korea, it was heavily regulated. The stringency of regulation fluctuated, but the regulations aimed to prevent inefficient resource allocation and excessive profits of players, which is the same as the current policy goal for the natural gas market. Any operation of the oil industry including refinery, agent, and gas station needed the pre-approval of the government under the return or license system. The Law unbundled functions among the refineries, agents, and gas stations and refineries could not directly operate gas stations directly. Expansion of the refinery capacity needed permission from the government and all exports and imports of crude oil and petroleum products were executed under governmental control. Limits were placed on the number of agents and gas stations and restrictions were issued to regulate the start-up of new gas stations within a certain distance from existing stations. One late regulation on gas station operation was the Pole Sign system introduced in 1992, which prevent gas stations from selling different manufacturers' products from the station's pole sign, which indicated the sold products' manufacturer. There was a price cap and the refinery companies' profits were monitored so that they would not exceed 10% in terms of the rate of return on their assets. This pricing was linked to the price of crude oil and later to that of petroleum products. This methodology was designed by government until pricing was fully liberalized. Moreover, taxes were heavily imposed on petroleum consumption to limit consumption in a country without indigenous resources; these taxes still remain. Although during these periods the government regulated the industry for efficient resource allocation and the minimization of the excessive profits, this era is remembered as "Golden

Age" to those engaged in the industry. The supply used to be short of demand because of the delayed-response in the administration process; players were limited and the prices were cost-based. It would have been strange if there had not been excessive profits. This domestic regulation failure and the changes in the global market that had a long period of a low crude oil price evoked demands of liberalization (KNOC, 2011).

4.1.3.2 Liberalization

The first major movement of liberalization was the abandonment of the gas station distance restriction from 1993-1995. During this time, the number of gas stations increased dramatically and unit sales amounts plummeted. The combination of the distance restriction abolition and the pole sign system caused severe competition between the refinery companies and led them to recruit and develop new gas stations. The refinery companies also developed loyalty programs like membership services and promotional campaigns. To compensate for the profit loss from retail competition, convenient stores were introduced to gas stations, similar to U.S. gas stations. During this transition in the retail market, the government announced the petroleum industry liberalization plan in 1994. In accordance with that plan, regulations about pricing, import, and export of oil were removed in 1997. Competition created tectonics in the industry: the refinery companies went through the turmoil of M&A and four major companies ended up surviving; product imports were activated; the price competition between gas stations was ignited and self-service stations were implemented to be cost efficient in terms of gas station management; retail competitions intensified and marketing plans like memberships and promotions became essential in the competitions. However, the apparent oligopoly by the four major refinery companies provoked suspicion about the effectiveness of the deregulations. Although the profitability had dropped for all tiers of the business, people still believed that excessive profits existed (Park & Park, 2004).

4.1.3.3 Post - liberalization

Another milestone of petroleum industry deregulation was brought about by external changes. Oil price was stable during the 1990s; the low price discouraged investments in locating oil resources and infrastructure. A later shortage in supply and increasing demand from developing countries raised the price beginning in the mid-2000s. Financial speculation added more impetus for the soaring oil price. As a result, after 2007, the crude oil price exceeded $100/bbl and this influenced the domestic petroleum product price as well. The tax increase during the financial crisis in the late 1990s worsened the situation such that the retail price doubled compared to that of ten years ago. People could not understand the rising price and demanded governmental investigation and intervention, which was a common practice in most countries. That surging price was quite systematic, but the government was pushed by negative public sentiment to look at the oil industry. Consequentially, the government found policy directions to promote more competition. The government forced refineries to publicly disclose weekly their average wholesale prices and built an on-line website providing live information about the street sales price of gas stations so that consumers could compare the prices and find cheaper gas stations. Moreover, the government loosened the pole sign system requirements, enabling gas station owners to sell mixed products from different manufacturers regardless of the manufacturer name on the pole sign. Horizontal transactions between an agent and another agent, a gas station and another gas station were also allowed. The government also advocated that warehouse stores implement complementary gas station in their parking lots. It even established an independent franchise brand of gas stations so that previously non-pole stations could compensate for their weak marketing power. Sometimes, the government forced refineries to cut retail prices in the name of public interest with the unreasonable allegation of excessive profits. There also were reverse discriminations between refineries and importers. The government favored importers by exempting duties and customs and loosened the qualification for importers. The government also established an electronic exchange floor and favored the participants on the floor (Choi & Hwang, 2013). However, suspicions about the effectiveness of the policy prevail, since the methods were implemented to please the public rather than cure the problem. The market is actually formed with various types and numbers of players like agents, importers, and gas stations, but the government only focused on the regulation on refineries, assuming an oligopoly domination of the market. Those interventions were a kind of abuse of administration power and an unconstitutional fringe on private property rights. The aftermath influenced other players' profits, not just refineries and led them to adjust their operations in accordance with the forced situation. Some people argue that if the government really wants to alleviate the problem in the people's lives due to the expensive gasoline retail price, it should lower the tax rate, though the government refuses to do so because the tax revenue from the petroleum consumption in Korea is responsible for 16.9% of total tax revenue (Jeong, 2007).

In sum, twenty years after the liberalization process, the debate on the effectiveness of the deregulation is still controversial. The opponents of the privatization view the example of the petroleum sector as a failure of the liberalization of the energy industry. They claim that market failure still exists since the Korean oil market ended up being an oligopoly structure and is inefficient. Conversely, there is much evidence that the market is working efficiently. Therefore, verification of the effectiveness of the liberalization of the petroleum sector is important in associating it with market reform in the gas sector.

4.2 COMPETITIVENESS OF THE KOREAN PETROLEUM PRODUCTS MARKET

To verify if the liberalization policy succeeded in achieving its goal of cheap and stable supply of oil in the Korean market, two areas need to be examined: the existence of excessive profit and deficit production due to the incumbent oligopoly. If there were no excessive profit and deficit in production (the main signs of the market failure of the oligopoly), it would be possible to declare that the market is effectively competitive.

4.2.1 Supply stability

In either monopoly or oligopoly market, dominating firms will produce less quantities of the item than the perfect competitive market. Verifying this is not difficult because statistics shows the result. Korea's total refinery capacity actually used to fall short of demand before liberalization. The country's petroleum consumption had soared from 822 Mbpd in 1989 to 2,025 Mbpd in 1996 and a deficit in capacity occurred during the same period of time. This deficit was resolved in 1997, only after liberalization, and Korea never had a deficit in capacity since then. Now, the total capacity is 3 MMbpd, which is much larger than the consumption. The operation rate has been high, from 80 to 99 %, so production amounts have exceeded consumption. Thus, the supply has been stable after liberalization. Therefore, the question is raised as to whether this surplus in the capacity is redundant investment or inefficiency; it is not. It has helped the stability of the industry. Refineries have exported the surplus amount in the open economy. Petroleum products have been one of Korea's top three export items since 2009. The export alleviates the national burden in the current trade balance during the era of the soaring oil price since the 2000s; the profit from the export has actually subsidized the payment for crude oil procurement. The profit-seeking behavior of the refineries also enhanced refinery companies' financial soundness. To stay in the game, they expanded their business to petrochemical and lubricant manufacturing. Most of the refineries' profits come from those sectors rather than petroleum products sales.

Year	Capacity	Consumption	Gap
1981	790	539	251
1988	840	717	123
1989	840	822	18
1990	840	1,017	(177)
1991	1,036	1,209	(173)
1992	1,442	1,454	(12)
1993	1,675	1,591	84
1994	1,700	1,750	(50)
1995	1,818	1,905	(87)
1996	2,018	2,025	(7)
1997	2,438	2,211	227
1998	2,438	1,836	602
2000	2,438	2,033	405
2011	3,010	2,036	974

Table 11: Comparisons between consumption and refinery capacity by years (KEEI, 2012)

Moreover, private companies are seeking a way to expand their upstream activities. Korea has tried but failed to find an indigenous oil reserve. The country then focused on acquiring shares from overseas reservoirs or participating in E&P projects. The role was given to KNOC since the cost of the duty was considered to be beyond the budget that the private sector could afford, but private energy companies soon followed, joining overseas E&P projects. The ratio between the output amount from the reservoirs and the countries import amount of oil and gas reached about 13.7% as a whole as of 2012. The investment amount grew to $ 42 billion by 2011; the amount invested by private companies reached $17 billion total (Kim C. , 2013).

Additionally, the refineries are also obligated to maintain a strategic reserve equivalent to forty days of their domestic sales amount, aiding the stability of the country's energy security.

All of these aspects indicate that the incumbent Korean market structure is providing fluent and stable supply of oil into the economy, which rejects the assumption of a deficit supply due to the oligopoly inefficiency.

4.2.2 Price stability

The debate about the oligopolistic power is more censorious in the matter of price. Many people are suspicious that the refinery industry is gouging people and enjoying the excessive profit rendered by market domination. Moreover, people cast more doubt on the wholesale market than on the retail market because of the existence of the four major refinery companies. In this section, the allegations will be examined in three aspects: Lerner index, price comparison by countries, and analysis on the refinery companies' profit.

4.2.2.1 Lerner index

The apparent oligopoly incurs a strong allegation of market domination. The argument is that the refineries cooperate inexplicitly because they know how to price each other, since their cost structures are similar. Moreover, they used the same price formula that has succeeded and shared during the long regulated period. Allegation of the collusion gave rise to several investigations by the Korean Fair Trade Committee (KFTC), but they could not find critical proof to verify the allegation. KFTC accused refinery companies with some minor charge but many of them turned out to be not guilty after litigation. However, many people have not put a stop to their suspicions. Thus, the verification of effective competition needs to start from the presence of the oligopoly power. The Lerner index is a common method to measure the degree of market domination in a non-competitive market. This index utilizes the property of the non-competitive market that takes the market demand curve to be the firm's demand curve, while firms in the competitive market have a flat demand curve determined by market equilibrium. The profit of a firm is maximized when the firms' marginal cost (MC) equals marginal revenue (MR). Formula 1 is the profit equation of a firm.

$$\pi = P(Q) * Q - C(Q) \tag{1}$$

Formula 2 is acquired from the differentiation of formula 1; profit is maximized when this formula equals zero.

$$P(Q) + \theta * \left(Q * \frac{dP(Q)}{dQ} \right) - \frac{dC(Q)}{dQ} = 0 \tag{2}$$

$\mathrm{P(Q)} + \theta \cdot (Q \cdot dP(Q)/dQ$ means MR in this equation and $\mathrm{dC(Q)/dQ}$ means MC. In the perfect competition market, P of the firm equals MR and so $\theta = 0$ in $\mathrm{P(Q)} + \theta \cdot (Q \cdot dP(Q)/dQ$. Convesely, in the monopoly market, $\theta = 1$, since the monopoly firm takes the markets demand curve as its demand curve. In other types of market, θ is between 0 and 1; a low index means higher competition. θ , the price-elasticity-adjusted Lerner index, is found by plugging in price elasticity (η_p) into formula 2.

$$\eta_p = - \frac{dQ}{dP} \Big/ \frac{Q}{P} \tag{3}$$

$$\theta = \eta_p * \left(\frac{P - MC}{P} \right) \tag{4}$$

In case of oligopoly, the symmetric Cournot model insists that the profit will be equally shared among the oligopolistic firms. Thus, assuming *n* numbers of firms, the index is 1/*n*. Given that there are four major refinery companies, the theoretical index is ¼, if oligopolistic power exists. However, the 2013 research of Choi and Hwang used the price elasticity adjusted Lerner index to verify the competitiveness of the Korean gasoline and diesel market; the index of the Korean gasoline market was nearly 0 during the period from January 2006 - March 2012.

	(P-MC)/P	η_p	θ
Mean	0.27622	0.14613	0.03965
Median	0.26458	0.14517	0.03978
Maximum	0.42424	0.23407	0.05883
Minimum	0.09629	0.07668	0.01535
Standard deviation	0.06866	0.02644	0.00939

Table 12: Details of the price elasticity adjusted Lerner index of the Korean gasoline market from January 2006 - March 2012 (Choi & Hwang, 2013)

Moreover, the regression of the index by months showed that the index had decreased during the same period.

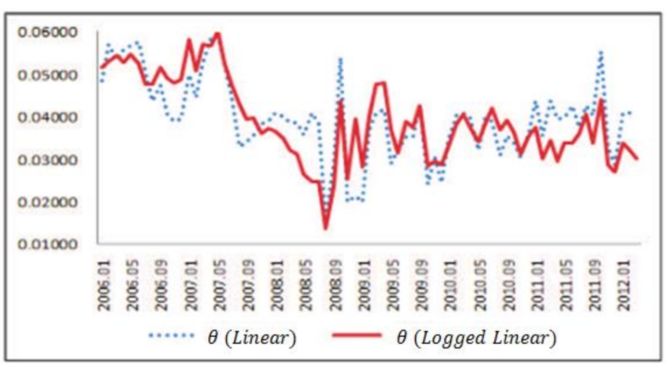


Figure 22: The trend of the price elasticity adjusted Lerner index of the Korean gasoline market from January 2006 - March 2012 (Choi & Hwang, 2013)

4.2.2.2 Price comparison by countries

The comparison of gasoline and diesel prices by country can provide more direct basis for decision about whether oligopolistic power exists or not. The comparison of price before tax between 23 OECD countries, performed by Choi and Hwang, shows that the price before tax of petroleum products in Korea is lower than those of the OECD average as shown in table 13.

(unit: KRW; as of the third week of July, 2012)

Country	Gasoline price	Rank	Diesel price	Rank
Japan	1,133	1	1,213	1
Denmark	1,071	2	1,213	1
New Zealand	1,061	3	1,213	1
Belgium	1,061	3	1,091	7
Ireland	1,023	5	1,086	8
Italy	1,018	6	1,057	13
Portugal	1,016	7	1,099	6
Spain	1,015	8	1,081	10
Finland	1,015	8	1,086	9
Luxemburg	1,010	10	1,047	16
Germany	1,007	11	1,062	11
Holland	1,004	12	1,048	14
Sweden	997	13	1,114	5
Canada	995	14	1,005	21
Greece	995	14	1,119	4
Hungary	993	16	1,059	12
Korea	**974**	**17**	**1,034**	**17**
Poland	967	18	1,021	19
Slovakia	962	19	1,048	15
France	957	20	997	22
Chec	939	21	1,027	18
Austria	933	22	994	23
The U.K.	920	23	1,009	20
Mean	1,003		1,075	
	Source: KPA		Source: Opinet	

Table 13: The comparison of auto fuel prices before tax among OECD countries (Choi & Hwang, 2013)

4.2.2.3 Analysis of the profit level of the Korean refinery companies

Looking into the income statement of the Korean refinery companies also weakens the suspicion of excessive profit. The average operating income (OI)/revenue ratio of the four refinery companies from 2002 - 2008 was 4.95%, lower than that of 6.5% of the overall manufacturing industries in Korea. Considering that the companies are exercising their business in the extended area, the profitability of the refinery industry becomes even worse. Those companies had expanded their business to the petrochemical and lubricant industry and most of their profits are actually coming from the extended sectors. When separating just the refinery divisions, the OI/revenue ratio drops to 2.85% (KFTC, 2009b).

(unit: KRW Bil.)

		2002	2003	2004	2005	2006	2007	2008
Revenue	Refining	33,732	32,676	39,922	50,273	57,208	63,604	96,111
	Non-refining	4,962	7,363	10,752	11,587	13,437	15,936	21,818
	Total	38,694	40,038	50,674	61,860	70,644	79,540	117,929
OI	Refining	552	726	2,193	1,474	899	2,209	2,633
	Non-refining	489	1,187	2,239	2,926	2,041	1,927	1,666
	Total	1,041	1,914	4,432	4,400	2,940	4,136	4,300
OI/Revenue	Refining	1.6%	2.2%	5.5%	2.9%	1.6%	3.5%	2.7%
	Non-refining	9.9%	16.1%	20.8%	25.2%	15.2%	12.1%	7.6%
	Total	2.7%	4.8%	8.7%	7.1%	4.2%	5.2%	3.6%

Table 14: The trend of revenue and operating income of Korean refinery industry (KFTC, 2009b)

The profitability worsened after 2010. In 2011, the total revenue of GSC, one of the four companies, was KRW 47 Trillion; KRW 39 Trillion of the profit was from the refinery division. However, the refinery division earned only KRW 653 Billion among its operating income of KRW 2 trillion. Thus, the refinery division took up 90% of the revenue, but earned only 30% of the profit. The division even showed net loss in the following year.

(unit: KRW Bil.)

		2010	2011	2012
Revenue	Refining	28,505	39,001	39,647
	Non-refining	6,811	8,945	7,836
	Total	35,316	47,946	47,483
OI	Refining	430	653	(509)
	Non-refining	770	1,367	1,020
	Total	1,200	2,020	511
OI/Revenue	Refining	1.5%	1.7%	-1.3%
	Non-refining	11.3%	15.3%	13.0%
	Total	3.4%	4.2%	1.1%

Table 15: The trend of revenue and operating income of GS Caltex

One more thing to consider in the profit analysis is that the profitability of the domestic refinery market is usually lower than that of the export market because of distribution costs. The domestic marketing requires a more complicated distribution process than the export transaction, where the refinery completes its role at the loading dock. GSC argued that the net selling price of the domestic market was lower than that of the export market by KRW 2.5 per liter (GSC, 2012).

If the refinery products were provided by public sector, the loss must be subsidized by tax revenue. However, thanks to private companies' efforts to survive, the domestic supply is subsidized by the companies' own internal operations. This low profitability is the result of effective competition. Even though the current share of the imported goods is nearly zero, excessive profit can attract the import at any time. The market share of importers increased after liberalization to 3.4% in 2002, but later decreased to below 1% (KFTC, 2009b). This fact does not indicate a weakened competition; rather it means that the refineries had given up their excessive profits. The Korean government favors importers by loosening entry barrier qualification requirements. There are potential competitors like petrochemical companies, trading companies, and large consumers like logistics companies. If they think the fuel business looks lucrative, they can import and supply the petroleum products with very little effort. In fact, Samsung Total Petrochemical Corporation, one of the petrochemical companies, launched its gasoline import in 2012 when the government promoted the competition (Cho, 2012). This openness of the market casts a serious threat to the refineries. The refinery plant prefers non-halted operation to maximize the economy of scale. Any disruption due to a slump in sales deteriorates the efficiency of the plant. Thus, refineries do not want to lose the market share despite a temporary loss for smooth plant operation.

4.2.2.4 Retail market

Considering this analysis, the possibility that manufacturers are obtaining excessive profit seems very low. How about the retail market? As discussed above, the number of gas stations in Korea exceeded 13,000 in 2012 and decreased to 12,692 as of August 2013. Hana Institute of Finance researcher Kim's 2013 research proposed the proper number of gas stations for the Korean oil market via a comparison by countries. He estimated that the number is between a minimum of 7,000 to a maximum of 12,000, which means there are an excessive number of gas stations are operating in the market.

The average gross margin/revenue ratio of gas stations dropped from 12.7% in 1995 to 4.5% in 2008. This results in relatively low profitability considering capital expense and operating capital; the dropping profitability indicates that the market has become more competitive after liberalization (KFTC, 2009b).

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
12.7	9.2	5.8	8	6.6	5.3	5.5	5.3	4.3	4.5	4.5

Table 16: Gross margin/Revenue ratio trend of gas station in Korea from 1995-2005 (KFTC, 2009b)

The trend of OI/Revenue rate shows extremely low profitability of gas stations. A Korea Development Institute research presented that the average OI/Revenue rate of Korean gas stations was 1.02%, much lower than that of the service industry in Korea (KDI, 2012).

	2006	2007	2008	2009	2010	Average
Gas Station	1.1	0.87	1.12	0.79	1.21	1.02
Service industry	7.13	7.62	3.67	5.23	5.91	5.91

Table 17: OI/Revenue ratio trend of gas station in Korea (KDI, 2012)

2011 research by Kim and Kim noted that a gas station in an urban area of Korea had, on average, nine competing stations within a one kilometer radius. Price competition is unavoidable given this situation in the retail market.

It is clear that there are no excessive profits in the retail market of the Korean oil industry. Some gas stations are more profitable than others because of their location, service quality, or complementary business, but a lack of profit cannot be interpreted as the presence of an unjust market dominating power.

Many people refuse to retreat from the suspicion of the oligopolistic refinery market structure. Thus, the industry has been a good target for the political fight and the populist policy. It is not easy for people to avoid the biased inference; however, many studies and empirical data show that the refinery industry in Korea is effectively competitive as presented above.

4.3 COMPARISON OF OIL MARKET IN THE CONSIDERATION OF GAS MARKET REFORM

The linkage between oil and gas is unfamiliar to people. Despite a similarity in basic property, the different forms of these fuels, gaseous and liquid, make it hard for people to compare them. Thus, few attempts have been made to compare the oil market and gas market in the gas market reform debate. Nevertheless, oil and gas are similar in many aspects. Both natural gas and oil are hydrocarbon energy sources, though oil has a higher energy density and is liquid at the atmospheric condition. Thus the use of the two energy fuels derives from their physical character, but their basic use is quite similar. The usage can be influenced by technology and infrastructure. In most countries, natural gas is used more in residential/commercial sectors and oil is used more in the transportation sector, but some countries like Pakistan use natural gas more in transportation. Thus, these two fuels are complementary and can be substituted for each other according to technology and infrastructure. Under this assumption, this section validates the gas market reform argument and show that the opposition to gas market reform can be rejected. Then, this section explores the direction of the reform by directly comparing the market structure of these two fuels in supply chains by each stage.

4.3.1 Validation of gas market reform by the comparison of oil and gas

In most countries, the oil industry implemented a competitive and open market, but the gas industry varies in its market structure from a competitive one in the U.S. and the U.K. to a monopolized and regulated one in Korea and Taiwan. The trend is obvious because European countries are carrying on reforms to convert the market to a competitive one. Korea has an open capitalism economy and also successfully liberalized its petroleum industry as discussed above. Then, what is the reason to hesitate liberalizing the gas industry? We can reject the argument that the difference between oil and gas leads to a different market structure and policy direction, as discussed below.

First, on the matter of the essential good, oil and gas have no differences regarding this issue. If gas is an essential good or a public good, so is oil, since they can be substitutes as discussed above. There is no plausible explanation for the assumption that gas is more essential than oil. In some degree, oil has more characteristics of an essential good since it has lower substitutability especially in the transportation sector, but oil fuels have been supplied well under the competitive market structure after its liberalization. Thus, the argument that gas is an essential good that should be supplied by the public sector is also rejected.

In terms of unified import function, global market power is tilted toward sellers in the global gas market, but this main reason for this purchasing power is alleviated just as with the oil market in the past. In the oil industry, OPEC countries once controlled the global market, but the imbalance disappeared after the production increase from non OPEC countries. A similar thing is happening in the gas market. The change is mainly because of diversifying gas supply countries. In the past, the regional separation was rigid such that Europe was mainly dependent on Russia or North African countries for its gas supply and the Asian region was dependent on the Middle East or Australia. However, they now have an alternative in North America after the shale revolution. Diversification will increase in the future because the possibility of shale production will expand worldwide due to the diffusion of shale production technology such as hydraulic fracture and directional drilling. Moreover, economic development and advanced financing methods improved the capital availability of developing countries irrespective of industry. The required capital expenditure in LNG infrastructure is no longer an impediment of the project. Korea already has many private companies that want to participate in the business. The Korean refinery companies have invested $10 Bil in their heavy oil upgrade facilities since 2007 to enhance their profitability and survive in the competition (Lee & Yoon, 2012). Those efforts actually stabilized the oil supply in the economy. The companies are capable of financing the required amount of capital to construct LNG import terminals. As discussed above, the purchasing power of KOGAS is an illusion. The diversified gas import will actually enhance gas supply stability.

Regarding the infrastructure investment for universal service, the high dependency on pipelines in the domestic distribution is not problematic for Korea anymore. The domestic transmission and local distribution pipeline networks are almost completed for universal service. Future extension of the network will be a decision about economics and efficiency, not universal service. The problem of monopoly disturbing the universal service occurs in the bundled operation of pipeline service and gas sales, which can form a monopoly and monopsony; that excessive market power can exclude some poor people from the universal service within the network. The U.S. regulatory body forced functional unbundling since it found that the market dominating power by a natural monopoly occurs in the midstream. Thus, the U.S. separated the sales and transportation functions to promote a competitive market. Pipeline service companies are treated as a common carrier. U.S. regulation also forces non-discriminative and open access to the pipeline (Bosselman, Eisen, Rossi, Spence, & Weaver, 2010). Functional unbundling also enabled the steep retail market competition in the Korean oil industry. The distribution of oil is diversified because the transmission line run by DOPC competes with marine or inland transportation run by each of the refinery companies. However, the presence of DOPC is helpful for the refineries to improve their transportation efficiency and effectively helps to unbundle the function.

Moreover, the final distribution to the end user is not completed by pipeline but by gas stations in a very competitive market. Therefore, the Korean oil market illustrates the effect of functional unbundling in a competitive market. In the US, local gas sellers buy gas from producers and importers in the individual contract or from the local open exchange market. They design and propose different rate plans to customers and the customers select a plan suitable for their consumption pattern. Switching is very convenient and requires just one call. This indicates that gas retail market also can be competitive despite its physical constraint— customers are tied down by pipeline networks.

In sum, the characteristics of gas and oil are quite identical and the differences are adjustable through technology and policy devices to a substantial degree. There is no reason for the Korean gas market to deny an application of a competitive market structure despite the competitive market of the Korean oil industry.

4.3.2 The comparison of oil and gas in supply chains

Assuming that oil and gas are substantially similar with regard to their traits and marketability, a deeper analysis of these two fuels' supply chains can provide a blueprint for the gas market after liberalization. When comparing the respective supply chains of oil and gas, a gas importing re-gasification terminal corresponds to a refinery plant with crude oil importing docks, gas transmission pipelines correspond to oil transmission networks including pipelines, vessels, railroads, and tank trucks with storage depots, and urban gas service network corresponds to oil retail channels with gas stations.

4.3.2.1 LNG import terminal and oil refining plant

First, gas importing terminals and refinery plants are the gateways to introducing these energy sources into an economy. Moreover, they change the properties of the fuels, thus making them marketable. The gas import terminal re-gasifies LNG so that gas can be usable and transportable through pipelines; the refinery plant refines crude oil into petroleum products like gasoline, diesel, and jet oil, although these process facilities are more complex than those of gas re-gasification because of the units used to produce non-fuel-used by-products like naphtha, lubricant base oil, and coker. A 7.5 mta capacity gas importing terminal supplies energy equivalent to about a 180 Mbpd capacity refining plant. As previously mentioned, a 7.5 mta capacity gas importing terminal costs around $1 billion while the equivalent refining plant costs $4 billon including non-fuel-by-products producing facilities. Compared to both a refining plant and an LNG liquefaction plant, the capital expense for the LNG regasification terminal is low; the process is much simpler than other facilities' and the main cost driver of LNG import terminal construction is storage tanks. Moreover, the site requirement in Korea is less burdensome than in other countries, like Japan, because of the low probability of earthquakes.

As discussed above, the Korean oil industry has more capacity than its domestic demand but its surplus capacity is well utilized and creates added value through products exports. Moreover, there are 33 additional tank facilities for the product import in the main port of Korea, called independent tank terminals. This demonstrates the immediate supply and competition in case of an arbitrage opportunity. Meanwhile, the total capacity of gas import terminals in Korea is also higher than the total annual domestic gas demands but this does not represent a meaningful surplus capacity because of a high TDR. KOGAS' three terminals have relatively large capacities, ranging from 10.5 mta to 26 mta, while the

POSCO-owned Gwangyang terminal has only a 1.7 mta capacity. KOGAS seems to have pursued an economy of scale but the cost composition of the import terminal is relatively low, as shown in Table 3. Moreover, the efficiency of gas supply networks needs to be evaluated as a whole, not based on individual terminals' efficiency. The oil industry utilizes an inland storage depot to diversify and improve the supply chain efficiency; the Korean oil industry is equipped with 48 storage depots and, from those points, various transportation methods can be used (Lee H. , 2013). However, most gas storage tanks are located within or near import terminals; as of 2014, Korea has only four terminals and transporting gas from these points is almost entirely dependent on pipelines. Thus, gas prices become expensive based on the distance from terminals; the expansion of urban gas services to the Gangwon and North Gyeongsang areas has been suspended. Now, KOGAS is constructing a new importing terminal for those areas, but if small-scale terminal investment had been allowed, the service to those areas would have materialized much earlier. For example, Japan has 23 import terminals with capacities varying from 0.5 mta to 25 mta (Tusiani & Shearer, 2007). Even without nationwide pipeline networks, the accessibility rate to urban gas in Japan already reached 82.6% in 1998 (Cha, 2001). Thus, the Korean gas industry needs to diversify locations and capacities of import terminals. This diversity is hardly obtained through the central plan; rather liberalization of the gas industry will achieve diversity much sooner through private investments.

4.3.2.2 Transmission and local distribution of oil and gas

Transporting oil and gas in the domestic market apparently looks similar because both industries use pipelines but their operation is different and the oil industry more often uses a variety of transport methods. The pipeline is one of oil's main transportation methods, but it is not as critical as in gas transportation. Since oil is liquid under an atmospheric state, any vessel or vehicle can load petroleum products. Thus, ships, railroad carriers, and tank trucks are used in oil transportation. Petroleum products are delivered from refining plants or import terminals to storage depots at first and then delivered to gas stations mostly by tank trucks. Storage spots are owned by refinery companies, DOPC, wholesale agents, or large consumers; gas stations are even more diverse in ownership. Thus, there are so many participants in the oil midstream and the transportation cost is only about one-fifth of gas transportation's cost. Though DOPC is the only pipeline company in Korea, it is not as influential as KOGAS in the gas industry because DOPC is competing with many other types of transportation. For this reason, all of those transporters in the oil industry are regarded as common carriers; this aspect is not considered to be a critical function in the industry.

However, the story is different with the gas industry. The transportation methods mentioned in oil's case can be also used in gas transportation but cost matters because gas companies need to be equipped with a cryogenic tank or a pressured tank to lessen the volume of gas and facilitate delivery. Thus, the pipeline is advantageous in most cases. This property places the most importance on the midstream part of the gas industry, and that is why pipeline carriers had monopoly and monopsony statuses in the early years in the U.S., as explained above. The worse situation in regards to Korea is that a single firm owns the monopoly right in importing transmission, although it is controlled by the government. For successful liberalization, legally-forced functional unbundling of the transporting function from both the importing function and retail function is a key factor to prevent market dominance. Therefore, the transmission part of KOGAS needs to be parceled off in the case of gas market reform, and the pipeline networks — including local networks operated by LDCs — should be open to all players without discrimination. (For instance, U.S. Order 636 presents the key factors in achieving open access of pipeline networks.) The distribution function and sales function should be unbundled. If a company conducts business in both parts, the order required an internal "Chinese wall." All the components in the supplying networks, including storage tanks and not just pipelines, should be shared to any gas shippers and customers. Moreover, the rates should be calculated with the same formula for all users and filed publicly (Bosselman, Eisen, Rossi, Spence, & Weaver, 2010).

4.3.2.3 Retail of oil and gas

Similar to how KOGAS exercises its function in both importing and transmitting, LDCs in Korea are responsible for both local distribution and retail sales of gas. The problem is that LDCs are monopolizing the divided areas, even though they are private companies. Thus, customers have no choices save for the existing service in their area; they have no way to determine if they are getting the best service. Even though LDCs are competing with CHP, competition is geographically confined to the urban planned district. However, the petroleum product market is extremely competitive. Some gas stations have intrinsic competitiveness due to location and are paid higher prices, but customers who do not want to buy fuel from those stations have alternative stations within their moving boundary. It is not easy for a gas station to price excessively higher than its locational advantage or they will have to provide a differentiated service or a promotion in order to be in business. As discussed above, the number of gas station in Korea is saturated and, in urban areas, one station can have nine competitors in a one kilometer radius.

However, unlike the oil market where customers have mobility, gas supply facilities are static and customers are not free to switch their serving companies. This physical constraint is removed by open access to the pipelines in the U.S and the U.K., as previously mentioned. Ironically, stringent regulation forcing functional unbundling of the distribution service is a pre-requisite of the deregulation of the retail gas market. Retailers do not necessarily possess the supplying hardware to conduct business under this condition. In practice, a minimum level of qualification will be required to guarantee unhalted service to customers but, conceptually, if a retailer is capable of negotiating supply conditions and signing a contract with a wholesaler, it is good to propose service plans to customers. For instance, a simple example would be a retailer proposing a proportional rate plan or a monthly flat–rate plan. The customer could then compare the plans and choose the plan that fits his or her consumption pattern with just a call or online registration. Customers would not need to know how gas is coming into their houses. The retailer would pay a tariff to the local pipeline operator. To implement the same structure into the Korean gas market, the incumbent LDCs need to be split between the pipeline service sector and the gas sales sector. Therefore all pipeline networks should open access to them.

The execution of the above-proposed reform will bring about severe protests from the labor unions of KOGAS and LDCs. Furthermore, reformers need to be careful not to impinge upon the constitutional private property right, since the LDCs are private companies. However, unbundling the pipelines is critical to reform the gas market and enables the local gas market to be competitive. There is no reasonable explanation to maintain the unfair monopoly status and the competitive oil market in Korea illustrates the benefits of this reform.

5. Conclusion

This study examined the validity of reform requests for Korea's natural gas market. Current market structure advocates believe that the system is more efficient regarding its universal service of gas as an essential good and the prevention of market failures due to a natural monopoly. The current Korean non-competitive market monopolized by KOGAS and LDC's structure has objectives with which to prevent productive and allocative inefficiencies; the government regulates prices and controls the investment and operation of the industry via KOGAS. Moreover, KOGAS's purchasing power due to the unified gas procurement is a boon for a stable and cheap gas supply. However, those arguments are defective because they mis-categorize gas. Gas is not an essential good because it has substitutes. The gas industry is not a network industry that can cause a natural monopoly. The connections of nodes in gas pipeline networks do not constitute a product; the network does not require repeated reinvestments. Moreover, purchasing power has failed to prove its presence after KOGAS made many mistakes.

Proponents of reform also argue that the non-competitive market is intrinsically inefficient. Agent theory argues that informational asymmetry between principals and agents, i.e. gas companies and consumers or gas companies and the government, can incur a moral hazard. Property theory also claims that an SCE is less motivated than a private company since they are not a residual claimant. Public choice theory also explains that governments and SCEs maximize their own interests rather than public interests.

Despite the failures of previous reform attempts due to the protests from invested interest groups like the KOGAS' and LDCs' labor union, this debate is ongoing and needs further discussion. This paper provides an empirical benchmark to support gas market reform by comparing the situation with the Korean oil market. The similarity between the two fuels has been ignored, but they are almost identical with regard to properties, usage, and origin. The Korean oil industry started from a regulated market and later liberalized to a competitive market. Twenty years after its liberalization, the industry is still giving the Korean economy a stable and affordable oil supply: refinery capacity is larger than the country's consumption; the private companies have extended their business to related sectors, which ended up subsidizing the low profitable domestic petroleum market; The Lerner index, a price comparison by countries, the refinery companies' profits analysis, and the number of gas stations all suggest that Korean oil market is effectively competitive.

The gas industry's effective competitive market can be achieved through functional unbundling. Dividing KOGAS into an importing function and transmission function and unbundling the local distribution part and marketing part of LDCs are key tasks for Korean gas market reform. It is natural that people worry about the unexpected consequence from reform. However, failures of the reform have usually been due to imperfect, unprepared, or delayed reform rather than market failure. The Californian electricity crisis or the soaring gas prices in the U.K. after liberalization, common examples of failed reform, were actually not genuinely failures of reform but rather were transition costs during the learning period. Korea absolutely needs guidance about energy utilization in order to overcome the drawbacks from having little energy source; this can be acquired through a collective discussion including members of both the public and private sectors through a liberalized market. Moreover, successful reform in the energy sector is of utmost importance; the decision should be grounded and not swayed by vested interest groups.

Acronyms

AEP	American Electric Power
AKIP	Atomic Knowledge Information Portal
APEC	Asia-Pacific Economic Cooperation
BMI	Business Monitor International
CH_4	Methane
C_2H_6	Ethane
C_3H_8	Propane
C_4H_{10}	Butane
C_5H_{12}	Pentane
$C_{16}H_{34}$	hexadecane
C3MR	Propane (C3) pre-cooled mixed refrigerant (MR) process
CHP	combined heat and power
CNG	compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxode
DOPC	Daehan Oil Pipeline Corporation
E&P	exploration and production
EIA	Energy Information Administration
GHG	Greenhouse gas
GSC	gas supply chain
GTCC	Gas Turbine Combined Cycle
GTL	Gas to liquid
H_2S	hydrogen sulfide

HD	Hyundai Oilbank Co., Ltd
HG	Hositng government
HOU	heavy oil upgrade
IC	SK incheon petrochemical co., LTD
IEA	International Energy Agency
IMF	International Monetary Fund
IOC	International oil comany
JCC	Japan crude cocktail
KDI	Korea Development Institute
KEEI	Korea Energy Economics Institute
KEPCO	Korea Electric Power Corporation
KERI	Korea Economic Research Institute
KFTC	Korean Fair Trade Commission
KIS	Korea Investor's service
kJ/m^2	Kilo joule per square meter
KNOC	Korea National Oil Corporation
KOC	Korean Oil Corporation
KOGAS	Korea Gas Corporation
KPA	Korea Petroleum Association
KRW	Korean won
LDC	local distribution companies
LNG	Liquefied Natural Gas
M&A	Merger and acquisition
MKE	Korean Ministry of Knowledge and Economics

MMbpd	million barrels per day
MMBtu	million british thermal unit
MMtpa	million tonnes per annum
MPR	mixed component pre-cooled refrigeration
MR	mixed refrigerant
NBP	National Balancing Point
NGL	natural gas liquids
NOC	national running oil company
NOX	nitrogen oxides
NTS	National Tax service
NYMEX	New York Mercantile Exchange
OECD	Organisation for Economic Co-operation and Development
OI	operating income
OPEC	Organization of the Petroleum Exporting Countries
PCC	pure component cascade
POSCO	Pohang Steel Company
PSC	profit sharing contract
SCE	state controlling enterprise
SO	S-oil Corporation
SO_X	sulfur oxide
SPA	sales and purchase agreement
SPL	Sabine Pass Liquefaction
TDR	top down ratio
TOP	take or pay

TPA	tonne per annum
UK	United Kingdom
UPC	utility power companies
US	United States
USD	United states dollar
USSR	Union of Soviet Socialist Republics
WACC	weighted average cost of capital

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