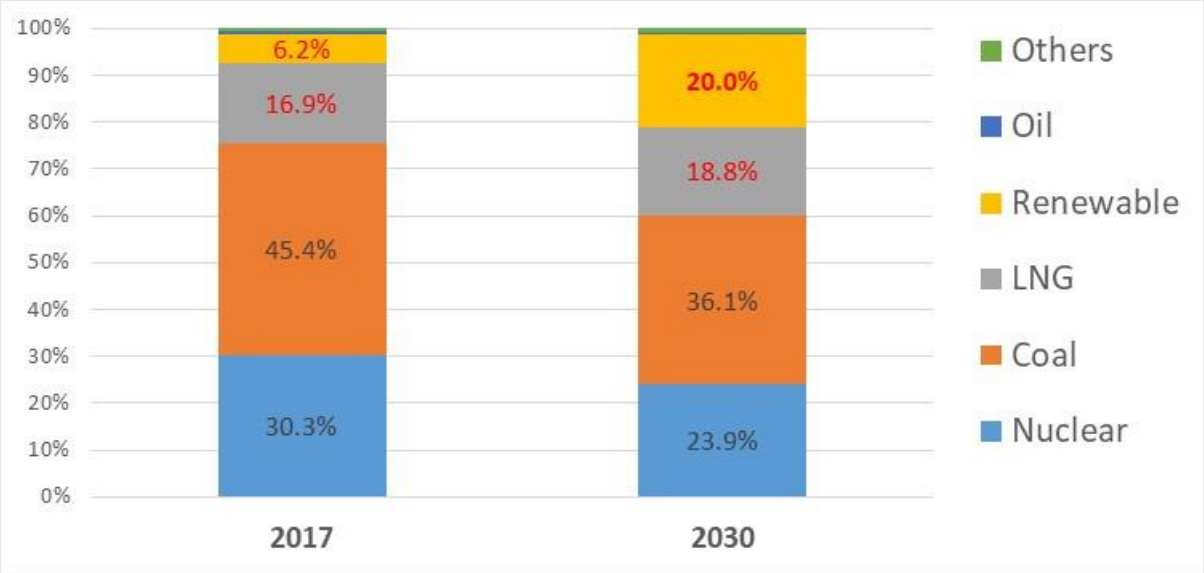
THE ROK ENERGY SECTOR: CURRENT STATUS, RECENT DEVELOPMENTS, AND ENERGY POLICIES

CHUNG WOO-JIN AND LEE TAE EUI

SEPTEMBER 14, 2020



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I. INTRODUCTION

In this Special Report, Chung Woo-jin and Lee Tae Eui describe the energy supply and demand situation in the Republic of Korea (ROK) energy sector, then describe existing projections of ROK energy use and the ROK energy policies likely to drive them. They discuss the ROK's involvement in development of regional energy cooperation projects, describe the ongoing updating of the ROK Working Group's energy futures model, and provide conclusions noting the energy sector opportunities and challenges facing the ROK

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Banner image: Plan of the future energy mix in ROK power generation to 2030, based on data from *Long-term Energy Outlook, KEEI, 2019*.

II. NAPSNET SPECIAL REPORT BY CHUNG WOO-JIN AND LEE TAE EUI
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Summary

The ROK has limited natural resources and is more than 90% dependent on external sources of energy. Energy security has been the main issue driving energy policy in the ROK. The newly-launched Moon administration has placed environment protection a key element of the ROK's energy transition policy. The government proclaimed an acceleration of the phase-out of nuclear power and of aging coal-fired power plants, while expanding renewable energy. Gas-fired power will be also expanded to play a role in supplementing nuclear and coal-fired power as those types of plants significantly reduce their electricity production, as well as supporting the generation of intermittent renewable energy (wind and solar) by providing power during periods of low output of renewable electricity systems. Energy trades with neighboring countries can provide important solutions that can help to improve the feasibility of the ROK's energy transition policy. It will be challenging, however, for the ROK to trade energy with Northeast Asia countries using overland pipelines and transmission lines, due to the military and political tensions between the two Koreas. ROK energy policies are thus standing at a

crossroads in terms of international political challenges as well as fuel supply economics.

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1 Introduction

South Korea, formally called the ROK (Republic of Korea) is located in North East Asia. The ROK occupies the southern portion of the Korean peninsula and is bordered by the DPRK (the Democratic People's Republic of Korea) to the north. The ROK's land area is comparatively

small, at 98,480 km^2. The country is largely mountainous, with small valleys and narrow coastal plains, and its population is about 51 million as of 2018. The country is one of the most densely populated countries in the world, but the population growth rate has fallen to 0.36% per annum by 2018, which is one of the lowest rates in the world. Among 224 countries in the world in 2015, South Korea's fertility rate ranked 220. Korean official estimates also show that its working age population is expected to decrease from 37 million in 2016 to 33 million in 2030 and 29 million in 2040, and the overall population will begin to decline in the next decade or so. About 85% of South Koreans live in urban areas, with over 20 million residing in and around Seoul, the capital city.

The ROK has adopted an export-oriented economic strategy to fuel its economy since its start the policies for economic development in the 1960s. As a result, the country has become the seventh largest exporter in the world and its economy relies largely upon exports with manufacturing of products such as semiconductor, electronics, ships, automobiles, and steels. Korea's economy has grown rapidly, with an average annual growth rate of 6.8% during the period from 1980 through 2010. Since then, however, its growth pace has slowed to 2~4% per annum except for the year 2015. The continuous economic slowdown in recent years indicates that over the long-term an economic growth model based on exports has encountered difficulties. Not only does the ROK have to contend with competition from advanced countries, but it now also has to face competition from other emerging economies. Many economists indicate that Korea's economy is now at a crossroads. The traditional approach that supported its economic growth through exporting manufacturing goods during the last two decades can no longer effectively promote ROK's economic growth at previous levels. The country needs to look for new alternatives if it is to continue its upward climb. In the long run, South Korea has to stand out in terms of developing advanced technology, maintaining strong innovation capacity, providing high-quality services, and achieving an irreplaceable position in the regional economic network.

The ROK has limited natural resources and is highly dependent on external sources of energy. The country has no oil and very limited reserves of natural gas, but some reserves of coal. Coal reserves are of the anthracite type. The ROK currently produces very tiny volumes of natural gas and small amounts of anthracite coal. In case of anthracite coal, almost all domestic coal mines have been closed since the end of the 1980s due to the high production costs, although coal was the country's main energy source before the last few decades. The ROK imports all of the crude oil and oil products needed to meet its demand and is a major refiner of crude oil. It also imported most of its natural gas demand. The ROK is the fifth-largest importer of crude oil and the seventh largest natural gas importer in the world. The country also imports all of the bituminous coal - steam and coking coal- that are consumed in industries and in electric power generation, with small amounts of domestic anthracite coal also used for power generation. Consequently, the ROK is more than 90% dependent on overseas countries to meet its energy demands.

Table 1 provides a summary of major energy and economic indicators for the ROK since 1980. Korea consumed 302 million toe of primary energy in 2017. Accompanying its high economic growth, ROK's energy consumption had also shown rapid growth during the 1980-2010 period. Since then, however, the growth rates of energy demand have been slowing along with the

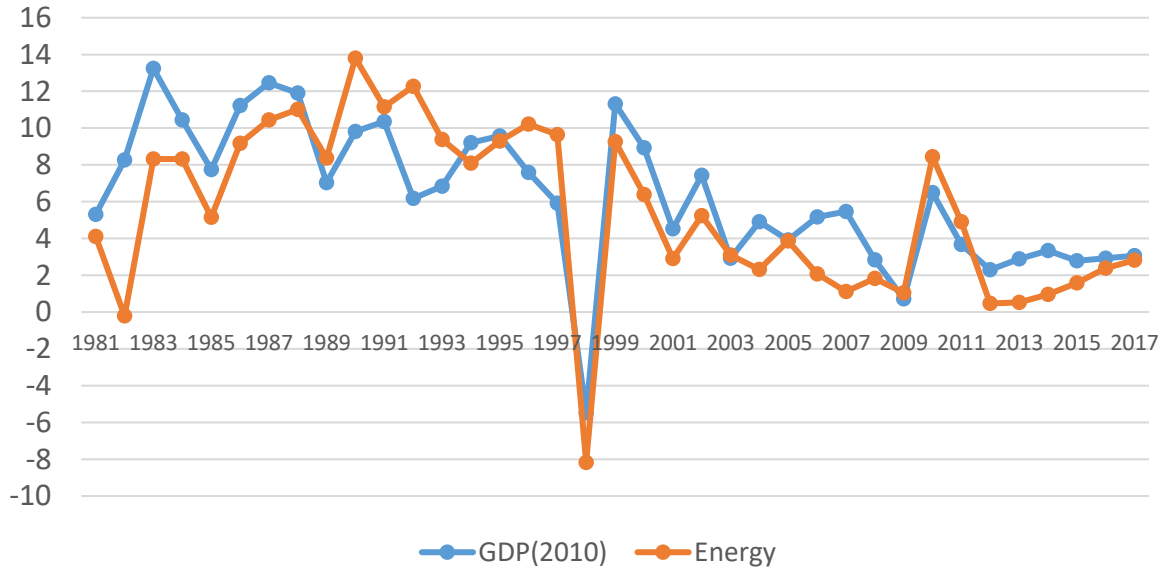
lower economic growth rates (see Figure 1).

Table 1: Major Energy/Economic Indicators

	unit	1980	1990	2000	2010	2015	2016	2017
Population	Million	38.1	42.9	47.0	49.6	51.0	51.2	51.4
GDP Growth Rate	%	6.1	9.4	6.2	7.0	6.5	4.2	3.1
Per Capita GDP	US$	1,598	6,505	11,865	22,105	27,171	27,681	29,745
Energy Consumption	Million toe	43.9	92.9	193.2	264.1	286.9	293.8	302.1
Per Capita Energy	toe	1.15	2.17	4.11	5.33	5.62	5.73	5.87
Energy/GDP	Toe/ th, US$	0.302	0.256	0.272	0.241	0.226	0.225	0.224
Overseas Energy Dependency	%	73.5	87.8	97.2	96.5	94.8	94.6	94.0

Source; Yearbook of Energy Statistics, KEEI, 2018

Figure 1: The Growth Rate of thr ROK Economy and Energy Consumption



Source; Yearbook of Energy Statistics, KEEI, 2018

Energy security, energy efficiency, and combating climate change have been the main pillars of energy policy for a long time in the ROK. In addition to these typical measures, the new Moon Jae-in administration, which began its term in early May 2017, has put environment protection at the heart of energy policy due to mounting public anxieties about nuclear safety

after the Fukushima nuclear accident in 2013 and about deteriorating air quality, especially due to fine particulate matter pollutant emissions (PM2.5). Consequently, the energy policy of the ROK is aiming to increase the shares of renewable energy and natural gas, on the other hand, to lower the shares of nuclear energy and coal in electricity generation. The ROK government announced its energy transition roadmap on October 2017, with plans to gradually phase out nuclear and coal power plants while expanding renewable energy from 4.8% of power generation in 2016 to 20% by 2030, while increasing natural gas use from 22.4% of the energy mix in 2016 to 38.4% in 2030. According to this plan, no new nuclear power plants will be built except for the two plants currently under construction, meaning the canceling of six planned nuclear reactors. The government also announced that it would shut down several aging coal-fired power plants.

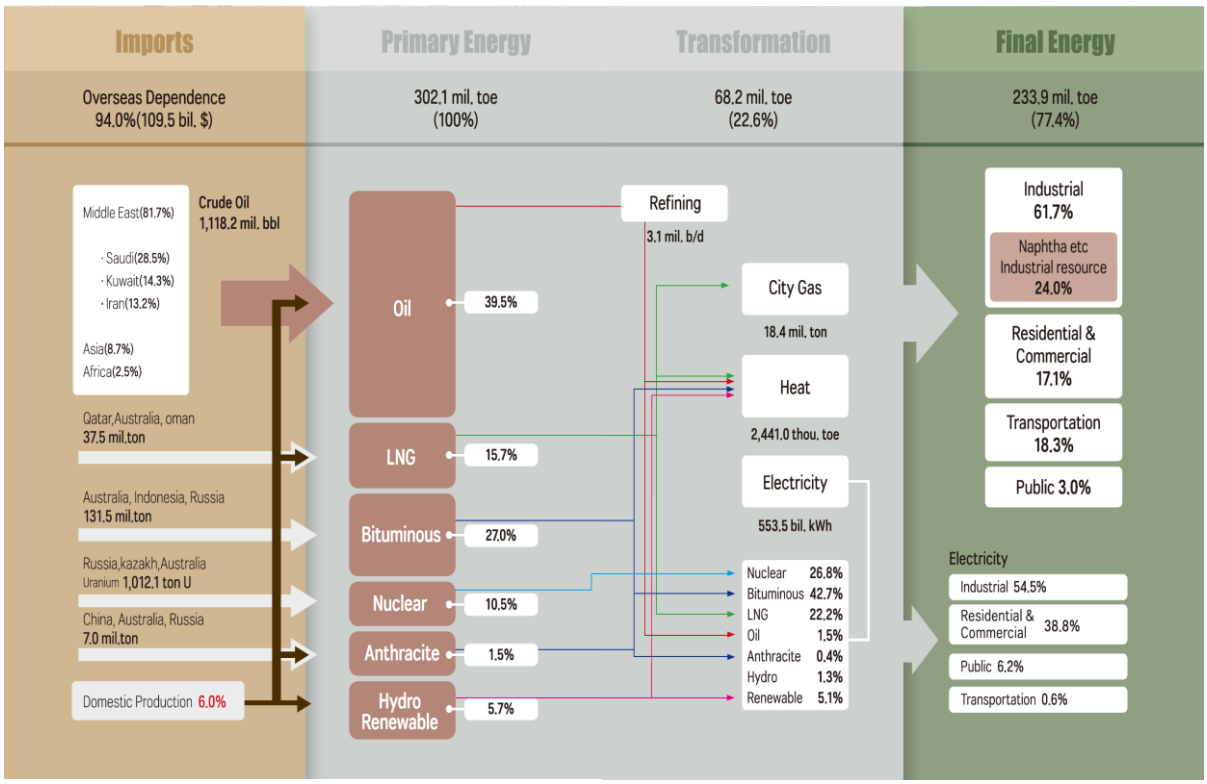
This radical shift in energy policies promoted by the current administration, however, has faced strong opposition from many opinion leaders, including energy experts and politicians. They warn that the plans to phase out nuclear reactors and coal power generation would threaten the country's energy security and push up electricity prices. Many energy experts are asserting that they are skeptical that the share of renewable energy in power generation can be increased to 20% by 2030. As a result, the ROK's energy policy is at a crossroads as to whether the government can push through its plan against strong opposition.

2 Energy Demand in the ROK—Current Status and Recent Trends

2.1 Total Primary Energy Supply

In 2017, 302.07 million tonnes of oil equivalent (TOE) in primary energy was consumed in the ROK. Oil is the dominant energy source in ROK, accounting for 39.5 percent of primary energy, followed by coal (at 28.6 percent), liquefied natural gas (LNG, at 15.7 percent), nuclear power (at 10.5 per cent), new and renewable energy (at 5.2 percent) and hydropower (at 0.5 percent), as shown in Figure 2. Energy consumption per capita was 5.87 TOE, and 94.0 per cent of the total primary energy used was imported.

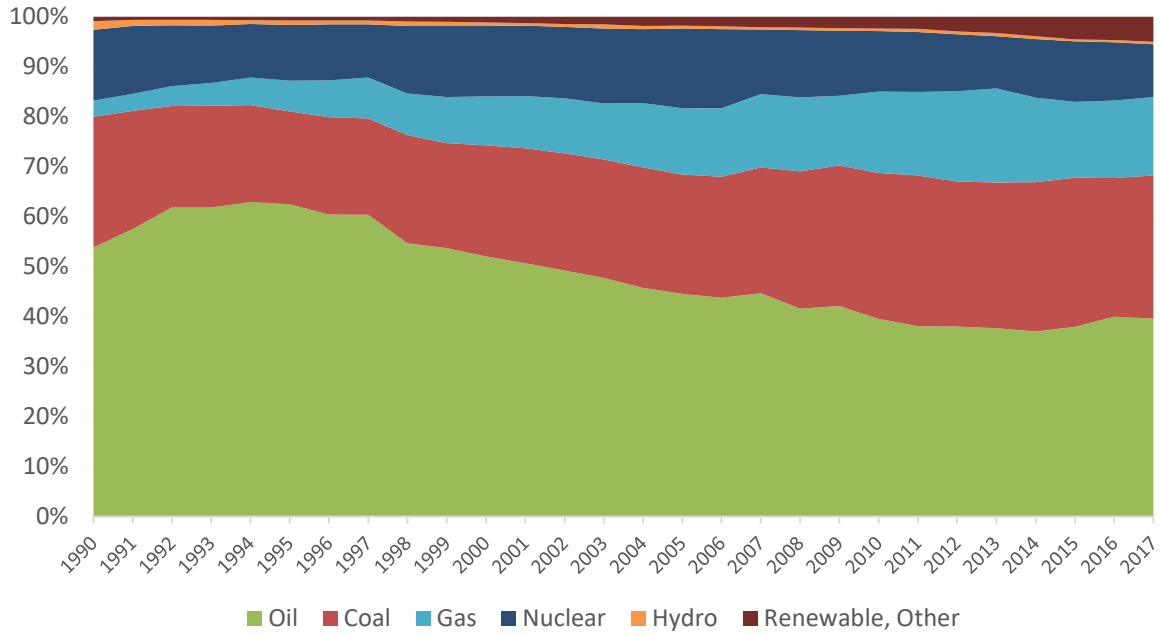
Figure 2: Energy Balance Flow in the ROK (2017)



Note: Based on TPES (total primary energy supply)
Source; 2018 Energy Info. Korea, KEEI, 2019

The share of oil in total primary energy has continued to decline after peaking at 63% in 1994. Despite government policy to reduce the ROK's oil dependency, petrochemical industry growth is sustaining oil demand. Thus, the share of oil is likely to remain near the current level even though there could be a slight decline in the future. Coal, which occupies second place in total primary energy use, showed an overall upward trend with a slight fluctuation after bottoming at 18.6% in 1995. Power generation is the biggest sector for coal use, and the iron and steel sectors also play a big role. However, the share of coal in primary energy will gradually decline due to the government's plan to reduce the fraction of coal-fired power generation and the slowdown trend in the steel industry. Natural gas consumption has been rapidly increasing since 1986 when Korea Gas Company (KOGAS) started to import natural gas (as liquefied natural gas, or LNG) from Indonesia. The industry and household sectors prefer natural gas to other forms of fossil energy because it is clean and convenient to use. Natural gas, as a major element of the ROK's energy transition policy, is a bridge to clean energy economy from the traditional fossil fuel economy. While oil and coal are forecast to peak around 2030 in domestic consumption, the share of natural gas, which accounts for 15.7%, is expected to increase steadily. Figure **3** provides a summary of the fraction of total ROK primary energy use by fuel.

Figure 3: Share of Trends in Primary Energy Shares by Source



Source; Yearbook of Energy Statistics, KEEI, 2018

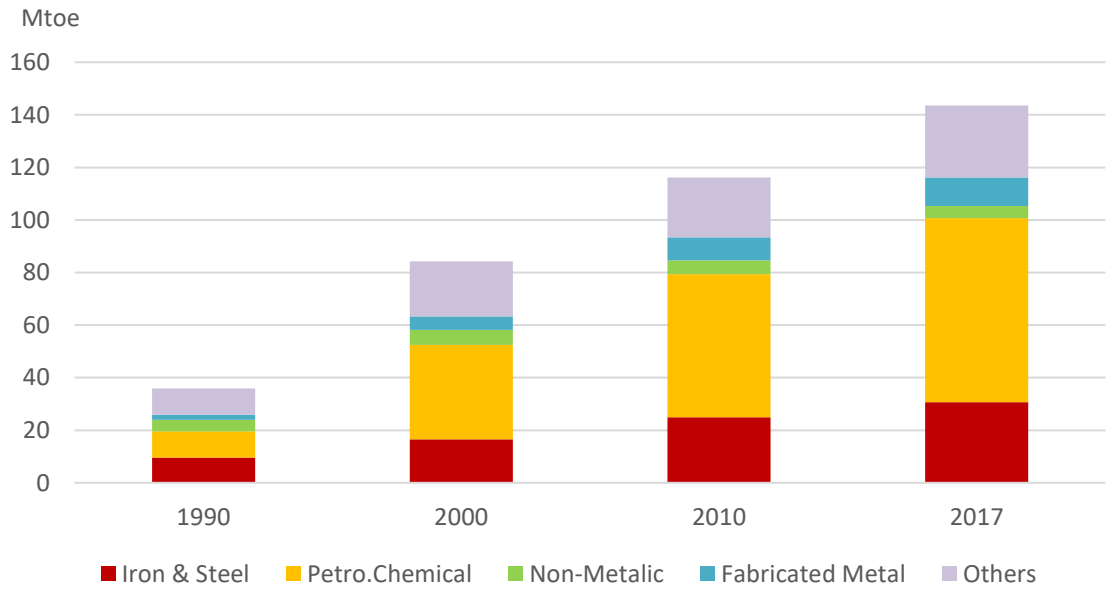
The share of nuclear energy in total primary energy peaked at 16% in 2005 and has since fallen to just over 10% by 2017. The first nuclear power plant in the ROK, Kori No.1, was launched by foreign companies, with Westinghouse as the supplier for nuclear reactors and turbines and GE as the primary construction contractor, in 1978. Since this first nuclear power plant entered successful operation, Korea had been promoting the nuclear industry in order to reduce energy imports dependency and to address GHG (greenhouse gas) emissions issues until the current government launched its nuclear phase-out policy. The proportion of coal / LNG has increased since the mid-2000s, as the supply of coal / LNG for power generation has increased. The proportion of renewable energy is increasing but it is currently very small. At present, the largest source of renewable energy is from power plants burning municipal solid wastes, but the energy transition policy is promoting increasing penetration of solar PV (photovoltaic) and wind power in the electricity sector.

2.2 The Industrial Sector

Energy demand grew at an average annual rate of 2.6% over the last 17 years, reaching 233.9 Mtoe. The industrial sector accounts for 61.7% of total energy demand. The growth rate of industrial sector demand is small, but the share of total demand contributed by the sector has steadily increased from 56% in 2000. Among the traditional energy-intensive industries, the contribution of steel and non-metal industries to energy demand has been decreasing, while demand from the petrochemical and metal fabrication industries has increased. Petrochemicals, which is the main linkage industry for metal fabrication, has been aggressively expanding its capacity since 2015, which is expected to increase the demand for energy into the future. Petrochemicals and steel accounted for 27.7% and 26.7% of the industrial sector in 1990, respectively. In 2000, this proportion changed to 42.7% and 19.7%, and to 48.8% and 21.4%

in 2017, respectively, but the two subsectors still occupy first and second place in energy demand in the industrial sector. In addition, as the demand for semiconductors increases with trends toward artificial intelligence (AI) and other technologies, the energy demand of the metal fabrication industry, where the semiconductor industry is categorized, has increased. The percentage of metal fabrication, which accounted for 5.3% of energy demand in 1990, increased steadily to 7.6% in 2017. Semiconductor exports from the ROK have increased by 56% in value compared to 2016. In addition to semiconductors, the production of automobiles and electric and electronic products, which are the main export products of Korea, are steadily increasing. On the other hand, steel demand is stagnating recently due to the slowdown in the global steel industry and in downstream industries, which include the shipbuilding industry. In sum, energy demand in the steel subsector as a fraction of demand in the industrial sector had increased from 19.7% in 2000 to 24.1% in 2014, but from 2014 it has gradually declined to 21.4% in 2017. Figure 4 shows final energy use by major industrial classification from 1990 through 2017.

Figure 4: Final Energy Consumption by Industry

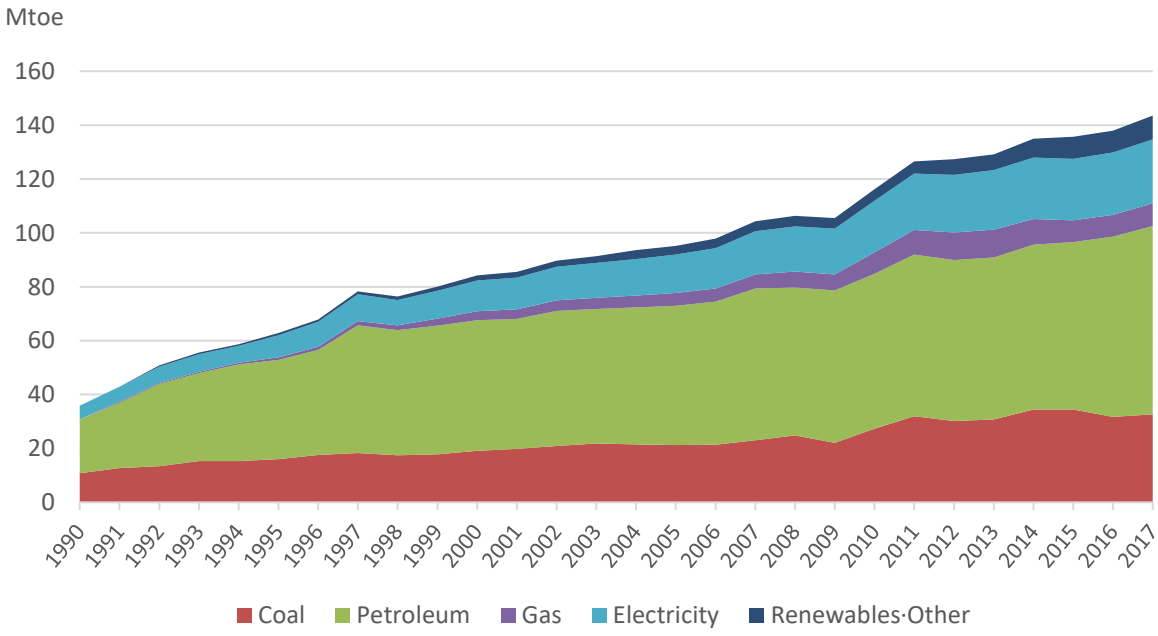


Source; Yearbook of Energy Statistics, KEEI, 2018

The consumption of conventional fossil fuels such as coal and oil is steadily increasing, but the share of those fuels in the overall energy mix of the ROK has fallen from 86% in 1990 to 71% in 2017. As GHGs and fine particulate matter are expected to be an increasingly important environmental issue in the ROK, the declining trend of conventional fossil fuels use is also expected to continue. Consumption of non-energy oil products including naphtha, a raw material used heavily in the petrochemical industry, is steadily growing, and it accounts for the largest portion of industrial sector oil and energy use. Coal demand had increased until 2014, mainly to fuel iron and steel production, but fell sharply after 2015 due to sluggish domestic

demand and intensified competition with Chinese steel. Due to the rapid growth of electricity-based metal fabrication, industrial demand for electricity increased to 23.8 Mtoe in 2017, at a CAGR (compound annual growth rate) of 4.4%, from 11.7 Mtoe in 2000. Gas consumption in the industrial sector increased at a CAGR of 8.8% from 2001 to 2013, thanks to price competitiveness based on high oil prices and its use as a resource for petrochemicals. However, as the growth in industrial output slowed due to the sluggish economic recovery after 2014, and the effects of the reverse conversion (gas to petroleum) phenomenon in industry caused by the plunge in oil prices were felt, the rate of growth in gas use has rapidly decreased. New and renewable energy is growing fastest among industrial energy sources, benefitting from strong policy support. Figure 5 shows the trend in industrial energy use by fuel in the ROK since 1990.

Figure 5: Industrial Energy Consumption by Source



Source; Yearbook of Energy Statistics, KEEI, 2018

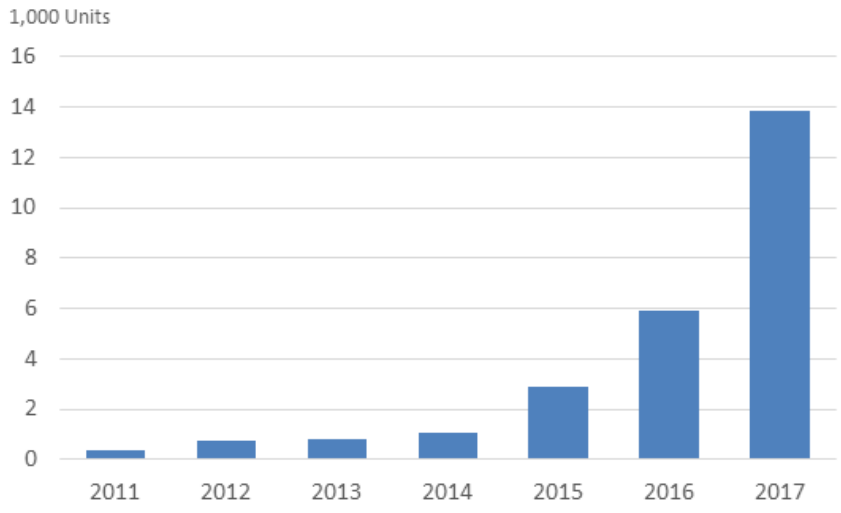
2.3 Transportation sector

The energy consumption of the ROK transportation sector increased at a CAGR of 4.2% from 14.2 Mtoe in 1990 to 42.5 Mtoe in 2017, although the energy growth trend was interrupted due to the 1997 Asian financial crisis and the 2008 global financial crisis. Although energy consumption growth slowed overall in the transportation sector by 2014, transportation demand grew by 7.1% and 6.2% in 2015 and 2016, respectively, due to the plunge in international oil prices since 2014. Energy demand in the transportation sector is expected to reach a peak around 2030 as the sales of vehicles with internal combustion engines are stagnating or declining, and sales of alternative-fueled vehicles, especially electric vehicles, are increasing.

This expectation is based on several factors such as the stock of internal combustion engine vehicles, improvements in efficiency, and the decline of population growth (and subsequent population declines). The ROK is undergoing a major demographic change, and by 2040, the total population of ROK will fall to the level of the population in 2016. The working-age population will steadily decline due to the rapidly declining fertility rate experienced in the 2000s. The working-age population, which has already peaked in 2016, is expected to decline from 73.4% to 56.4% of the ROK's population in 2040, and aging of the population is already happening faster than in other OECD countries. In 2018, ROK entered an 'Aged Society' phase in that more than 14% of the population were aged 65 or older. Despite the cohort effect, which compares activity level of current aged people with the same age people in the past, and shows that today's older people are more active than the same age people in earlier decades, the aging effect, which measures a diminishing rate of activity level between aged people and the working-age people, dominates the overall effect of changing demographics in the ROK.

Major countries in the world actively support the diffusion of eco-friendly vehicles as a means to provide improvements in energy security, the environment, and local industry. The support has taken various forms, such as purchase incentives, driving incentives (charging credits, lower toll fees, allowing high-occupancy vehicle lane use, etc.), investing in charging stations, and research and development. As a result of these technology dissemination policies, the number of global hybrids, plug-in hybrids, and battery electric vehicles has increased to 9.389 million units in 3Q 2016. In the ROK, despite the government's aggressive promotion of eco-friendly vehicles and the increasing interest in environmental issues, eco-friendly vehicles have been not yet popular due to the convenience of internal combustion engine cars, and the lack of convenient charging stations for electric vehicles (EV). Moreover, the government's supply targets for eco-friendly vehicles had not yet been met through 2016. This trend changed starting in 2017. The supply of EVs sold in 2017 exceeded the total cumulative supply up to 2016 (see Figure 6). The effect of EV diffusion on energy consumption, however, appears to be insignificant thus far, even with strong 2017 EV sales.

Figure 6: EV Sales in the ROK

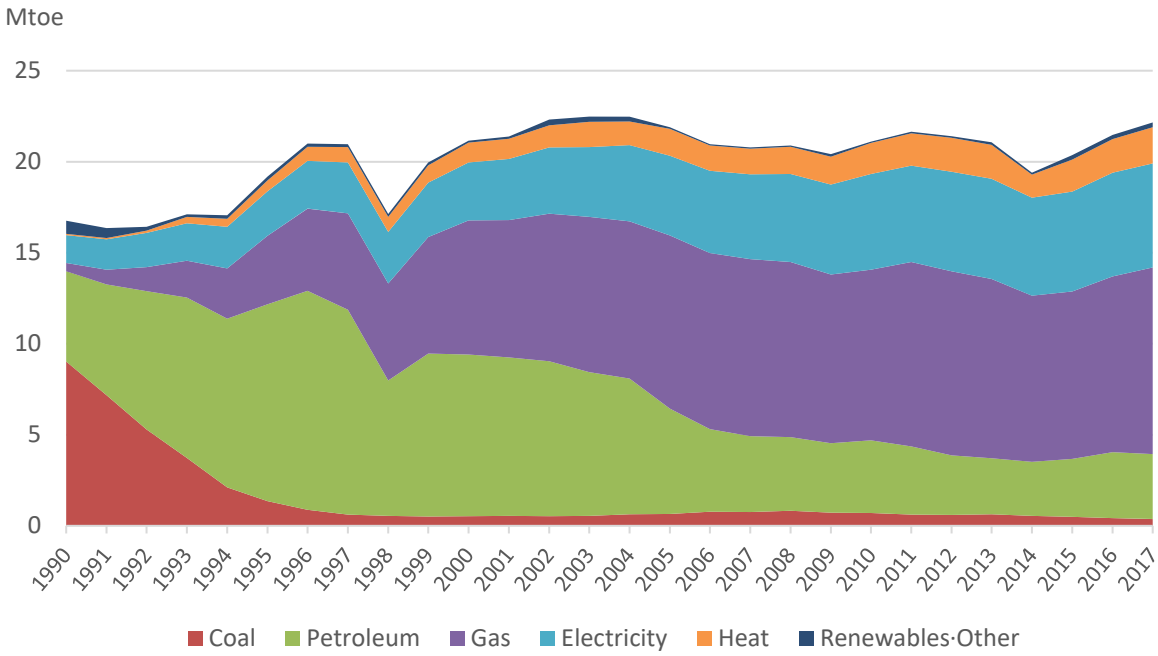


2.4 Residential sector

Energy consumption in the residential sector has steadily declined since the mid-2000s, reaching 22.2 million toe in 2017. Until the mid-2000s, the number of households grew by more than 2% per year and housing supply grew at an average annual rate of nearly 4%. As of the mid - 2000s, however, growth in the total population, the number of households, the number of dwelling units, and household income have all slowed. Moreover, diffusion of alternative energy sources and growing energy efficiency have led to a decrease in household energy consumption. Energy demand per household and per unit of GDP are expected to decline more in the future due to improved efficiency, but per capita energy consumption is expected to remain at its current level due to an increase in single-person households and elderly households, and an increase in household income.

As shown in Figure 7, most of the coal and oil used for heating and cooking have been replaced by city gas and district heating. During the 1990s and 2000s, as the construction of a new cities and areas around urban centers focused on clusters of apartment buildings, the supply of apartments rapidly increased. Since ROK apartments provide better living quality overall than traditional homes, the preference for easy-to-use appliances using electricity also increased. As a result, domestic coal and oil consumption declined by an average of 11.1% and 1.2% per annum between 1990 and 2017, respectively, District heating consumption increased by 12.2% and 13.3%, respectively, during the same period. The expansion of use of household electric appliances including air conditioners and the diversification of home appliances such as electric ranges, air cleaners, and dryers are expected to increase electricity consumption further, but the increase is expected to be less than 1% per year. New and renewable energy is rapidly increasing, largely from solar PV systems, driven by the government's new renewable energy policy.

Figure 7: Residential Energy Consumption by Source



Source; Yearbook of Energy Statistics, KEEI, 2018

Heating and cooking energy, which account for the largest portion of household energy demand, show declining trends due to changes in residential housing types and the development of home insulation and heating technologies. Heating energy accounted for 77% of residential energy consumption in 2000, but decreased to less than 70% in 2017. Cooking energy consumption was estimated to account for 8% of household energy consumption in 2017, and has been steadily declining since 2014 due to stagnant household numbers and population declines.

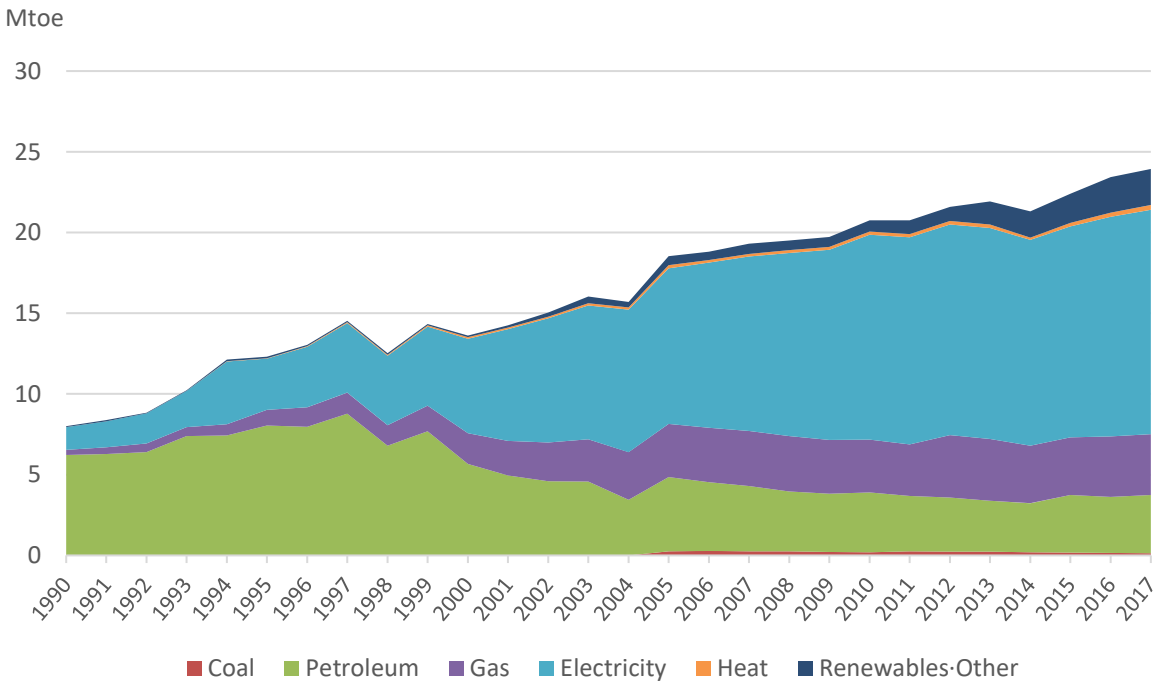
Electricity demand for lighting and heating is decreasing, but the demand for air conditioning and household appliances is rapidly increasing, leading to a rise in residential energy consumption. Electricity consumption for cooling shows the highest increase rate among all electricity end uses with an average annual increase of 18.7% between 2000 and 2017. Electricity consumption for other household appliances will also increase rapidly due to income increases and the diversification of electrical equipment. On the other hand, housing types are continuing to shift away from houses to apartments and multi-family units where insulation technologies are better and the latest technologies are applied more quickly. As a result of these trends, the energy consumption in apartments is estimated to average than one-half that of consumption in houses on a per-unit basis.

2.5 Service sector (Commercial, Public)

Growth in the use of electricity led to an increase in service sector energy consumption. From 1990 to 2000, except for 1998, commercial/public energy use increased by more than 10% every year. Even in the 2000s, the CAGR was 8%. Since then, however, the growth rate has slowed considerably and the CAGR for commercial energy use has fallen to 1.3% in the 2010

~ 2017 period. The use of gas has been a minor part of commercial sector energy use relative to electricity consumption, which accounted for 58% of total sectoral consumption as of 2017. Gas use accounted for 16.7% of total energy consumption in 2017, ranking second in the sector. Although new and renewable energy has not yet taken a significant share of consumption, in recent years, government energy policies have been changing the trends and the new and renewable energy consumption is rapidly spreading. Oil, which is mainly used for heating energy and once accounted for the majority of energy consumption in the service sector, was quickly replaced by gas and electricity. Oil accounted for 77.4% of energy consumption in the service sector in 1990, as shown in Figure 8, but its use rapidly declined to 15.1% in 2017 due to substitution by gas and electricity. District heating and energy efficiency improvement projects have also helped to reduce oil consumption in the sector.

Figure 8: Commercial Energy Consumption by Source



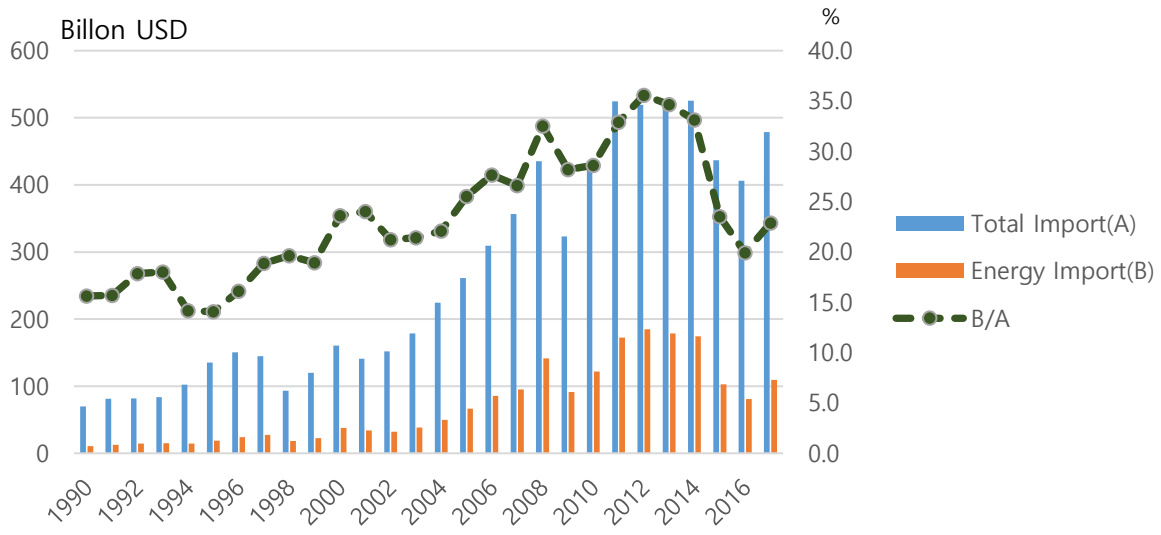
The service sector shows large differences in the patterns of energy consumption by subsector due to the diversity of service industries and the nature of each industry. Among them, wholesale and retail trade and health/social welfare services have led the increase in energy consumption in the service sector. In the wholesale and retail industry, consumption is increasing due to expanding e-commerce and modernization with large-scale marts and outlets replacing smaller shops. In addition, the health and social welfare industries have been consuming more energy due to the rapid increase in demand for medical services that has accompanied the aging of the population.

3 Primary Energy Supply in the ROK

3.1 Oil

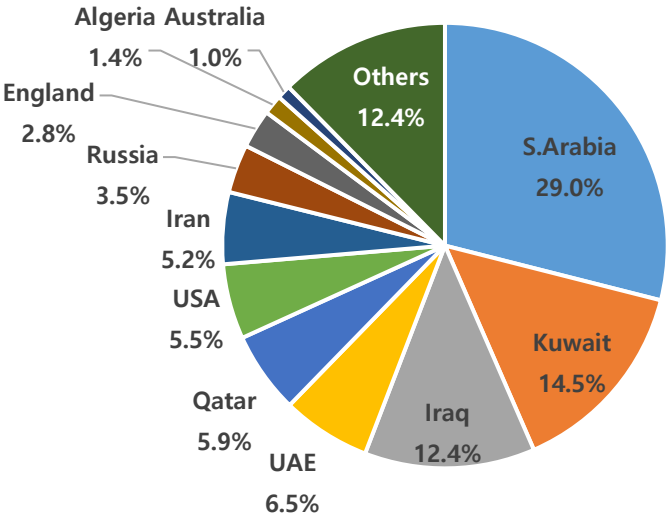
The ROK meets almost all of its energy demand from imports due to the absence of any significant energy resources. The ROK's dependency on overseas energy has remained above 90% for the past 20 years and was at 96% in 2017. The ROK's energy import costs are a burden to the economy, totaling 15~35% of the ROK's total import costs in any given year (see Figure 9), depending on prevailing international energy prices.

Figure 9: Trends of Total Imports and Energy Imports



The ROK depends on imports to meet its entire oil demand, making it the fifth-largest oil importer in the world. The ROK imports more than 80% of its crude oil from Middle Eastern countries, mainly from Saudi Arabia, Kuwait, Iraq, and the UAE (Figure 10). The ROK has for a long time tried to diversify the regions from which it sources crude oil imports. The high dependency on oil from the Middle East, however, has not improved markedly because transport costs from the Gulf region to Korea are lower than from other import regions, and also the properties of Middle Eastern crude oils are well suited to the technical requirements of Korean refinery facilities. The state-run company KNOC (Korea National Oil Company) and some privately-owned companies are involved in the exploration and development of oil and gas in oil-producing countries. Given the responsibility by the government for strategic oil storage, KNOC is running nine stockpiling bases with a total capacity of 146 million barrels of oil, and held 96 million barrels of reserves, excluding joint stockpiling reserves, as of December 2018.

Figure 10: Shares of Crude Oil Import in the ROK by Countries (2018)



Source: Petronet, KNOC

Though it has no oil reserves of its own, the ROK has tried to develop its downstream oil industry and consequently refining capacity had increased to 3.1 mb/d (million barrels per day) by 2018, which significantly surpasses domestic demand for petroleum products (2.4 mb/d in 2018). The refining industry plays an important role in the country's export earnings. The ROK's refineries are run by four privately-owned companies including the SK group. Oil markets are fully liberalized and open to foreigners over the range of activities from import and export to refining and distribution. The four large domestic refinery companies, however, dominate the market.

3.2 LNG and Domestic Natural Gas

The domestic offshore gas field of Dong-Hae 1 in the Korean East Sea entered into service in 2004 as the first domestic gas production in the ROK. At Dong-Hae, KNOC (the Korean National Oil Corporation) is producing around 0.15 bcm (billion cubic meters) per year of natural gas, which amounts to less than 1% of total natural gas consumption in the ROK. This natural gas reserve is getting exhausted and production is expected to cease in 2021. KNOC is exploring other natural gas reserves in the Korean offshore areas but has not found additional reserves as of yet. The ROK started to import LNG in 1986 and since then, the volumes of LNG imports have grown quickly: from 2.2 Mt (3 bcm) in 1990, to 15.2Mt (19 bcm) in 2000 and 37.5 Mt (53 bcm) in 2017. The ROK was the world's third largest LNG importer in 2017, following Japan and China (whose imports were slightly higher than the ROK's for the first time in 2017).

Approximately 32% of the LNG used by the ROK is imported from Qatar, 19% from Australia, 10% from Malaysia, 9% from Indonesia, 5% from Russia, another 5% from the United States and the remainder (20%) from several other countries. The major importing sources of natural gas have been shifting from the south-east Asian countries to Middle Eastern countries and

Australia, and the United States is emerging as the ROK's new source of LNG since 2017. The contract price of natural gas from the United State is linked to the price of gas at the U.S.' Henry Hub, where prices of gas on the spot market in the United States are set, while LNG prices for imports from other countries are typically linked to crude oil prices. Table 2 summarizes the ROK's long-term gas supply contracts currently in force.

Table 2: ROK's Long-term Gas Supply Contracts

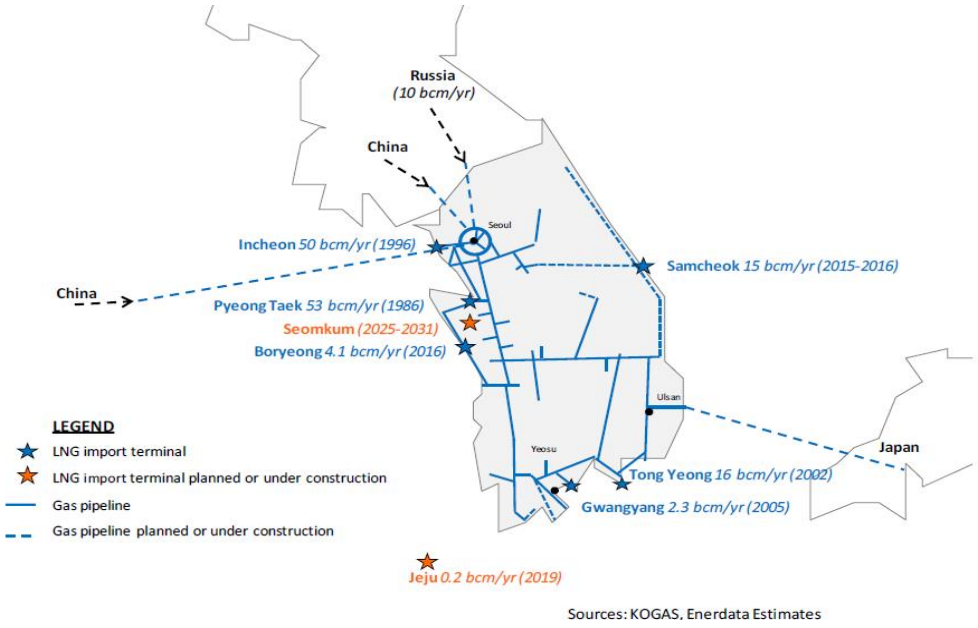
Producer Country	Project Name (Supplier)	Volume (Mt/year)	Contract Period	Delivery Option
Qatar	RasGas	4.92	1999-2024	FOB
	RasGas II	2+mid-term V	2012-2032	DES
	RasGas III	2.10	2007-2026	DES
Australia	GLNG	3.00+option 0.5	2015-2035	FOB
	Prelude	3.64	2013-2038	DES
	Total	2.00	2014-2031	DES
Malaysia	MLNG III	1.50+option 0.5	2008-2028	DES
Indonesia	Badak	1.00	1998-2018	FOB
Oman	OLNG	4.06	2000-2024	FOB
Yemen	YLNG	2.00	2008-2028	FOB
Russia	Sakhalin II	1.50	2008-2028	FOB
USA	Sabine Pass	2.80	2017-2037	FOB
Shell	Portfolio	3.64	2013-2038	DES
Korea (Domestic)	Dong Hae Gas	0.40	2004-2018	PNG
Total		28.56+1.0		

Note: DES means Delivered EX-Ship

Source: KOGAS and Korea Gas Union (2018)

KOGAS (Korea Gas Corporation, the state company), is the sole gas importer, with the exception of some industrial companies that import gas directly, typically in smaller volumes for their own uses. KOGAS is listed on the Korean Stock Exchange, and its major shareholders are government entities, including the central government (26.9%), KEPCO (the state electricity company 24.5%), local governments (9.6%) and the Treasury (6.1%). KOGAS is also the wholesaler that owns and operates national gas trunk lines and six LNG terminals with many large-scale gas storage tanks. The company supplies natural gas to power generation plants, industries, and provides gas to city gas companies. In addition to these businesses, KOGAS has invested in exploration and development projects for oil and gas in various countries including Mozambique, Canada, Iraq, Qatar, Oman, and Australia. There are 30 local city gas companies in the ROK that are private gas retailers and monopolistically distribute gas to the households and commercial in their regions. Figure 11 presents a map of major gas infrastructure in the ROK, including import terminals and major pipelines.

Figure 11: Map of Natural Gas Infrastructure



KOGAS is preparing to purchase a large volume of natural gas by executing new contracts with natural gas exporting countries, as many of its long-term contracts for LNG imports are approaching their expiration periods. Several long-term contracts totaling 9.5 million Mt/year are scheduled to expire before 2024, and the contracts of an additional 7 million Mt/year will have expired by 2030. Furthermore, KOGAS will be pressured to secure more natural gas as the demand of natural gas is expected to grow more than the one that is reflected in existing long-term energy plans due to the new government's policies to restrict the new deployment of nuclear and coal-fired power plants. KOGAS is closely watching international gas market conditions while seeking lower prices and more flexible contract terms. The company wants more flexible take-or-pay terms[1] and to be able to resell part of the volume it imports to third parties, depending on LNG supply conditions in the domestic market. Under its current contract terms, KOGAS can't sell imported LNG on to other consumers or buyers even when the company has a large surplus stock.

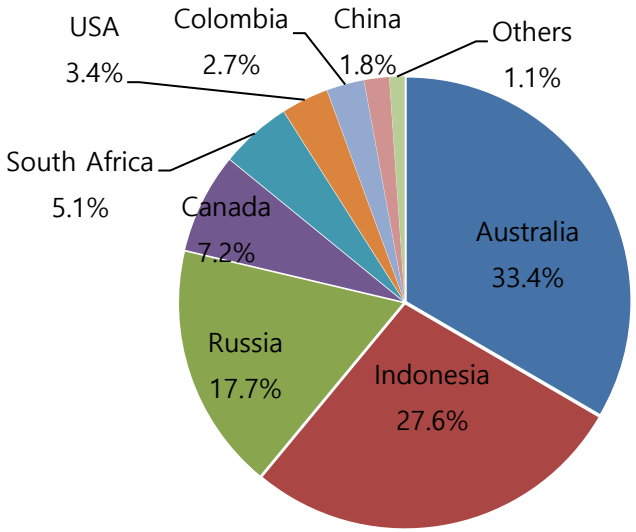
3.3 Coal

The ROK imports all of the bituminous coal and most of the anthracite coal that it consumes, and is the world's fourth-largest coal importer, following Japan, China, and India. As of 2017, 95 million tons of thermal coals and 7 million tons of anthracite coals were imported, along with 36.4 million tons of coking coal, which is used as a raw material in steel making. The ROK spent 15.2 billion dollars on coal imports in 2017. Australia, Russia, Indonesia, and

[1] "Take-or-pay" terms in natural gas contracts oblige the purchaser to accept delivery of gas or pay for the gas not delivered if, for example, gas demand is not sufficient to use up the contracted supply and/or gas storage facilities are full.

Canada are the major coal exporters to the ROK (see Figure 12), and among them, Australia is the largest exporter. All coal is imported by Korean companies that use coal and by coal trading companies. The ROK's coal imports are significantly influenced by electricity demand and electricity sector policies because almost all thermal coal is consumed in power plants. In that respect, the growth rate of coal imports is expected to slow markedly or even show an absolute decrease in imports in the long-term because, as noted above, the government is restricting construction of new coal-fired power plants along with nuclear power plants, and is trying to reduce the operation of existing coal-fired power plants. Coal plant emissions have become a very serious social issue in the ROK as air quality in the country has continued to deteriorate due largely to coal plant emissions. The government is, therefore, considering lowering the operating rates of coal power plants, which emit the majority of fine particulate matter originating from domestic sources. To start the process of implementing this policy, the government has decided to raise the tax on thermal coal by as much as 27% starting from April 2019, while lowering the tax on LNG by 74% as part of efforts to reduce coal consumption by the electric utilities and substitute coal power plant fuel with LNG.

Figure 12: Shares of Bituminous Coal Import to the ROK by Countries (2017)



Source: Energy Year Book, KEEI, 2018

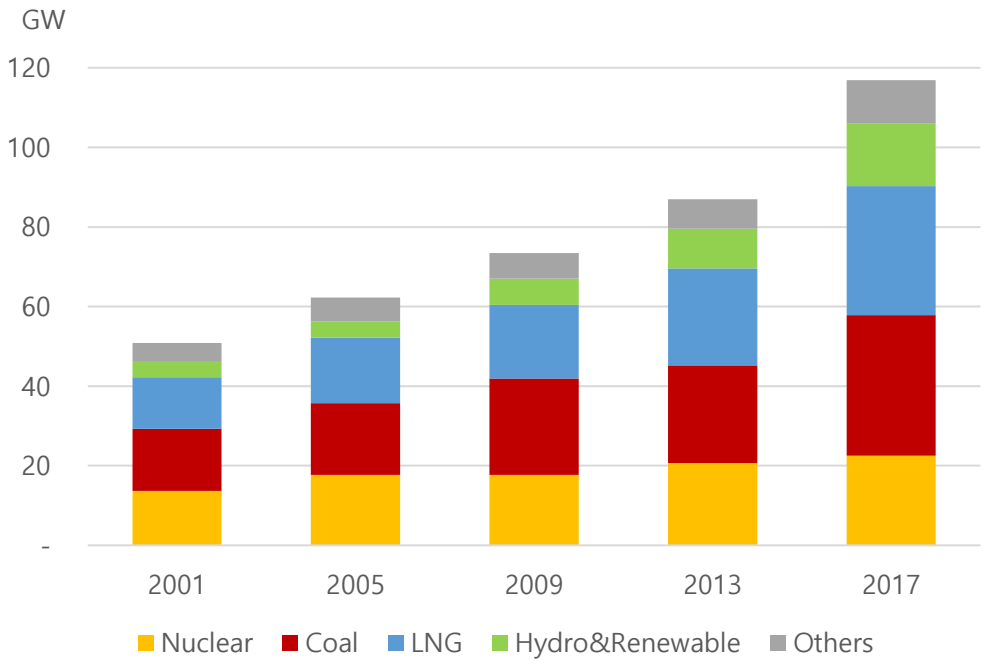
Five anthracite coal mines are currently operating in the ROK; together they produced less than 1.5 million tons of coal in 2017, a substantial decrease from 23.6 million tons of production in 1986. The anthracite coal produced in the country is mainly used in the household and commercial sectors, while most of the imported anthracite coal is used in industry, with small volumes used in power plants. The Korean government has made a policy of closing most domestic coal mines since the late 1980s as the productivities of most mines had significantly declined over time. The government does, however, intend to keep a small amount of domestic coal production active as an energy security measure, as anthracite coal is the only significant

fossil fuel produced in South Korea. In order to keep domestic coal mines operating, the government subsidizes the production of coal, though production costs at mines in the ROK are higher than the prices of imported coal and also higher than the prices paid for coal (imported or domestic) by ROK consumers.

4 Electricity Supply in the ROK

The capacity of the power generation system in the ROK has increased more than five-fold over the last three decades, from 21 GW (gigawatts, or million kilowatts) in 1990 to 117 GW in 2017 (see Figure 13). As of 2017, coal-fired power plants constitute the largest portion of capacity (30%), followed by gas-fired plants (28%), and nuclear power plants (19%). The rest of the capacity is provided by oil-fired plants (9%), and renewable energy (8%). According to the government's energy transition policy, which was launched in 2017, the capacities of nuclear and coal-fired plants are expected to shrink substantially in the future. On the other hand, the capacity of renewable generation facilities will increase sharply as the energy transition policy aims to raise the proportion of renewable energy supply to 20% of the total generation by 2030. Gas-fired plants are expected to bridge the gap between reduced baseload generation (coal and nuclear) and introduced renewable energy generation, and as a result, the capacity of gas-fired plants is expected to expand significantly in the 2030s.

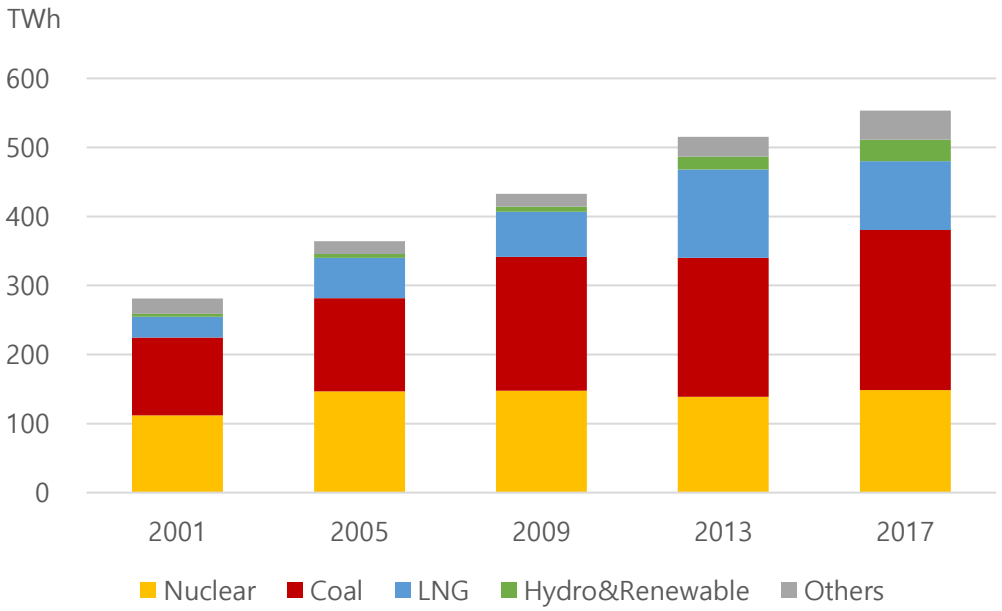
Figure 13: Electricity Capacity in the ROK by Source (2017)



Source: Statistics of Electric Power in Korea, KEPCO, 2018

The total electricity generation in 2017 was 554 TWh, and generation grew at an average annual rate of 5.3% between 2000 and 2017, as shown in Figure 14. The rank of electricity generation shares by fuel in 2017 was coal 232 TWh (42%), nuclear power 148 TWh (27%) and LNG 136 TWh (25%). In addition, hydropower, including pumped-storage plants, produced 7 TWh (1%) and petroleum-fired units produced 6 TWh (1%).

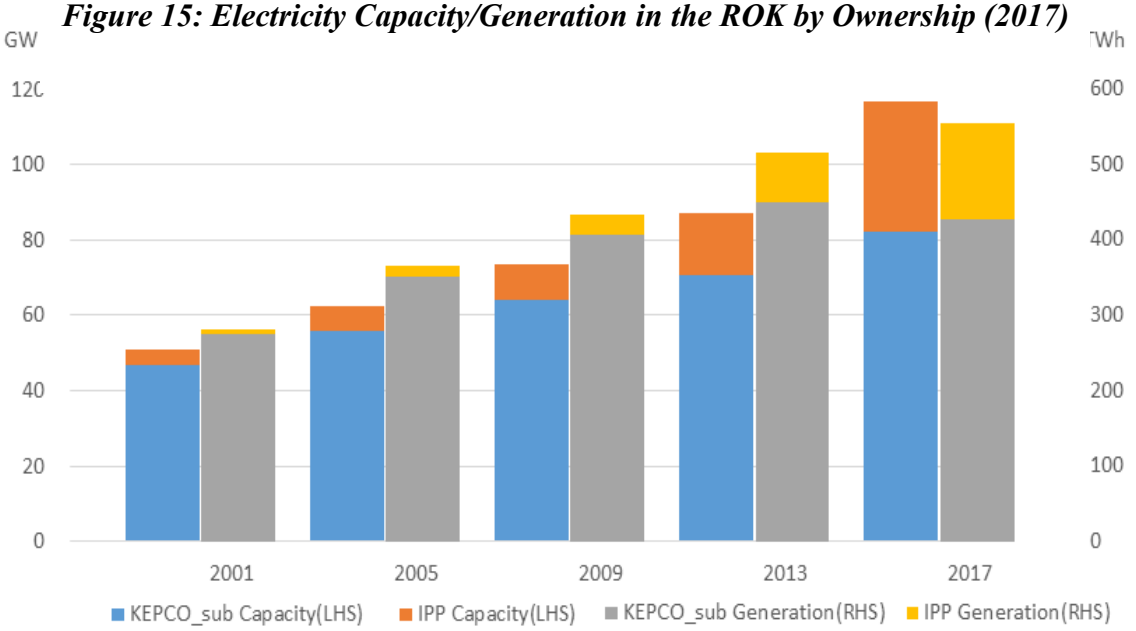
Figure 14: Electricity Generation in the ROK by Source (2017)



Source: Statistics of Electric Power in Korea, KEPCO, 2018

Up until the restructuring of the electric power industry in 2001, Korea Electric Power Corporation (KEPCO) had operated as a vertical monopoly system integrating power generation, transmission, distribution and sales. In April 2000, however, the power generation division was separated into six KEPCO subsidiaries (all of which remain 100% KEPCO-owned). In the power generation sector, there currently are other power generators such as GS Power, K-Water, and various integrated energy and combined-cycle power generation companies, but KEPCO still has a monopolistic position because it accounts for 70% of ROK power generation facilities and 77% of national power generation. Figure 15 shows the ownership of generation capacity in the ROK and the output of generators by type of ownership. KEPCO is responsible for domestic sales, transmission, and distribution of electricity. The Korea Power Exchange (KPX) was established in 2001 to take charge of the sales of electricity that KEPCO and other producers generate. KPX is not only coordinating the wholesale electricity market but also operating the transmission system. Although KPX is a non-profit corporation and KEPCO is a public corporation whose overall cost recovery is guaranteed, recently KEPCO's net profit declined sharply due to the reduction in nuclear power generation, incremental increases in fuel costs, and a national policy of avoiding increasing electricity rates.

Figure 15: Electricity Capacity/Generation in the ROK by Ownership (2017)



Source: Statistics of Electric Power in Korea, KEPCO, 2018

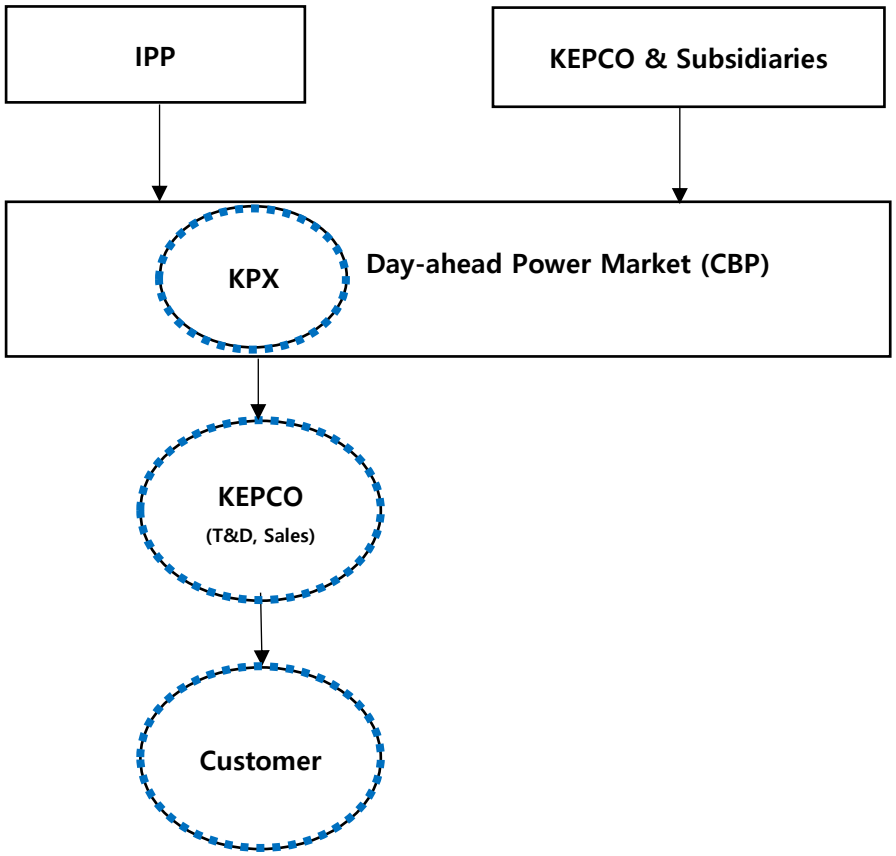
The Korean power market (see Figure) is an offer-only market. Therefore, only the power generation sector participates in the bidding. Instead of demand-side bidding, KPX estimates the demand and reflects the estimated demand into the market for supply. The consumers are KEPCO and Community Energy Service (CES), which are price takers. The price mechanism of the power market is Cost-Based Pool (CBP). In other words, instead of bidding directly at the price, the generator participates in the bidding market based on its variable cost (fuel cost). In the day-ahead market (DAM), the market puts the generators in the order of low cost to meet the demand of electricity by time and sets the market price based on the System Marginal Price (SMP). In addition to SMP, a fixed cost-based capacity price (CP) is paid to the Scheduled Generator[2] to compensate for fixed costs and attract investment. The power market is operated at the market price determined by the day-ahead market, but there is a difference between the predicted and actual power supplied and used during trading days. To account for this difference, a compensation system called CON/COFF is operating. Another characteristic of the Korean electricity market is the Mandatory Pool. All electricity trading must go through the power exchange and all market participants are obliged to join the power exchange. However, exemptions exist for power generators that are not connected to the grid and for renewable energy generators of less than 1,000 kW.

The government establishes a long-term plan for electricity supply and demand for the next 15 years in the basic plan for long-term electricity supply and demand, which is updated every two years. The updated plan also includes assessments of past plans, long-term demand forecasts, demand management objectives, plans for power generation and transmission facilities, and efforts to reduce greenhouse gas emissions. The 8th Basic Plan for Long-term

[2] Dispatchable generators over 20 MW.

Electricity Supply and Demand released in December 2017 includes step-by-step reductions in nuclear power and coal-fired capacity and the expansion of renewable and LNG generation. In addition to the generation plan, plans for transmission and distribution facilities have been established, but construction of some transmission lines has been delayed and issues have arisen regarding transmission constraints. Of the projects under construction by KEPCO, 91 construction projects were postponed due to delays in the development of construction sites (83 cases) and slowing demand growth (8 cases). Since 2007, power generation facilities have grown at an average annual rate of 5.5% through 2017, while the length of transmission lines has increased by an annual average of 1.5%. The government believes that construction delays are due to low residential acceptability of transmission and transformer (such as substation) facilities, and the Act on Transmission Facilities and Assistance to Adjacent Areas was implemented in 2015, but local residents' acceptance of new electricity generation and transmission facilities is still low.

Figure 16: Electricity Market Structure in the ROK



Most power generation facilities are located in areas remote from major demand areas, and are particularly remote from the major demand center of the Seoul area, and thus require large-scale transmission facilities to move power to where it is consumed. In addition, as the construction of transmission and distribution facilities is delayed, a policy goal of spreading

Distributed Energy Resources (DERs) is being established in order to minimize the need for construction of new large-scale transmission.

In the 7th Basic Plan for Long-term Electricity supply and demand, released in 2015, Distributed Energy Resources (DERs) are defined as small power generation facilities of 40 MW or less and demand area power generation facilities (that is, generation facilities located near demand centers) of 500 MW or less that can help to minimize the need for construction of new transmission lines. In 2017, Distributed Energy Resources (DERs) accounted for 11.2% of total power generation and are expected to increase to 18.4% of required generation by 2030, as shown in Table 3.

Table 3: Distributed Energy Resources Outlook

Year			2017	2022	2026	2030	2031
Generation Output of DERs (TWh)	Renewable		12.2	27.3	41.8	59.3	61.8 (9.4%)
	Self-generation	Renewable	13.9	14.9	15.9	17.1	17.1 (2.6%)
		Other	7.3	7.3	7.3	7.3	7.3 (1.1%)
	Integrated Energy (incl. CES)		31.0	37.3	37.3	37.3	37.3 (5.6%)
	Total		64.4	86.7	102.2	120.9	123.4
Share of DERs			11.2%	13.8%	15.7%	18.4%	18.7%

Source; Motie, the 8th Basic Plan for Long-term Electricity Supply and Demand, 2017

The proliferation of renewable energy, which is expected to play a large role in distributed energy resources, is improving the power grid system. If the amount of electricity generated through a consumer's solar facilities is larger than the actual usage, surplus electricity is carried over and the surplus is credited by subtracting its value from the consumer's next month's electricity charges. However, surplus power can also be settled in cash for small-scale "prosumers" (customers with generation systems that are both consumers and producers of electricity) with PV systems. The capacity limits for this "net-billing and cash out" rule have been raised from 'up to 3 kW' in 2005 to 'up to 10 kW' in 2012 and 'up to 1000 kW' in 2016, and the scope of the offset has been extended to large-scale customers with large power consumption, such as large buildings and factories. Even with the increased generated volume of PV power, the profit to the prosumer was limited due to the 50% trading volume limit of the PV electricity generation capacity. In March 2017, the government eliminates the 50% trading volume limit, so that all of the surplus generated can be traded, which allow prosumers more possible profit.

5 Energy Projections and Energy Policies

5.1 National Energy Plans in the ROK

The Energy Master Plan represents the central energy policy strategy in the ROK. The plan provides the primary guidance on all areas relevant to the energy sector and defines the direction of the mid to long-term energy policy. The Energy Master Plan is based on the Law on Low Carbon Green Growth and the Energy Law. The plan is revised and re-implemented every five years, and covers a period of twenty years into the future. In the ROK, the national energy plan was actually first established in 1997 with a period of ten years and was revised every five years. In 2008, however, the time span of the national energy plan was changed to twenty years with the change of the base laws and title of the plan. Therefore, the first Energy Master Plan prepared as the new longer-term national energy plan was introduced in 2008 and the second Energy Master Plan was established in 2014. The third Energy Master for the period through 2040 is scheduled to be announced this year by the government of the ROK after being renewed and approved by three separated entities—the National Energy Committee, the Presidential Committee on Green Growth, and the State Council—in a three-step process.

Strengthening energy security, improving energy efficiency and reducing greenhouse gas (GHG) emissions have been major challenges when establishing national energy plans in the ROK. The expansion of nuclear power generation was the main method to resolve energy security and climate change mitigation needs in the two previous Energy Master Plans, which were set up by the two former conservative governments, although aggressive shifting of the share of renewable energy up to 11% of total energy demand was also an important strategy to reduce GHG emissions in these plans. Even after the Fukushima nuclear disaster in 2011, no significant change occurred in policy planning for nuclear energy under the two previous governments, despite the incident having provoked significant anti-nuclear power protests in the ROK. But the new progressive government that took power in May 2017 has put securing the safety of nuclear plants and reducing fine dust pollutant emissions at the core of its energy policies. To realize these energy policies, the government proclaimed an acceleration of the phase-out of nuclear power and of aging coal-fired power plants, while expanding renewable energy. Gas–fired power will be also expanded to play a role in supplementing nuclear and coal-fired power as those types of plants significantly reduce their electricity production, as well as supporting the generation of intermittent renewable energy by providing power during periods of low output of renewable electricity systems. The new administration has already reflected its energy policy in the plans set up by energy sources including “the 8th Basic Plan for Long-term Electricity Supply & Demand for 2017-2031” released in December 2017, and the “13th Long-term Natural Gas Supply Plan for 2018-2031” announced in April 2018.

Before the establishment of the third Energy Master Plan, Korea Energy Economics Institute (KEEI), a national energy think-tank, projected long-term energy demand (2017-2040) under a BAU (business as usual) scenario last year (2018). This projection has been and will be used a base to set up the target energy demand after 2040 under the scenario in which more aggressive energy policies are implemented in order to achieve the energy policy direction set forth by the government. The government has organized a working group consisting of 70 experts from industry, academia, and other sectors, including representatives from NGOs, and organized into five departments: General Division, Demand Division, Conflict Management

and Communication Division, Industrial Jobs Division and Supply Division. The working group has advised and recommended policy directions to meet the target demand in the Energy Master Plan, providing advice on the following six policy tasks.

- Rational energy consumption
  - Implementation of a high-energy-efficiency society through the innovation of energy demand management
- Optimization of energy supply
  - Integrated smart energy systems centered on renewable energy
- Creating new markets and jobs
  - Promoting new energy industries for creating markets and jobs
- Implementation of coexistence ecosystem
  - Implementation of decentralized energy governance with enhanced public participation
- Enhancing energy security
  - Strengthening energy cooperation for energy security enhancement
- Strengthening the credibility of energy policy
  - Expansion of infrastructure for the fourth industrial revolution and future energy transitions.

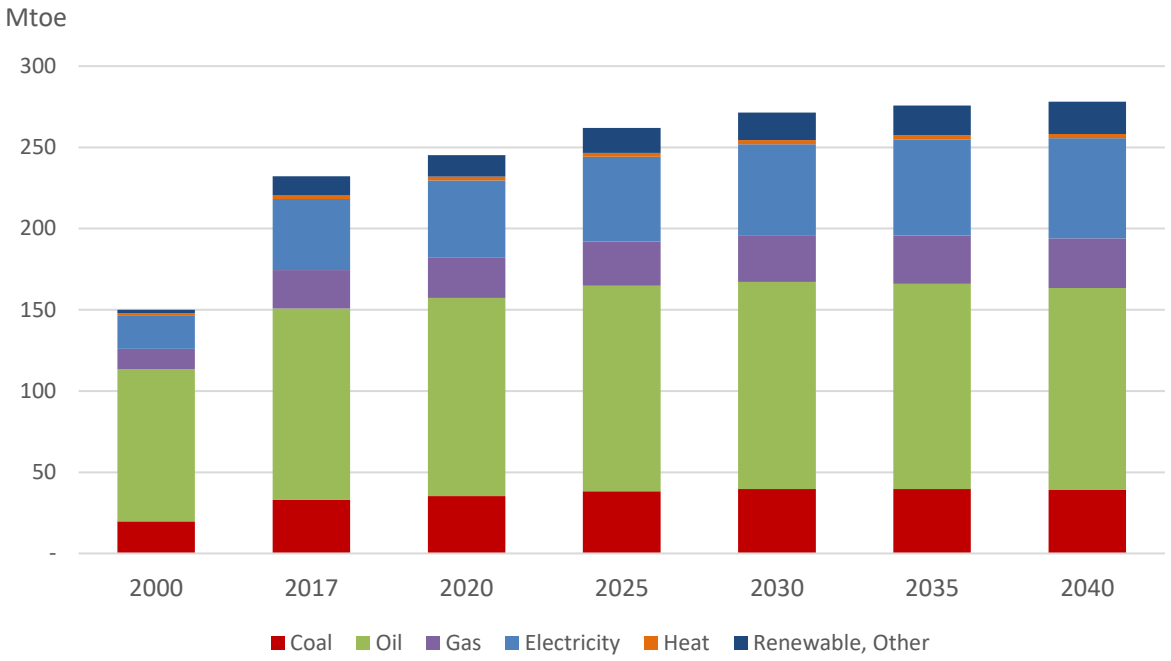
5.2 Energy projection to 2040 under BAU scenario

Final energy consumption will peak in the middle of the '30s, which will leave the 2017-2040 CAGR of final energy consumption over the full period at an average of just 0.6%. The growth rate of final energy consumption will continue to fall sharply as the rates of population growth and economic growth continue to slow. Electricity (CAGR of 1.5% through 2040) and renewable energy (CAGR of 2.3%) lead energy demand growth, as electrification in all sectors grows and new and renewable energy spreads rapidly in the industrial and building sectors (see Figure 17).

Petroleum is expected to account for 27% of final energy demand in 2040, which is less than the share of electricity (29%) if petroleum demand for industrial non-energy use (such as naphtha and other inputs to petrochemical products) is excluded. Even though petroleum consumption for transportation and heating will decline by 0.2% per annum, overall petroleum consumption is expected to grow at a CAGR of 0.6% between 2017 and 2030 due to steadily increasing petrochemical production, the increasing capacity of petrochemical facilities, and the need to maintain NCC (naphtha cracking center) competitiveness. After 2030, petroleum consumption is expected to stagnate. This is because petroleum consumption for transportation will decline due to the expansion of the use of electric vehicles, and the growth rate of the

petrochemical industry is expected to decline.

Figure 17: Final Energy Consumption Outlook in the ROK



Source: Long-term Energy Outlook, KEEI, 2019

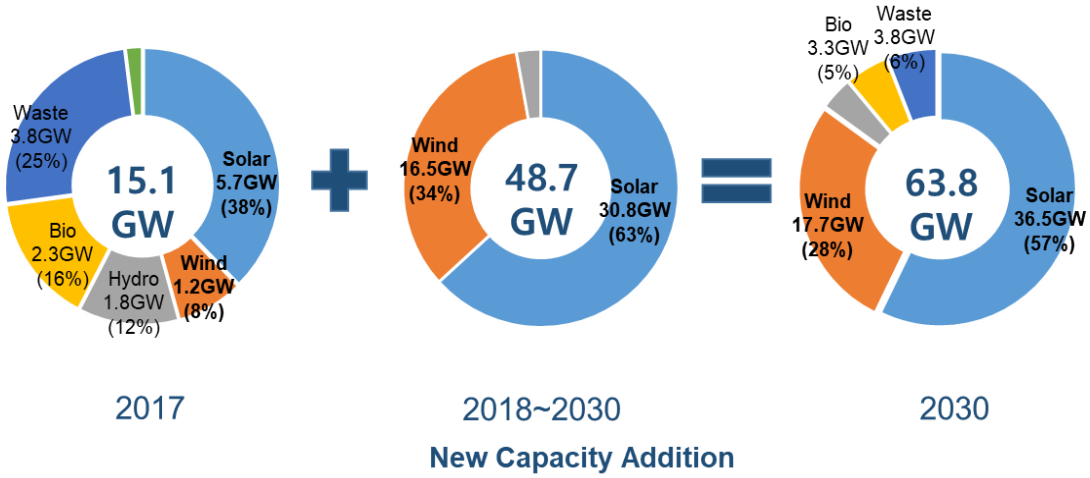
Gas accounts for 15% of the final consumption growth between 2017 and 2040, mainly fueling industrial and building sector demand. Even though the industrial sector consumption of gas recently fell sharply due to low oil prices, the industrial sector accounts for the largest portion of gas consumption in the forecast period due to rising demand for industrial gas as a result of a projected rebound in oil prices. In the household sector, which accounted for the largest portion of consumption in the past, gas demand is likely to stagnate due to the current high penetration rate of city gas (which is unlikely to grow substantially) and the expansion of the use of electric household appliances such as induction cooktops.

Demand for coal will increase, with an average CAGR of 0.7% between 2017 and 2040. Coal demand for residential and industrial fuel use will decrease, but the demand for steel, which accounts for the largest portion of final consumption of coal, is expected to grow at CAGR of 0.8% even factoring in higher global steel market competition and lower domestic steel demand, and with increasing steel demand comes increased requirements for coking coal.

New and renewable energy will grow at the fastest rate of the ROK's energy sources, at an average of 2.3% per annum. It is expected to increase rapidly in accordance with the government's policy to expand the supply of renewable energy, including policies such as mandatory installation of new and renewable energy in public institutes, mandatory installation of ESS (Energy Storage Systems), and expansion of zero-net-energy building practices and

residential solar power supplies. The government has a specific plan for renewable energy "Renewable Energy 30-20 Plan", which was announced in December 2017. The plan is to increase the share of renewables to 20% in the electricity generation mix, mainly from solar and wind energy by 2030. In order to achieve this target, the capacities of solar photovoltaic and wind power are planned to increase 7-fold and 15-fold, respectively by 2030, relative to 2017 (see Figure).

Figure 18: Renewable Energy in Power Generation by Sources



Source: Renewable Energy 3020 Plan, MOTIE, 2017.12.

The energy transition is one of the main political issues in the ROK. During the 2017 presidential election campaign, the energy transition, which includes the nuclear power phase-out, the coal-fired power phase-out, and the expansion of renewable energy, was the common theme among candidates. After Moon Jae-in won the election, the government established a Public Engagement Commission to determine whether the construction of the Shin-Kori 5 and 6 nuclear reactor units should continue. After three months of discussion, the public committee finalized its support of the construction of Shin-Kori 5 and 6, but recommended scaling down nuclear power generation gradually. In October 2017, the government, therefore, announced the restart of construction work on the two reactors. At the same time, a nuclear phase-out roadmap was also proclaimed, which includes;

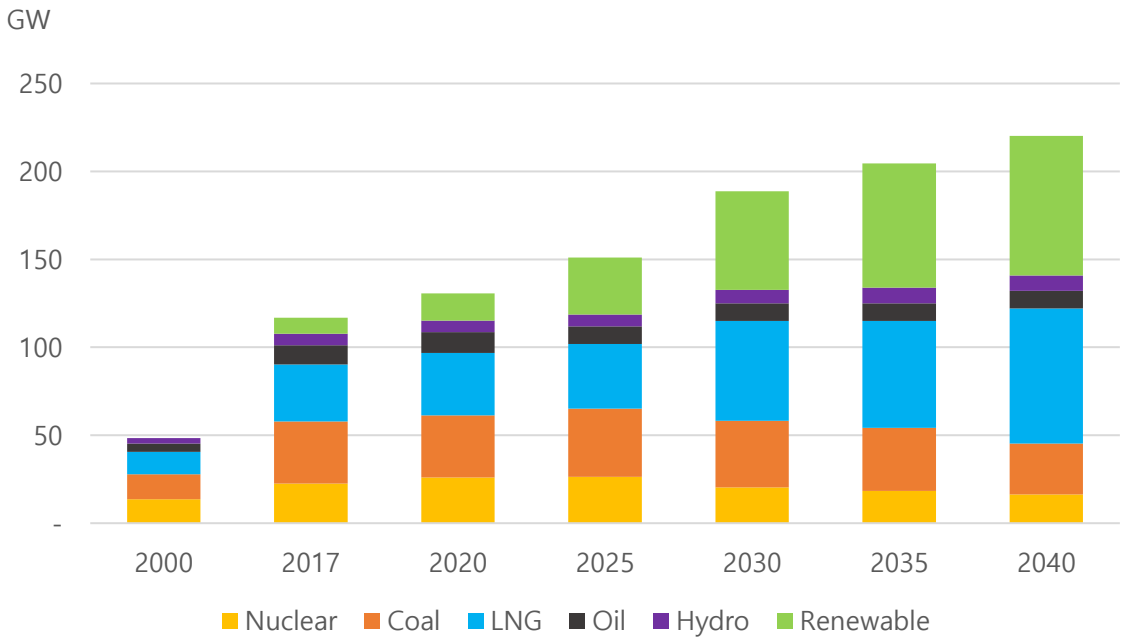
1. The cancellation of construction plan for six new nuclear reactors (totaling 8.8 GW, Shin Hanwool 3 and 4, Cheonji 1 and 2, etc.);

2. No extension of the shutdown schedule of 14 older nuclear power reactors (12.5 GW will be shut down by 2038);

3. Shutting down of Wolsong 1 (0.7 GW) earlier than the end of its scheduled lifespan.

With Shin-Kori 5 and 6, nuclear power capacity will initially increase to 27.5 GW by 2022 and then will shrink to 20.4 GW by 2030 and to 16.4 GW by 2040 as older reactors are decommissioned. The Moon government also plans to increase gas power generation, from 16.9% of the energy mix in 2017 to 18.8% in 2030, and the share of new and renewable energy, from 6.2% in 2016 to 20% of electricity generation in 2030. Figure provides a summary of projected generation capacity by source through 2040 under the energy transition plan.

Figure 19: Electricity Capacity Mix Outlook in the ROK



Source: Long-term Energy Outlook, KEEI, 2019

5.3 Controversial Issues in Energy Policy and Projections

The Moon-Jae-in administration has implemented its energy transition policy, which is designed to reduce electricity supply from nuclear and coal-fired power plants and to expand generation from renewable energy and LNG. The government will strengthen energy transition policies and try to implement these policies as a part of the third Energy Master Plan. The previous two governments set up target shares for renewable energy in the primary energy mix at 11% by 2035 in the two past Energy Master Plans, and at that time too, many skeptics regarded the target share as unattainable. Last year, the Moon administration accelerated the development and adoption of renewables, targeting a 20% share in the electricity mix by 2030 in its “Renewable Energy 30-20 Plan”. The government claims that the reliability of renewable energy is rapidly improving due to technical developments like energy storage system (ESS), and thus the target is achievable.

But many energy experts and politicians have doubted the capability of renewable energy to function as the core means to meet the future’s increasing energy needs and reduce GHG

emissions in a way that meets the national targets (37% reduction from BAU levels by 2030) that the ROK's government signed on to the Paris agreement of the UNFCCC (UN Framework Convention on Climate Change) in 2015. These critics have claimed that renewable energy technology is still uncertain to be sufficiently reliable to cost-effectively meet needs, although it has shown significant development in the past. Moreover, the ROK has relatively small resources of renewable energy, compared to other nations, as well as unfavorable rules and regulations that may serve as barriers in securing the lands needed for renewable energy facilities due to the nation's limited land area, high population density, and the residents' historical (and growing) strong resistances on energy facilities.

There are also other concerns and criticisms over the government's strategy for the energy transition. Some energy experts insist that electricity bills would inevitably go up if coal and nuclear energy are replaced with more expensive renewable energy and LNG in the power sector. They also worry that if LNG prices soar along with crude oil prices after many nuclear reactors are phased out, the consequences will be disastrous for the economy. When it comes to commercial nuclear technology, the ROK has global competitiveness. Some experts have concluded that Korea's construction costs for nuclear power plants are the lowest in the world because of the ROK's long experience in constructing reactors, and the fact that the country's domestic industries can provide almost all of the infrastructure and components needed for building nuclear power plants. The ROK has ambitious plans to export reactors abroad based on its advanced nuclear technologies. State-run KEPCO, for example, is building the two 1,400 MW reactors in the United Arab Emirate (UAE). The government's anti-nuclear policy, however, could send a negative signal to the countries looking to buy reactors from the ROK.

The government and the experts who support the government's energy transition policies have said that the critics of the energy transition policies often exaggerate the problems with those policies. Nevertheless, the government says that the third Energy Master Plan will be established with full consideration of opposing views. Those who object to the government's energy policies all agree that the direction of energy transition should encourage renewables and restrict nuclear and coal powers. These critics of the policy, however, worry that the government is being too hasty in implementing the policies and has not given full or adequate consideration to the possible serious problems that could arise from implementing the energy transition policies. As such, the administration's energy policies are standing at a crossroads in the ROK, and lack a solid basis for social consensus, and as a result the third Energy Master Plan that will be established soon by the government could be a vulnerable plan.

6 ROK Involvement in Discussions on Regional Energy Sharing

6.1 Electricity

The ROK is a so-called "energy island" because three sides of its land area are surrounded by the sea, while the fourth is connected to the mainland but has been blocked from direct connections with its neighboring countries by the political dispute between the DPRK and the international community. Given this situation, the ROK is obliged to build costly reserves for electricity generation in case of an emergency because it can't trade electricity with other

countries. The ROK also can't purchase lower cost electricity, if available from other countries, or sell the electricity during times when it has a generation surplus. In addition, the country has a large population within a small land area, which has brought about difficulties in securing sites for power plants.

The ROK started getting interested in the energy resources of its neighboring countries in the early 1990s when it began to form economic relationships and trade commodities with Russia and China as those nations opened their doors to capitalist countries. In particular, East Siberia in Russia has ample energy resources including coal, natural gas, and hydropower, and most of these resources are untapped due to the small population and energy demands in the region. East Siberia, including the Russian Far East, was also an almost undeveloped region when the Soviet Union was in the transition that ultimately resulted in the governance of the region by the Russian Federation. As such, the Russian government has had plans to export energy resources such as natural gas and coal as well as electricity from East Siberia and the Far East of the country to North-Eastern Asia in order to finance the economic developments of the region.

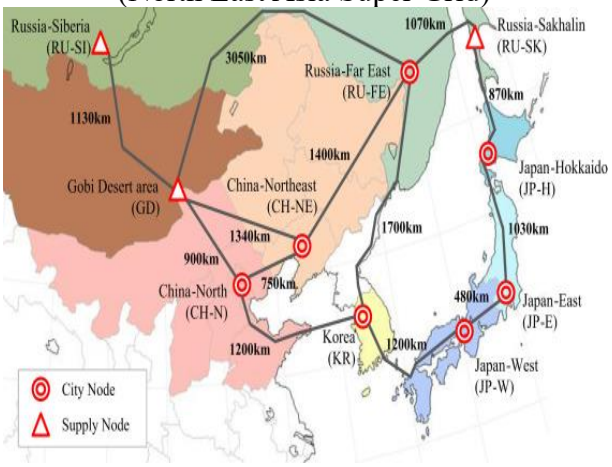
The ROK began talking with Russia about grid connections to and electricity imports from East Siberia when Russia announced its desire to participate in the North-East Asia Super Grid concept in 1998, though discussions on potential natural gas trade had been underway between two countries since around 1993. The North-East Asia Super Grid was designed to be a multilateral power grid project to connect Russia's East Siberia to China, Mongolia, the two Koreas, and Japan. The electricity company in the Russian Far East also suggested to KEPCO, the state electricity company of the ROK, a grid connection from Vladivostok to the ROK transiting the DPRK as of the early 2000s, when the Russian grid company was discussing with the DPRK's government the possibility of a grid connection from Vladivostok to Chung-Jin, a city located in northeastern area of DPRK. This suggestion failed to develop into an agenda for full discussion between Russia and the ROK to create power grid projects because the two Koreas still were under political tension at that time, although they did adopt the June 15th North-South Joint Declaration in 2000 that promoted economic cooperation and exchanges in civic, cultural, sports and all other fields between the two Koreas under a peaceful relationship. Since then, however, many ideas and concepts on power grid connections between Russia and the ROK have been exchanged in many study research efforts and seminars, together with the scheme of the North-East Asia Super Grid and sometimes as one of the policies considered to try and build the South's economic cooperation with the DPRK. In 2009, KEPCO and Inter Rao UES, the public electricity trading company in Russia, signed a Memorandum of Understanding (MOU) for a joint feasibility study on setting up transmission infrastructure between Far Eastern Russia and the ROK transiting the DPRK. But this study ultimately did not move forward due to the increasing political tension in the region provoked by the DPRK's nuclear weapons test.

Russia started to strengthen interest in cross-border electricity trade again and revised its policies to develop the Russian Far East after Vladimir Putin began a new term as Russian Federation president in 2012. Russia held the 2012 APEC summit meeting in Vladivostok and newly established the Ministry for the Development of the Russian Far East as a federal executive body for promoting the economic and social development of the region. The Far

Eastern Forum was also established in 2015 to encourage international investments, especially Asia-Pacific countries' investments in the Russian Far East. The Forum takes place every year in Vladivostok, hosted by Russian president Putin, who announced the policy "Turn to the East", his ambitious plan to boost Russia's economic growth by looking to the Asia-Pacific region. At that time, the concept of "the Asian Super Grid" was announced by Japan's Softbank CEO "Son". In this concept, Mongolia's Gobi Desert would be the site of a giant electricity production farm utilizing renewable energy resources such as wind power and solar photovoltaic power that would feed a regional grid linking Mongolia to the other North East Asian countries. In this scheme, as shown in Figure, Russia's Irkutsk would supply hydropower and export electricity to the North East Asian regions.

Figure 20: Designs for Super Grid across North East Countries

(North East Asia Super Grid)



(Asia Super Grid)

Source: KEPCO

During the years since 2013, the ROK and China have announced policies to strengthen regional economic and social cooperation, including in North East Asian areas. In the ROK, the former president, Park Keun-hye, proposed the "Eurasia Initiative" on October 2013, which reinforced the ROK's cooperation with the Russian Far East, Mongolia, Central Asia and the states on the Eurasian Continent, in addition to improving relations with the DPRK. In the same year, Xi Jinping, the Chinese president, initiated the "One belt One road" initiative, which is designed to build a network (trade route) of roads, railways. oil pipelines, power grids, ports and other infrastructure between China and the wider world including Central Asia, Europe, and South-West Asia. In 2015, China also announced "the Global Energy Interconnection" (GEI), which is a globally interconnected strong and smart grid backbone of UHV (Ultra-high Voltage) transmission facilities. According to GEI schemes, electricity bases in the Arctic region and Equator region and intercontinental interconnection will be set up by 2050. In 2016, the President of Russia, Putin, proposed the "East Asia Super Energy Ring", which aims to build energy links between the Russian Far East and the Asia Pacific region.

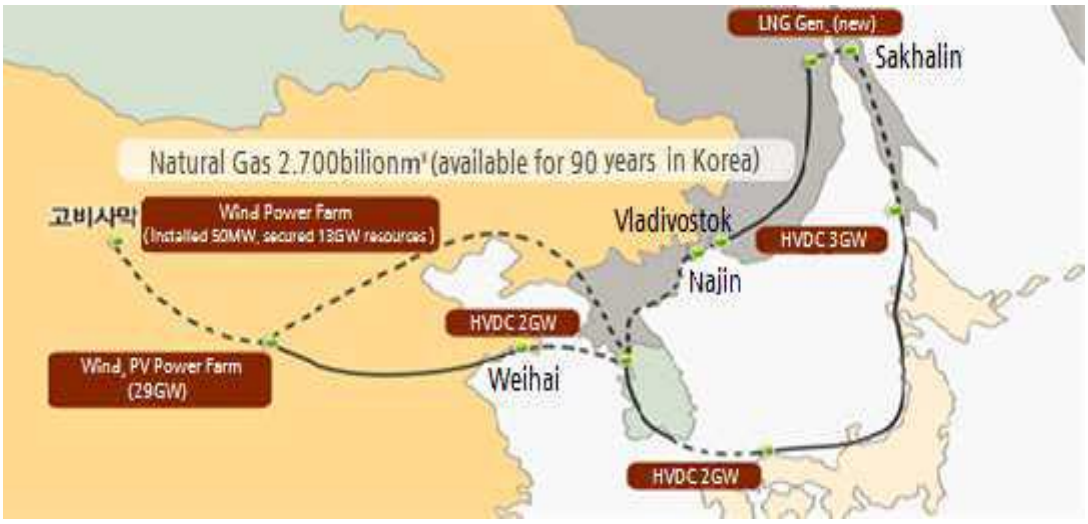
Thanks to the various initiatives for regional cooperation in the fields of the economy, social relations and energy, including power grids, announced by the North East Asian countries since 2014, the ROK has actively tried again to have dialogues and discussion about grid connections with Russia, China, Mongolia, and Japan on a governmental basis. KEPCO, the state electricity company, carried out joint research to share their ideas on grid connections with ROSSTI, the Russian state grid company in 2015, and with SSGC, the Chinese state grid company, in 2016. In addition, since 2016, KEPCO has participated in the Asia International Grid Connection Study Group with ROSSTI, SSGC, and Softbank of Japan. The group published an interim report on a feasibility study for power grid connection in Northeast Asia in April 2017.

The ROK's Moon Jae-in administration, which took office in May 2017, has put economic cooperation with Northern countries as one of its top priority policies and established "a Presidential Committee on Northern Economic Cooperation" in order to supervise northern economic cooperation under the direction of the President. President Moon offered the "9-bridge strategy" at the Eastern Economic Forum at Vladivostok in September 2017. This northern economic strategy is aimed to pursue close cooperation with Eurasian countries, with Russia playing a key role in nine sectors including electricity (as well as gas, railways, shipbuilding, ports, agriculture, fisheries, jobs creation, and development of the Arctic transit route). As parts of the Northern economic cooperation policies, the new government has established a long-term plan for the ROK's grid connections with neighboring countries as a part of the 8th Basic Plan for Long-Term Electricity Supply and Demand released in December 2017. This plan is revised every two years. According to the plan, the ROK will start to construct a part of the grid infrastructure needed for interconnection and complete the ROK-Russian joint research by 2022, as well as building robust public-private cooperation among the countries, and plans to participate in a working-level review after a consensus is reached on the Super Grid in Northeast Asia by 2019. This plan, however, looks vague and tentative and could just reflect the ROK's government's aspirations, as it appears to have been compiled without having in place contracts or MOUs with its proposed partner countries. In particular, the political and military issues between the two Koreas have inserted key uncertainties not in the ROK's plans to establish energy linkages to its continental neighbors but also to shape a scheme for the super-grid to integrate power generation and distribution in Northeast Asia. In this regard, it is expected that a boost will be provided to power grid connection projects from the ROK to other countries as well as to the super grid projects interconnecting the region as the DPRK starts to have dialogues on denuclearization with the United States of America and economic and social exchanges with the ROK (assuming the trends of recent years continue, though many factors contributing to instability in the relationships between the nations do remain.

According to KEPCO's feasibility study report on the grid connection to neighboring countries, China, Russia, and Japan, as submitted to the ROK parliament as of December 2018, the total costs to build power grid lines to the three counties is estimated to be over 7 trillion won (US$ 6.2 billions). In case of a grid connection to China, KEPCO reviewed a proposal to link the transmission line from the western port of Incheon in the ROK via undersea power cables to the eastern port of Weihai, China. Such a line would cover some 370 km and have an associated construction cost of 2.9 trillion won. KEPCO is negotiating to connect that grid line with the transmission network operated by the Chinese state grid corporation SSGC. It is also

estimated that an investment of 2.4 trillion won would be needed to link Vladivostok in Russian Far East, via the DPRK to the northern part of Gyeonggi province in the ROK using an overland transmission line, which would cover approximately 1,000 km. To connect grids with Japan, the report proposed linking Goseong in South Gyeongsang Province with either Kitakyushu or Matsue, both on the northern coasts of the southern part of the Japanese archipelago. This connection via undersea cables is expected to cost around 1.9 trillion to 3.3 trillion won to build. The connections identified in KEPCO's report are illustrated in Figure .

Figure 21: Super Grid Flows Centering the ROK



Source: The 8th basic plan for long-term electricity supply and demand, Ministry of Trade, Industry and Energy, Dec 2018

6.2 Natural Gas

PNG (Pipeline Natural Gas) introduction projects with Russia have been regularly and continuously reviewed as means to diversify the supply of natural gas to the ROK and to improve the ROK's natural gas supply-demand stability and bargaining power (see Figure 22). The idea of linking a Siberian natural gas pipeline through North Korea has been discussed intermittently at the private and government levels since the 1990s. The Chayanda project (Yakutia gas field), which was discussed in the early 1990s, is a PNG project that would route gas from Russia to ROK via DPRK. This project consisted of a Korean consortium (14 companies including Korea National Oil Corporation, Daewoo and LG), and a Russian Consortium including Gazprom and Sakha Consortium. The project scale was estimated to be about US$ 17.5 billion to US$ 20 billion (based on the estimated investment cost). From 1995 to 1996, a joint feasibility study was conducted, but the ROK abandoned the project due to lack of economic feasibility including issues such as the problem of passing through North Korea, excessive investment costs, and market imperfections. The Irkutsk project, which was discussed in the late 1990s, is a project to participate in PNG projects between China (CNPC) and Russia (RP) and to examine the introduction of a subsea PNG pipeline in the Korea West Sea from China to the ROK. According to a preliminary feasibility study conducted between

December 1996 and July 1997, the Irkutsk gas field reserves amounted to 8.5 billion tons, and it was estimated that the ROK would be able to be supplied with 7 million tons of natural gas per year for 30 years. The estimated investment cost was $11 billion. In 2003, the consortium decided to pursue the West Sea route, but in 2004 the project was abandoned because Russia had changed its stance regarding the natural resources controlled by the Unified Gas Supply System (UGSS).

Figure 22: Attempted Gas Development and Pipeline Network in Northeast Asia

Another proposed PNG project, which was promoted by an MOU between KOGAS and Russia's Gazprom in 2008, failed to resolve supply security issues associated with the pipeline passing through the DPRK, due to the political issues associated with the DPRK's nuclear program. As a result, the project could not proceed. In December 2016, the MOU between Korea Gas Corporation and Gazprom was re-signed and an LNG cooperation system was to be expanded, based on the desire of the ROK to diversify its suppliers of LNG (see Table 4 In April 2017, joint research on the possibility of resuming the PNG project (10 BCM annually) was under review.

Table 4: ROK LNG Import Rank and Share by Country

Year	1st	2nd	3rd	4th	5th
2012	Qatar (28.4%)	Indonesia (20.6%)	Oman (11.4%)	Malaysia (11.3%)	Yemen (7.2%)
2017	Qatar (30.8%)	Australia (18.6%)	Oman (11.3%)	Malaysia (10.0%)	Indonesia (9.4%)

Source: The 13th Basic Plan for Long-term Natural Gas Supply and Demand, MOTIE, 2018

First, in order for the Russian PNG project to take place, favorable political and diplomatic conditions are necessary, because security should be at a priority in order to minimize potential situations leading to supply disruptions with Russia, the supplier, and the DPRK, the transit country. Although the DPRK has been trying to improve its international relationships recently, those efforts have not yet resulted in a situation that can guarantee long-term natural gas supply security. KOGAS conducted a comparative feasibility study on the gas pipeline project relative to LNG supplies. The results of the study showed that the total cost of LNG, including transportation costs, was estimated to be $22.6 billion over 25 years, while that of PNG was $4.79 billion. Even considering the cost of DPRK transit fees at $150 million per year, the result is that PNG is only about one-third the cost of LNG. In other words, it was calculated that the ROK could import gas at about 30% ~ 70% lower price if gas was imported as PNG versus LNG. It will be necessary, however, to resolve the sanctions against the DPRK and Russia that have been imposed by the United Nations (UN) and the United States (US), respectively, in order for the project to move forward. The payment of the gas pipeline transit fee and the use of the DPRK labor force in the project would not be permitted under existing UN sanctions, so those sanctions would need to be removed. In addition, investing in Russian export pipelines or providing energy to DPRK is a target of US sanctions covering the DPRK and Russia.

In addition, it is necessary to secure cost competitiveness against LNG to reach a public consensus and to prove business feasibility. The LNG trading market is currently a buyer's market, and global LNG prices are lower and falling with the shale gas revolution that is taking place in the US and other nations. Therefore, it is necessary to rigorously review whether the new PNG introduction business is beneficial to the ROK economy relative to a future in which LNG prices may fall. How beneficial to the ROK the PNG project might be is not only related to the price of PNG but also based on domestic market conditions. Russian PNG includes many components other than pure hydrocarbons (such as methane and ethane), and it is not certain whether the gas component (calorific content) of Russian gas meets ROK domestic standards. Therefore, it is necessary to examine whether Russian PNG is likely to cause damage to existing gas supply facilities and end-user equipment if Russian PNG is to be directly connected to the current ROK pipeline network. In the event that Russian gas does not meet ROK standards, it may not be easy to secure economic feasibility for PNG introduction business if the PNG from Russia only uses a direct connection to (presumably large) ROK consumers without utilizing the existing natural gas pipeline network of KOGAS, as feeding into KOGAS's network would provide a much broader suite of potential consumers. In other words, the construction and utilization of PNG pipelines other than existing domestic pipelines would have to have sufficient annual demand, either through direct connections with consumers with a guaranteed stable consumption pattern throughout the year, or through the use of large gas storage facilities.

6.3 Oil

The ROK has traded only relatively small amounts of petroleum with Northeast Asian countries

in the past. Russia is the only country in the region from which the ROK imports crude oil, and the volume of imports from Russia accounted for just 3.5% of the ROK's total crude oil imports in 2018. The ROK has imported very tiny volumes of petroleum products from China and Japan, but on the other hand, it has exported quite large amounts of petroleum products to China and Japan, as well as very small volumes to Russia, from the ROK's huge refining complexes. The ROK has not traded oil with Mongolia or the DPRK in recent years. Table 5 summarizes the ROK's 2018 oil trades with other nations in the region.

Table 5: ROK's Oil Trades with North East Asian countries (2018)

(units: thousand bbl)

	Russia	China	Japan	Mongolia	Regional Total	Total
Crude Oil Import	39.3	-	-	-	39.3	1116.3
Petroleum Product import	-	0.5	0.2	-	0.7	341.6
Petroleum Product Export	0.1	112.9	63.2		176.2	531.1

Source: the Petronet, KNOC

As described in previous sections of this report, the ROK is dependent on the Middle East for more than 80% of its oil supply, which unsettles the energy security of the country, as it also imports most of its energy requirements from outside the region. Furthermore, all of the ships transporting oil from the Middle East countries to the ROK must pass through the Strait of Hormuz in the Middle East region and/or the Strait of Malacca in South East Asia, where there are territories disputed among the neighboring countries, and thus potential conflicts that could shut down these narrow sea lanes. These concerns have induced the ROK to place the diversification of the nations from which it imports oil as one of its key national energy policies, along with domestic oil stockpiling. To address the need for oil source diversification, the ROK has tried to increase its import of oil from Asian countries closer to the ROK, such as Indonesia, Vietnam, and Malaysia, but oil production and exports have declined in those countries due to their relatively small reserves and their rapidly increasing domestic oil demand as their economies grow. Russia has emerged the key alternative area for diversifying ROK crude oil imports in the time since the last segment of the ESPO (East Siberia Pacific Ocean) oil pipeline traversing East Siberia and the Russian Far East was completed at the Kozmino port located in the southern end of the Vladivostok area in December 2012. The ESPO oil pipeline runs for 4,857 km from Taishet in East Siberia to Kozmino port, and has a total capacity of 1 million b/d (barrels per day). The oil pipeline is divided into two segments. The first segment of 2,757 km, with an annual capacity of 50 million tons of crude oil, runs from Taishet to Skovorodino in the Amur region of the Russian Far East, near the border with China. At that point the pipeline is connected to a Chinese oil pipeline delivering the Russian crude oil to the Daqing oil field, the largest oil production area in China. A second segment of the ESPO pipeline runs

for 2,100 km from Skovorodino to Kozmino, and has an annual capacity of 35 million tons. The route of the ESPO project is shown in Figure 233.

Figure 23: ESPO Route

Source: http://likebulb.blogspot.com/2013/02/asian-energy-piplines-open-fresh.html

ESPO crude oil has been delivered mainly to Asian countries along with the USA. The ROK's refinery companies have tried to increase imports of ESPO crude oil from Kozmino port as much as possible. With high competition among oil importing counties in the Asia-Pacific region, however, and especially considering China's diplomatic efforts to purchase the ESPO oil from Russia, only less than 10% of the ESPO oil exported from Kozmino port have been distributed to the ROK's refineries, although the ROK was the third largest importer of ESPO oil following China (65%) and Japan (19%) in 2018. In order to raise the volume of oil that can be exported via the ESPO route, additional pipelines are being constructed and the total capacity will increase to 1.6 million b/d from the current 1.0 million b/d by 2020. The ROK's refineries are expecting to import more ESPO oil when the additional pipelines are completed. But some analysis indicates that it could be hard for Korean companies to increase their volumes of ESPO exports due to fierce competition from other importers.

The ROK had unsuccessfully invested in exploring an oil field in the west part of the Kamchatka peninsula of the Russian Far East, a project that took place from 2005 through 2009. Since then, there have been no ROK investments in oil fields in East Asia or the Far East of Russia.

7 Report on Development of the ROK LEAP Model.

We are building a LEAP (Long-range Energy Alternatives Planning) model to provide outlooks for energy supply and demand in the ROK through 2050. LEAP is an energy supply-demand analysis and mid-to-long-term outlook software tool widely used in many nations. The main function of LEAP is to evaluate the physical energy flows, as well as economic and

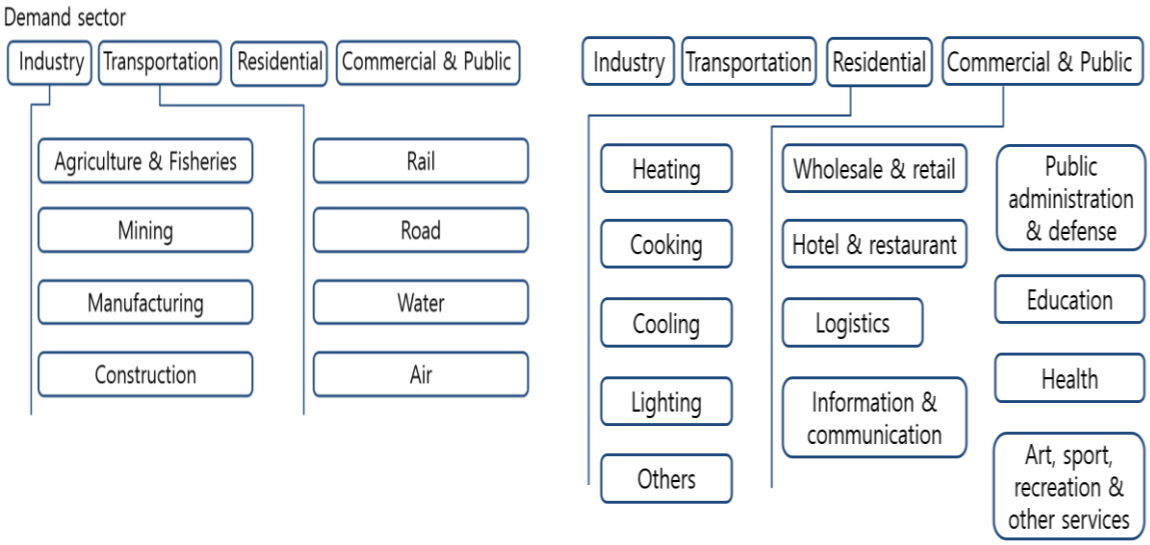
environmental effects, of current and future energy policies, programs, and investments in the energy sector. LEAP includes a database function to systematically manage and store energy and related information, a forecast function to project mid/long-term energy supply and demand, and a policy analysis function that simulates and evaluates the impacts of energy policies and measures. In particular, LEAP is designed to analyze the effects of introducing specific technology alternatives or policy alternatives under scenarios that have been (for example, in existing national plans) or could be proposed for a nation or other area, making it convenient to use for policy analysis purposes. The Energy Scenario tools in LEAP allow the description of energy demand, transformation, biomass production and use, and environmental impacts, and an Evaluation feature allows the calculation of results and the comparison of scenarios. Energy scenarios can be used to analyze the energy plans of any geographic area or energy system, including countries, regions, and other groupings of energy supply and demand.

LEAP can also be used for integrated energy planning. By analyzing the correlation between energy demand, supply, land use, utilization of biomass resources, environmental sustainability, and economic development with modules connected via energy scenarios, various analyzes that can be used to inform policy decision making.

In actual demand analysis, LEAP decomposes energy demand into several stages of hierarchical structure, as do other models. An illustrative division of energy demand for use in LEAP is sector (such as industrial), subsector (such as steel production), end-use (such as iron smelting), and device (such as a particular kind of blast furnace), which would represent a four-stage classification, but in actual operation, LEAP can be divided into more stages or less for any sector, depending on data available and modeling requirements.

The ROK LEAP model is being built based on 2018 energy balance data from Korea Energy Economics Institute (KEEI) statistical compilations. The KEEI assumption for the BAU scenario is used for the LEAP model, based on several announced outlooks from various institutes, including population forecasts from Kostat, and economic growth rates from KDI (the Korea Development Institute). The ROK LEAP model uses the energy balance published in 2018 as a reference, as well as other updated outlooks. These outlooks vary widely depending on the time of forecast. For example, Kostat released a new population census at the end of March 2019, with a new population growth forecast, which shows minus 0.04% average annual population growth through 2040, whereas average growth was +0.06% in the previous Kostat outlook. Figure 24 shows the demand structure of the ROK LEAP database.

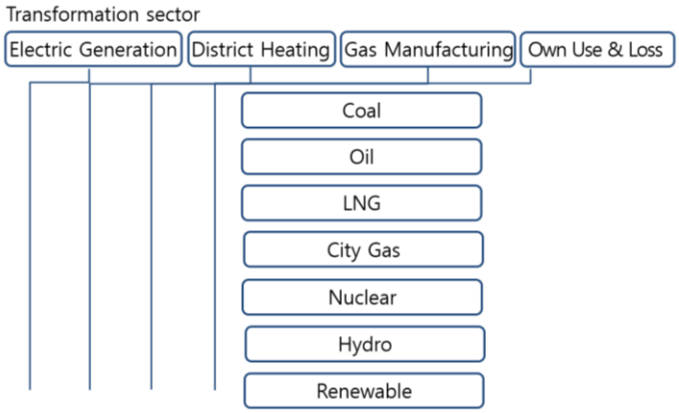
Figure 24: ROK LEAP Database Demand Structure



The ROK LEAP demand structure is divided into four sectors: industry, transportation, residential, and commercial & public. The Industrial sector divided into Agriculture & Fisheries, Mining, Manufacturing, and Construction. The transportation sector is divided into rail, road, water, and air. The Residential sector is divided into end-uses, which are heating, cooking, cooling, lighting, and others. Finally, the commercial & public sector consists of information & communication, public administration & defense, education, health, and other subsectors.

In the KEEI energy balance, there is an energy transformation section that reports the activities that convert primary energy resources into fuels and other forms of energy (such as heat and electricity) for final consumption. Energy transformation can be divided into Electric Generation, District Heating, Gas Manufacturing, and Own Use & Losses, which jointly transform coal, oil, LNG, city gas, nuclear, hydro, and renewable fuels into another form of energy for use in the end-use sectors. Figure 25 provides the structure of the energy transformation portion of the ROK LEAP model.

Figure 25: ROK LEAP Model Transformation Structure



The data used in each sector are mainly based on information from KEEI sources. Other data and assumptions are obtained based on official data from a number of specialized institutions, such as Kostat and the Bank of Korea. The major specific sources for data in each sector of the ROK LEAP model are as shown in Table 6.

Table 6: Sources of Data for the ROK LEAP Model

Sector	Sources
Residential	Energy: Energy Consumption Survey (KEEI), Household Energy Standing Survey (KEEI) Activities: Population Census (kostat)
Industrial	Energy: Energy Consumption Survey (KEEI), Yearbook of Energy Statistics (KEEI) Activities: Economic Statistics System(http://ecos.bok.or.kr)
Commercial	Energy: Energy Consumption Survey (KEEI), Household Energy Standing Survey (KEEI) Activities: Sectoral floor space information from Wholesale & Retail Survey and Service Industry Survey
Transportation	Energy: Energy Consumption Survey (KEEI), Household Energy Standing Survey (KEEI) Activities: Vehicle Fuel Economy and CO2 Emissions (KEMCO), Statistical Yearbook of MOLIT (http://stat.molit.go.kr)
Transformation	Household Energy Standing Survey (KEEI), Korea Electric Power Corporation (http://www.kepco.co.kr/), Korea Gas Corporation (http://www.kogas.or.kr), Korea Coal Corporation (http://www.kocoal.or.kr), Korea District Heating Corporation (http://www.kdhc.co.kr/)
Socioeconomic	Statistics Korea(http://kostat.go.kr), Bank of Korea (http://www.bok.or.kr), Korea Development Institute(http://www.kdi.re.kr)

We will set up the basic scenario for the current government's nuclear phase-out policy and the improvement of energy efficiency based on the 3rd Master Plans for the energy sector, which is scheduled to be announced in May 2019. We plan to develop a regional cooperation scenario for the ROK in consultation with LEAP model development teams in other countries.

8 Conclusions

As described in previous sections of this Report, energy policies in the ROK currently stand at a crossroads. The ROK has long secured energy resources that can be supplied inexpensively to maintain its rapid economic growth. As a result, coal accounted for the largest share of electricity generation (39.1%), followed by nuclear power (30%) and LNG (21.4%) as of 2017. Nuclear power has played a critical role in energy security in the ROK, which imports almost all of its energy demands, and the use of nuclear power has significantly contributed to reducing the ROK's GHG emissions. 25 nuclear power reactors are operating in the ROK, ranking sixth in the world by number. In terms of nuclear power density (nuclear power installation capacity divided by national land area), the country ranks first in the world. The fine dust problem (particulate matter air pollution) has become a key political issue, as the concentration of fine dust particles has surged to record levels every year, severely threatening public health and the environment in the ROK, and coal-fired power plants have been regarded as one of the main sources of emissions of $PM_{2.5}$.

Given these situations, the new government's pledge to implement a transition toward renewable energy represents a dramatic change in the ROK's energy policy, which has focused on the expansion of nuclear and coal-fired power production since the 1970s. After the current administration came to power, it decided to decommission the 11 reactors whose life spans are scheduled to run out before 2030, in addition to shutting down the Wolsung 1 reactor (which has already shut down) without prolonging its licensed life span. 10 aging coal-fired power plants are also due to be decommissioned earlier than the schedules set up in the previous electricity master plan. Electricity from renewables and LNG-fired power plants will fill the supply gap that caused by decommissioning nuclear and coal-fired power plants.

But, the energy transition policy has become embroiled in a major social controversy. The issues in the controversy center on whether or not renewables can play a role technically sufficient to help to bridge the supply gap caused by retirement of coal and nuclear power. First of all, lots of large-scale sites must be secured in order to expand renewable energy sufficiently, because large spaces are usually required to build most types of renewable energy facilities. the ROK has limited space, and 70% of its land area is mountainous. The target share of renewable energy in the electricity energy mix was set up to be 20% by 2030 in the 30-20 Renewable Energy Plan released by the current government in 2018. The main sources of renewable energy to be used to attain the target are solar photovoltaic and wind power, which will account for 82% of the renewable electricity energy mix. Previous ROK governments have also long tried to expand the use of renewable energy, and as a result, the current renewable share in the electricity energy mix has increased to around 5% in terms of power capacity. To be more precise, however, the portion of eco-friendly renewable sources such as solar and wind power is less than half of that total, with most of the other renewable sources listed coming from waste to energy power plants. This means that in order to achieve the target of the 30-20

plan, the power generation capacities of solar photovoltaic and wind power should increase by factors of 7 and 15, respectively, by 2030. This implies that the ROK has a long way to go in order to attain the goal of 20% of renewable energy in its generation mix. Natural gas is the most expensive fossil energy source for the ROK, and if its prices return to past levels reached when oil prices were over $80-100 per barrel, ROK electricity bills could jump, leaving many ROK consumers carrying the burden of paying for the energy transition. Some opponents of the transition insist that the total volume of national GHG emissions will grow as the use of LNG increases to replace reduced nuclear power since the latter doesn't emit GHGs. At present, the amount of tax placed on the coal is not high enough to restrict its consumption or promote the use of renewable energy and LNG. The government has proposed a draft energy tax code that would increase the fuel tax on thermal coal by 28% while lowering the tax on LNG by 75%. Even after adjusting these taxes on energy sources, however, it is estimated that coal-fired generation will remain cheaper to run than gas generation. This implies that for the government's energy transition to be possible, it is necessary to introduce an environmental tax that imposes a tax on the energy sources based on the amount of GHG emissions from each resource. But such a tax system could put pressure on domestic energy prices, and thus place a further burden on the ROK's economy, which is currently in recession.

Energy trades with neighboring countries can provide important solutions that allow the ROK's energy transition policy to be feasible. For example, if the ROK imports electricity on a large scale from Russia or/and China, the plans for the phase-out nuclear and coal-fired power plants, which are the main policies for the energy transition, could be carried out more feasibly. Without a lessening of military and political tension between the two Koreas, however, it will be a difficult task for the ROK to trade electricity with Northeast Asia countries over land-based transmission lines. Currently, dialogues for resolving the nuclear threat on the Korean peninsula are in progress between the United States and the DPRK, and the results of these dialogue will significantly affect the energy transition policies that the ROK's government plans to pursue. As a result, energy policies are standing at a crossroads in terms of political challenges as well as fuel supply economics in the ROK.

The next step of this project is developing a LEAP model for ROK based on recent energy data and current and projected energy trends. The ROK LEAP model that we are currently working on will consider scenarios of energy trading among the Northeast Asian countries, along with domestic energy transition scenarios. The ROK's 3rd Energy Master plan, which provides the policy basis for 10 energy sector sub-plans, is about to be announced. The 3rd plan will describe long-term domestic and international energy policy goals. The ROK LEAP model will consider current political issues associated with the Master plan, as well with the other sub-plans that have already been announced.

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III. NAUTILUS INVITES YOUR RESPONSE

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