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2012 Modularization of Korea's Development Experience:

Energy Policies

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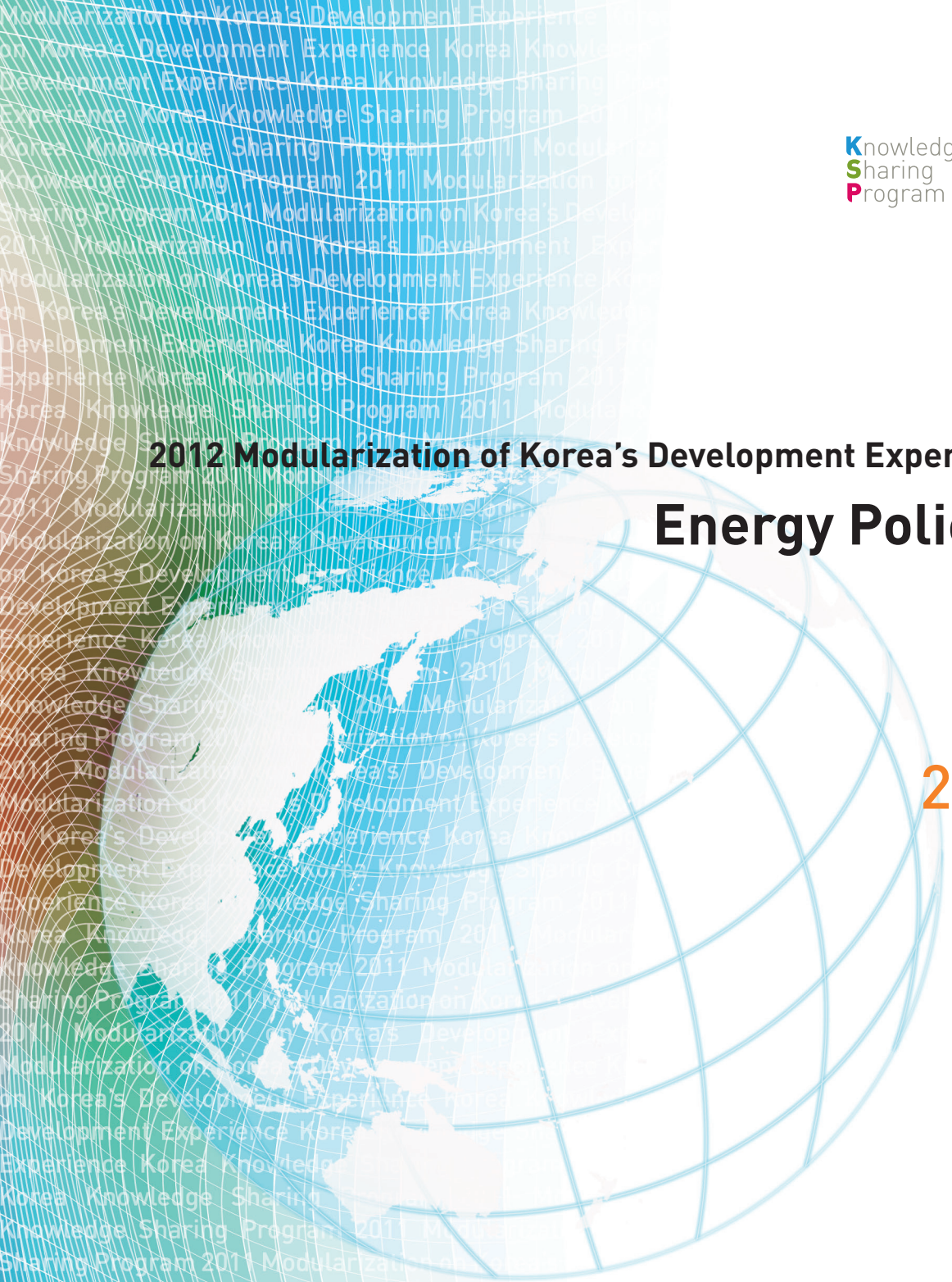

MOTIE
MINISTRY OF TRADE, INDUSTRY & ENERGY

Korea Resources Economics Association

2012 Modularization of Korea's Development Experience:

Energy Policies

2012 Modularization of Korea's Development Experience

Energy Policies

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Prepared by	Korean Resource Economics Association
Author	Kyung-Jin Boo, Seoul National University, Professor Ji-Chul Ryu, Korea Energy Economics Institute (KEEI), Senior Research Fellow Ho-Chul Kim, Korea Energy Forum, Director General Jimin Park, Korea Energy Economics Institute (KEEI), Associate Fellow
Advisory	Hoesung Lee, IPCC, UNFCCC, Vice Chair (Korea Energy Economics Institute (KEEI), Former President)
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Preface

The study of Korea's economic and social transformation offers a unique opportunity to better understand the factors that drive development. Within one generation, Korea has transformed itself from a poor agrarian society to a modern industrial nation, a feat never seen before. What makes Korea's experience so unique is that its rapid economic development was relatively broad-based, meaning that the fruits of Korea's rapid growth were shared by many. The challenge of course is unlocking the secrets behind Korea's rapid and broad-based development, which can offer invaluable insights and lessons and knowledge that can be shared with the rest of the international community.

Recognizing this, the Korean Ministry of Strategy and Finance (MOSF) and the Korea Development Institute (KDI) launched the Knowledge Sharing Program (KSP) in 2004 to share Korea's development experience and to assist its developing country partners. The body of work presented in this volume is part of a greater initiative launched in 2010 to systematically research and document Korea's development experience and to deliver standardized content as case studies. The goal of this undertaking is to offer a deeper and wider understanding of Korea's development experience with the hope that Korea's past can offer lessons for developing countries in search of sustainable and broad-based development. This is a continuation of a multi-year undertaking to study and document Korea's development experience, and it builds on the 40 case studies completed in 2011. Here, we present 41 new studies that explore various development-oriented themes such as industrialization, energy, human resource development, government administration, Information and Communication Technology (ICT), agricultural development, land development, and environment.

In presenting these new studies, I would like to take this opportunity to express my gratitude to all those involved in this great undertaking. It was through their hard work and commitment that made this possible. Foremost, I would like to thank the Ministry of Strategy and Finance for their encouragement and full support of this project. I especially would like to thank the KSP Executive Committee, composed of related ministries/departments, and the various Korean research institutes, for their involvement and the invaluable role they played in bringing this project together. I would also like to thank all the former public officials and senior practitioners for lending their time, keen insights and expertise in preparation of the case studies.

Indeed, the successful completion of the case studies was made possible by the dedication of the researchers from the public sector and academia involved in conducting the studies, which I believe will go a long way in advancing knowledge on not only Korea's own development but also development in general. Lastly, I would like to express my gratitude to Professor Joon-Kyung Kim and Professor Dong-Young Kim for his stewardship of this enterprise, and to the Development Research Team for their hard work and dedication in successfully managing and completing this project.

As always, the views and opinions expressed by the authors in the body of work presented here do not necessary represent those of the KDI School of Public Policy and Management.

May 2013

Joohoon Kim

Acting President

KDI School of Public Policy and Management

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Summary

This report explores a series of energy policies Korea has pursued the last half century during its economic development, growth and stabilization periods (1960s~2000s). The purpose of this report is to derive lessons that could help policy makers in developing countries to formulate and implement efficient and cost-effective energy policies, which, as a policy agendain the pursuit of national economic growth, is a high priority. Developing countries recognize the Korean economic achievement, but without a systematic approach to understand how Korea attained its unprecedented economic growth, the steps required to emulate this success remain unclear.

This report concludes with assessments of the policies that the Korean government developed and implemented, along with the corresponding policy implications and recommendations for policy makers in developing countries. This report covers not only traditional energy sectors, but also energy efficiency, renewables and the environment and safety, providing a guide to understanding and addressing the energy challenges that developing countries face.

1. Executive Summary

Korea rose from being one of the poorest countries in the 1960s to one of the top teneconomies in the 21st century. Such an unprecedented economic achievement would not have been possible without a key role of energy. This report explores a series of energy industry promotion policies Korea has pursued over a half century period during its economic development, growth and stabilization periods (1960s~2000s). The purpose of this report is to extract lessons that could benefit energy policy makers in the developing world, where energy industry promotion is an important policy goal.

The great strides made by the Republic of Korea over the last half century are not confined to its economy; its energy industry's infrastructure and security similarly leapt forward. Though Korea has no direct connections to neighboring countries that could enable it to rely on electricity imports or piped natural gas, the country has rapidly electrified, built a diverse electricity supply portfolio, developed a robust nuclear energy industry and become one of the pioneers in the liquefied natural gas trade. Such progress is remarkable and has enhanced policy goals such as improving economic efficiency and environmental sustainability to energy security.

Between 1960s and 2000s, the most remarkable trend in energy policies has been the awareness of the close nexus between energy and the environment that emerged. The second key trend was the introduction of competition and the third one was a shift of policy weight from energy supply-oriented into demand-oriented one. As these trends progressed, Korean energy policy evolved towards a policy target that balanced economy and the environment in lieu of the initial energy security-oriented focus.

Policy is an organized set of actions devised to respond to a problem. When a problem emerges, a crisis could result if countervailing policy measures are not adopted. Ideally, policy is made before a problem reaches a crisis level by effectively identifying and mitigating risks. Assessing the agenda and priorities also contributes to this policy-making process. However, in Korea's energy policy, this ideal has not been attained, and almost all the policies reflected a reaction to unanticipated problems.

2. Summary by Chapter

2.1. Historical Overview of the Korean Energy Policy

In the Korean context, internal and external energy problems emerged over time. In the 1940s and 1950s, energy poverty was atop-priority issue which requireda concerted national response. In the 1960s, a sufficient and relatively cheap supply of energy was required to fuel the nation's rapid economic growth. During the oil shock in the 1970s and 1980s, the vulnerability of nation's energy system to external shocks was the major issue. Thereafter, the environmental degradation due to greater use of lower-grade fossil fuels emerged as another priority issue. The internal issue of obsolescent governance structures in the energy industry, caused in part by the increasing scale and complexity of energy industries exacerbated pressures. In recent years, the trend of rising oil prices combined with the escalating global climate change issue has made the sustainability of Korea's energy system a national agenda a top priority.

Similarly, energy policy directions changed over time. In the 1950s, policies aimed to develop domestic coal resources were implemented, followed by the policies in 1960s that targeted the increasing the use of oil, or 'oilization', in the nation's energy system to fuel the successful industrialization of the economy. During and following the two oil shocks in 1970s and early1980s, stringent policieswere executed to enhance the energy security under the three core principles of diversification, conservation and oil-stockpiling. In the late 1980s and 1990s, the energy policy focus shifted again to responding to issues of environmental degradation as more low-quality fossil fuels were used. At the same time, the policies to reform governance were launched targeting deregulation, privatization and pro-competition, in other words, the increasing the application of market mechanisms in managing the energy industry. In recent years, the policy focus shifted again reflecting the commonly-shared perception that technological breakthrough offered the most likely approach to improve the energy system's sustainability.

The oilization policy had the positive effect of increasing Korean economic growth, though at the cost of increasing import-dependency for energy supplies. As a result, the energy security policy was implemented after the first and second oil shocks. This initiated the evolution of the Korean energy supply and demand management system which was based on the diversification of energy sources in conjunction with supply sources, energy conservation, and strategic oil stockpiling. These policies were integrated to improvethe energy supply and demand and to promote relevant energy industries, which strengthened energy security. Entering the 21st century, the environment has become a key word in addressing energy policy, with the key objective of restoring environmental quality to the level recommended by the World Health Organization (WHO).

2.2. Energy Security

Energy is an indispensable factor to sustain economic growth, industrial activities, and national welfare. In this regard, each country's policy aims to supply the energy needed for national economy stability. As a resource-poor country, Korea's domestic energy resources could not even come close to satisfying the energy demand to fuel continuous economic industrialization. Therefore, the primary goal of Korea's energy policy has been to ensure a stable energy supply to support economic development. Energy security has always been a principle objective of the national energy policy.

Specific measures to enhance energy security capability include:

- Diversifying energy sources from oil to coal, natural gas and nuclear
- Expanding energy infrastructures

• Encouraging overseas energy development projects, and

• Emergency strategic oil stockpiles

Korea's past experience strongly indicates that the lack of domestic energy resources do not necessarily create a bottleneck for economic development. Korea's energy supply is totally dependent on imports acquired on the international energy market. Korea's openness to the international energy market was a key factor in formulating energy security for Korea's economic development process. In order to minimize the impact of international oil price fluctuations on the Korean economy, Korea considered all possible energy options other than oil, including nuclear, coal, and natural gas, and introduced them into Korea' energy mix. This diversification has contributed to making Korea's economic energy system more robust since the 1960s.

In Korea, the energy security policy included nuclear energy in the energy mix in the early 1970s. The Korean government supported the development of nuclear technologies and maintained energy diplomacy with countries thathad advanced nuclear technologies. Natural gas was also adopted in the government's long-term plan by introducing it for use in urban areas and power generation. The government also initiated the construction of related gas infrastructure, such as the liquid natural gas (LNG) receiving terminals and a nation-wide trunk pipeline system.

An energy crisis couldoccur when a bottleneck emerges in an energy supply system. Short-term energy shortages can be overcome by implementing emergency preparedness system and tapping a nation's emergency oil reserves. In the longer-term, the most effective energy crisis management system is to enhance market mechanisms in pursuing the energy security and to maximize the market transparency in investment in the energy industry and energy pricing system.

2.3. Fostering the Energy Industry

The Korean government actively fostered the energy industry, and thus the government initiated and helped the industry to expand the construction of energy-supply production facilities, to ensure an uninterrupted supply. Examples included projects such as oil refineries and power generation plants which enabled the energy sectorto become a pivotal driving forcefor Korean economic growth. Since the 1960s, Korea has successfully establishedan energy production and supply infrastructure system as part of its rapid economic development.

The energy industry in Korea has successfully developed enabling it to play a significant role as one of the driving forces for economic growth and industrialization. Despite the lack of domestic energy resource reserves, Korea's energy production and supply facilities are

among the best in the world, as the most advanced technology was introduced when the energy facilities were installed. Korea is home to some of the largest and most advanced oil refineries in the world.

Korea was the world's tenth largest energy consumer in 2010, and for lack of domestic energy resources, Korea imported most of the needed energy, becoming one of the top energy importers in the world. The country is the fifth largest importer of crude oil, the third largest importer of coal, and the second largest importer of LNG. Korea Gas Corporation is the largest single LNG importer in the world. Korea is also the world's third-largest importer of hard coal behind Japan and China.

In sum, the energy industry in Korea evolved through three major approaches, 1) openness, 2) government's strong leadership, and 3) industrial structure based on market mechanisms.

2.4. Development of Technology

Considering the long-term nature of the energy technology development cycle, it is too early to fully assess the policy outcomes and work continues towards achieving the objectives set for the next decade. Also, skepticism remains about the feasibility of the long-term roadmap with many experts criticizing the inefficiency of the government's R&D budget allocation. However, there are emerging signs that progress towards objectives has been made. For example, the level of overall technological capability was assessed to have risen from 60.2% of the advanced group to 69% between 2006 and 2010. Another example isthe export of new and renewable energy (NRE) technologies which rose to 4.6 billion dollars in 2010 from 1.9 billion dollars in 2008. Also, it was estimated that a macro-economic value equivalent to 4,025 billion KRW was realized by commercializing innovative R&D products (commercialization ratio 24%: 172 projects among 717 attempted), and a total of 5,412 new jobs were created.

2.5. Energy Conservation and Efficiency Improvement

Energy conservation and efficiency improvement policies, initiated in 1970s, were systematically implemented. Right after the first and second oil shocks, the government introduced a series of energy conservation policies which, however, were less efficient and effective in terms of scale and quality. Considerable outcomes followed the promulgation of the Act on Rational Energy Utilization followed by the establishment of the Korea Energy Management Corporation (KEMCO) pursuantto the law. Between the 1980s and the early 1990s, there were a variety of policy tools and programs developed and implemented under the auspices of the Ministry of Energy and Resources (now the Ministry of Knowledge and

Economy: MKE). Since the 1990s, three Basic Plans for Rational Energy Utilization have been introduced and implemented in series. The Korean energy conservation policy has been firmly established.

2.6. New and Renewable Energy

Since Korea has few domestic conventional energy sources, it focused on developing and deploying new and renewable energy (NRE) as clean, environment-friendly and domestic energy sources. In this context, the first, second and third *Basic Plans for Renewable Energy Development and Deployment* were established sequentially in which deployment targets and strategies were introduced and implemented to foster relevant industries and create a market. While those basic plans were implemented, the policy infrastructure has evolved. Many policy measures and programs have been devised, some of which have been made obsolete and replaced by more advanced ones.

Thanks to the Korean government's unprecedented efforts in terms of organizations, programs and necessary budget to fulfill policy goals and strategies, the NRE R&D activities and deployment of NRE has been successfully executed. As of 2011, deployment of NRE was 7,583 thousand TOE, sharing 2.75% of the TPES which is still below expectations. However, the hardware and software has been firmly established compared other countries. In particular, policy tools such as feed-in tariffs (FIT), renewable portfolio agreements (RPA) and renewable portfolio standards (RPS) are regarded as some of the best mechanisms in the world which have evolved through years of experience and implementation.

Korea has carefully designed and adopted its policy measures and programs in order to maximize their effect, taking into account natural and economic conditions in Korea. While basic and common policy approaches such as subsidies, low-interest rate finance, tax incentives and other administrative actions are provided, more beneficial incentive systems to promote a larger deployment of NRE have been developed, and implemented: FIT and RPS. These two mechanisms adopted different approaches; RPS was more market-oriented while FITwas more subsidy-oriented. After ten years of employing FIT, the Korean government decided to replace it with RPS which was seen as a more cost-effective policy tool.

In recent years, as environmental problems such as climate change and local air, soil, water pollution have become a major issue, NRE is regarded as a core area of low-carbon green growth which is being implemented, domestically as well as globally. In addition, it is to be seen as a new growth engine which will feed the economy in the coming decades. It is highly expected that this industry would become a lucrative export item based on the current technology, industry, and policy infrastructure for other developing countries.

2.7. The Environment and Safety

Entering the 1990s, in response to the intensifying international regulation for the environment, the Korean government tried to build energy systems in harmony with the environment. Meanwhile, safety issues have emerged as the nation suffered from a number of accidents associated with the installation and operation of the energy-related facilities, particularly, nuclear power plants. Environmental impact assessments, various support programs, disclosure of the safety information of nuclear power plants, and establishment of environment monitoring organization were developed and implemented to secure sites for energy facilities and to prove energy safety.

The Korean government has taken steps to promote eco-friendly energy systems with economic growth. The Korean government organized a pan-government UN Framework Convention on Climate Change (UNFCCC) joint task force and has intensively promoted expansion of clean energy supply (renewable energy, nuclear energy and natural gas), energy saving and improvement in energy efficiency. Moreover, a systematic approach to greenhouse gas (GHG) statistics, clean development mechanism (CDM) for reducing GHG, the creation of a carbon market based on cap-and-trade, and the development of energy technologies are in progress. In June 2010, the plan to introduce an energy cost system including the cost of production and environment was announced.

Recently, the Korean government has proposed and implemented policies that capitalize on the environment as a new engine. Greening of existing industries and creating of new green industries were placed on the agenda of top priority. The major industries are expected to increase their exports of green products from 10% in 2009 to 22% in 2020. The government is encouraging small and medium-sized enterprises (SMEs) to green its businesses by promoting green energy technologies, such as NRE and energy efficiency, and smart grid technologies.

While many tasks remain, the policies mentioned above are worth an attempt to produce expected outcomes in the areas of the environment and safety. Though the GHG emissions in Korea remains relatively high, the rate of increase in GHG emissions has been slow. Additionally, the survey of public acceptance for the nuclear power plants indicates more encouraging results than that in the past.

2012 Modularization of Korea's Development Experience
Energy Policies

Chapter 1

Introduction: Economic Development and Energy

1. Background
2. Energy in Economic Production
3. Change in the Structure of Energy Supply and Demand in the Stages of Economic Development

Introduction: Economic Development and Energy

1. Background

Energy is indispensable for economic development and growth but mainstream theory of economic growth disregards this role. Most of the literature on energy and economic development deal with how economic development affects energy use and rather than vice versa. Corresponding economic growth models mostly focus on the functional form in which dependent variable is GDP and independent variables are capital, labor, and technology. Only recently, as energy becomes increasingly important as a production input, hasit been included as an endogenous variable in the production function.

This report explores a series of energy policies that Korea pursued over a half century of its economic development, growth and stabilization (1960s~2000s). The purpose of this report is to derive lessons that couldhelp policy makers in the developing worlddevelop and implementefficient and cost-effective energy policies as a high priority area of the policy agenda to pursue national economic growth. Developing countries recognize the Korean economic achievement, but without a systematic approach to understand how Korea attained its unprecedented economic growth, they do not have a clear idea of the steps required to emulate this success.

The great strides that the Republic of Korea has made over the last half century were not confined to its economy; its energy industry's infrastructure and securityalso leapt forward. Though Korea has no direct connections to neighboring countries that could enable it to rely on electricity imports or piped natural gas, the country has rapidly electrified, built a diverse electricity supply portfolio, developed a robust nuclear energy industry and become one of the pioneers in the liquefied natural gas (LNG) trade. Such remarkable progress is enviable to those developing countries that had been in a better position than Korea 60 years ago

when the Korean Civil War (1950~1952) devastated the peninsula and made Korea one of the poorest countries in the world.

2. Energy in Economic Production

Energy is not only a necessary good but also an indispensable input for economic production. This dual characteristic of energy implies that energy demand increases as economic activities expandand level of income increases. Productive demand caused by an increase in economic production will increase faster than the precedingeconomic growth, but, eventually will slow down after a certain point.

This phenomenon occurs due to a change in the industrial structure, technological advances, and the substitution of labor by capital. As an economy grows, the structure of its industry transforms from labor-intensive primary industries to secondary industries which are relatively more capital- and energy-intensive and finally to when heavy and petrochemical industries dominate. Later, the higher level of economic growth leads to a tertiary industry which requires less energy consumption. Consumptive final energy use increaseas fast as income levels increase, however, reaching a certain income level, energy use slowsdown and only the base demand will increase as the population grows. Nevertheless, the demand for cultural and luxury goods increases along with rising demand for home appliances and passenger cars, though it will eventually decrease as a mature stage is reached.

Thus, demand shifts from a low quality energy sources to higher quality ones which while it burdens the economy, is also a driver to support well-designed energy policy. Korea, which has undergone this cycle over the last four decades, is a good example. The major energy source shifted from firewood to coal in the 1960s, which was then replaced by oil, and more recently dominated by electricity and commercial heat (CHP), as economy grew, and incomes and living standards rose.

Figure 1-1 | Primary Energy Demand by Source

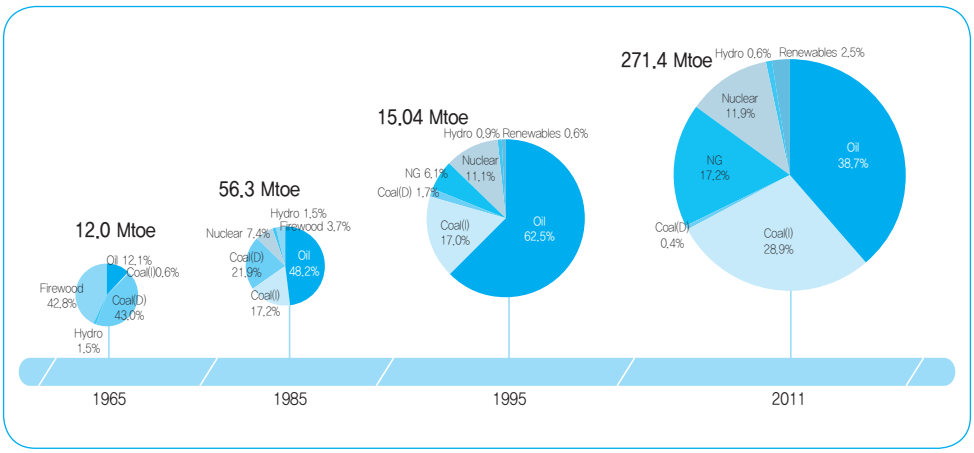
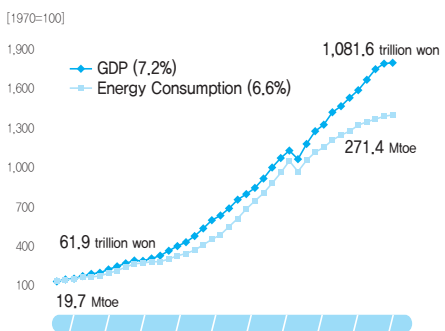


Figure 1-2 | GDP and Energy Consumption



	1970	1980	2011	(70–98)	AAGR (98–11)	(70–11)
GDP (trillion won)	62	557	1,082	8.3%	5.0%	7.2%
Population (Million)	32	46	50	1.3%	0.6%	1.1%
Energy Con. (Mtoe)	20	166	271	7.9%	3.9%	6.6%
Per Capita Energy (toe)	0.61	3.61	5.45	6.6%	3.3%	5.5%
Energy/GDP (toe/trillion won)	0.32	0.29	0.25	0.4%	−1.1%	−0.6%

3. Change in the Structure of Energy Supply and Demand in the Stages of Economic Development

3.1. Prior to the First Oil Shock (1964~1973)

In the early 1960s, the Korean economy was characterized by self-sufficient and underdeveloped economic structure with a per capita GNP of less than $100 of which manufacturing industry accounted for 14.5% of GDP while a primary industry's share was 48%; export accounted for only 7% of GDP.

Since the economy was small and had alow income level and underdeveloped industrial structure, Korea's energy consumption was similarly low and the energy supply and demand structure was underdeveloped. Energy consumption per capita was 0.41TOE with firewood and anthracite coal accounting for 45% and 44%, respectively, for a totalshare of 89% of final energy consumption. During this period, Korea's energy consumption was characterized by not so much a demand for production as a demand for consumptive energy.

Before the firstoil shock, the Korean economy had increased in scale and accordingly, the volume and the structure of energy supply and demand expanded accordingly. Between 1962 and 1973, real GDP grew at an annual rate of 10% as the export volume expanded from 6% in 1962 to 31% of GNP in 1973. Meanwhile, the share of primary industry shrunk to 26% whereas that of manufacturing industry increased. In addition, the share of manufacturing industry for export had expanded from 55% in 1962 to 88% in 1973.

As the Korean economy grew in terms of quantity as well as quality, its energy supply and demand had similarly undergone a quantitative as well as qualitative change. The most salient change was an abrupt expansion of the total energy consumption and a structural change to a higher quality energy source. Total energy demand had increased at an annual growth rate of 8.6%, resulting in 2.5 times as much in 1973 as in 1962 of which oil's share increased from 10% to 53.8% with a corresponding fall for firewood and anthracite from 87.4% to 42.1%. During this period, energy demand was led by the manufacturing industry and the share of consumptive energy demand weakened whereas the share of productive energy demand increased.

Between 1962 and 1973, import-dependence for energy supply and the corresponding energy burden on the economy weakened the stability of energy supply and demand. However, due to stable crude oil prices and a higher growth rate for exports than for imports during this period, oil-driven energy policy played a key role without the need for energy conservation or energy efficiency policies.

3.2. Energy Supply and Demand between 1973 (the First Oil Shock) and 1979 (the Second Oil Shock)

During the first oil shock, the Korean economy continued to grow and energy consumption continued to grow along, however, the oil price hike resulted in a serious economic burden. Between 1973 and 1979, the Korean economy grew at an annual rate of 9.7% with an export growth rate of 28% per year, resulting in an import-dependence from 31% in 1973 to 36% of GNP.

Despite the firstoil shock, and declining coal productivity in the late 1960s, the government switched its mainenergy source from coal to oil, establishing an oil-oriented energy supply system to fuel the rapid growth of light industries while promoting heavy and chemical industries. During this period, the Korean economy experienced a rapid increase in energy demand, oil in particular, due to growing oil-consuming heavy and chemical industries. Oil consumption increased from 62,720 thousand barrels in 1970 to 90,583 thousand barrels in 1973 and to 163,147 thousand barrels, most of which were coming from the Middle East. While energy demand increased rapidly, domestic energy production had rapidly decreased, resulting in a low level of energy self-sufficiency and energy import-dependency grewfrom 55.5% in 1973 to 73.4% in 1979.

As a consequence, the Korean economy became much more vulnerable to oil supply disruption, theexternal energy market and geopolitical conditions. The weighted average price of imported oil had spiked from $2.95/bbl. up to $17.96/bbl. in 1979, so the oil import expense cost 11 times more than six years earlier. During the secondoil shock, due to huge foreign debts, high inflation rates and high interest rates, the Korean economy suffered from economic burdens and mounting difficulties caused by these complex negative factors. As a result, the economic growth rate dropped to 6.1% in 1979, and marked unprecedented negative growth rate of -4.2% in 1980.

3.3. After the Second Oil Shock (1980~1987): High Oil Price and Energy Supply & Demand

As mentioned above, right after the second Oil Shock, the Korean economic growth rate dropped to an unprecedented rate. Among all adversaries, rapid oil price hike had a great impact on the Korean economy because 100% of its oil supply was imported from OPEC members. In response to the intensifying global geopolitical conflict and tightening oil market along with an escalation of oil price, the Korean government began to work on developing and implementinga variety of policies.

The most outstanding policies werethe Act on Rational Energy Utilization (1980) which diversified energy sources and suppliers. Strict enforcement of energy conservation and efficiency policies to reduce energy consumption took effect through the Act on Rational Energy Utilization. Since 1982, oil price stabilized at a low level which alleviated the energy burden on the national economy.The share of oil import in the GNP decreased from 10.5% in 1981 to 6.1% in 1985.

Policies aimed at diversifying energy sources and importing countries along with importing methods also took an expected effect. The government diversified energy sources by introducing nuclear power, coal, and LNG by restraining the construction of steam-power generation for securing stability of power supply. Further it concentrated on building nuclear power plants and bituminous coal power plantsas well as introducing renewable energies.

As a result, the share of oil in total energy consumption decreased from 58.1% in 1981 to 43.7% in 1987. Countries from which crude oil was imported were diversified from seven countries in 1981 to 21 countries in 1986. In particular, the share of oil as a fuel for power generation sharply decreased from 74.7% in 1981 to 3.0% in 1987.

3.4. Stable Low Oil Price (~2000)

Oil price hikes in the first and second Oil Shocks forced oil importing countries to reduce oil consumption by implementing a variety of energy conservation policies and diversifying energy sources. They also started to developalternative energy sources such as oil sands and renewable energies. As a result, in the mid-1980s, oil demand was left behind greater oil supply, resulting in and oversupply of oil; the oil price dropped to the half of its price in 1981.

With the advent of low-oil price era, energy consumption in Korea increased at a rate of 8.6% as compared to 4.5% between 1980 and 1985. Energy/GDP elasticity increased from 0.73 between 1980 and1985 to 1.19 between 1986 and 2000. Energy demand in the transportation sector in particular showed a sharp increase from 14.3% in 1985 to 20.7% in 2000. In the industrial sector, energy increase showed an abrupt hike from 42.6% to 56% in 2000 reflecting a fast up-scaling in petrochemical and heavy chemical industries.

The increasing energy consumption trend was characterized by a relatively rapid increase in high quality energy such as petroleum (gas oline and diesel) and electricity. For instance, anthracite coal showed a trend of continuing decline since1987 whereas petroleum showed an increasing trend in consumption right before the International Monetary Fund (IMF) financial crisis. Electricity consumption also showed a similar increasing trend at an annual growth rate of 10.9% between 1986 and 2000.

3.5. Era of New High Oil Price (2000 and thereafter)

Oil prices, which had continued to fall to $11/bbl. in the early 1999, bounced back to $36/bbl. in the late 2000s. In Korea, the total energy consumption had decreased by 8.1% due to the financial crisis and had increased at an annual growth rate of 4.7% until 2005, which a lower level of in energy consumption compared to the previous period of low oil prices. This phenomenon was mainly caused by the economic recession and high oil prices. Another factor was the change in industrial structure by newly emerging Information and Communications Technology (ICT) (semi-conductor and information & communication technology) which required less energy consumption.

As of 2010, Korea's Total Primary Energy Supply (TPES) were 263.8 million TOE which was 1.4 times bigger than that of 2000, or an annual increase of 3.2% during the period. The renewable energy supply recorded the highest average annual growth rate of 11.0% among the energy resources during the period. Natural gas and coal supply followed renewable energy with the average annual growth rate of 8.6% and 6.2% respectively. Only hydro energy supply recorded the smallest increase during the period with a 1.4% annual increase.

What was remarkable in the primary energy mix during the period from 2000 to 2010 was the decreasing share of oil. Despite the sharply decreasing share, oil still accounted for the biggest share in the primary energy mix. There has been no entry of new energy sources during the period and the share of oil has decreased from 52.0% in 2000 to 39.7% in 2010. The share of hydro also decreased from 0.7% in 2000 to 0.5% in 2010. All the other shares of primary energy sources increased during the period. The share of coal expanded from 22.3% in 2000 to 29.2% in 2010, and the share of natural gas also expanded from 9.8% in 2000 to 16.3% in 2010.

There was a growing consensus that urgent steps were needed in Korean energy sector to secure stable energy sources and to establish efficient and environmentally sound energy system for the national economic competitiveness. Also, the Lee Myung-Bak administration proclaimed that Korea's new development growth strategy would be Low Carbon Green Growth. Following this, the government confirmed The First National Basic Plan for Energy (2008~2030) which servesas a cornerstone of Korea's green growth strategy.

Chapter 2

A Brief History of the Korean Energy Policy

1. Domestic Coal Development Policy Regime (1950s)
2. Oilization Policy Regime (1960s~early 1970s)
3. Energy Security Policy Regime (late 1970s~1980s)
4. Environmental Protection Policy Regime (1980s~1990s)
5. Market-Oriented Policy Regime (1990s~)
6. Energy Technology Policy Regime (2000s~)
7. Development of Nuclear Energy Industry: History and Lessons

A Brief History of the Korean Energy Policy

1. Domestic Coal Development Policy Regime (1950s)

1.1. Initial Conditions

At the time of the emancipation from the Japanese occupation in August 1945, there were relatively advanced energy industries in the Korean Peninsula. However, most of them were located in North Korea. The South only inherited a handful of small power plants and anthracite coal mines: 199MW of power generation capacity and 1.4 million tons of coal production capacity in total <Table 3-1>. The poor inheritance made Korea one of the poorest energy economies of the world. To exacerbate the situation, the existing energy supply facilities had been almost totally destroyed during the Korean War (1950~1953). According to official reports, the power generation and coal production capacities were reduced by half by the destruction during the War.

Table 2-1 | South Korea's Energy Supply Capacity in August 1945

	Korean Peninsula (A)	Inherited by South Korea (B)	B/A
Power Generation Capacity (MW)	1,131	199	17.6%
Coal Production Capacity (10^6 ton)	7.05	1.41	20.0

Because of the dearth of modern energy industries, Korea depended on firewood to meet its energy demands. In 1955, over 75% of energy demand was met by firewood with the rest met by coal, petroleum and hydro power <Table 2-2>. To make the situation worse, the firewood resource itself was nearly exhausted due to the uncontrolled use by households. This urgency together with poorness in energy supplying industries constituted the "first energy crisis" for Korea, which required a stringent policy response.

Table 2-2 | Comparison of Energy Indicators: 1955 vs. 2010

	1955 (A)		2010 (B)		B/A
Total Energy Consumption (10^6 TOE) Total Electricity Consumption (TWh)	8 0.9		26.3 496		3.7% 0.2%
Per Capita Energy Consumption (TOE) Per Capital Electricity Consumption (kWh)	0.3 41		5.37 8,883		5.6% 0.0%
Overseas Dependence of Energy Supply (%)	15		96.5		-
Energy Mix (%)	Fire wood	75.7	Oil	39.7	-
	Coal	19.2	Coal	28.9	
	Oil	3.7	LNG	16.4	
	hydro	1.4	Nuclear	12.2	
			Others	2.8	

1.2. Launching of Domestic Coal-Based Development Strategy

After the Korean war ended in 1953, the Lee Seung-Man Administration adopted a coal-based development strategy. It consisted of step-by-step economic development strategies: (1) to develop nation's energy system by developing domestic anthracite coal industry; (2) to develop fertilizer industry by using energy; (3) to increase nation's agricultural production; (4) and then, to develop manufacturing industries using capital earned by exporting agricultural products. Among the sequence of strategies, the development of the coal resources and the coal-fired power system was the first step and, thereby, the crucial platform for the success.

Korea was poorly endowed with natural resources and its domestic energy resources were strictly limited to the anthracite coal and renewable energies. Though Korea had reserves of oil and gas in the continental shelf area, their development was beyond Korea's poor technical and financial capabilities. The recoverable anthracite reserves were known to be 604 million tons which would be enough to supply several decades. However, the deposits were located in remote and rugged mountainous North-Eastern area (Taeback and Jungsun

areas), which required the costly construction of transportation infrastructure. Moreover, due to economic poverty, the financing sources were limited except for the foreign aid from the United Nations and the U.S.A.

1.3. Policy Outcomes

In these hostile conditions, the development project was launched in 1954, with three policy goals; (1) to develop Taeback-Jungsun coal deposits, (2) to construct the railroad necessary for logistics to and from the area, and (3) to build a total 100MW of new coal-fired power plants (3 plants in Seoul, Masan and Samchuk respectively). As a result of the intense development efforts and the financial aid from the U.N. and the U.S.A., the development projects were completed in the late 1950s. This initial success was followed by a series of development projects in both the coal and the power generation sectors. Encouraged by these successes, the supply of domestic coal had increased, and had begun to substitute firewood for fuel. As shown in <Table 3-3>, the share of coal in the total primary energy supply increased rapidly from 19.2% to 43.6% during the period 1955~1965, while that of firewood dropped from 75.7% to 42.8%. During the same period, the supply of electricity tripled from 879GWh to 2,464GWh and, in 1964, Korea's electric power supply and demand was normalized for the first time since the emancipation in 1945. This suggested that the initial, though still poor, platform for further energy development had been prepared.

Table 2-3 | Structural Change in Korea's Energy Mix (1955~1965)

		1955 (A)	1965 (B)	B/A
Total Energy Consumption (10^3 TOE)		7,778	12,013	1.54
Total Electricity Consumption (GWh)		879	2,464	2.80
Energy Mix (%)	Fire wood	75.7	42.8	-
	Coal	19.2	43.6	-
	Oil	3.7	12.1	-
	Hydro	1.4	1.5	-
	Total	100.0	100.0	-

2. Oilization Policy Regime (1960s~early 1970s)

2.1. Background: Launching of Economic Development Plans

With this poor energy base, the first five-year economic development plan (1962~1966) began in 1962, followed by the second five-year plan (1967~1971) in 1967. To achieve a rapid economic growth, the Park Jung-Hee Administration adopted an export-driven development strategy. Under the formula, energy and manufacturing sectors would co-evolve in a way to support mutual development and, thereby, fuel the overall economic growth. The first step was to develop a solid energy system by introducing foreign loans, which would support a massive take-off of manufacturing industries. And then, the manufacturing industries would produce industrial products, the export earnings thereof could then serve as the financial basis for investments and imports of goods and equipment required for further economic expansion.

2.2. Vigorous Pursuit of Oilization Policy

With the strategy, the nation's energy development strategy shifted to the oilization policy away from the past coal-based strategy. The change in policy paradigm occurred in the early 1960s when policy makers began to realize the approaching limits of domestic coal production. The domestic coal industry would keep its expansion for a while. However, it would almost certainly not be enough to support the massive economic take-off which itself is an energy-intensive process. Furthermore, the coal crisis in 1964 and the electric power supply crisis in 1967~1968 triggered an acceleration of the policy transition towards oil.

The oil-based development regime started with the construction of the oil refinery in Ulsan (currently SK refinery) under the 50% foreign direct investment (FDI) contract with Gulf Oil. As soon as the Ulsan refinery was completed in April 1964, consumption of oil surged to an annual growth rate of over 30% compared to the past annual 2%. With the coal crisis in the winter of 1964, the government adopted a comprehensive oilization policy measures aiming at promoting oil consumption, including the free import of oil using devices and equipment as well as the subsidy for fuel substitution investment away from coal to oil. The electric power supply crises in 1967 and 1968 triggered the construction of more oil-fired power plants instead of coal-fired plants. In the late 1960s, two additional oil refineries were built to supply rapidly growing demand for oil; the Honam (currently GS-Caltex) and the Gyuengin refineries under the same FDI arrangements with Caltex and Unoco, respectively.

2.3. Policy Outcomes: Rapid Oilization with Increasing Overseas Dependence

The oilization of the energy system brought positive effects on Korea's economy. The overall fuel efficiency improved significantly, while the transportation and handling cost was reduced by a big margin. No one would deny that this improvement in fuel economy was key to the successful take-off of Korean economy which grew at an average annual growth rate of 10.2% during the period 1966~1973, while the value share of manufacturing industries rose from 11% to 20% of the GNP. Thus, the Korean economy transformed itself from a traditional agricultural economy to a major developing economy <Table 2-4>.

This rapid industrialization was fueled by a simultaneous rapid growth of energy consumption which grew at an annual rate of 9.6% during the period 1965~1973. The electric power consumption grew even more rapidly at 22.3% per annum. As shown in <Table 2-4>, the change in the energy mix was dramatic. Firewood, once the major source of energy, declined. The once-growing share of coal continued to drop with its peak recorded in 1966 (46.2%). Instead, the share of oil, all of which was imported from the Middle East, rose from 12.1% to 53.8% due to low prices and excellent energy service. Accordingly, the role of domestic sources of energy diminished, while dependence on imported sources rose rapidly from 12.7% to 55.5% <Table 2-4>.

Table 2-4 | Structural Change in Korea's Energy Mix (1965~1973)

		1965 (A)	1973 (B)	Growth Rate (%/yr)
GDP (billion Won, 1980 constant)		10,496	22,754	10.2
Energy Consumption (1,000 TOE)		12,013	25,010	9.6
Electricity Consumption (GWh)		2,464	12,367	22.3
Energy Mix (%)	Firewood	42.8	14.7	-
	Coal	43.6	30.2	-
	Oil	12.1	53.8	-
	Hydro	1.5	1.3	-
	Total	100.0	100.0	-
Overseas Dependence (%)		12.7	55.5	-

The rapid rise of overseas dependence was enough to raise alarms that called for policy measures supporting energy security. However, it was almost neglected except for two important policy choices. The first was the government's decision in January 1968 to build a nuclear power plant at Kori (currently KoriUnit One). Secondly, responding to the protests

from coal industries and the growing warning against declining energy self-sufficiency, Korean government declared that it would continue the development regime for domestic anthracite coal industry and adopted a couple of policy measures towards this end. The measures consisted of various subsidies for the mechanization and operations of mines, funded by taxes levied on heavy-oil consumption.

3. Energy Security Policy Regime (late 1970s~1980s)

3.1. Response to the First Oil Shock: Drift of Security Policies

The two Oil Shocks in 1973, and then again in 1979, inflicted economic hardship not only on the Korean economy but also on the world. However, the first Oil Shock was generally unnoticed by the Korean people. As shown in the <Table 2-5>, the growth rate in consumption of energy and oil in Korea continued to be much higher than the world average as reflected by its higher economic growth. Though the Korean government adopted energy security enhancement policies at the outbreak of the first Oil Shock, most of the policies drifted without any substantial outcomes. Even in 1973, the government launched an ambitious investment project to develop energy-intensive heavy and petrochemical industries. Still in 1979, almost 100% of Korea's crude oil was imported from the Middle-East by foreign investors: Gulf Oil, Caltex and Unoco.

Voices demanding energy security measures such as diversification, conservation and stockpile building were generally ignored due to optimistic negligence. However, the warnings were heeded somewhat as evidenced by the decision to construct nuclear and bituminous coal-fired power plants, and the establishment of an institute specialized in energy conservation (currently KEMCO). Though late, it was a positive move for Korea to establish an independent energy ministry (Ministry of Energy and Resources: MOER) in January 1978, in response to the tightening international oil market. This policy stance was comparable to those in Japan and Taiwan that were hit more severely than Korea during the first Oil Shock and initiated an intensive structural adjustment to be able to cope with the second shock more successfully than Korea did. Meanwhile, Korea continued to build an oil-intensive economy, with an emphasis put on developing energy-intensive heavy and petrochemical industries.

Table 2-5 | GNP and Energy Consumption: International Comparison (1960~1979)

(unit: %/yr)

		Fee World	Developed Countries	LDC	Korea
Real GNP	1960~1969	5.2	5.1	5.3	8.7
	1970~1979	3.9	3.5	5.9	9.8
Total Energy Consumption	1960~1969	5.2	4.9	7.5	12.0
	1970~1979	2.6	1.9	5.5	8.3
Oil Consumption	1960~1969	10.1	9.8	11.5	29.5
	1970~1970	2.8	2.1	5.5	11.6

3.2. Response to the Second Oil Shock: Stringent Efforts for Security Build-up

When the second Oil Shock hit the Korean economy, Korea suffered considerable economic damage which might have been otherwise avoided. In 1980, the economy recorded a negative growth for the first time in the post-planning period. The Korean currency, KRW, depreciated rapidly, while the trade balance recorded a deficit. Higher inflation rates pushed up domestic prices, while foreign debt continued to increase. The Korean economy was facing growing troubles, while the exit was not apparent in the midst of uncertainty. After all, the Korean economy could not help but go through years of ordeals until the so-called Price War happened in 1986 when the Middle-Eastern crude oil price suddenly dropped to $10/bbl <Table 2-6>.

Table 2-6 | Trend of Selected Economic Indicators (1970~1982)

(Growth rate, %/year)

	1970~1973	1974~1975	1976~1978	1979~1980	1981~1982	1970~1982
Real GNP	9.4	7.6	12.3	-0.1	5.9	7.7
Export	50.9	25.5	35.7	17.4	11.7	31.5
Import	23.5	31.0	27.2	22.0	4.3	22.0
Exchange rate	6.9	10.3	-	16.8	6.5	7.1
WPI	9.6	34.1	10.9	28.4	12.3	16.6
CPI	11.0	24.8	13.8	23.4	14.1	15.9

Note: 1) Exchange rate is in KRW/Dollar
2) During 1974~1979, Korea maintained a fixed exchange rate system

Being shocked by the economic hardship, the Korean government adopted a series of energy security policy measures: (1) diversify energy mix away from oil, (2) diversify energy import sources, (3) promote energy conservation, and (4) promote strategic oil stockpile. Being different from the policy experiences in the first Oil Shock period, the measures were implemented stringently with long-term consistence. In order to support the projects financially, a special fund called the Petroleum Enterprise Fund was introduced. A semi-tax on petroleum products consumption was levied and put into the fund, to finance various projects for security improvement.

The new policy regime led to a significant change in Korea's energy system and the industrial structure. First, its impacts on the oil stream were dramatic as the growing demand for oil was reversed. Owing to the vigorous diversification efforts of import sources, the share of the Middle-Eastern oil in the total oil import decreased from 100% to 76% in 1982 and further to 64% in 1987. The 100% dependence on three FDI majors (Gulf, Caltex, Unoco) for oil importation dropped to 13% in 1982, with the remaining 87% imported by the Korean importers including trading companies. Also, the number of oil import sources increased from the previous Middle-Eastern three suppliers (Saudi-Arabia, Kuwait, Iran) to 12 origins scattered over the world. The share imported through spot-market contracts rose from nil to 45% in 1987 <Table 2-7>.

Table 2-7 | Changes in Oil Import Structure (1978~1987)

	1978	1982	1987
Number of import sources	3	9	12
Dependence on Middle-East	100%	76%	64%
Dependence on 3 FDI majors	100%	13%	n.a.
Share of spot-importation	-	8%	45%

The diversification of energy sources was dramatic. First, the cement industries, which accounted for about 30% of industrial B-C oil demand, completely switched to bituminous coal for their energy needs. Some of oil-intensive industries followed the example. The percentage of oil in total energy consumption in the industrial sector, the largest consumer of oil in Korean economy, dropped from 70% to 50% in 1987.

Secondly, in the electricity sector, the second largest consumer of oil, stringent de-oilization policies were implemented. Most of all, the government decided to halt the construction and the operation of oil-fired power plants and several existing oil-fired plants were converted to coal- or LNG-fired plants. Meanwhile, a vigorous campaign for building nuclear and bituminous coal-fired plants was promoted under the de-oilization policy in the electricity sector. According to the newly adopted power sector expansion plan, the

combined share of electricity supplied by nuclear- and bituminous coal-fired plants was to rise from the near nil to more than 60% in the 1990s. Thanks to these stringent policy efforts, the share of oil in power generation sector recorded a dramatic drop from the previous 77% in 1979 to 6.5% eight years later.

Thirdly, another bold move was the decision made in October 1980 to import LNG and LPG into the Korean energy market. Under the policy, the initial network to import LNG and to distribute it domestically was completed at the end of 1986, and the first shipment of LNG from Indonesia arrived at a Korean harbor to supply natural gas to Korean consumers <Table 2-8>.

Table 2-8 | Change in Energy Mix in Industrial and Power Generation Sectors (1975~1987)

(Unit: %, end-use energy)

		1975	1979	1982	1987
Industrial sector	Oil and gas	80.5	70.9	53.8	52.7
	Coal	8.4	17.7	32.7	32.5
	Electricity	11.1	11.4	13.5	14.8
	Total	100.0	100.0	100.0	100.0
Power generation Sector	Oil	80.1	77.0	73.3	6.5
	Coal	11.2	5.5	10.5	21.2
	LNG	-	-	-	11.0
	Nuclear and hydro	8.7	17.5	16.2	61.3
	Total	100.0	100.0	100.0	100.0

Note: The first nuclear power plant, KoriUnit One, began its operation in 1978

At the outbreak of the second Oil Shock, Korea's strategic oil stockpile was only equivalent to seven days usage, far shorter than the 90-day standard recommended for oil importing economies. To fill the gap, the Korean government adopted a long-term policy of constructing at least a 90 day-equivalent strategic oil stockpile by the end of 1996. Under the objective, construction began on three oil stockpiling facilities, which were completed at the end of 1985 and the oil stockpile reached the initial target by the end of 1987. Another new policy approach for security enhancement was overseas oil development. It began in January 1981 when the historic co-development agreement was signed between Korean and Indonesian counterparts to develop the West Madura oil field in Indonesia. The first shipment from Madura arrived at a Korean harbor in August 1984. Buoyed by the achievement, activities of overseas resource development were accelerated to reach a total of 16 projects spread over the world by 1988.

3.3. Policy Outcomes: Emergence of More Resilient Energy System

Overall, the economic hardship during the second Oil Shock era and the stringent policy responses brought forth a significant structural change in Korea's energy system. As shown in <Table 2-9>, the once ever-growing dependence on oil decreased from its peak 63.3% in 1978 to 43.7% in 1987. Instead, bituminous coal, nuclear energy and LNG emerged as the new major primary energy sources. Though the share of LNG was still low at 3.1%, its role would continue to expand in the coming decades. As a whole, the diversity of Korea's energy mix improved in a rather shorter period. However, because all these are from foreign sources, Korea's dependence on imported energy kept growing to reach 80% in 1987 <Table 2-9>.

Table 2-9 | Changes in Energy Mix (1973~1987)

(Unit: %/year)

	1973	1978	1987
Oil	53.8	63.3	43.7
Anthracite coal	28.5	22.2	19.0
Bituminous coal	1.7	3.8	15.8
LNG	-	-	3.1
Nuclear energy	-	1.5	14.5
Hydro	1.3	1.2	2.0
Firewood & others	14.7	8.0	1.9
Total	100.0	100.0	100.0
Overseas dependence	55.5	69.3	80.0

Korea's economic hardship came to an end when the world oil market stabilized. The world oil market had slowly transformed into a buyer's market. By January 1986, the official prices of Middle-Eastern crude oil dropped to $10/bbl level., owing to the oil glut and the intense competition among suppliers. In addition to this positive turn-around, both the world interest rate and the value of US dollar dropped. Together, these brought another era of higher growth to the Korean economy, which lasted a decade until the financial crisis occurred at the end of 1997. It is worthwhile to note that, with the turn-around, the nearly collapsed engine for the co-evolution of energy and economy sectors began to operate again and continued to gain strength. For example, the once criticized heavy and petrochemical industries because of their energy-intensiveness emerged as the new major exporting industries so that their earnings were enough to pay for growing energy imports

from abroad. This may imply that, being contrary to the common expectation, the oil crisis made the Korean energy economy become more resilient than in the past.

4. Environmental Protection Policy Regime (1980s~1990s)

4.1. Background: Increasing Policy Demand for Better Environmental Quality

Energy is a major source of environmental degradation including air and water pollution. Due to the high population density, rapid industrialization and urban sprawl in Korea, air and water pollution problem became more of a concern in the 1980s. Energy use had a negative effect on air quality in particular, and, to a lesser extent, on water quality, as well as municipal and industrial solid waste disposal. Major sources of air-pollution included emissions from industrial energy use, residential heating, electric power generation, and automobiles.

During the 1970s, air-pollution level increased significantly in urban areas, and became a source of great concern in the 1980s. As shown in <Table 2-10>, sulfur dioxide concentrations in Seoul and major cities exceeded internationally accepted air-quality standards. The total suspended particulates (TSP) levels were much higher than those in major urban areas abroad. Acid rain became a serious environmental problem that demanded an urgent policy response.

Table 2-10 | Air Pollutions in Korea in the 1980s

	Reference Year	Korea's Air-contamination by Major Cities	Major Cities Abroad
SO2, ppm	1980	Seoul 0.094, Busan 0.058 Daegu 0.038, Inchon 0.026 Gwangju 0.009, Ulsan 0.053	Tokyo 0.016, LA 0.009 WHO standard 0.015~0.023
TSP, μg	1986	Seoul 183, Busan 194, Daegu 140, Inchon 153, Gwangju 133, Ulsan 172	Nagoya 40, LA 71, London 22
acid rain, ph	1986	Seoul 5.3, Busan 5.2, Daegu 5.4,Inchon 5.5, Gwangju 6.1, Ulsan 5.2	normal rain 5.6

This degradation of air quality was primarily due to two causes: the ever-increasing use of lower-quality fossil fuels and the lack of well-organized environmental control policy. As shown in <Table 2-11>, during the period 1960~1990, the use of fossil fuels increased by 25 times, much higher than that of the total primary energy. Thus, its share rose rapidly from 35.3% to 83.2%. Accordingly, air-pollutants thereof increased 18 fold. It was because the evolution of environmental protection policy was protracted under the shadow of the growth-paradigm. Though Korea's first version of environmental protection law, the Public Nuisance Prevention Law, was enacted in 1963, it was not enforced until much later.

Table 2-11 | Fossil Fuel Consumption and Air-Pollutants Thereof (1960~1990)

	1960 (A)	1970	1980	1990 (B)	B/A
Total energy consumption, 1000TOE	8,773	19,679	43,911	93,192	10
Fossil fuel consumption, 1000TOE (share in total energy consumption, %)	3,099 (35.3)	15,113 (76.8)	40,047 (91.2)	77,536 (83.2)	25
Air-pollutants thereof, 1,000 ton	276	1,209	1,879	4,948	18

However, the general social atmosphere began to change in the 1980s. In response to the growing demand for environmental protection from civil society, environmental policy became a top priority on the national agenda. The policy initiative began with the enactment of the Environmental Conservation Law in 1977, followed by the establishment of the Office of Environment in January 1980. It was elevated to the ministerial level in January 1990, and was renamed the Ministry of Environment. The Environment Conservation Law was replaced by six new laws dealing separately with general environmental policy, air quality, water quality, noise and toxics. Thus, in the 1990s, the conservation paradigm came to share the dominate policy priority arena with the once paramount growth paradigm.

The rapid evolution of environmental policy in the 1980s was fueled by the growing awareness of environmental protection in Korean society. The civil movement towards the better environment stewardship began in the early 1980s when several non-governmental organizations (NGOs) raised their voices for a policy response. This movement strengthened in the latter half of the decade when the democratization process arose in Korea's socio-political arena. Civil protests against major development projects that were deemed to be hazardous to environment increased. The so-called NIMBY[1] phenomena spread all over the nation and became major obstacles that hindered the timely and economical launch of major construction programs such as electric power generation plants.

1. NIMBY stands for Not In My Back Yard.

4.2. Evolution of Environmental Protection Policy

The changed atmosphere triggered awareness of environmental protection in the energy policy arena. The first step was taken in 1980 as the result of year-long policy dialogue between the Ministry of Energy and Resources and the Office of Environment. The use of low-sulfur (1.6%S) fuel oil was mandated for power plants and large industrial users in major urban areas. In 1985, KEPCO, Korea's electric power monopoly, adopted a long-term investment plan to reduce the emission of pollutants in the power generation sector. It was followed by a decree mandating the nation-wide use of unleaded gasoline in 1987.

The level of policy enforcement was enhanced for the 1988 Seoul Olympic. It became mandatory to use cleaner fuels (gas and higher quality petroleum products) and the use of solid fuel was banned in densely populated urban areas. This triggered a series of policy steps promoting fuel-shift toward a cleaner energy system; this change had a profound impact on Korea's energy industries. (1) Construction of a city-gas supply system started in major urban areas. (2) The number of district heating systems increased. The first district heating plant began operating in 1985, and the decision to build four more plants in the new city areas around Seoul was made in 1988. (3) In 1988 after several years of preparation, the Korean Government adopted a policy to rationalize the domestic anthracite coal industry, with implementation starting in 1989 and led to the rapid reduction of briquette-coal use in urban areas. (4) The government decided to build four LNG-fired electric power plants in 1988, which eventually opened the gate for LNG to serve as the major fuel for power generation. (5) In parallel to these policy steps in the energy supply sector, the emission standards continued to be enhanced to reach the level of advanced nations.

4.3. Policy Outcomes: Emergence of Energy System with Less Pollutants Emission

Due to these policy responses, the once-deteriorating environmental quality improved slowly to reach the standards recommended by international health institutes. As shown in <Table 2-12>, both the shares of clean energy (gas, hydro and nuclear energy) in total primary energy supply and power generation rose from a meager 4.1% and 14.6% in 1980 to 34.1% and 57.7% in 2005, respectively. Due to the shift in the energy mix and the stringent emission controls, the coefficient of air-pollutants emission from energy use dropped from 0.043 tons/TOE to 0.012, which made the sulfur dioxide (SO2) concentration in Seoul drop enough to satisfy the World Health Organization's (WHO) recommended standards.

Table 2-12 | Changes in the Share of Clean Energy and the Air Quality

	1980	1985	1990	1995	2000	2005	Growth Rate (%/yr)
Share of clean energy in total primary energy supply	4.1%	11.6%	23.0%	22.5%	29.1%	34.1%	-
Share of clean energy in electric power generation	14.6%	35.2%	63.9%	50.5%	53.6%	57.7%	-
Emission of air-pollutants (Ton/TOE)	0.043	0.040	0.053	0.028	0.013	0.012	-5.0
Emission of CO_2 (Ton/TOE)	n.a.	n.a.	2.56	2.44	2.24	2.15	-1.2
SO2 concentration in Seoul (ppm)	0.094	0.054	0.051	0.017	0.006	0.005	-
Acid rain in Seoul (ph)	n.a.	5.3	5.0	5.8	4.8	4.4	-

5. Market-Oriented Policy Regime (1990s~)

5.1. Background: Paradigm Change in Economic Management

Korea's energy market was dominated by the government through stringent regulations, intervention, subsidization and the operation of state-owned monopolies. It was the product of a development regime that had dominated Korea's economic management after the inauguration of the first five-year economic development plan in 1962 when the government tightly regulated prices of energy products and services and monopolized major investment decisions. The electric power industry and the LNG supply businesses were monopolized by the Korea Electric Power Corporation (KEPCO) and the Korea Gas Corporation (KOGAS), while about half of the petroleum products and domestic anthracite coal production were supplied by state-owned refinery and coal production corporations. The government also used various tax and subsidization mechanisms to support domestic energy industries.

However, in response to the upheaval of the Oil Shocks in 1970s and the less than satisfactory performance of the economy during the 1979~1982 period, the government adopted a strategy of introducing more market mechanisms into the nation's macro-economic management. It aimed to allow more autonomy for private actors and, thereby, enhance innovations required for further economic growth.

In the past, the government had set detailed quantitative targets for macro-economic variables and strongly influenced the direction of economy through fiscal policies and direct intervention. The new policy, instead, would be "indicative", while defining basic policies rather than targets or investment plans was emphasized. Aside from a limited number of large-scale projects, investment choices were left to private initiative and the government only indicated the general framework and direction in which to choose. The government further reduced its intervention in market mechanisms by reducing regulation and protection, and adopted various new incentive systems to foster creative efforts in the private sector.

This policy paradigm calling for more market mechanisms was further enhanced when the New Economic Plan started in 1993, which targeted a full-fledged adoption of market mechanisms in the Korean economy. The pricing of major commodities and services were to be made by the private hands rather than the government, while more deregulation was promoted. Through a series of state-owned enterprise reforms, most of the state-owned corporations were to be privatized in the mid-term time range. Again, in the years 1998~1999, this policy shift was further intensified when the Kim Dae-Jung Presidency promoted a massive economic reform policies right after the financial crisis at the end of 1997. About half of the regulations on business activities were lifted across all economic sectors, while a massive privatization campaign was promoted for state-owned enterprises.

5.2. Launching of Deregulation and Privatization Policies

Though slower than in the other sectors, a market-oriented policy evolved in the energy sector. First, the rationalization program of domestic anthracite coal industry was adopted in 1988, and implemented from 1989. The industry was suffering from the chronic financial deficits, and barely continued operations since it was indebted to massive government subsidies. The aim of the rationalization policy was to expedite closing marginal coal mines by providing financial support, and thereby reduce the ever-growing demand for subsidies. The results were substantia: the number of coal mines fell to 27 in 1995 from 347 in 1988, while coal production dropped from 24 million tons to about 6 million tons in the same time period.

Secondly, reform had been promoted through the energy commodities pricing. In the past, one of the objectives of Korea's energy policy was to ensure a cheap supply to ensure industrial competitiveness and as an instrument of social policy. Based on these rationales, energy prices had been kept low by tight government regulation. In the early 1980s the government took steps to reduce its intervention in oil pricing. The prices for jet fuel and solvent were deregulated in 1983, asphalt in 1988, premium gasoline and naphtha in 1989 while regular gasoline, kerosene and heavy oil remained under government control. However

in 1995, as one of the key reform policies under the New Economic Plan, the government deregulated the pricing for the remaining three oil products, followed by LPG price in 2001.

State-owned production as a form of direct government intervention was used extensively during the development era in Korea's energy sector where diminishing marginal cost prevailed because of the high initial cost of establishing a supply network. Thus, compared to other sectors, state-owned enterprises dominated the energy sector: Korea Electric Power Corporation (KEPCO), Dae Han Coal Corporation (DHCC), Dae Han Oil Corporation (DHOC), Korea Gas Corporation (KOGAS), and a number of smaller state-owned enterprises. However, the policy climate began to change in 1980s, in a way of introducing more market mechanisms into the management scheme in order to improve the competitiveness of state-owned enterprises.

The reform policy consisted of three strategies: to provide more autonomy in management decisions, to make the relevant industry competitive through de-monopolization, and finally to privatize state-owned enterprises. The first policy step was laid in 1980 when the government privatized the Dae Han Oil Corporation, the biggest refinery in Korea. In 1985, the Public Enterprise Management Law was enacted to bring consistent standards of treatment to those aspects of business management. The law gave substantial management autonomy to state-owned enterprises and sharply limited day-to-day intervention by ministries and other government agencies in their management. To further enhance competition in the power generation industry, the government decided to open the market to the private enterprises in 1993.

Finally in 1999, the government adopted a massive restructuring scheme for the state-owned energy monopolies (KEPCO, KOGAS), the target of which was to divide them into several independent competing companies both in production and distribution, and finally to privatize them. Under the scheme, the power generation sector of KEPCO was divided into six state-owned power generation companies (GENCOs) in 2001. Meanwhile, the Korea Power Exchange (KPX) was established in the same year to manage the competition in wholesale of generated power. However, due to the severe protests from the labor unions and civil activists and the one-month long strike by the laborers in GENCOs in 2002, the government decided to stop further restructuring process at the end of 2005 so the final outcome of this policy remains unknown.

5.3. Policy Outcomes: Substantial Progress with Policy Drifts

The market-oriented policy regime produced substantial outcomes. Owing to the successful implementation of the rationalization policy, the size of domestic anthracite coal industry, once the typical subsidized industry in Korea, was reduced significantly. The price

regulation regime on petroleum products was entirely lifted and left to the market to decide. The once proliferating regulations on market activities were reduced by half, and the scope of free and innovative market initiatives was expanded significantly. Due to the reform policy on state-owned enterprises, the scope of managerial autonomy was expanded, while the door to market entry by private hands into energy market once-dominated by state-owned enterprises opened widely. The six independent entities (GENCOs) that emerged from KEPCO led to the assessment that the degree of market competition has increased significantly, and the environment for technological innovations had been created.

However, the regime continued to struggle with many real-world obstacles hindering its progress. Despite full-fledged deregulation, the culture of government intervention remained in the form of indirect interventions. For example, the government was still inclined to intervene to affect the price of petroleum products. In case of pro-competition policy on electric power and LNG industries, the further implementation of the policy was stopped amid restructuring due to severe opposition from labor unions and civil organizations. There even exists a growing voice to restore the original state-owned monopoly system to benefit public interests. Against these policy drifts, Korean government declared its determination to apply more market mechanisms as the principle of future energy policy. However, these symptoms may indicate that longer years and stringent policy efforts were required to achieve the final policy outcomes.

6. Energy Technology Policy Regime (2000s~)

6.1. Korea's Energy Technology Policy: Historical Context

Energy service is a co-product of energy resources (R), capital in forms of supply and utilization facilities (K), and technology (T). This implies that technology is an indispensable element for supplying energy service. Furthermore, it is widely recognized that technology is the key driver for energy system development. Energy resources are produced and transported using human labor and capital stocks. The capital stocks could be viewed as physically embodied past knowledge and the labor reflects the process knowledge. This implies that as a nation's energy system develops to a certain developmental stage, technology becomes the key driver for further evolution.

In Korea's energy policy history, the technology policy remained peripheral in overall energy policy mix until recently. In the 1950s, the energy policy emphasized the development of domestic anthracite coal. From 1960s, a dual policy focus included the oilization and the construction of modern energy supply facilities such as power plants and oil refineries. During the oil crisis era in the 1970s and the 1980s, the priority agenda was to

transform nation's energy system to ensure energy security. When policy makers struggled with the subsequent environmental problems, technology was still considered to be a minor factor. Until recently, the government budget allocated to advancing technology was minor compared to that allocated for resource development and supply facilities construction.

However, with regard to the status of technology policy in Korea's energy policy arena, three points are note-worthy. First, the technology policy served a small, though significant contributing role in coping with the nation's energy problems. Second, its rank in overall policy mix kept rising, though slowly, from the periphery to the core. Third, during the long-term process of its evolution, institutional arrangements were made to serve as the platform for the rapid evolution of technology policy regime started in the middle of the 2000s.

The first policy step by the Korean government was the enactment of Atomic Energy Law in 1958. Based on the law, Korea Atomic Energy Research Institute (KAERI) was established in 1959, which became the incubator of the nation's first generation of scientists. In 1980, another research institute, the Korea Institute of Energy and Resources (KIER), was established as the cradle of energy technology research and innovation other than atomic energy, followed by the establishment of several other research institutes both in state-owned and private sector organizations.

One of the notable success stories in the history of technological innovation was the briquette-coal improvement program. It was promoted by the Korean government in the 1960s and 1970s to improve the heat efficiency of briquette-coal and, thereby, improve the convenience of handling it. It was estimated that, following the success of the program, the consumption of coal by households was reduced by half. This implies that, without this innovation, Korea could have experienced difficulties in meeting the growing demand of coal for residential use.

Another success story was the new electric lighting technology innovation program in the 1990s. Under the scheme, a concerted effort was made to promote technological innovation projects among electric light industries, universities and research institutes. As the result of decade-long R&D efforts, the nation's electric lighting devices were almost totally replaced by new and more efficient ones, which led to at least a 5% saving in the nation's electric power demand.

6.2. Triggering Events for Recent Rapid Evolution

In Korea's energy policy arena, technology policy went through a long and slow evolutionary process until it became a top-priority agenda item in the mid-2000s. The heightened awareness among policy actors about the strategic importance of technological

advance was the impetus that increased its priority level. Several external and domestic factors triggered it: the rapid rise in world oil price, the emergence of the climate change issue, and the emergence of Korean economy into a knowledge economy.

From the mid-2000s the price of crude oil rose rapidly to exceed $100/bbl. The so called New High Oil Price Regime prevailed. Naturally, new warnings had predicted a gloomy energy future including the exhaustion of fossil energy resources in near future. For energy importing economies like Korea, it was imperative to find a new growth paradigm to cope with the coming pessimistic future to sustain economic growth.

Second, following the UN Framework Convention on Climate Change (UNFCCC) in June 1992, the Kyoto Protocol came into effect in 2005, and the subsequent evolution of international regulation regime on GHG emissions began. For an economy like Korea that consumes a notable amount of carbon-rich fossil energy and whose dependence on trade is much higher, the realization of low-carbon energy system was an imperative for further economic prosperity.

The two imperatives called for a new national strategy to create an alternative energy path ensuring low-carbon emission and, at the same time, sustained economic growth. That is, Korea pursued a new development paradigm: the sustainable growth or the green growth. In doing this, various policy schemes were organized. However, among them, the key break through driver was a technology development strategy.

Third, the recognition of technology's key role was fueled by the policy awareness that the Korean economy had entered into the first stage of a knowledge economy around the year 2000. This implies that, technology development through successive innovation of knowledge would be the key driver for future development. In addition, a formidable capability of technology development had been accumulated through past technological learning process. Thus, if a stringent and massive policy effort was promoted consistently, this could become the platform for the successful realization of both a knowledge economy and sustainable growth.

6.3. Deployment of Energy Technology Policy

The rapid evolution of technology policy began in 2006 when the first National Energy Technology Development Plan (2006~2015) was developed and adopted by the National Science and Technology Committee. In 2008, the newly elected President Lee Myung-Bak declared that a green growth strategy would be the national agenda's top priority, with an emphasis on energy-related technology development. Subsequently, a series of plans for energy technology development were introduced.

The overall objective of Korea's energy technology policy was to develop the technological competitiveness of Korea's energy-related industries to match the level of advanced nations and, thereby relaize sustainable growth. The specific objectives, as detailed in the second National Energy Technology Development Plan (2012~2020), were to achieve the following strategic targets by the year 2020: (1) to improve the overall energy efficiency by 12%, (2) to reduce the emission of global warming gases by 15%, (3) to create about one million new employment opportunities, and (4) to develop new and renewable energy industries equipped with advanced technological capability. To achieve the objectives, hundreds of R&D projects were organized and promoted under the long-term technology development roadmap. The projects were categorized into four major fields: energy efficiency, new and renewable energy sources, clean fossil fuel, and power generation and nuclear energy <Table 2-13>.

Table 2-13 | Content of Energy Technology R&D: Overview

Major Field	Major Sub-field
Energy Efficiency	- Small district heating and cooling - Efficiency renovations - Heat pumps - New materials and motors etc.
New and Renewable Energy Sources	- Green cars - Hydrogen/fuel cells - Solar photovoltaic - Wind power generation - Coal liquefaction and gasification - Hydrogen economy - Energy storage etc.
Clean Fossil Fuel	- CO_2 separation, utilization, sequestration - Waste heat recovery - Air pollutants reduction (SOx, NOx) etc.
Power Generation and Nuclear Energy	- Smart grid - Cleaner power generation - Super conductivity material - Nuclear power generation and safety - Fusion energy etc.

Many laws serve as the institutional platform for policy promotion such as the Energy Law (2006), the Energy Use Rationalization Law, the Electricity Business Law, the Atomic Energy Law, and the Korea Institute of Energy and Resources Research Law. In particular, the Energy Law required the government to formulate and implement a long-term energy technology development plan every five years. Many organizations participate in the policy formulation and implementation process. (1) Responsibilities for energy technology R&D are shared between the Ministry of Knowledge Economy (MKE) and the Ministry of Education and Science (MES). While the MES leads the nuclear and fusion energy fields, the MKE leads the other fields including nuclear power generation. (2) Many research institutes, state-owned corporations, private companies and universities participate in the policy process and contribute to the overall R&D activities. (3) The Korea Energy Technology Evaluation and Planning Institute (KETEP) was established in 2007 with the mission to draft a long-term technology development road-map, and manage the overall R&D projects by evaluating, coordinating and allocating funding under the oversight of the MKE.

Under these institutional settings, various policy measures were being employed to promote technological innovation and commercialization activities: increasing the government R&D budget investment, employing financial and tax incentives for R&D investments, creating markets for new technologies, creating informed consumers, and creating and improving infrastructure for technological innovation.

Since the first National Energy Technology Development Plan was established in 2006, Korean Government's R&D investment budget increased rapidly at an annual growth rate of 19%: from 521 billion KRW in 2006 to 1,007 billion KRW in 2010. Thus, Korea became the sixth largest nation of the world in terms of annual government R&D investment in the field of energy technology (the third highest nation in terms of investment amount to GDP). The budget was allocated to R&D actors such as private industries, research institutes, universities and consortiums. Various types of financial and tax incentives were provided to actors to promote investments in R&D and the commercialization of new technologies.

One of the government's principal means for promoting technological innovation was through the creation of initial purchasing markets for newly developed technologies. The typical examples were the feed-in tariff (FIT) program for electricity generated by new and renewable energy sources, the renewable portfolio standards (RPS) program with green certificates, the mandatory purchase and utilization program, and the inter-governmental partnership program for local energy development between central and local governments.

The Korean government also operated a series of education and information programs to enhance the awareness of innovative technologies in civil society. In addition, the Korean government promoted policy programs to create and improve the infrastructure

for technological innovation, including the cultivation of capable human resources and the promotion of international cooperation in the field of energy technology.

6.4. Policy Outcomes: Emerging Signs of Positive Progress

Taking into account the long-term nature of the energy technology development cycle, it is too early to fully assess the policy outcomes. Korea is still in its earlier stage of intensive technology development efforts, and may need decades to achieve the goals. Also, skepticism remains around the feasibility of the long-term roadmap with many experts criticizing the inefficiency of government R&D budget allocation.

However, there are emerging signs that progress towards objectives has been made. For example, the level of overall technological capability was assessed to have risen from 60.2% of the advanced countries to 69% during the period between 2006 and 2010. Another example is the export of new and renewable energy technologies rose to 4.6 billion dollars in 2010 from 1.9 billion dollars in 2008. Also, it was assessed that a macro-economic benefit equivalent to 4,025 billion KRW was generated by the commercialization of innovative R&D products (commercialization ratio of 24%: 172 projects among 717 attempted), and a total of 5,412 new jobs were created.

7. Development of Nuclear Energy Industry: History and Lessons

7.1. Introduction: Background and Overview

In December 2009, Korea was selected as the principal contractor to deliver 4 units of nuclear power plants to the United Arab Emirates (UAE) and, thereby, became the world's sixth exporter of nuclear power plants. As of 2011, a total 21 nuclear power plants with a capacity of 18,716 MW were in operation to supply 31.1% of the electricity and 11.7% of the total primary energy needs. This demonstrates the important and indispensable role of nuclear energy industry in meeting the nation's energy demand.

The first step to develop a nuclear energy industry was taken in the 1950s under a dream of solving the then severe energy poverty. In Korea, nuclear energy was perceived as the "dream energy" with limitless availability. The dream was realized when the first nuclear power plant, Kori Unit One, began operations in July 1978.

Korea's nuclear energy industry reached its full-fledged development stage in the 1970s and 1980s when the two oil crises occurred. Nuclear energy was adopted as one of the alternatives to reduce dependence on oil and, thereby, enhance nation's energy security. This perception

encouraged Korea to promote a massive expansion of nuclear power plants. Thereafter, when the air pollution and the global warming issues arose, the construction of nuclear power plants continued under the rationale that nuclear energy is a cleaner source of energy.

However, the journey the industry made was not an uneventful one. In the early developmental stage, Korea had to cope with problems associated with limited technological and financial capabilities and had to rely on foreign suppliers and loans. In the aftermath of the Three Mile Island (TMI) accident in 1979 and the Chernobyl accident in 1986, the socio-political perspective of Korea's nuclear energy industry was severely aggravated, with the advent of anti-nuclear and NIMBY movements. The crisis was overcome by a set of policy measures aiming to enhance public acceptance. However, the recent Fukushima nuclear accident reignited the anti-nuclear climate.

Thus, Korea's nuclear energy industry took a long evolutionary path, full of challenges and responses, until arriving at the current position and competence. Many factors have contributed to this achievement. For example, a primary driver has been the strong policy stance in support of nuclear energy industry promotion, which has been maintained consistently by successive governments ever since the Rhee Seung Man administration in the 1950s.

7.2. Policy Deployment and Outcomes

7.2.1. Initial Institutionalization for Industry Development (1950s)

The initial stage of Korea's nuclear energy industry development was led by the strong leadership of President Rhee Seung Man. In December 1953, President Eisenhower of the U.S.A. delivered a speech "Atom for Peace" at the UN General Assembly, in which he advocated the peaceful use of nuclear energy: the ultimate "dream energy" that would serve the human race forever. With that event as a turning point, construction of nuclear power plants began to spread quickly among advanced nations. To President Rhee, the nuclear option was seen as a way to solve the then severe nation's energy poverty and to advance science and technology at the same time. Being encouraged by the bright future of nuclear power, President Rhee led the policy process that laid the initial institutional basis for nuclear energy industry development.

Under the President Rhee's leadership, Korean government signed a bilateral cooperative agreement in the field of nuclear energy with the U.S.A. in February 1956, and joined the International Atomic Energy Agency (IAEA) in August 1957. In March 1958, the Atomic Energy Law was enacted, followed by the establishment of administrative and research organizations in 1959: the Atomic Energy Board (AEB) in January and the Korea

Atomic Energy Research Institute (KAERI) in March. In March 1962, a research reactor (TRIGA Mark II) was installed with aid from the U.S.A. and, research activities on nuclear technology began.

At the same time, a professional human resources development program was promoted. Between1956 and 1959, 150 young and talented scientists were sent to academic and research institutes abroad for training. Before they left the country, President Rhee invited each of them to his office and conveyed a word of encouragement. The program lasted until 1973 and additional 316 scientists were sent for overseas training. Upon their return to Korea, they started working for universities, research institutes, industry and government, and served to advance Korea's nuclear science and technology.

7.2.2. Construction of the First Nuclear Power Plant (January 1968~ July 1978)

Since its establishment in 1959, the Atomic Energy Board (AEB) has led the efforts in constructing the first nuclear power plant, as announced in January 1968 by the Korean government. It took a decade-long incubation to reach a consensus and the final adoption. During that decade, AEB promoted a series of preparatory works including the periodic surveys on international trends, the feasibility studies on nuclear power plant construction and the case studies on overseas experiences related to nuclear power plant operation. Despite the endeavors by the AEB, the policy adoption was delayed, due to Korea's limited technological and financial capability at that time.

It was beyond Korea's reach to build a nuclear power plant which is technologically sophisticated and capital intensive in nature. From the technical viewpoint of power system management, it was against the normal expectation to build a 500 MW scale of nuclear power plant in Korea with a total generation capacity of less than 1,000 MW at that time. In addition, both the Ministry of Commerce and Industry (MOCI) and the Korea Electric Power Company (KEPCO) who were in charge of electric power system expansion, were uncomfortable with the idea. They were committed to building coal- and oil-fired power plants to meet the rapidly growing demand for electricity. To them, the nuclear power plant was not yet a feasible option with its huge capital cost and much longer construction time than the traditional fossil-fueled power plants.

In January 1968, the Korean government officially announced its decision to build the first nuclear power plant, Kori Unit One (587 MW). The decision was supported by the changed perception of MOCI and KEPCO toward the nuclear option. In the middle of 1960s, they were confronted with the growing concerns on both the coal and the oil options in building the future power mix. To them, the limited resource base of domestic coal would not be enough to meet the future demand, while the growing dependence on oil would

certainly aggravate the nation's energy security. Thus, the nuclear option emerged as the third viable option for the fuel mix in power generation. On top of this, two domestic energy crises which threatened a successful expansion of the Korean economy triggered the final decision: the coal supply crisis in the winter of 1964 and the electric power supply crisis in 1967.

In sum, the AEB examined the idea for a decade and then real world necessity in the form of energy crises that threatened the successful expansion of Korean economy prompted a decision. To outsiders, it was an irrational decision beyond the commonly shared practice of power system management. After the decision was made, a turnkey contract was signed between KEPCO and Westinghouse in March 1970 with the condition of providing financing for the construction cost. After eight years of construction, the Kori Unit One started operations in July 1978, and Korea emerged as one of the major economies with nuclear power genration.

7.2.3. Expanded Construction of Nuclear Power Plants Triggered by Oil Crises (1970s~1980s)

The two oil crises in 1970s and 1980s opened a new chapter for Korea's nuclear energy industry. In light of the serious economic hardship incurred by the oil crises, the Korean government adopted a policy regime in favor of nuclear power. The massive construction of nuclear power plants was boldly promoted, with the rationale of reducing the higher oil dependence in electric power generation and, thereby, enhancing nation's energy security.

In 1973 when the first oil crisis occurred, Korea's dependence on oil was 82.3% for electric power generation and 53.8% in total primary energy consumption. From the viewpoint of energy security, the Korean economy was operating at the risk of vulnerability to an oil price hike and threatening global oil market. In an attempt to solve the problem, the Korean government adopted a comprehensive energy plan in May 1974, in which the government declared its determination to "expand the construction of nuclear power plants and, thereby, reduce its dependence on oil."

However, contrary to expectations, dependence on oil in the power generation sector rose to 85.9% in 1976 owing to the electric power supply crisis at the end of 1974 and the continued construction of oil-fired power plants in response.

Greatly disappointed with the progress, the Korean government took a more intensified pro-nuclear policy stance in the Five-Year Power Expansion Plan established in October 1976. The key points were: (1) to construct large-scale nuclear and bituminous coal-fired power plants, and (2) to lay a supportive institutional arrangement for the effective implementation of the massive power capacity expansion program for non-petroleum fuels.

In regards to the latter, it was decided: (1) to enact a special law to facilitate the siting and licensing processes, and (2) to convert KEPCO into a 100% state-owned corporation and, thereby, strengthen the financial base for the massive power expansion program.

Under these policy directions, the construction of six new nuclear power plants began, together with four large bituminous coal fired power plants. Also, a special law called the Electric Power Development Promotion Law was enacted in December 1978. And, after buying back privately owned stocks over a number of years, KEPCO was converted to a 100% state-owned corporation in January 1981.

The Korean government's pro-nuclear policy stance was further intensified by the second oil crisis in 1979. The government re-emphasized its commitment to reduce its dependency on oil in the Five-Year Power Expansion Plan adopted in June 1981. The intent was to shift the nation's electric power system away from oil almost completely through the enhanced construction of nuclear and bituminous coal-fired power plants. Under this policy direction, the construction of five additional nuclear power plants started. In this way, the current geographic network of four nuclear power generation complexes (Kori, Wolsung, Uljin, and Youngkuang) finally surfaced, while the share of nuclear energy in total electric power generation rose to 53.1% in 1987, with the oil share fell sharply below 10%.

7.2.4. Launch of Nuclear Energy Technology Indigenization (1980s~1990s)

Developing domestic nuclear energy technology had been the long sought dream of Korea's nuclear energy arena. Compared to other types of power generation, a nuclear power plant is both capital and technology intensive. Therefore, the self-reliance of technological capability and the self-manufacturing of equipment would bring a multi-faceted strategic effect. Not only would it enhance nation's energy security but also enable it to develop the related industries and technologies. The dream became reality when the Korean government adopted the Ten-Year Nuclear Energy Technology Indigenization Plan (1986~1995) in July 1985. Target of the plan was fourfold: (1) to increase the self-reliance of design, manufacturing and construction technologies to 95% level within ten years, (2) to develop 1,000 MW class the Korean Standard Nuclear Power Plant Model, (3) to achieve self-reliance of nuclear fuel fabrication technologies, and (4) to improve skills required for nuclear power plant operation.

To achieve the targets, an implementation strategy was adopted: (1) to designate domestic organizations as the main actors to promote domestic technology by field (e.g. equipment design and manufacturing, construction, operation, nuclear fuel fabrication), (2) to be sufficiently technologically capable to be self-reliant in the construction of nuclear power plants by letting each organization acquire advanced technologies from foreign suppliers.

In addition, a phase-management strategy was adopted. Phase I (1986~1995) was the technology transfer phase. During the period, two nuclear power plants were to be constructed by 1995, in which foreign suppliers would participate as sub-contractors under the condition that technologies would be transferred to Korean counterparts. Through it, technological capability of domestic organizations rose to 95% by the end of 1995, and the Korean Standard Nuclear Power Plant Model was established. In phase II starting in 1996, continued up-grading of technological capability were sought through the repeated construction of the standard nuclear power plants.

The plan was implemented by the Ministry of Energy and Resources (MOER). First, MOER organized a cooperative forum in which relevant domestic organizations and companies participate, in order to facilitate cooperative dialogues and information exchanges among them. Second, in June 1985, MOER designated organizations in charge of technology development (see <Table 2-14>).

Table 2-14 | Designated Organizations and Foreign Suppliers

Technology Field	Designated Organization (Prime Contractor)	Foreign Supplier (Sub-Contractor)
Overall construction project management	KEPCO	-
Plant design	Korea Power Engineering Co. (currently KEPCO E&C)	Sargent & Lundy
Nuclear fuel system design	Korea Atomic Energy Research Institute (KAERI)	Combustion Engineering
LWR fuel fabrication	Korea Nuclear Fuel Co. (KNF)	Combustion Engineering
Equipment design and manufacturing	Korea Heavy Industries and Construction Co. (currently Doosan Heavy Industries and Construction)	Combustion Engineering (reactor), General Electric (turbine and generator)

The substantial parts of the first phase plan began in April 1987 when the Youngguang Units Three and Four were ordered by KEPCO. Supply contracts were signed, in which domestic organizations participated as prime contractors and foreign suppliers as the sub-contractors. Under the scheme, the construction project started in May 1987 and was completed in March 1995. As the results, Korean Standard Nuclear Power Plant Model was developed, while the technological self-reliance rose to 95% from the initial 60%. The phase I was followed by the phase II projects. And, through the repeated construction of Korea's standard plant model, the technological capability was refined. The plan's major outcomes are summarized in <Table 2-15>. (1) As mentioned earlier, the self-reliance of

nuclear energy technologies rose to 95% in 1995 from the initial 60% level. Also, Korea came to have its own standard plant model, which began to be applied from Ulgin units 3 and 4 whose construction began in May 1992. (2) Domestic fabrication of nuclear fuel for both the LWR and the HWR was indigenized. (3) The average capacity utilization factor of nuclear power plants rose to 80% in 1987 from the past 65~70% level, while annual average number of unplanned outages dropped substantially. Indebted to these, the unit generation cost of nuclear power plants decreased substantially. Overall, the most profound outcome was: the domestic plan and outcomes served as the platform for the further development of technological capability and, through this, Korea has eventually evolved as the exporter of nuclear power plant.

Table 2-15 | Major Outcomes of Nuclear Energy Technology Indigenization Plan

Target Area	Major Outcome
Indigenization of design, manufacturing, Construction technologies	• Self-reliance level : 60% → (1995) 95%
Development of Korea's standard nuclear power plant model	• Completion of development → application from Ulgin units 3 and 4 whose construction began in May 1992
Indigenization of nuclear fuel fabrication technology	• LWR fuel : indigenization was realized in 1995 • HWR fuel : indigenization was realized in 1987
Improvement of nuclear power plant operation skills	• Capacity utilization factor : 65~70% → (1987) 80% • Unplanned outage per unit : (1984) 8.1 → (1995) 1.1 • Unit generation cost : (1984) 43.53 KRW/KWH → (1987) 36.61

7.2.5. Promotion of Nuclear Safety and Public Acceptance Policies (Late 1980s~)

Korea's nuclear energy industry met its biggest adversity in the late 1980s when anti-nuclear and NIMBY movements spread. Being triggered by the Three Mile Island (TMI) accident in 1979 and the Chernobyl accident in 1986, Korea's civil organizations formed and intensified the anti-nuclear movement. In 1988, a heavy water leak at Wolsung unit 1 was disclosed at the Audit Session of the National Assembly, which caused the domestic anti-nuclear movement to intensify further. The anti-nuclear movement, in turn, affected the local residents living in the neighborhood of nuclear power plant sites and, thus, the NIMBY phenomena against nuclear power plants spread among them. They demanded that the government stop construction and compensate the economic cost inflicted by the siting and operation of nuclear power plants. In the meantime, the local governments, who had

been traditionally cooperative to government's nuclear energy policy, changed their attitude and joined the voices of local residents.

Likewise, the socio-political climate surrounding nuclear energy industry continued to deteriorate. In a word, the industry faced a challenge that threatened its future and even sometimes its normal operations. Policy responses to the challenge were promoted in two ways: (1) continuous improvement of nuclear safety management system and (2) introduction of measures to enhance the public acceptance towards nuclear power plants.

a. Improvement of Nuclear Safety Management System

In the Korean context, it is fair to say that evolution of nuclear safety management policy showed a typical reactive behavior; policy responses reacted to some triggering event such as a nuclear accident, instead of being prepared in advance.

a) The origin of Korea's nuclear safety management system dates to the 1958 Atomic Energy Law which instituted a few regulation provisions such as the management of fissile materials. After Korea adopted the decision to build the first nuclear power plant, government enacted the Nuclear Damage Compensation Law in January 1969, introducing principles of the strict liability of nuclear operators and the state compensation obligation. However, at that time, the scope of the nuclear safety management system was primitive.

b) It was the Three Mile Island (TMI) accident, in March 1979, that triggered Korea's nuclear safety management system's first major step forward. The accident shocked Korea since it had become a nuclear energy generation country just a year earlier. Fueled by the shock, the Korean government established Nuclear Safety Center under the umbrella of Korea Atomic Energy Research Institute (KAERI), with the major function of providing technical support necessary for safety regulations. Second, in April 1982, nuclear operators were required to observe the revised Atomic Energy Law: (1) obligation to comply with environmental conservation standards and (2) obligation to conduct education and training program to their employees.

c) In April 1986, the worst nuclear accident ever recorded took place at the Chernobyl nuclear power complex located in the former Soviet Union. It had profound impacts on Korea which then had seven nuclear power generation units scattered throughout the nation. The anti-nuclear movement intensified along with the NIMBY attitude. Immediately after the accident, Korean government amended the Atomic Energy Law in May 1986 and, through it, reformed the governance structure of the National Atomic Energy Committee, the supreme policy making organization related to nuclear energy, so that the Prime Minister served as the Chairman of the committee instead of the former Minister of Science and Technology. This move by the government signaled its determination to treat the nuclear safety issue as the nation's priority policy agenda.

d) The period from late 1980s to middle 1990s corresponded to the years that Korea's nuclear safety management system evolved rapidly in response to peaking anti-nuclear and NIMBY movements. First, in October 1989, Nuclear Safety Sub-Committee was newly established under the National Atomic Energy Committee. In December of the same year, the Korea Institute of Nuclear Safety (KINS) was established through the enactment of KINS Law. Both steps by the government reflected its determination to enhance expertise in the policy making and implementation related to nuclear safety. Second, in September 1993, Ministry of Science and Technology (MOST) in charge of nuclear safety began to install a computerized safety management system, Computerized Technical Advisory System for Radiological Emergency Preparedness (CARE). Third, government announced the Nuclear Safety Policy Statement in September 1994, in which principles of safety management policy were declared: (1) independent, clear, efficient and reliable nuclear safety regulation and (2) complete disclosure of information related to nuclear energy policies and activities.

e) Improvement in the nuclear safety management system has continued until the present. In December 1996, National Nuclear Safety Committee was established as an independent committee dealing with safety issues, apart from the National Atomic Energy Committee. Second, starting from 1998, standing organizations called the Civil Environmental Monitoring Committee were established in each four nuclear energy generation complexes respectively. The committee's function is to constantly monitor the safety of nuclear power plants with participation of local assembly members and residents. Third, shortly after the Fukushima accident occurred in March 2011, the Korean government established the Nuclear Safety and Security Commission (NSSC) in October 2011, as a standing independent regulatory organization reporting directly to the President.

The historical trajectory described above recounts the incremental improvements in Korea's nuclear safety management. As the result of these steps, the average annual number of unplanned outages per unit continued to decline from 7.5 in 1985 to 0.5 in 2000 and 0.33 in 2011 <Table 2-16>.

Table 2-16 | Number of Unplanned Outage of Nuclear Power Plants: Historical Trend

	1978	1980	1985	1990	1995	2000	2005	2010	2011
Number of nuclear power units (A)	1	1	4	9	10	16	20	20	21
Total number of unplanned outages (B)	17	8	30	18	11	8	10	2	7
Average outages per unit (B/A)	17	8	7.5	2	1.1	0.5	0.5	0.1	0.33

b. Introduction of Measures to Enhance Public Acceptance

As discussed, the socio-political environment surrounding nuclear power plant site worsened in the late 1980s. Due to a strong NIMBY attitude, only eight plant sites were secured among 18 required to expand electrical power. Thus, stable acquisition of plant sites became the nation's top-priority policy imperative. In some cases, even the daily operation of existing power plants was threatened due to the intense anti-nuclear protests. To solve the problem, Korean government adopted two policy approaches aiming to enhance public acceptance: (1) promotion of regional cooperation and (2) complete disclosure of nuclear information.

In June 1989, the Korean government enacted the Power Plant Neighborhood Assistance Law and, through it, introduced a regional cooperation system. The scheme was to create a regional cooperation fund and, from the fund, provide subsidies to the socio-economic development programs promoted by local neighborhood. In addition, other assistance measures were introduced to promote regional development and welfare of local residents. For example, the expanded employment for local residents, purchasing more local products, and more opportunities for local businesses to participate in projects related to power plant construction, operation and maintenance. In 1995, a discounted electricity rate system was applied to the local neighborhood as well. Overall, the rationale behind this institutional arrangement was to equalize the socio-economic burdens arising from the siting and operation of power plants. It was considered to be unfair that only local neighborhoods had to carry the whole burden and so it was divided among all electricity consumers.

Second, MOER announced the Nuclear Energy Information Disclosure Guideline in May 1990. In the guideline, government declared its willingness to disclose all information related to nuclear power plants to the public. The decision reflected the changed perception among policy makers: a very profound cause of the negative public opinion and distrust on the safety of nuclear power plants was the government's secrecy. Under the guideline, the government published its first Nuclear Power Generation White Paper in June 1990. In March 1992, Korea Nuclear Energy Promotion Agency (KONEPA) was established, as an organization that specialized in promoting public relations in the field of nuclear energy. Also, the introduction of Civil Environmental Monitoring Committee was a part of information disclosure policy. The result was that the once-aggravated public gradually lessened its opposition and local governments and residents agreed to provide the sites. <Table 2-17> shows the improved environment for nuclear energy industry. The share of positive response to the necessity of nuclear power generation rose to 95% in 2005 from 62% of 1989, while the share of positive response to the siting of nuclear power plant in the neighborhood area rose to 51% from 12%.

Table 2-17 | Trend of Public Acceptance for Nuclear Power Plant (1986~2005)

Public Opinion	1986	1989	1995	2000	2005
Share of positive response to the necessity of nuclear power generation, %	72	62	86	84	95
Share of negative response to the safety of nuclear power plant, %	53	73	69	66	29
Share of positive response to the siting of nuclear power plant in the neighborhood area, %	n.a.	n.a.	12	11	51

7.3. Summary and Lessons

The historical trajectory of Korea's nuclear energy industry has been the continuation of challenges and responses. The foundation was laid when Rhee Seung Man Government created the initial institutional basis in the 1950s. Thereafter, the decision to build the first nuclear power plant was made in response to two domestic energy crises. During the Oil Shock period of the 1970s and 1980s, expanded construction of nuclear power plants was promoted as a way to improve nation's energy security. For a decade after 1986, the Korean government implemented a ten-year plan to build domestic nuclear energy technology capacity. With this as the platform, the industry's technological capability evolved and Korea finally emerged as the exporter of nuclear energy technology. The journey, however, was not a smooth one. From the late 1980s, the industry met a strong reactionary wind in the form of the anti-nuclear and NIMBY movements that threatened its further development. To overcome the adversity, the government introduced a regional cooperation scheme and the complete information disclosure guidelines. As a result, public acceptance improved which enabled Korea's nuclear energy industry to continue its progress.

To summarize, Korea's nuclear energy industry is the outcome of the five decades of rigorous efforts by policy actors, professionals and industry workers. It is not a product of any simple rational long-term design, but an incremental accumulation of adaptive responses to the problems arising contingently during the journey. One element that was common along the journey was that Korean government never faltered in its willingness to develop domestic nuclear energy industry under the belief that, for resource-poor Korea, nuclear energy was the vital part of energy mix. Also, it could be said that, in hindsight, Korean government adapted to the changing environment fairly well, though not without some missteps. Then, what policy lessons can be derived from the Korean experience?

First, the task of developing a nuclear energy industry is economically costly and socio-politically sensitive. Therefore, ongoing close attention and strong policy leadership by the nation's top policy maker is an indispensable element for its successful promotion. It was

the leadership of President Rhee Seung Man that laid the initial foundation in the 1950s. Thereafter, the nuclear energy issue was almost always treated as the top-priority on the President's agenda.

Second, Korea promoted a professional human resources development policy consistently over the years. The policy started with an overseas training program in the 1950s. Thereafter, a mass of professional human resources in the field of nuclear energy continued to be cultivated through university education and professional training; they served as vital actors contributing to the industry's development.

Third, institutions that provided the legal basis and promotional capabilities are indispensable elements for the successful policy implementation. Without adequate institutions, real world outcomes cannot be expected. The Korean case indicates that most policies were followed by the corresponding institutionalization. Examples include the enactment of Atomic Energy Law and the establishment of AEB and KAERI in the 1950s, followed by the Power Plant Neighborhood Assistance Law of 1989, and the establishment of NSSC in 2011.

Fourth, technology development is a core element for industrial development. As illustrated, continued promotion of technology R&D was key to the nuclear energy industry's progress. In particular, the plan to develop domestic nuclear energy technology capabilities promoted in the period 1986~1995 served as the key platform from which industry has evolved to realize its current competence.

Lastly, Korea actively promoted international cooperation in the field of nuclear energy and continues to comply with international norms, which is another core element for smoother industrial development. Ever since joining in the IAEA in 1957, Korea has participated in various cooperative activities and has complied with international norms such as non-proliferation standard. Also, Korea has promoted bilateral cooperation with many nations under bilateral nuclear energy cooperation agreements.

Chapter 3

Energy Policy and Policy Tools

Energy Policy and Policy Tools

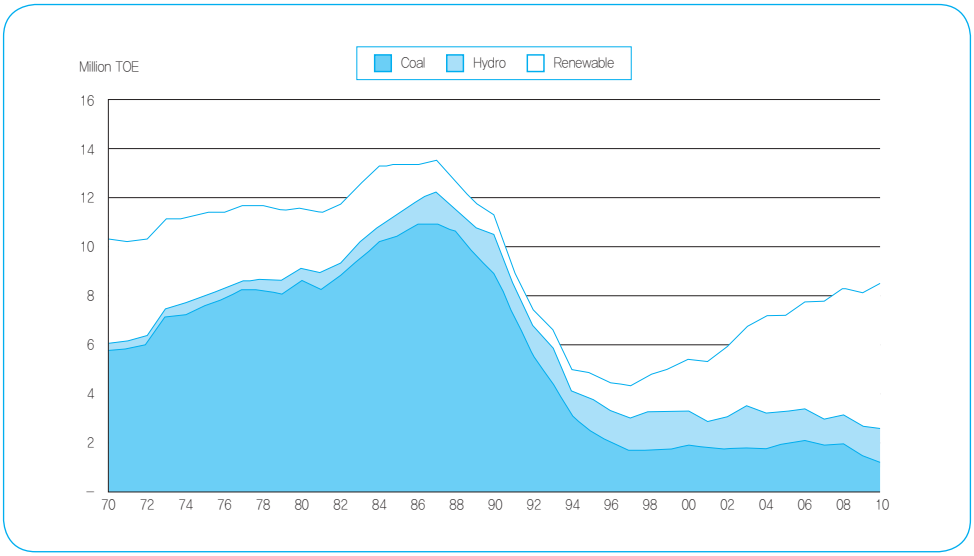
1. Energy Security

1.1. Background

As a resource-poor country, Korea's domestic energy resources include only small deposits of anthracite coal and hydropower. Domestic energy production in 2010 totaled 8,964 thousand tons of oil equivalent (TOE), accounting only for 3.5%of Korea's total primary energy supply. Production of domestic anthracite coal has declined significantly in recent years. As a result of rationalizing the coal industry production fell from 7,748 thousand TOE in 1990 to 969 thousand TOE in 2010. Hydro-electricity generation and renewable energy production in 2010 were 1,391 thousand TOE and 6,603 thousand TOE, respectively.

These domestic energy resources do not even come close to satisfying the energy demand to fuelcontinuous economic industrialization. Hence, Korea imports most energy, including oil, bituminous coal, nuclear fuel, and natural gasto meet the increasing energy demand. Therefore, Korea's import dependence ratio of energy consumption has steadily increased from 73.5 % in 1980 to 96.5% in 2010 (with nuclear energy included).

Figure 3-1 | Domestic Energy Production by Fuel Type in Korea



Therefore, the primary goal of Korea's energy policy focuses on ensuring a stable energy supply to support economic development. Nations commonly consider energy security to be a principle energy policy objective because it plays a critical role and is an essential ingredient of every action and process in economic activities. Considering that Korea has to rely almost completely on imports for its energy supplies, it was not surprising that the government set securing stable energy sources as one of its top priorities.

1.2. Policy Approach

Given the lack of domestic energy resources, the Korean government, promoted a wide range of policy tools to achieve the goal of the energy security. Energy security has multidimensional aspects. Energy security does not simply mean maintaining a stable energy supply, but it also includes all the aspects of energy policies such as energy pricing conservation policy, energy industrial policy, energy diplomacy, and so on. This implies that energy security could be achieved through harmonization of all the energy related policies.

To guarantee a stable energy supply and strengthen energy security, Korea aimed to achieve energy source diversification, to increase self-sufficiency through strategic overseas resource development and the concurrent expansion of domestic energy supply infrastructure. Korea also implemented demand-side measures to establish an effective system for reducing energy consumption and promoting more efficient energy use. In recent years, Korea expanded overseas resource development as a national priority to

strengthening energy supply stability. Korean energy companies have made substantial overseas investments in the oil and natural gas supply chain.

Specific measures to enhance energy security capability include:

- Diversifying energy sources from oil to coal, natural gas and nuclear
- Expanding energy infrastructures
- Encouraging overseas energy development projects
- Emergency strategic oil stockpiles

1.3. Fuel and Import Source Diversifications

1.3.1. Energy Source Diversification

Korea experienced a significant structural change in energy mix over the last three decades. The share of oil in total primary energy supply declined from 58.1% in 1981 to 39.7% in 2010, while those of natural gas and nuclear significantly increased to 16.4%and 12.2%, respectively in 1981 and 2010.

This is mainly due to the government's active implementation of fuel diversification policy for energy security purposesto reduce the economy's vulnerability to oil price hikes and supply shortages after the two Oil Shocks in the 1970s and 1980s. The most notable policy development for energy security in Korea was an active policy for fuel diversification away from oil to cheaper and more stable energy sources such as coal, natural gas and nuclear power. After the second oil shock, the Korean government actively implemented diversification of both energy and import sources in the 1980s.

Table 3-1 | Energy Mix in Korea

(Unit: million TOE, share in %)

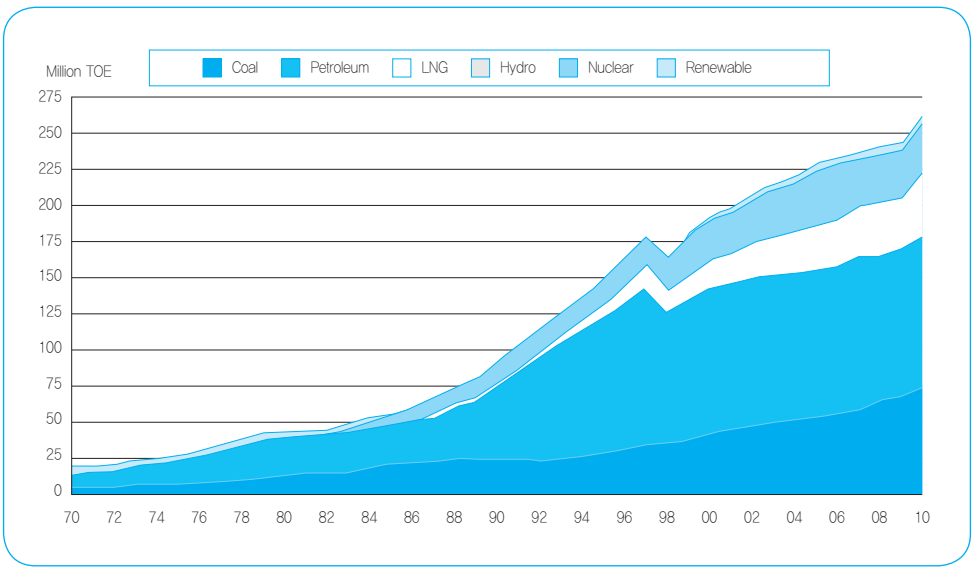
	1981	1990	2000	2010
Coal	15.2 (33.3)	24.4 (26.2)	42.9 (22.2)	75.9 (28.9)
Oil	26.6 (58.1)	50.2 (53.8)	100.3 (52.1)	104.3 (39.7)
LNG	0 (0.0)	3.0 (3.2)	18.9 (9.8)	43.0 (16.4)
Hydro	0.7 (1.5)	1.6 (1.7)	1.4 (0.7)	1.4 (0.5)
Nuclear	0.7 (1.6)	13.2 (14.2)	27.2 (14.1)	31.9 (12.2)
Others	2.5 (5.5)	0.8 (0.9)	2.1 (1.1)	6.1 (2.3)
Total	181.4 (100.0)	279.5 (100.0)	192.9 (100.0)	262.6 (100.0)

Note: Number in ( ) indicates the share in total energy supply

Source: Yearbook of Energy Statistics, 2011, KEEI/MKE

Imported steam coal actively replaced oil in the 1980s particularly in the cement industry and power generation sectors. Nuclear energy was also introduced with high emphasis on power generation since the 1980s for base-load generation. Natural gas was introduced in the form of liquefied natural gas (LNG) into the Korean energy market in 1987 as a fuel for the residential and commercial sector and also for cogeneration and district heating systems. However, oil still accounts for the largest share in Korea's total primary energy mix.

Figure 3-2 | Energy Mix Changes in Korea



The criteria for fuel diversification was not simply being out of oil but also included various factors, such as the long-term supply and price stability, economics, public acceptability, technology feasibility, and so on. For example, coal and nuclear were introduced for power generation because of their supply stability and price, while natural gas was adopted to reflectpublic acceptability and environmental reasons in urban areas. These criteria were the underlying concepts in energy supply-demand planning for the long-term and in designing implementation plans and policies in Korea.

Notably, the fuel mix in power generation changed markedly between 1980 and 2010. Since Korea's first reactor was commissioned in 1978, nuclear power generation has expanded rapidly and Korea is now the fourth most nuclear reliant country in the world. Korea has 21 nuclear power plants in operation at four sites. In 2010, nuclear plants generated 30.3% of total electricity supply. Coal and LNG were first used in Korea for power generation in the early to mid-1980s, with the first LNG fired power plant completed

in 1986 and the first bituminous coal-fired power plant completed in 1983. The shares of LNG and coal in total electricity generation reached 20.8% and 40.3% in 2010, respectively.

1.3.2. Energy Import Diversification

With regard to crude oil import sources, Korea's oil imports are mainly from the Middle East. Korea's crude oil import dependency on the Middle East fell to 81.8% in 1990 from 98.8% in 1980, when oil import sources were diversified. To encourage the diversification of crude oil supply sources outside the Middle East, the government offered subsidies of up to 90% of the additional transport cost of importing crude oil from non-Middle Eastern countries. However, policy to reduce the high dependency on Middle East has not been very successful and Korea is still highly dependent on the oil from that region. Another 13.9% of Korea's oil imports came from Asia, 1.4% from Africa and 0.3% from America/Europe. Despite the heavy reliance on imports from the Middle East, the countries of origin are relatively well diversified. By country, Saudi Arabia (33% of the total) was the biggest source of crude oil imports in 2011, followed by Kuwait (14%), Qatar (10%), United Arab Emirates (10%), Iraq (9%) and Iran (9%). Approximately 76.4% of Korea's crude oil imports are covered by long-term commercial contracts, which is beneficial in terms of security of supply.

Table 3-2 | Crude Oil Import Source in Korea

(Unit: million barrels)

		1980	1995	2000	2005	2010
Middle East	Volume	181	487	687	689	713
	Share (%)	98.8	77.9	76.9	81.8	81.8
Asia	Volume	1	82	112	112	152
	Share (%)	0.4	13.1	12.6	13.3	13.9
Africa	Volume	0	38	68	34	5
	Share (%)	-	6.1	7.6	4.1	1.4
America/Europe	Volume	1	18	27	8	2
	Share (%)	0.7	3.0	3.0	0.9	0.3

Source: Yearbook of Energy Statistics, 2011, KEEI/MKE

Korea started importing LNG in 1986 and is one of the world's largest LNG importers. Natural gas in the 1990s was imported mainly from the Asian countries such as Indonesia, Malaysia and Brunei. However, imports are well diversified with supply coming from approximately 16 producing countries. Imports from the Middle East haveincreased since

2000 when Korea started to import from Oman and Qatar, and the Middle East dependency for natural gas in 2007 was about 50.2% in 2010.

Table 3-3 | Natural Gas (LNG) Import Sources in Korea

(Unit: million ton)

	1986	1995	2000	2005	2010
Indonesia	0.1	5.3	6.1	5.5	5.5
Malaysia	-	1.0	2.4	4.7	4.7
Qatar	-	-	3.3	6.2	7.5
Oman	-	-	1.6	4.2	4.6
Others	-	0.8	1.2	1.7	10.3
Total	0.1	7.1	14.6	22.3	32.6

Source: Yearbook of Energy Statistics, 2011, KEEI/MKE

Korea is the world's second largest importer of coals after Japan. Although Korea's import sources of coal have been diversified, most imported coal has historically come from Australia, which has remained stable. Korea met the growth in demand for coal by dramatically increasing imports from China, which replaced imports from Indonesia and South Africa in recent years. However, it is expected that rapidly growing coal demand in China particularly for power generation will significantly reduce China's exports of coal in near future, so Korea may need to diversify its coal import sources from China including the Russia Federation and North America.

Table 3-4 | Coal Import Source in Korea

(Unit: million ton)

	1990	1995	2000	2005	2010
Australia	8	18	22	29.8	39.2
Canada	4	6	6	4.1	9.9
China	3	7	21	18.1	4.3
Russia	3	1	3	3.5	8.0
Indonesia	1	2	4	12.9	37.7
Other	4	8	5	0.9	7.0
Total	23	42	60	69.3	106.1

Source: Yearbook of Energy Statistics. 2011. KEEI/MKE

1.4. Strategic Oil Stockpiling

As a measure of short-term emergency preparedness, the Korean government developed the strategic oil stockpiling system in the 1980s. Korea's emergency reserves consist of both government and industry stocks.

Emergency oil stocks are held entirely in the national territory. Korea held approximately 175.7 million barrel (mb) of emergency oil stocks at the end of December 2011, equivalent to 189.1 days of 2010 net imports. This was composed of 89.6 mb of government stocks (held by KNOC) and 86.1 mb of industry stocks. Roughly 67.4% of the total stocks were held in the form of crude oil. Government stocks in Korea at the end of December 2011 were about 89.6 million barrels, accounting for slightly over half of the country's total stocks; 86.8% of the government stocks were held in the form of crude oil, while the rest included LPG (4.3%) and other refined products (8.9%). The government plans to increase its own oil stock levels to 101 mb by 2013. With regard to total industry stocks, these amounted to 86.1 mb at the end of December 2011: 47.2% was stored in crude oil and 52.8% refined product. Obligatory industry stocks may be commingled with operational and commercial stocks. A domestic ticket market does not exist in Korea.

Table 3-5 | Strategic Oil Stockpiling in Korea (as of the end of 2011)

(Unit: million barrels)

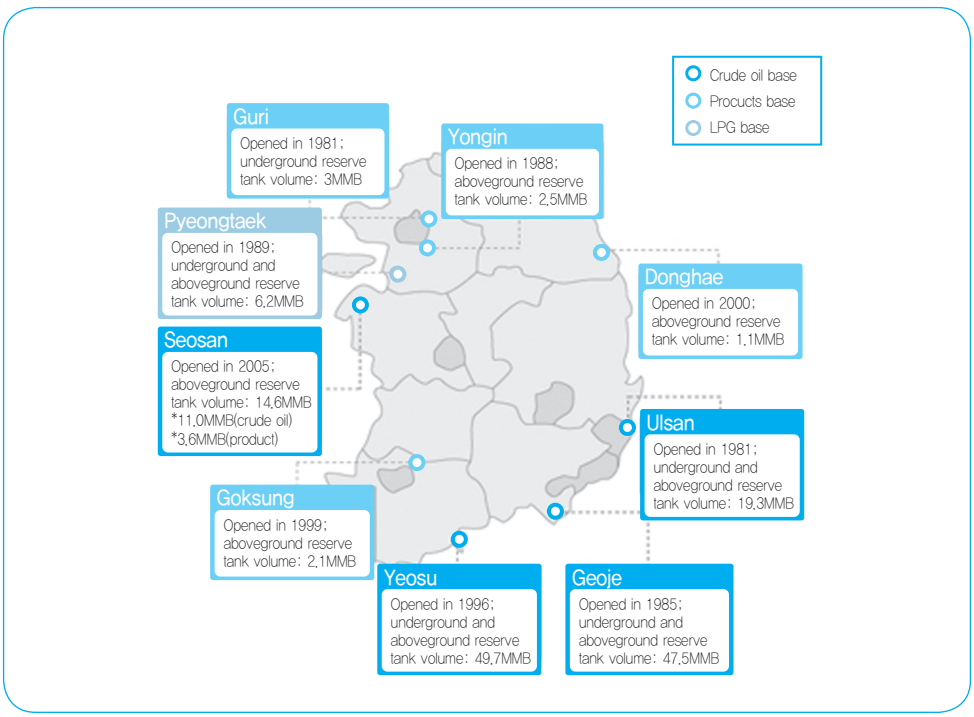
	Capacity	Stockpile reserve	Net import day (IEA standard)
Government	146.0	89.6	100.7
Industry	145.4	86.1	88.4
Total	291.4	175.7	189.1

The Korea National Oil Corporation (KNOC) was established to maintain and operate the government stocks. Under the Petroleum and Petroleum-Alternative Fuel Business Act, the government determined the amount of oil to be stored by oil companies doing business in Korea. Crude refiners are obliged to hold at least 40 days of stocks based on a 12-month average of their previous year's sales, though they generally hold between 60 and 80 days of industry stocks for operational and commercial purposes, in addition to the domestic stockholding requirement. The total domestic sales of the four refining companies averaged about 1 mb/d in 2011. In addition, product importers, LPG importers and petrochemical companies are required to hold at least 30 days of stocks, on the basis of their domestic sales.

The Ministry of Knowledge Economy (MKE) is the lead government body responsible for managing oil supply disruptions in Korea. The Petroleum and Petroleum-Alternative Fuel Business Act and the Korea National Oil Corporation Act form the legal basis for Korea's stockholding regime. Under these Acts, KNOC manages the state-owned oil emergency reserves. KNOC is responsible for monitoring quantities, qualities and locations of industry stocks, as well as collecting industry data. KNOC is authorized to visit commercial storage facilities to verify physical stock levels.

Concerning the initial set-up and capital costs of government stocks, the construction of government stockpiling facilities was funded by the central government budget. Costs to purchase the oil for government stocks were funded by the central government budget and KNOC's internal revenue. About 94% of Korea's government stocks were funded by the government. Operational costs of government stocks were also financed by the central government budget or KNOC's revenue. The Korean government does not provide financial support for building compulsory industry stocks. All refiners and importers must bear the operational costs of meeting emergency requirements internally. These costs are passed on to consumers.

Figure 3-3 | Oil Stockpiling Facilities in Korea



1.5. Energy Production/Supply Infrastructure Expansion

One of the most important aspects in energy security is to construct and expand energy production and supply facilities in timely manner to meet the increased energy demands along with economic and income growth. In Korea's case, the government policy set this policy objective as a high priority in the process of economic development in the 1980~2000's.

Table 3-6 | Energy Production/Supply Facilities in Korea

	Unit	1980	1990	2000	2010
Oil Refinery	million BPSD	640	840	2,438	2,935
PowerGen Capacity	GW	9.4	21.0	48.5	76.1
City Gas Customers	thousand	99.8	1,220.0	7,926.6	13,891
DH System Customers	thousand	-	40.2	980	1,590

Source: Yearbook of Energy Statistics, 2012, KEEI/MKE

Energy production capacity in Korea was expanded significantly; refinery facility was increased from 640 thousands BPSD in 1980 to 2,935 thousands BPSD in 2010, and power generation capacity from 9.4 GW in 1980 to 76.1 GW in 2010. The inter- and intra-city gas distribution networks were expanded along with the introduction of LNG since 1987, and thus the number of customers of city gas significantly increased from 99.8 thousand in 1980 to 13,891 thousand in 2010. Korea introduced district heating systemsfor the residential complexes in major cities in 1989, and the number of households receiving heat from the system rapidly increased and reached 1,590 thousand in 2010.

The expansion of energy production and supply (network) system is an important energy security measure particularly for the end-users because it guarantees the accessibility to the energy which they need and want to consume. Since the early 1990's, Korea has invested heavily to establishenergy network infrastructure, gas and oil pipelines and power transmission and distribution grids systems.The investments and construction were mainly made by the state-owned utility companies, namely the KOGAS (Korea Gas Corporation) and the KEPCO (Korea Electricity Power Corporation), although the oil and city gas industries in Korea have been completely privatized.

1.6. Overseas Energy Resource Development

With few domestic reserves of energy resources, Korea promoted overseas resource development in the upstream to strengthen the foundation of energy supply security. The

state-owned Korea National Oil Corporation (KNOC) is responsible for the exploration, development and production of oil and natural gas in the upstream. Private companies also have participated in overseas upstream business for oil and gas. The Korean government has encouraged private E&P overseas through tax benefits and the extension of credit lines to IOCs by the Korea Export-Import Bank, as well as by providing diplomatic aid in international negotiations.

Korean overseas resource development projects were launched in 1977. Since then, Korean companies have participated in 341 overseas oil and gas development projects, and currently, a total of 198 overseas oil and gas exploration and production projects are in progress in production fields in Vietnam, Indonesia, Australia, Canada and the Gulf of Mexico, in addition to exploration and development projects in several other countries.

Table 3-7 | Overseas Resource Development Projects in Korea

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Oil & Gas	109	122	128	141	166	209	244	275	301	341
〈On-going〉	51	55	56	65	83	123	155	169	180	198
Production	21	24	26	25	26	34	43	51	53	69
Development	10	9	6	7	9	12	14	17	27	25
Exploration	20	22	24	33	48	77	98	101	100	104
〈Terminated〉	58	67	72	76	83	86	89	106	121	143

With these projects, Korea has attained a self-sufficiency rate of 13.7 % for oil and gas, imports from the Korean equity projects, 52.2 % for coal, and 6.6 % for uranium.

Table 3-8 | Achievement of Overseas Resource Development Project in Korea

(Unit: %)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Oil & Gas	2.8	3.1	3.9	4.1	3.2	4.2	5.7	9.0	10.8	13.7
Coal	24.2	26.8	24.2	22.2	38.0	37.7	37.9	43.7	48.3	52.2
Uranium	-	-	-	-	-	-	-	1.1	3.5	6.6

1.7. Outcomes and Evaluation

The energy sector has played a key role in rapid economic development period in Korea over the last four decades, and securely allowed Korea's rapid rate of economic growth to be maintained. The Korean government set energy security as high priority in the energy

policy objective and promoted a wide range of policies regardingenergy security such as to diversify energy sources, to strengthen emergency strategic oil stockpiles, to expand energy production and supply facilities, and to encourage overseas energy development projects. This was particularly important given Korea's own limitedenergy resources. Energy policy increasingly reflected the need to enhance energy supply capability required in supporting the economic and industrial activities. Diversity of energy sources, enhanced energy producing facilities and storage infrastructure, and higher levels of oil stocks were established.

A broad range of policy initiatives were developed and implemented to achieve greater diversity in the energy supply mix from oil to coal, natural gas and nuclear. Given the continuously increasing demand for energy and its paucity of domestic resources, Korea imported energy sources from overseas. Korea could also choose cheaper energy sources such as nuclear, coal and natural gas, which are more stable in the international energy market than oil. Consequently, Korea was very effective in building a robust energy mix system to secure the energy supplies from overseas. In particular, Korea developed a strong nuclear power generation capacity. Nuclear power is a major component of Korea's energy mix for power generation, providing 29% of its electricity, and nuclear has been the main contributor to providing affordable energy, and lessening Korea's dependency on imports.

To guarantee a stable energy supply and strengthen energy security, Korea also successfully expandedthe domestic energy supply infrastructure. The positive aspect of this policy was that domestic supply infrastructures and nation-wide network for oil, gas, and electricity and district heating systems in urban areas established. Long-term plans for the natural gas and electricity sectors were also adopted, and Korea had a successful experience in establishing energy production and supply infrastructure system in a process of economic development over the past decades.

Korea meets its stockholding obligation to the International Energy Agency (IEA) by holding government stocks and by placing a minimum stockholding obligation on industry. Korea also emphasizedits energy security on expanding overseas resource development, as a national priority. Korea achieved energy self-sufficiency through strategic overseas resource development and Korean energy companies, including state-owned companies such as KNOC and KOGAS have made substantial overseas investments in the oil and natural gas supply chains.

However, negative results were that, due to energy-intensive economic structure and heavy reliance on fossil fuels, Korea was highly exposed to world energy market disruptions and international environmental movement. The state-owned ownership and strong government intervention led to energy market inefficiency that implies inefficient allocation of resources due to lack of fair competition in the Korean energy industry. Achievement of Korea's

energy security goal needs to be improved to be more efficient and effective if the steps taken towards a more competitive market-based approach are continued and accelerated. The government encouraged energy industries to facilitate market mechanisms, and thereby support energy policies that were conducive to the enhancement of ability to flexibly absorb possible sudden price or quantity changes.

1.8. Future Challenges

The necessity of energy security will increase steadily as Korea's demand for the energy required to sustain its economic growth expands. However, in this process, it is expected that Korea will encounter a number of internal and external challenges in the future. Internally, it will have to resolve the difficulties associated with securing sites for energy-related facilities in a timely manner. Externally, it is anticipated that various difficulties related to energy security will emerge, as the global energy market will be under constant pressure due to the increasing energy demands resulting from the rapid economic development of large-scale developing countries like China and India, OPEC's significant political clout, and intensified competition for clean natural gas.

Due to the steady rise in living standards and diversification of lifestyles, demand for high-quality energy is expected to increase rapidly in future. Thus, appropriate government measures will be required to ensure a steady supply of high-quality energy, including electricity and natural gas. In this regard, power plants and LNG storage facilities will have to be built and expanded in a timely manner to satisfy this increased demand for electricity and natural gas. In addition, with the vast majority of Korea's energy needs being satisfied by imports, effective government measures are needed to secure a reliable supply of energy resources.

Korea's ever-increasing demand for energy means that it will have to continuously import more energy from overseas sources in order to satisfy its growing needs. Therefore, Korea must strive to secure energy resources on a long-term basis by establishing energy supply bases in conjunction with energy-producing countries. Korea should undertake overseas resources development projects as national priorities, and establish a corporation that specializes in overseas energy exploration to overcome Korea's status as a latecomer in the areas of energy exploration and development. In this regard, target areas should be strategically selected and adequate support made available to facilitate the development of promising projects.

In particular, in light of steadily increasing demand for natural gas and electricity in the future, Korea needs to undertake efforts to develop a long-term transport network infrastructure with neighboring countries, which would involve coordinated endeavors to

trade natural gas and electricity among the countries in Northeast Asia by connecting Russia to the North and South Korean energy systems. The installation of pipelines and electricity supply networks as a part of energy cooperation projects, including the participation of North Korea, could well lead to the establishment of an integrated inter-Korean energy supply system, while also enhancing the energy security of both Koreas.

Korea's dependency on oil will remain much higher than those of other major OECD countries so it needs to find ways to reduce its reliance on oil through energy conservation or the increased use of alternative sources of energy. To curtail Korea's dependency on oil, it will be necessary to reinforce the resource distribution function of a petroleum-product pricing system, while encouraging the use of alternative fuels for the transportation and heating sectors. In addition, the existing heating systems utilized by individual households and industrial enterprises, centered on the use of petroleum fuels, should be replaced with local heating systems and natural gas for heating and air-conditioning to maximize energy efficiency. For transportation, accelerating the move away from oil based on further R&D on alternative energies, such as more efficient electric vehicles, compressed natural gas, and fuel cells are also needed.

Korea needs to formulate and implement comprehensive policy measures to establish a sustainable, long-term energy security system, while paying close attention to any developments in the domestic or foreign energy markets that might result in an energy crisis. In particular, rather than depending on government involvement and regulation, energy security should be attained via market mechanisms.

2. Fostering the Energy Industry

2.1. Background

In the process of economic development, energy supply is needed in an appropriate and timely manner. The oil and power industries need to be increased to enhance production and supply capability to meet the demand for oil product and electricity which increasewith the economic growth. Also to meet the increasing demand for clean fuels, the related energy industries, such as gas and community energy projects for district heating in large residential complexes and industrial parks should be introduced and established.

However, in the early 1960s, when Korean economic development was just beginning, the energy industry was very poor and limited. As the role of energy as an important input for economic development rapidly grew, the Korean government actively fostered the energy industry. The government initiated and helped the industry to expand the production of energy-supply facilities construction, to ensure an uninterrupted energy supply. Thanks

to the subsequent five-year economic development plans, which were also adopted in the early 1960s, energy supply facilities, such as oil refineries and power generation plants, greatly expanded and the energy sector became a pivotal driving force in promoting Korean economic growth.

2.2. Policy Approach

In general, the energy industry requires large-scale capital and advanced technology to build the infrastructure and so is by nature capital-technology-intensive. Therefore, in promoting the energy industry and facilitating the construction of energy infrastructure, large-scale capital investment and technology should be mobilized. In fact, in most cases, major market players in the energy industry are limited to a small number of players and the government ownership of energy firms a common to reach the critical mass necessary to proceed with massive projects. However, government can also act as the energy industry regulator to secure the public interest in the energy sector.

In Korea, the government became the energy providers as evidenced by Korea's state-owned power and gas companies (KEPCO and KOGAS). This was mainly to improve the efficiency of the energy industry than to meet a public interest. Actually in the early stages of Korea's economic development, the development of the energy industry was led by the government because of the weakness of the domestic capital market and technological back wardness, since the private sector at that time could not mobilize the necessary capital and technology.

By the 1970s and 1980s, the Korean government had long been actively involved in the energy sector, so that a secure, stable supply of energy reinforced economic growth. Then in 1978, the Ministry of Energy and Resources (MOER) was created to be responsible for planning and guiding all energy-related activities at the national level. The major reason for the heavy government involvement was to ensure that the energy sector was managed to provide low cost energy supplies to encourage and sustain economic development. Keeping energy prices low was viewed as being essential to ensuring industrial competitiveness and to supporting social welfare to ensure that all customers could access to reasonably priced energy regardless of its cost.

In general, with protected state-owned firms, not only was it easier for the infant energy industry to quickly attain the needed critical mass, but it was also easier for the government to controlvia central planning, than with private firms. To secure financing sources for energy related investments, the Korean government created the *Petroleum Business Fund* in 1980, which was turned in the current *Energy-Resources Business Special Account* in 1995. This fund was a major source of government investment for activities to enhance energy

security capability, including strategy oil stockpiling, subsidies and investment for overseas energy development, construction of energy infrastructures, energy R&D, and so on.

In the 1990s and 2000s, energy policy in Korea shifted to a new phase for the modernization of energy infrastructure, strengthening the market mechanism, and responding to increasing concerns about environment problems. In the 1990s, the government rationalized the domestic coal industry due to declining demand and low productivity, and instead actively invested for construction/expansion of nationwide natural gas and oil trunk pipeline systems as well as district heating systems for households use by utilizing waste heat from the combined heat and power (CHP) plants. These investments were undertaken to meet the public's demand for cleaner and efficient energy as their income increased.

In the late 1990s, the government began to recognize the importance of the market pricing mechanism in pursing energy security in a more efficient and effective manner. Thus, petroleum prices were completely liberalized in 1997. The government encouraged energy industries to adopt market mechanisms, and energy policies that were conducive to enhancing the ability to absorb possible abrupt price or quantity changes.

In sum, the Korean energy industry developed through three major approaches, 1) openness, 2) government's strong leadership, and 3) industrial structure based on market mechanisms.

2.3. Oil Industry Development

The oil refining industry in Korea was launched in 1964 with an initial capacity of 35,000 barrels per stream day (BPSD). Along with the increase in petroleum demand, the Korean refining sector expanded its crude distillation capacity. The combined crude refinery capacity of Korea's oil refineries stood at 2,925 thousand BPSD at the end of 2010, or about 84 times that of 1964, was also the world's sixth largest refinery capacity.

Table 3-9 | Oil Refining Capacity by Company in Korea

(2010, Unit: thousand BPSD)

	S K	SK-Incheon	G S	S-OIL	Hyundai	Total
Crude Distillation	840	275	850	580	390	2,925
Heavy oil cracking	175	-	215	148	70	603
Kerosene-diesel de-sulfurizing	252.8	87.5	272	120	144	875.5
Naptha reforming	45	40	106	45	25	261

Source: MKE (2011)

Domestic oil refiners also had secondary facilities, which included heavy oil cracking de-sulfurizing facilities (603 thousand BPSD), heavy oil de-sulfurizing facilities (145 thousand BPSD), naphtha reforming facilities (261 thousand BPSD) and kerosene-diesel de-sulfurizing facilities (875.5 thousand BPSD). As environmental regulations become more stringent, the maximum sulfur content permitted in heavy fuel oil decreased from 0.5 % to 0.3 % in July 2001.

Table 3-10 | Oil Refining Capacity in Korea

(Unit: million BPSD)

	1998	2005	2006	2007	2008	2009	2010
Crude Distillation	2,438	2,735	2,808	2,855	2,875	2,925	2,925
Heavy oil cracking	247	393	398	461	534	534.5	603
Kerosene-diesel de-sulfurizing	659	701	701	781	874	893.3	875.5
Naptha reforming	181	230	230	250	341	259	261

Source: MKE (2011)

Private companies such as SK Corp. (formerly Yukong), GS-Caltex (formerly Honam), S-Oil (formerly Ssangyong Oil) and Hyundai Oil dominate the Korean oil market. SK Corp. is 100% Korean-owned. Caltex owns a 50% stake of GS-Caltex. S-Oil is 35% owned by Saudi Aramco. The relatively young Korean refining industry operates very efficiently and is very competitive internationally.

The Korea National Oil Corporation (KNOC), a state-owned enterprise that engages in exploration, development and production of oil and natural gas, and builds and maintains

Korea's strategic oil stocks. The Daehan Oil Pipeline Corporation (DOPCO), which delivers oil products via pipeline to the Seoul metropolitan area, was privatized in 2000. DOPCO is the major oil pipeline company in Korea that is jointly owned by the four refining companies. It is responsible for operating the nationwide oil pipeline system consisting of six oil product pipelines which connect the refineries with major cities, airports, military bases and oil stockholding facilities..

There are technically no non-market barriers to entry into the Korean refining and retail markets by new competitors, or to their commercial access to the DOPCO pipelines. The oil industry is also subject to general business regulation by the Fair Trade Commission.

2.4. Gas Industry Development

Korea introduced natural gas in 1986 in the form of liquefied natural gas (LNG). Since then, demand for LNG increased steadily and significantly from 1.6 million tons in 1987 to 33.1 million tons in 2010. Korea currently relies on imported liquefied natural gas (LNG) for most of its natural gas, though it began producing a small quantity of natural gas from one offshore field from early 2004. Imports of LNG began in 1986, after the state-owned monopoly LNG importer Korea Gas Company (KOGAS) was founded.

The state-owned monopoly, Korea Gas Corporation (KOGAS),was created in 1983 as the LNG importerto manage the import, storage, transmission and wholesale distribution of LNG in Korea. For the gas retail market, there are twenty private gas companies whoare supplying gas to 13.9 million consumers nation-wide.

Table 3-11 | Existing LNG Terminals in Korea

Name	Owner	Regasification			Storage	
		Nominal capacity		Number of vaporizers	Capacity (mcm of LNG)	Number of tanks
		Mcm of LNG per year	Bcm per year of gas			
Gwangyang	Posco	3.9	2.4	2	0.365	3
Incheon	KOGAS	84.5	51.8	37	2.880	20
Pyeong-Taek		83.6	51.3	34	2.960	21
Tong-Yeong		36.7	22.5	12	2.480	16
Total		208.7	128.0	85	8.685	60

Source: Ministry of Knowledge and Economy (2011)

There are four LNG terminals operating in Korea. Three out of the four LNG terminals are owned and operated by KOGAS. The privately owned Posco, a steel mill owner, operates an LNG terminal in Gwangyang to support its power plant and also to supply a K-Power-owned plant. The four terminals are currently able to supply the national gas transmission system with about 33 million tons of natural gas per year. Currently, despite recent reform efforts, third-party access to the LNG storage facilities, transmission network and LNG terminals owned by KOGAS is relatively limited.

Figure 3-4 | Natural Gas Infrastructure in Korea

At the end of 2011, Korea had 60 tanks at four LNG terminals, with a total storage capacity of 8.7 mcm of LNG. The total storage capacity was able to meet about 42 days of average gas demand in 2010 and 22 days of peak gas demand in the same year. KOGAS owns approximately 97% of the country's total storage capacity at its three LNG terminals in Incheon. Pyeong-Taek and Tong-Yang, while the remainder is held by POSCO at its LNG Terminal in Gwangyang.

Korea does not have any cross-border gas pipelines. The nationwide transmission pipelines, totaling to 3,099km in length, are all owned and operated by KOGAS.

Table 3-12 | LNG Demands in Korea

(Unit: thousand tons)

	1987	1990	1995	2000	2001
City Gas	–	575	3,413	9,528	17,571
Power Generation	45	1,741	3,606	4,688	15,300
Own use	8	12	100	340	213
Total	53	2,328	7,118	14,557	33,083

Source: KEEI/MKE, 2011, Yearbook of Energy Statistics

LNG is mainly used in electricity generation and gas which is made from LNG, and used as a fuel for cooking and space heating in the residential and commercial sector. Demand for LNG in the production of this gas has increased from 0.6 million tons in 1990 to 17.6 million tons in 2001. Demand for LNG in power generation increased from 1.7 million tons in 1990 to 15.3 million tons in 2010. Compressed natural gas (CNG) is used in vehicles in Korea, as the government embarked on the program to introduce intra-municipal CNG buses in operation by end of 2002 in major Korean cities.

2.5. Electricity and Power Development

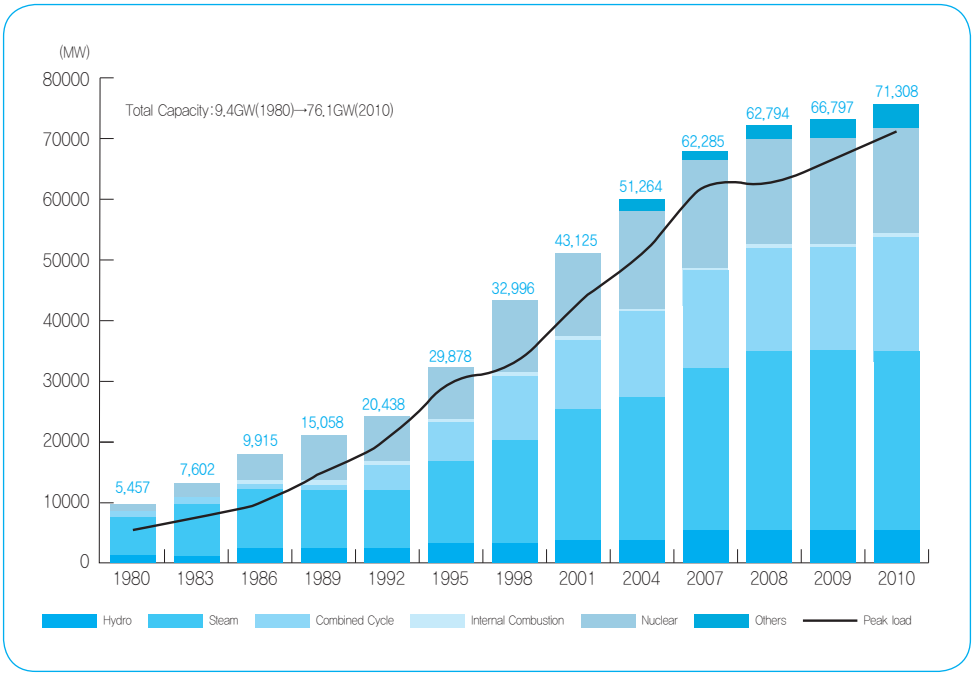
The electricity sector in Korea grew rapidly to ensure that electricity was supplied reliably to facilitate the industrial development of the Korean economy. Electricity generation capacity increased more than around eight times since 1980, from nine gigawatts (GW) in 1980 to 76 GW in 2010. Gross power generation also increased significantly from 37 terawatt-hours (TWh) in 1980 to 475 TWh in 2010, in line with increases in demand for electricity. In Korea's installed capacity of 73.1 GW in 2010, coal (24.2 GW) was the largest source, followed by natural gas (20.0 GW) and nuclear (17.7 GW). The generation capacity also contains a small amount of hydro (5.5 GW) and oil-fired capacity, (5.9 GW) and a very small amount of new and renewable energy (excluding hydro).

Table 3-13 | Electricity Generation in Korea

	1980	1990	2000	2010
Capacity (Mw)	9,391	21.021	48,451	73,078
Gross Generation (Gwh)	37,239	107,670	266,400	474,660

Source: KEEI/MKE, 2011, Yearbook of Energy Statistics

Figure 3-5 | Power Capacity by Type in Korea



The fuel mix in electricity generation changed markedly between 1980 and 2010. Oil was the major fuel for power generation in Korea prior to 1980, but declined in importance from 79% of total electricity generation in 1980 to 3% in 2010. LNG and bituminous coal were first used in electricity generation in the early to mid-1980s, with the first LNG fired power plant completed in 1986 and the first bituminous coal fired power plant completed in 1983. The shares of LNG and coal in total electricity generation reached 21.20% and 45.2% in 2010, respectively. Domestic anthracite coal was used for a small portion of coal-fired generation. Of all the fuel types available, nuclear power increased most sharply between 1980 and 2010, and is now the major energy source for electricity generation in Korea, accounting for 29% of total power generation in 2010. Hydropower is also used to meet peak demand, but its share in total generation was only 0.9% in 2010.

Table 3-14 | Fuel Mix in Electricity Generation in Korea

(Unit: %)

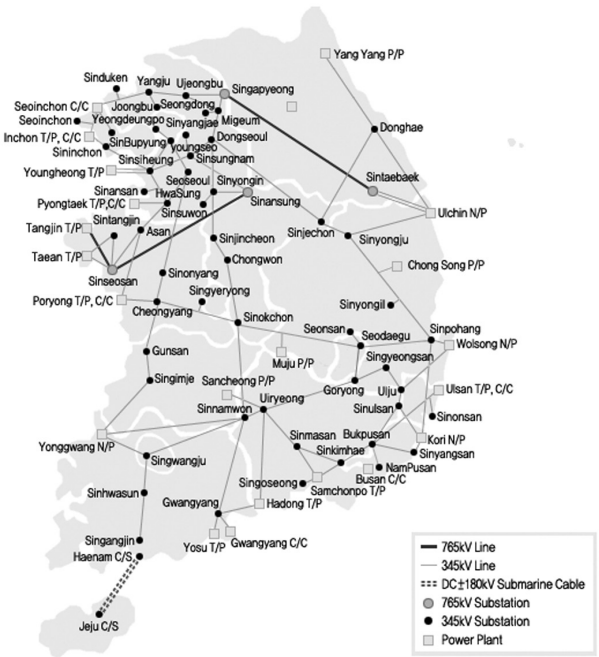
	1980	1990	2000	2010
Oil	78.7	17.6	9.8	2.9
LNG	–	8.9	10.6	21.2
Coal	6.7	18.5	36.6	45.2
Nuclear	9.3	49.1	40.9	29.1
Hydro	5.3	5.9	2.1	0.9

Source: KEEI/MKE, 2011, Yearbook of Energy Statistics

The electricity industry in Korea is dominated by the Korea Electric Power Corporation (KEPCO), a major state-owned utility power company that owned 94% of generating capacity and 100% of transmission and distribution. The Korea Electric Power Exchange (KPX) was established in April 2001 as a non-profit corporation responsible for operating both the electricity system and the electricity market.

KEPCO's generation division was divided into one nuclear-hydro company and five companies that use fossil-fuel or pumped storage generation. The five non-nuclear generation companies are: Korea South-West Power Co. Ltd (KOSEPCO), Korea Midland Power Co. Ltd. (KOMIPO), Korea Western Power Co. Ltd. (KOWEPCO), Korea Southern Power Co. Ltd. (KOSPO), and Korea East-West Power, Ltd. (KEWESPO). The number of companies was determined partly by the need to balance a minimum scale of efficiency with the risk of collusion if too few companies were created. The companies were divided relatively equally so that each would have a similar mix of generating capacity by fuel type and location. Both foreign and domestic firms invested in the new power generation companies. The nuclear power generation company known as Korea Hydro and Nuclear Power Co. Ltd. (KHNP) remained a state-owned company. It owns and operates the nuclear power plants in Korea as well as the hydropower generation capacity.

Figure 3-6 | Power Generation and Transmission Infrastructure in Korea



KEPCO owns and operates the national power grid and all of the distribution networks. The transmission network is approximately 31,250 km long including 835 km of 765 kV lines, 8,653 km of 345 kV lines and 21,530 km of 154 kV and below lines. The majority of transmission lines in the country have a capacity of 154 kV, but transmission voltages can be 154 kV or 66 kV for local networks, although many of these smaller lines are now being replaced. Transmission lines tend to run from the north-western and south-eastern coastal regions, where much of the generating capacity is located, to major urban and industrial centers in the north-west while submarine high-voltage direct current (HVDC) cables connect the island of Jeju in the south to the mainland.

2.6. Domestic Coal Industry

Anthracite coal is Korea's only domestic fossil fuel. In the 1960s and 1970s, the government took a series of measures to promote coal production, to meet the sharp increase in energy demand. The government has subsidized the domestic coal mining industry since 1967 to increase domestic energy security. As a result, the coal mining industry has made

great progress and by 1987, there were 363 mines producing 24 million tons of anthracite coal.

Anthracite was one of the principal energy sources in the residential and commercial sector, since it was easily adaptable to small-scale uses, including low-sulfur content and good bonding characteristics for making briquettes. Anthracite coal was used mainly for space heating in the residential sector, though this has been largely replaced by oil, gas and district heating systems. As a result, anthracite demand significantly declined over the last two decades.

Table 3-15 | Production of Domestic Anthracite Coal

(Unit: million tons)

	1980	1985	1990	1995	2000	2010
Production	18.6	22.5	17.2	5.7	4.2	2.2

Source: KEEI/MKE, 2011, Yearbook of Energy Statistics

The coal mining industry began to decline from the latter half of the 1980's because the demand for anthracite coal decreased rapidly. Also, most of the coal mines are located in mountainous areas, and require labor-intensive underground mining. Production costs are higher than those of imports because low levels of mechanization and generally thin seams keep productivity low.

Consequently, the Korean government actively promoted the rationalization of the anthracite coal industry, encouraging and assisting uneconomic mines to close down with assistance from theCoal Industry Promotion Board (CIPB) which was established in 1987. The government providedgrants to mines opting to close down, and it also paid benefits to miners who lost their jobs as a result of mine closures. As a result of the rationalization, 384 mines with a combined production capacity of approximately 14.2 million tons closed and 33,427 miners left the industry between 1989 and1995. Most of the mine closures to date have been privately owned, small scale operations. By 2010, there were only three coal mines in the industry, and the production of anthracite coal decreased to 2.1 million tons in 2010 from 24 million tons in 1987.

2.7. Outcomes and Evaluation

The energy industry in Korea has successfully developed to play a significant role as a driving force for the growth and industrialization of the economy. Given few domestic energy resource reserves, the energy industry in Korea was developed using three major

approaches, 1) openness, 2) government's strong leadership, 2) industrial structure based on market mechanisms. Also, Korea's energy production and supply facilities are among the best in the world, as the most advanced technology was introduced when the energy facilities were installed.

Korea was the world's tenth largest energy consumer in 2010, and with its lack of domestic reserves, Korea is one of the top energy importers in the world. The country is the fifth largest importer of crude oil, the third largest importer of coal, and the second largest importer of liquefied natural gas (LNG). Korea Gas Corporation is the largest single LNG importer in the world and the world's third-largest importer of hard coal behind Japan and China. Korea is also a home to some of the largest and most advanced oil refineries in the world.

The government maintains its strong position in the electricity and wholesale side of gas industries in Korea. In the early 2000s some tentative steps were taken to introduce liberalized natural gas and electricity markets, although more effective regulation of electricity and gas markets were taken recently. The state-owned power company, KEPCO, retains a near-monopoly position in transmission, distribution and retail, and owns the six main generating companies. At the same time it is losing money because electricity prices do not fully reflectmarket conditions. In the gas sector, the implementation of third-party access and the introduction of competition in the import of natural gas represent progress, but KOGAS retains an almost 95% share of the import market and controls the transmission network and three of the four LNG import terminals, which makes it difficult for others to enter and compete in the domestic market. Full unbundling would further promote competition. There is further progress to be made to fully liberalize the energy industry in Korea.

For a country like Korea that imports all of its required energy sources, an energy crisis is usually believed to originate from external factors. However, factors impeding energy security are not only from external sources, but also could rise internally from domestic market. For example, stability of energy production and supply to the market could be constrained without having proper capital investment for energy production and/or distribution facilities and infrastructure. So the achievement of energy security objectives needs to be accomplished by improving the market environment for industry rather than direct involvement and control of the government.

2.8. Future Challenges

Corresponding to the higher demand for energy, the need for new facilities will also increase as people seek to ensure a reliable supply of energy. Since an increased demand for energy will mean a higher demand for electricity, oil, and gas, new facilities will have to be constructed to increase their production capacity. Moreover, as part of the restructuring of the electricity and gas industries, energy supply facilities and related infrastructure will need to be built in a timely manner by expanding private-sector cooperation, sharing the roles between the state-owned enterprises and the private sector, with the promotion of market mechanisms. It is highly likely that discrepancies may arise in the energy supply as a result of domestic factors, such as excessive regulation and a lack of investment capital for the sector. As a result, during the process of restructuring the energy industry, investment-inducement measures should be introduced along with a streamlining of the regulatory system, while consumers are encouraged to conserve energy and use alternative energy resources.

Given the difficulties associated with securing sites for energy-related facilities, the current energy system should be converted into a small-supply system including agreater dispersal of consumption areas. The demand for additional energy-supply facilities needs to be gradually reduced by improving energy efficiency and conservation efforts. At the same time, an environmentally friendly supply and demand system should be established by developing clean energy, along with the environmental technology to maximize energy efficiency, to prepare for more stringent domestic and external environmental regulations in the future.

3. Building of Policy Infrastructure

3.1. Background

The responsibilities for energy policy development and implementation are spread across a number of government institutions. In addition, the government is planning to establish a National Energy Committee, to be chaired by the President and to include non-governmental experts, to deliberate and mediate major energy policies and plans.

3.2. Government and Regulatory Institutions

3.2.1. Relevant Governments

The Ministry of Knowledge Economy (MKE) is the primary government body for energy policy. Within MKE, the Energy Policy Office handles most energy matters, nuclear energy. Overall, MKE is the main agency for energy policy planning, supervision of the industrial sector, climate change matters and price controls, among others. Transport issues are mostly handled by the Ministry of Construction & Transportation while policy related to finance and taxation is generally the responsibility of the Ministry of Finance & Economy.

As part of its liberalization efforts, Korea established the Korea Electricity Commission (KOREC) in 2001, to regulatethe electric power sectorunder the Electricity Business Act. It now regulates generation, transmission, distribution, independent power producers (IPPs), generation companies and the Korean Power Exchange (KPX), in addition to overall industry functions. While KOREC is under MKE, deliberations and decision-making activities such as authorization and licensing of electricity businesses are conducted by KOREC's committee without government intervention. While a secretariat attends to the affairs of KOREC, KOREC and MKE share staff. KOREC's nine commissioners are appointed by the President on the recommendation of MKE, and cannot be dismissed except in cases of dereliction of duty or imprisonment. Final decisions are made by MKE following the rulings or deliberations of KOREC; normally MKE's minister does not overrule KOREC'sdecisions.

The Fair Trade Commission (FTC) is Korea's anti-trust agency, monitoring monopoly problems and unfair business practices, whereas KOREC manages technical and professional competition policy. Since 2001, the FTC and KOREC have had memoranda of understanding outlining their respective roles, duties and functions in the electricity industry.

3.2.2. Semi–government Institutions

The Korea Energy Economics Institute (KEEI) develops energy policies related to the production of energy statistics and demand and supply overviews, energy conservation and climate change, the petroleum industry, the gas industry, the electricity industry and the new and renewable energy industry, among others. It is financed directly by the government.

The Korea Institute of Energy Research (KIER), a government-funded research institution, is Korea's major energy technology research institute and aims to develop technologies in the energy sector. It is divided into five major research departments: energy conservation, energy efficiency, energy environment, new and renewable energy, technology expansion.

The Korea Energy Management Corporation (KEMCO) plays a key role in achieving Korea's research and development (R&D) policy goals for energy efficiency, energy conservation, clean energy and new and renewable energy technologies. It also manages R&D planning and financial support and management. Within KEMCO, the New & Renewable Energy Centre (NREC) works on R&D in the renewables field. The Korea Atomic Energy Research Institute (KAERI) conducts studies related to nuclear power.

3.3. Energy Laws

The Energy Law defines basic matters for the establishment and enforcement of energy policies and energy related plan to secure stable, efficient and environment friendly energy demand and supply.

The major points in the law are:

- Establishment of regional energy plan
- Establishment of energy emergency plan
- Organization and operation of National energy committee
- Establishment of Energy technology development plan

Special Account Law for Energy and Resources Projects governs the installation of special account to promote efficient expedite of energy and resources projects and stable energy demand and supply and price.

The major points of the law are:

- Tax revenues and expenditures
- Transfer general account to special account
- Revenues and expenditures of loan account

New and Renewable energy development, utilization, diffusion promotion law secures diversification of energy source, stable supply of energy, environment friendly energy structure and GHG reduction through promotion of development, utilization and diffusion of NRE.

The major points of the law are:

- Establishment of basic plan for NRE
- Organization and operation of NRE policy screening committee
- Development of fund NRE technology development and diffusion

• Mandatory installation of NRE facilities

• Certificate of NRE facilities

• Feed-in-tariff for electricity generating NRE

• Making our NRE statistics

• Establishment of NRE Center

The Energy use rationalization law contributes to sound progress of national economy, the public welfare and GHG reduction throughout stable energy demand and supply and rational use of energy.

The major points of the law are:

• Basic plan for rational use of energy

• National committee for energy conservation

• Implementing plan of rational use of energy

• Measures for stable energy demand and supply

• Investment plan for demand side management (DSM) of energy supplier***

• Consultation on energy supply and rational utilization plan

• Financial, tax support system

• Policy measures for energy consuming facilities

• Policy measures for rational use of energy in industry and building sector

• Management of heat consuming facilities

The Collective energy business law contributes to energy conservation and the public'swelfare through rational installation and operation of collective energy business.

The major points of the law are:

• Basic plan for the supply of collective energy

• Financial support to supplier

• Permission of collective energy business

• Responsibility of heat supply

• Technical standard

• Safety management

• Establishment of Korea District Heat Corporation (KDHC)

The oil and oil replacing fuel business law contributes to the progress of national economy and the public's welfare by securing stable oil demand and supply and price and quality of petroleum products and its replacing fuel.

The major points of the law are:

• Forecast of oil demand

• Registration of oil refinery business, oil sailing business, oil export and import business

• Imposition of penalty

• Establishment of oil stockpiling plan

• Instructions for emergency oil demand and supply

• Quality management of oil products

• Establishment of Korea Institute of Petroleum Management (KPETRO)

• Oil replacing fuel business

The City gas business law protects consumer's profits and to secure rational development of gas business, and also to secure public safety through definition of the installation, maintenance, safety management of gas supplying facilities and gas utilizing devices.

The major points of the law are:

• Permission of city gas business

• Natural gas export and import business

• Gas supplying facilities and utilizing devices

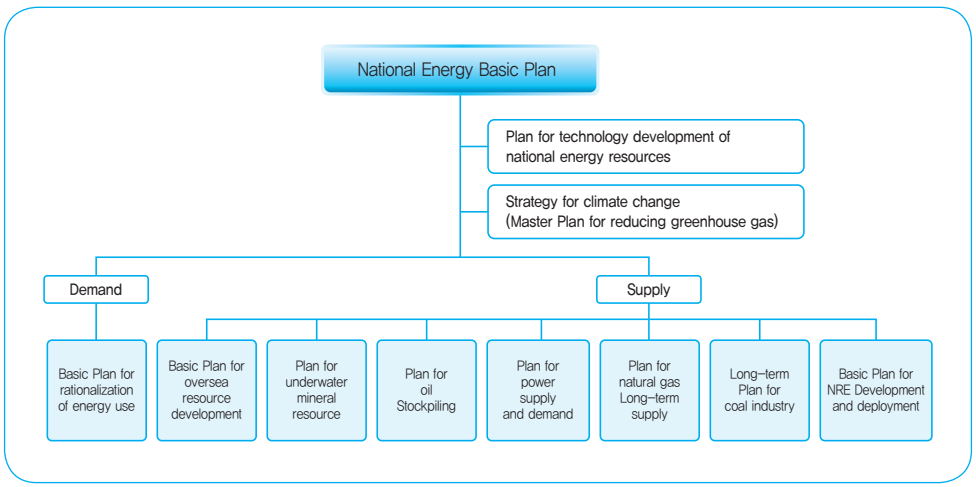
3.4. National Energy Basic Plan

3.4.1. Background

Most major economies periodically establish mid- and long-term national energy strategies because energy is recognized as a key strategic commodity. Most salient among them are the U.S.A.'s New Energy Policy (2006), Japan's New National Energy Strategy (2006), EU's Energy Strategy Report (2006), and China's Mid- and Long-Term Development Plan (2004). In response to this global trend, Korea established a 25-year National Energy Basic Plan. The time horizon of the latest plan ends in 2030. This basic plan is the highest level in the hierarchy of basic plans under which there are many other sub-level energy-related plans.

The plan includes policies to minimize energy-related factors which damage the environment and contributes effectively to achieving national energy policies to expedite the development of energy related technologies. The basic plan covers all fields related to energy. It is systematically connected with other energy related plans and is coordinated at a high level. The plan has priority over other energy-related plans and provides principles and directions for the sub-plans in each energy source and sector. The plan is subject to intensive consultation in which the government collectsopinions from government agencies, suppliers and citizens' bodies with the aim to reach a consensus.

Figure 3-7 | Structure of Energy Basic Plan



The First Basic Plan for Energy, established in 2008, covers the following:

- Schemes to stably secure, introduce, supply and manage energy
- Schemes for the supply and use of environment-friendly energies like new and reproduced energies
- Schemes to reduce greenhouse gases emission through rationalizing the use of energy
- Schemes for safe energy management
- Developing and diffusing energy-related technologies
- Fostering energy-related professional human resources
- Promoting international harmonization and cooperation in connection with energy policies and the related environmental policies
- Developing and using domestic energy resources

Since the plan is published every five years, the Second National Energy Basic Plan will be developed towards the end of 2012.

3.4.2. Basic Policy Directions of the First National Energy Basic Plan

The primary goals of the basic plan were: (1) to improve energy intensity by 47 % and reduce dependence on fossil fuels; (2) to increase petroleum and gas independent development rates from 4.2% in 2006 to 40% in 2030; (3) to expand the new and renewable energy share from 2.4 % in 2006 to 11 % in 2030 by investing in R&D and equipment; and (4) to develop nuclear energy as a realistic alternative to reduce greenhouse gas (GHG) emissions.

The National Energy Basic Planalso contains energy safety and welfare system policies to safely use the minimum energy required for people of all social stratum to live. Energy welfare policy is to implement mid- and long-term programs to reduce energy costs of lower-income classes. These efforts are expected to achieve gas supply rates by 85%, implement energy efficiency improvement projects for 800,000 houses by 2030 and enhance the safety policy for lower-income classes' use of electricity.

3.5. Statistics

Energy statistics provide energy planners and analysts with basic means and information required in energy planning and in establishing energy policy development and assessment and also in conducting research related to energy market and industry. Thus, creating an energy database as an instrument for evidence-based energy policy for the country could be a valuable asset, in the sense that it could enable policy makers to analyze actual data on current and future energy trends as well as to identify policy issues facing the country.

An energy database is a systematic and integrated set of data and information related to activities of production, transformation and consumption of energy. Therefore, it contains a wide array of data including, for example, data on consumption by fuel source and demand sector, data on production by fuel source and data on transformation.

A typical format of an energy database is an energy balance table which presentsthe physical flows (input/output) of energy from its primary base through the transformation processes to final consumption. For an energy database to be comprehensive in terms of scope, it could also include information on variables which affect the energy system, for example, macro-economic performances, sectoral economic activities, industrial structures, prices, income, demographic factors, technology, environmental burdens related to energy production and consumption, and so on. At the same time, the coverage of an energy database could be extended to includequalitative data, such as the government policy, regulations and socio-economic conditions, as necessary.

The design and identification of data required for an energy database depends on policy issues to be addressed and analyses to be carried out in the planning process. An energy database is not an end in itself but is an important instrument for use in energy planning, which couldhelp analysts and policy makers to identify, generate and compile information required for energy analysis and decision making. The planning process became more sophisticated and more interactive. The development of energy database is an important task in the energy planning process, and there is an interdependent relationship between database development and energy planning.

In Korea, the Korea Energy Economics Institute (KEEI) in collaboration with the government and other relevant institutescompile a comprehensive energy database, which include energy supply and demand statistics and, the domestic and international energy-related indicators, and has published the Yearbook of Energy Statistics from 1983 on an annual basis. This Yearbook is Korea's only comprehensive publication of national energy statistics, covering total energy demand, energy source supply and demand, price, energy facilities, mineral resources, and so on.

In December 1979, the government enacted the Energy Use Rationalization Act to mandate the conduct of Energy Census every three years. The objective of the Energy Census is to investigate the energy demand end-use sector in more details. The Korea Energy Economics Institute conducts the Energy Census every three years, starting with the first Census done in 1981.

3.6. Outcomes and Evaluation

In relation to the policies are concerned, Korea has one of the best policy infrastructures in the world. Over the last half century, the policy infrastructure has evolved from a very straight forward government-led command and control system to an incentive- and market-based approach. There have been a number of various policies developed and implemented in response to changes in the energy market and the domestic and global industry. The current policy infrastructure is the result of the Korean government' songoing efforts in collaboration with relevant research institutes and academia. Policies are dependenton their respective legislation. In this regard, the Korean government has been very effective in mobilizing experts to draft laws and collaborating with the Ministry of Government Legislation and the National Assembly.

The basic elements to build a good policy infrastructure are responsible governmental organizations, legal framework, financing source, human resources and relevant statistics and database. Fortunately, Korea is equipped with these resources and has developed a very effective policy infrastructure. In every sector of energy, policies are introduced and

implemented with the associated support of legislation, adequate finance, human resources, and relevant statistics and databases. For example, Korea Energy Economics Institute (KEEI) has been working on the National Energy Basic Plan and the Basic Plans of NREs, Rational Use of Energy, Overseas Resource Development and Import, etc.

Energy policies in Korea are hierarchically positioned based on their priority, importance and relevant sectors. As previously mentioned, the National Energy Basic Plan is placed at the forefront and at the top of policy framework, governing all sub-level energy policies. These policies are developed in synchronization with each other. However, each policy has its own agenda to address and schedule to follow, so there has been no close interaction between them as they devise and implement their policies and plans. To derive synergy among the basic plans that deal with overlapping and common issues, they need to interact. In recent years, there have been efforts to avoid this mistake by inviting the collaboration among experts or staffs from multiple task forces.

4. Technology Development: Introduction and Indigenization

4.1. Background

As illustrated in Chapter 2, Korea's energy technology policy went through a long and tedious evolutionary process though it was only in the middle of 2000s that energy technologyper sebecame one of the top-priority policy issues in Korea's energy policy arena. The heightened awareness among policy actors of the strategic importance of technological advance was the impetus brought it from the periphery to the core policy agenda. Several external and domestic events triggered this change: the rapid rising trend in world oil price and the Kyoto Protocol in 2005, followed by the regulationson global warming gas emissions, the need for a technology-oriented break through strategy to further develop the energy industry, and the growing public voicesupporting sustainable growth. The full-fledged evolution began in 2006 when the first National Energy Technology Development Plan (2006~2015) was adopted by the National Science and Technology Committee.

4.2. Policy Objectives

The overall objective of Korea's energy technology policy is to develop the technological competitiveness of Korea's energy-related industries to the level of advanced nations and, thereby, realize the sustainable growth. The specific objectives, as detailed in the second National Energy Technology Development Plan (2012~2020), are to achieve the strategic targets by the year 2020: to improve overall energy efficiency by 12%, to reduce the emission of global warming gases by 15%, to create about one million new employment

opportunities, and to develop NRE industries equipped with advanced technological capabilities. To achieve these objectives, hundreds of R&D projects are being promoted under the long-term technology development road map. The projects have been categorized into four major fields: energy efficiency, NRE sources, clean fossil fuels, and power generation and nuclear energy.

4.3. Institutional Arrangements

A combination of laws formsthe institutional platform for policy promotion. Among themare: the Energy Law (2006), the Energy Use Rationalization Law, the Electricity Business Law, the Atomic Energy Law, and the Korea Institute of Energy and Resources Research Law. In particular, the Energy Act requires the government to formulate a long-term energy technology development plan every five years and implement it.

Many organizations take part in the policy formulation and implementation process. First, responsibilities for energy technology R&D are shared between the Ministry of Knowledge Economy (MKE) and the Ministry of Education and Science (MES). While the MES is responsible for the nuclear and fusion energy fields, the MKE handles the other fields including nuclear power generation. Second, many research institutes, state-owned corporations, private companies and universities participate in the policy process and overall R&D activities. Third, the Korea Energy Technology Evaluation and Planning Institute (KETEP) was established in 2007 with the mission to develop a long-term technology development road-map, and to manage the overall R&D projects by evaluating, coordinating and allocating funds under the oversight of the MKE.

4.4. Policy Measures

Various policy measures are employed to promote technological innovation and commercialization activities: investment of the government's R&D budget, employment of financial and tax incentives for investments, creation of markets for new technologies, creation of informed consumers, and creation and improvement of infrastructure for technological innovation.

4.4.1. Investment of Government R&D Budget

Since the first National Energy Technology Development Plan was established in 2006, the Korean government's R&D investment budget has increased rapidly at an annual growth rate 19%: from 521 billion KRW in 2006 to 1,007 billion KRW in 2010. This made Korea the sixth largest nation in the world in terms of annual government R&D investment in energy technology (the third highest nation in terms of investment amount per GDP

ratio). The budget is allocated to R&D actors such as private industries, research institutes, universities and consortiums.

4.4.2. Employment of Tax and Financial Incentive System

Various types of financial and tax incentive are provided to actors to promote investments in R&D and commercialization of new technologies.

4.4.3. Creation of Market for New Technologies

One of the government's principal means of promoting technological innovation is through the creation of initial purchasing markets for newly developed technologies. The typical examples employed in Korea are the differentiated feed-in tariff program (FIT) for electricity generated from NRE sources, the renewable portfolio standard program (RPS) with green certificate, the mandatory purchase and utilization program and the inter-governmental partnership program for local energy development between the central and local governments.

4.4.4. Creation of Informed Consumers

The government also operates a number of education and information programs to enhance the public awareness of innovative technologies.

4.4.5. Building &Improvement of Infrastructure for Technology Innovation

Lastly, the government promotes policy tools and programs to build and improve the infrastructure for technological innovation. The cultivation of capable human resources and the promotion of international cooperation in the field of energy technology are among them.

4.5. Policy Outcomes

Considering the long-term nature of energy technology development cycle, it is too early to assess the policy outcomes and work continues towards achieving the objectives set for the next decade. Also, skepticism remains about the feasibility of the long-term roadmap with many experts criticizing the inefficiency of the government R&D budget allocation. However, there are emerging signs that progress towards objectives has been made. For example, the level of overall technological capability was assessed to have risen from 60.2% of the advanced group to 69% between 2006 and 2010. Another example is the export of NRE technologies which rose to 4.6 billion dollars in 2010 from 1.9 billion dollars in 2008. Also, it was assessed that a macro-economic worth the equivalent of 4,025 billion

KRW was realized by commercializing innovative R&D products (commercialization ratio 24%: 172 projects among 717 attempted), and a total 5,412 new jobs were created.

5. Energy Conservation and Energy Efficiency

5.1. Background

Since 1993, Korea has developed five-year Rational Energy Utilization Basic Plans which are revised at the end of each five-year period. The fourth Basic Plan was announced in 2008, and set the target to improve energy intensity 11.3% by 2012, while introducing various measures to achieve this target. The target of the 3rd Basic Plan in 2004 targeteda 7% reduction in the expected total primary energy consumption in 2008.

The Ministry of Knowledge Economy (MKE) announced several energy savings measures to encourage the general public to conserve energy voluntarily. Among these measures were a series of energy conservation campaigns called the Voluntary Energy Conservation Campaigns,were launched to reduce heating fuel consumption, which accounts for about 13% of the nation's total energy use. In particular, the public campaigns were organized to promote energy saving habits such as keeping room temperatures between18C° and 20C° during winter and wearing thermal underwear to stay warm. According to MKE, if households, businesses, and organizations lowered room temperatures by 3C° during winter, the nation's energy consumption would fall by 20% which would translate into savings of about 1.5 trillion KRW.

The government designated the Energy Week, which featured exhibitions to highlight the need for energy conservation and introduce various energy saving tips. Furthermore, the government urged energy-intensive industries to enhance energy efficiency of their products. In addition, MKE and the Board of Audit and Inspection of Korea formed a task force to examine 660 state-owned and private organizations to measure their progress in implementing the voluntary energy saving plans.

5.2. Policy Tools

5.2.1. Voluntary Agreements

The Korean government has been implementing voluntary agreements (VAs) since 1998 as a major element of its energy efficiency strategy. Under VAs, the government conducts a preliminary energy assessment after which a company sets its own energy conservation targets, proposes implementation methods and executes the plan. The government, in turn, provides incentives in the form either of direct financial support or tax incentives. Voluntary

agreements are for five-year periods and the target indicator is the efficiency improvement rate or the emissions reduction rate of CO_2. There are no penalties for non-compliance, although companies that do not comply with the standards will be publicly named and may lose incentives. To date, 80% of companies that collectively consume two thousand tons of oil equivalent (kTOE) or more have signed VAs.

With 1,288 companies taking part in the program, or nearly 60% of the total industrial energy consumption, government analysis shows that 990 companies have made some progress towards their commitments, representing savings of about 1.76 MTOE. The government has spent 645.2 billion KRW on incentives over the life of the program. Currently voluntary agreements do not have an additionality requirement such that government incentives only reward improvements above what would happen in a business-as-usual scenario. The government is considering imposing such an additionality requirement or providing enhanced incentives for stretch goals.

5.2.2. Energy Audits

By measuring and analyzing the actual use of energy in large companies or buildings that consume significant amounts of energy, loss factors were determined and improvement measures proposed. The government offers free energy audits for small and medium-sized companies, while larger companies could purchase an audit. As a result of the 6, 200 audits performed between 1980 and 2004, the government estimates that a 10% average energy savings rate has been achieved, equivalent to savings of 3.5 MTOE over the period.

5.2.3. Energy Service Companies

The Korean government provides two types of support for energy service companies (ESCOs). It provides money directly to ESCOs to support preliminary work for still-unproven efficiency technologies and provides funding directly to industrial companies to pay for ESCO services. The government pays the initial investment cost and then collects repayment based on subsequent energy savings. Once the government's initial investment has been repaid, the remaining benefits flow directly to the customer.

5.2.4. Building Codes and Efficiency Audits

To improve Korea's building energy codes which are currently relatively low compared to other IEA countries, the Korea Institute of Construction Technology was tasked with investigating building energy efficiency assessment standards and strengthening current codes and policies in July 2005. Based on the results, the government prepared action plans and implemented them in 2007. In addition, the existing program, which requires a building energy savings plan for new buildings over a certain size, were strengthened and expanded

to other building types. In addition, a performance-based energy code, which limits total energy use per unit area, has been implemented in these buildings.

The government is currently working on more stringent building insulation standards that will become more stringent over time. Insulation standards which are currently mandatory for all new buildings will also be expanded to apply to significant renovations of existing buildings. To improve energy efficiency for windows, the Korean government also plans to introduce more stringent standards. In addition, Korea is studying whether to mandate that all real estate transactions for large buildings include an energy efficiency certification, with the associated document attached to all sale and purchase transactions. In 2007, the government mandated that energy audits be conducted every five years for buildings with energy consumption more than 2,000 TOE/year with an exemption for buildings that achieve outstanding energy performance.

5.2.5. Appliance Labeling and Standards

In 2004, Korea set a goal that the standby power of all electronic products be reduced to one watt by 2010, a goal that was later codified into e-Standby Korea 2010. The e-Standby program aims to promote the widespread use of energy saving products that reduce standby power consumption. Standby power is electricity consumed by appliances which are plugged in but not in use. The products that meet the one-Watt standard are entitled to bear the Energy Saving Label. When they fail to meet the standard, the Standby Warning Label is displayed on the front of the product.

The program is implemented in three stages according to the Standby Korea 2010 roadmap. The program's ultimate goal is to reduce standby power of each electrical device below one watt by 2010. The first stage was the Voluntary One W Policy that ran from 2005 to 2007. The second stage was the Preparation for Transition to a Mandatory One W Policy from 2008 to 2009. From 2010, the Mandatory One W Policy, the ultimate goal of the roadmap was implemented. At this stage appliances sold in Korea were subject to compliance with a one-watt usage of power or less when in standby mode.

Korea is actively working to promote energy efficiency standards and labeling for appliances. The energy efficiency standards and labeling program, launched in 1992 and subsequently reviewed in 2004, requires companies to label the energy efficiency of products in 18 categories, including refrigerators, air-conditioners and cars. The comparative energy labels range from five (least efficient) to one (most efficient or target level) and no product with a rating less than five may be sold after the effective date.

5.2.6. Fuel Economy

The Korean government introduced its first mandatory fuel economy standards whereas previously there were only voluntary targets. In January 2006, regulations came into force requiring car manufacturers to meet average fuel economy standards of 12.4 km/l for vehicles with engines of less than 1500cc and 9.6 km/l for vehicles with engines over 1500cc. It also provided incentives for manufacturers that achieved the target to improve fuel economy within each vehicle category by 5% by 1996 and 10% by 2000 over the 1991 base year.

Although it is impossible to directly compare all fuel economy standards, those currently required in Korea are more stringent than those imposed in the United States. However, they are generally less stringent than those that came into force in 2008 in the EU and those in place in Japan, which was expected to become more stringent. Japan currently has the most stringent fuel economy standards in the world though the proposed EU standards planned for 2012 would surpass them.

MKE has implemented a Fuel Efficiency Labeling Program to inform consumers about the relative fuel efficiency of the vehicleson the market. Since January 1988, sales advertisements have been required to include information on vehicle mileage rating. This applies to domestic passenger cars and imports. Since September 1992, new passenger cars have been required to exhibit KEMCOs mileage ratings label on the vehicle to provide consumers with better information on vehicle fuel economy. Vehicles are classified into one of eight categories based on engine capacity. Within each category, there are five gas mileage labeling ranks (first through fifth) with 42% of all vehicles (domestic and import) falling into the third ranking. This Fuel Efficiency Labeling Program applies to 317 vehicle models of domestic and imported passenger cars using gasoline and LPG (as of 1998).

5.2.7. Public Transit and Mode Shifting

Public transit is common transport mode in Seoul. The subway accounts for 36% of all workers' commute while those commuting by subway or bus combined comprise 62% of all commuters. In Busan, the subway rate is 14% and in Inchon the combined subway-bus rate is 20%. Korea is working to further expand public transport usage by enhancing public transit service and financial and other incentives to encourage use while rapidly expanding its public transport service. Over 80 km of light railroad service in five cities were added between 2001 and 2008. In 2004, the government drew up plans to build 22 rapid transit bus routes measuring 540 km by 2012, all located in the Seoul metropolitan area. In addition to an enhanced light railroad service, the government is expanding the heavy railroad service.

5.3. Policy Assessment

Despite Korea's considerable progress to date to improve energy efficiency such as limiting standby power consumption to one watt for electronic equipment, the government has continued to actively focus on energy intensity, and to considereven more ambitious targets. In particular, since the targets for the transport andresidential sectors, if fully achieved, deliver relatively small benefits, they may be strengthened along with detailed energy efficiency strategies to cover these sectors. To that end, the new long-term 2020 efficiency goals for the transport and building sectors area good first step in this direction.

The single most powerful tool to encourage energy efficiency is through transparent and cost-based prices, which send market-based signals to customers toconsume the right amount of energy at the right time. While transparent, liberalized markets are the most effective means of delivering such signals, cost-based prices under the current energy system could also be effective. Removing all subsidies for energy customers is critical to this to succeed. For example, if industrial electricity customers receive subsidized rates, their electricity prices should be increased so that they reflectthe costs to encourage improved efficiency. Furthermore, all energy subsidies to low-income consumers should be removed, such as subsidies for coal briquettes, and replaced with direct social subsidies for low income households that do not distort market prices.

Korea introduced mandatory fuel economy standards for vehicles in 2005, which were stricter than those ofthe United States, Australia and Canada. The government has monitored implementation of the standards, ensuring adequate enforcement. Since companies have not complied with the standards, the Korean governmentis ready to impose a more effective compliance mechanism. Although the Korean standards are currently comparable with those in other countries, the government ensures that they evolve to keep up with world's best standards. To provide regulatory certainty to vehicle manufacturers, the government established a clear timetable for implementing morestringent standards over the long-term as quickly as possible. As a major vehicle exporter, Korea's fuel economy standards could have a large impact on the fuel economy of other countries' car fleets, giving its fuel economy policy decisions the power to impact world energy use.

Korea's Stand by 2010 program is a model for other countries. The government has taken the initiative to spur reductions in standby power consumption and its efforts will have an impact not only on the energy efficiency of Korean appliances, but also on world residential energy efficiency via the appliances that Korea exports. As the government further develops its standby power policies, it should consider better integrating them with overall energy performance standards for major appliance classes. Currently, active power use and stand by power use are regulated separately under different regulations and by separate government

offices. The government should consider setting total energy use standards, covering all appliance modes, formajor appliance categories in order to reduce the administrative and regulatory burden of the policy for both the government and the affected manufacturers. For all other appliances not covered by a comprehensive performance standard, the government should consider adopting a uniformone-watt standby standard, replacing the differentiated stand by standards currently in place.

6. New & Renewable Energy Development and Deployment

6.1. Background

New and renewable energy (NRE) is currently seen as a key solution to the two major issues: energy security and climate change. In this regard, many countries, regardless of their level of development, are making great efforts to develop and deploy renewable energies and thereby fostering corresponding industries. To keep up with this global trend, the Korean government provides a variety of policy incentives and programs to promote a larger uptake of NREs and to promote NRE industries. In recent years, the Korean government's investment in NRE has been accelerated in response to the climate change as well as energy security, resulting in a large amount of budget over one trillion KRW and NRE deployment of 7.6 million TOE, sharing 2.8% in the total primary energy consumption.

In last two decades, the Korean government has set ambitious goals for the penetration of NRE into its energy mix to lower its reliance on fossil fuels and imported energy, and to enhance its energy security as well as to attain its environmental goals. The first national target was to supply 3% and 5% of the total primary energy supply (TPES) by NRE in 2006 and 2011, respectively. These were too ambitious and challenging, given that in 2004, NRE accounted for just 2.1% of Korea's TPES. This necessitated Korea to step up its NRE promotion policies and modify the implementation of existing policies so that government policies and funding maximized the gains in the NRE supply.

The Korean government started to implement feed-in tariffs (FIT) which compensates the premium cost of electricity powered by NRE to createbusiness investment opportunities in 2003. A huge amount of investment has been put into solar photo voltaic (PV) and wind power industries. Annual total volume of solar PV installation, for example, was just over 200kW prior to 2004. However, since the FIT scheme was announced, solar PV installation increased dramatically, reaching 498MW in 2011. While FIT effectively promoted a larger and faster uptake of NRE, its drawbacks include moral hazards and government financial overburden. As a result, the government developed a market-based policy tool known as renewable portfolio standards (RPS). RPS mandates power producers supply a certain

portion of the total power generation by renewable energy similar to the cap and trade scheme used in the carbon market.

The Korean National Assembly passed the law of RPS in 2010, followed by presidential decree and rules including RPS renewable energy certificates (RECs) and RPS trading and operating system. The system was finally launched in January, 2012. Eligible entities for RPS included those power generators with generating capacity over 500MW. Eligible power sources and technologies are solar PVs, wind, hydro, fuel cells, marine energy (tidal power, etc.), geothermal, bioenergy, waste-to-energy, andintegrated gasification combined cycle (IGCC). Flexible mechanisms were introduced to ease eligible entities to meet mandatory targets: borrowing and banking. Penalties for failing to meet the obligation were set at 1.5 times as high as RECs for eligible power source or technologies. The final target of RPS is 10% to be attained by 2022, starting with 2% in 2012.

Table 3-16 | Evolution of New & Renewable Policies

Year	Legislation	Notes
1987	Promulgation of the Promotional Act of NRE Development	Legal basis of NRE R&D activities
1997	Promotional At of NRE Development, Utilization and Deployment (first Amendment)	Amendment for legal basis for NRE dissemination
2002/3	Promotional Act of NRE Development, Utilization and Deployment (second/third Amendment)	Obligation on public bldgs. (const. cost.). Certification, FIT
2003	The second National Basic Plan for NRE Technology Development and Deployment	10 year plan, target: 3% (2006), 5% (2011)
2004	Promotional Act of NRE Development, Utilization and Deployment (fourth Amendment)	Including standardization, RESCOs, etc.
2008	The third National Basic Plan for NRE Technology Development and Deployment	Target: 2020 (mid), 2030 (long), NRE industry promotion
2009/10	Promotional Act of NRE Development, Utilization and Deployment (5th Amendment)	RPS: 2012 (2%) → 2022 (10%) Obligation on public bldgs (load)
2011	The fourth National Basic Plan for NRE Technology Development and Deployment (underway)	The Second Nat'l Energy Basic Plan, NRE industrialization, Export

While the government began to pay attention to biofuels as an alternative to gasoline and diesel in the transportation sector, no targets for biofuels penetration have been set. A successful biofuels policy would help reduce Korea's reliance on imported oil. The

government should enhance its biofuels policy, in particular by establishing realistic and cost-effective targets along with clear timetables and milestones for implementation. The government should put in place promotion policies and measures that allow the biofuels target to be met in a flexible, market-based and cost-effective manner.

6.1.1. Definition and Deployment of NREs

According to Chapter 2 of the Promotional Law of NRE Development, Application, and Deployment, NREs is defined as energy sources and technologies other than fossil fuels which are classified into two categories: renewable energies such as solar PVs, solar thermal, wind, bioenergy, hydroelectricity, geothermal, marine energies and new energies such as hydrogen, fuel cells, and coal liquefaction or gasification.

6.1.2. Deployment of NREs

In 2011, NRE deployment totaled 7.583 million TOE, sharing 2.75% of TPES, 275,688 thousand TOE. Of the total amount of NRE supply, waste-to-energy contributed the largest proportion with 67.54 %, followed by hydro power with 12.73%, and other types of energy such as solar photovoltaics (PVs) with 2.60%. NRE power generation has rapidly increased in solar PV and wind, due to the introduction of the FIT scheme. Solar PV-powered generation rose nearly 30 times to 917,198MWh in 2011 from 31,022MWh in 2006 while wind increased up to 862,884MWh from 238,911MWh. Fuel cell is emerging as a significant power source and their output in 2011 was almost 40 times higher than that in 2006, marking 294,621MWh. NRE generation accounted for 17,346GWh (1.24%) of total 501,527GWh of electricity generated in 2011.

6.2. Basic Plans for New and Renewable Energy

According to the NRE Promotional Law, the Korean government is supposed to establish a national basic five-year plan to promote NREs, reflecting changes in energy demand and supply as well as energy market and industry. To date, the Korean government has developed and revised three basic plans. The most recent version is the third National Basic Plan for NRE Development and Deployment and the fourth National Basic Plan for NRE is now underway.

6.2.1. Ten-Year Alternative Energy Technology Development Plan

This plan, actually, should have been named as the first National NRE Basic Plan though due to different interpretations of the concept and definition of alternative energy, it remained unaltered. This ten-year plan differentiated policy based on the following categories of energy technologies: Core technologies such as solar PVs, solar thermal, fuel-

cell and IGCC, general technologies such as waste-to-energy, bioenergy, wind power and coal utilization technology, and basic technologies such as small hydro, ocean, hydrogen and geothermal. The plan sought to attain the targets by 2006 of reducing the total expected energy consumption by 10% and supplying 2% of the total primary energy consumption from NRE.

6.2.2. The Second National NRE RD&D Basic Plan (2002)

In December 2002, the government announced anNRE R&D Basic Plan, which updated the program begun in 1987, as a renewed framework for further development of renewables. The Basic Plan set a supply target for NREs of which 3% of primary energy was to be supplied by NREs in 2006 and 5% in 2011. It was officially documented later in the second National Basic Plan for NRE Technology Development, Utilization, and Deployment (2003), which is a revision of the previous Basic Alternative Energy Development and Deployment Plan (2001). The Basic Plan's Selection and Concentration Strategy targeted wind, solar PVs, hydrogen and fuel cells as top-priority technology areas on which the government would focus its R&D support.

Financial support and preferential tax treatments for R&D renewable technologies were to be provided. Financial assistance included low-interest loans (5.5% with a three-year grace period and five years to repay) for companies that installed renewable energy technologies and facilities. A company could deduct up to 10% of its investment in R&D activities as well as facilities on renewables from its corporate tax. The plan indicated a possible introduction of renewable portfolio standards (RPS), making it mandatory for wholesale electricity purchasers to buy a specific portion of their electricity from renewables. The government also required state-owned institutions to purchase renewable energy equipment and facilities.

The aim was to meet 2% of the total energy demand from state-owned institutes through renewable energy sources. In addition, the government conceived a mechanism by which surplus electricity sold to KEPCOs grid from renewable energy facilities would be purchased at rates that provide sufficient incentives to make renewable energy projects viable, which became later Feed-In Tariff (FIT) program.

As mentioned earlier, wind, PV, and hydrogen/fuel cells as the three major NREs, were selected for intensive government policy support to upgrade the domestic fuel cell and PV industries to the level of the global standards by 2011, to foster an export industry. If the target is achieved, Korea's power generation capacity using NREs is expected to reach a total of 4.9 GW in 2011, which, considering the low capacity factors of NRE facilities is equivalent to two nuclear power generation plants (1,000MW units). A government investment of over six trillion KRW (9.1 trillion KRW, including loans) was expected to be

needed from 2004 and 2011 to achieve a 5% supply target for NREs by 2011. In the funding plan, solar PVs and hydrogen fuel cells receive the largest share. However, solar PVs and, in particular, hydrogen fuel cells were expected to make up a relatively small share of total NRE in 2011 compared with other sources such as wind and geothermal.

6.2.3. The 3rd National NRE RD&D Basic Plan (2008)

In 2008, the Korean government established the third National Basic Plan for NREs with the ultimate goal of building a sustainable energy system based on NRE development and deployment. The Basic Plan has two sub-goals: one is the quantitative goal to supply 11% of the primary energy with NRE by 2030; the other is the qualitative goal to foster NRE as a green growth industry. Four strategies were proposed to attain these two goals: industrialization of NRE, larger deployment, infrastructure building, and introducing market mechanism.

Figure 3-8 | Goals and Strategies of the Third NRE Basic Plan

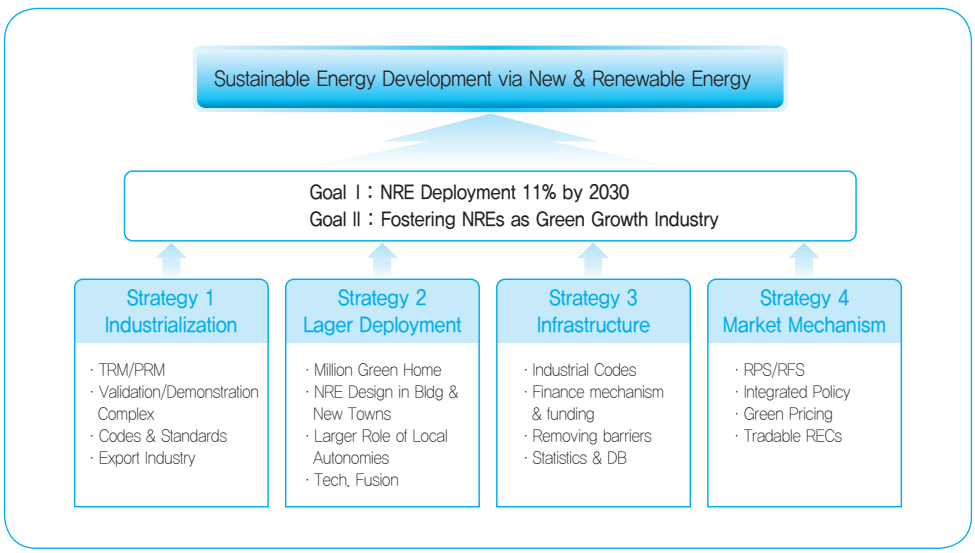


Table 3-17 | Long-Term Deployment of NREs

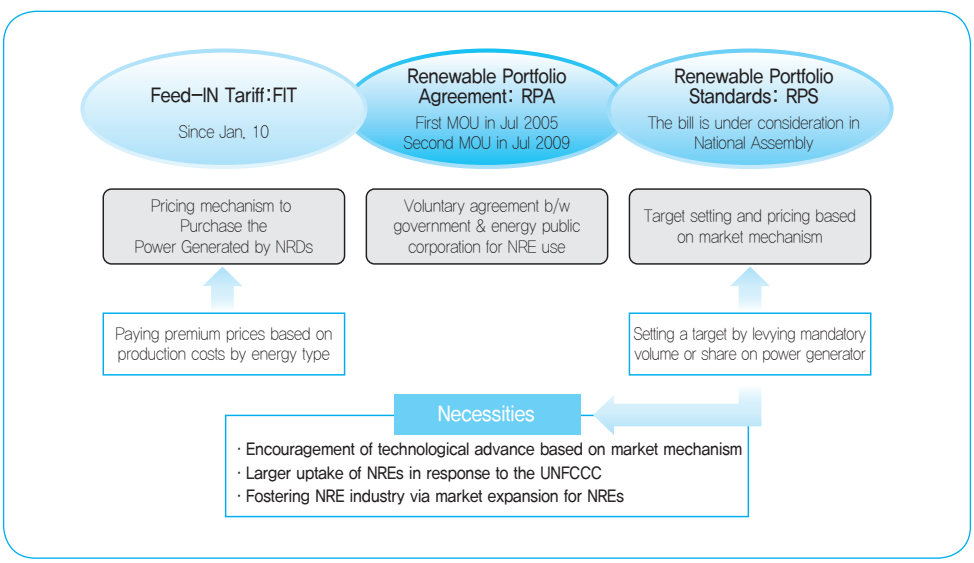
		2008	2010	2015	2020	2030	~2020	~2030
BaU	Share (%)	2.6	2.9	3.6	4.2	5.7	6.3%	5.3%
	10^3 TOE	6,360	7,390	10,323	13,233	19,558		
Policy	Share (%)	2.6	3.0	4.3	6.1	11.0	8.8%	7.8%
	10^3 TOE	6,360	7,566	11,731	17,520	33,027		

According to the third National NRE Basic Plan, the proportion of waste-to-energy and hydro power are to be reduced to 30% while natural renewable energy such as solar, wind, marine, and geothermal, are projected to increase up to 70%, with a share of bio-energy increased up to 31.4%, taking the second position just behind waste-to-energy.

6.3. Major Policies, Policy Tools and Measures

To date, the government has developed and implemented various measures to directly support NREs deployment, including a feed-in tariff (FIT), renewable energy portfolio standards (RPS), direct support, tax benefits and R&D funding. Among them, FIT and RPS have been the two most effective and powerful market generating policy tools. FIT was initiated in 2002 and endedin 2011 when it was replaced by RPS in 2012. In between the major two policy tools, renewable portfolio agreement (RPA) served as a bridge in the transitional period.

Figure 3-9 | Major Policy Tools for NRE Deployment



6.3.1. Feed-In Tariff (FIT)

Feed-in tariff (FIT) was one of the government's main policy tools to achieve its NRE supply target. The Electricity Business Law mandated both the purchase and the fixed price of electricity generated from renewable sources. Any renewable energy generator that was connected to the grid was eligible to sell electricity to the grid at fixed prices. KEPCO was responsible for purchasing electricity from renewables, which guarante edrates for 15 or 20 years. The FIT varied by technology with the tariff for solar PVs nearly seven times higher than the rate paid for wind, which received the second-highest subsidy.

As renewable electricity generators bid into the Korea Power Exchange (KPX), KEPCO compensated eligible renewable energy generators for any difference between the pool price and the FIT. The guaranteed FIT is granted on a first-come, first-served basis up to the limit. The government paid 11.7 billion KRW in subsidies between 2002 and 2011, for 110 MW of renewable power (equivalent to 40 power plants). The total power generated by the support system was 664, 662 MWh as of the end of April 2005. Starting in 2009, a decreasing rate was applied to solar PV of 4% per year and to wind power of 2% per year. In addition, a decreasing rate of 3% per year was applied to fuel cells starting in 2010.

Table 3-18 | Feed-In Tariff Except for Solar PVs

Power Source		Eligible Facilities	Category		FIT (₩/kwh)		Note
					Fixed	Variable	
Wind		10kw or larger	-		107.29	-	Reduction Rate: 2%
Hydro		5MW or smaller	Comerce	1MW or larger	86.04	SMP+15	
				1MW or smaller	94.64	SMP+20	
			Others	1MW or larger	66.18	SMP+5	
				1MW or smaller	72.80	SMP+10	
CMW (incl.RDF)		20MW or smaller	-		-	SMP+5	Fossil Fuel content: Less than 30%
Bio-Energy	LFG	50MW or smaller	20MW or larger		68.07	SMP+5	
			Less than 20MW		74.99	SMP+10	
	Biogas	50MW or smaller	150MW or larger		72.73	SMP+10	
			Less than 150kw		85.71	SMP+15	
	Biomass	50MW or smaller	Ligneous biomass		68.99	SMP+5	

Power Source		Eligible Facilities	Category		FIT (₩/kwh)		Note
					Fixed	Variable	
Marine Energy	Tidal Power	50MW or larger	tidal range: 8.5m or higher	with dike	62.81	-	
				No dike	76.63	-	
			tidal range: 8.5m or lower	With dike	75.59	-	
				No dike	90.50	-	
Fuel Cells		200MW or larger	Biogas-based		227.49	-	Reducion Rate: 3%
			Other fuel-based		274.06	-	

Table 3-19 | Feed-In Tariff for Solar PVs

Period		Duration	30kW or smaller	30kW ~200kW	200kW ~1MW	1MW ~3MW	3MW or larger
~ 2008.9.30		15 years	711.25	677.38			
2008.10.1~2009.12.31		15 years	646.96	620.41	590.87	561.33	472.70
		20 years	589.64	562.84	536.04	509.24	428.83
2011.1.1 ~12.31	Open Area	15 years	566.95	541.42	510.77	485.23	408.62
		20 years	514.34	491.17	463.37	440.20	370.70
	Using Structure	15 years	606.64	579.32	546.52	-	-
		20 years	550.34	525.55	495.81	-	-
2011.1.1 ~12.31	Open Area	15 years	484.52	462.69	436.50	414.68	349.20
		20 years	439.56	419.76	396.00	376.20	316.80
	Using Structure	15 years	532.97	508.96	480.15	-	-
		20 years	483.52	461.74	435.60	-	-

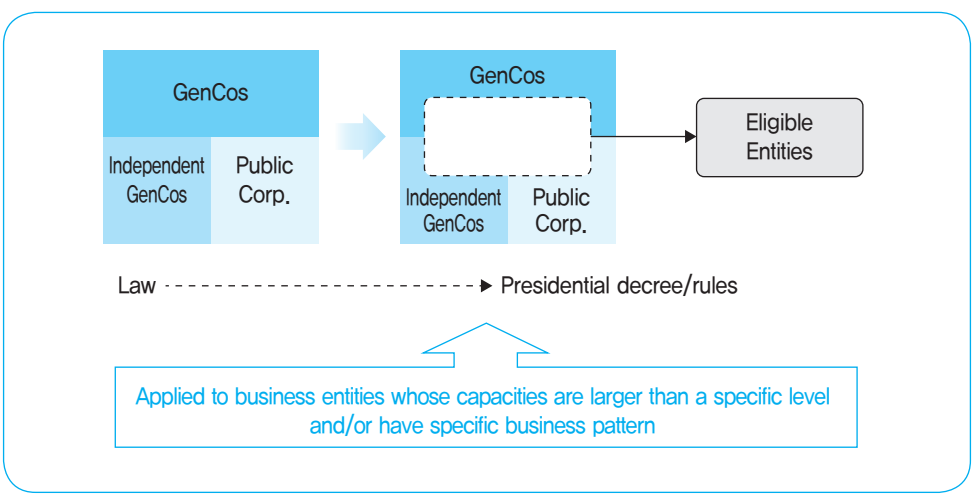
The government lowered differentials for FITs over time to reflect the technology learning curve. This would help avoid entrenched over-subsidization for particular technologies, as shown in the <Table 3-14>. Additionally, FIT was a very expensive way of funding technology development. As an example, Korea's USD 0.70 per kWh feed-in tariff rate for solar photovoltaics provided a payment of USD 1,600 annually per 2-kW panel, equivalent to a ten-year simple payback time, a favorable rate, considering that payments were guaranteed for 15 years and the operational lifetime of a solar panel is longer than 20 years.

6.3.2. Renewable Portfolio Standards (RPS)

The Korean government, seriously considering the issues mentioned above, turned to more market-based alternatives to feed-in tariffs, specifically, RPS which has been successfully implemented in U.S.A., UK, Australia, and Japan. However, to avoid the sudden impact and shock incurred by introducing a significantly different policy tool, the government introduced and implemented Renewable Portfolio Agreement (RPA) in the state-owned energy sector. The Renewable Portfolio Agreement is a NRE investment agreement between the government and energy suppliers. The Korea Electric Power Corporation and six power companies and nine other companies including Korea District Heating Corporation and Korea Water Resources Corporation agreed to invest USD 1.260 million for three years starting 2006. USD 430 million was invested in 2007 and USD 706.8 million was invested over 2008.

Under the RPS scheme, the government set a target for a certain percentage of power to come from renewables and, possibly, new energy sources, but left it to market participants to procure the power as cheaply as possible which automatically lowered the support for renewables as technologies advanced. This flexible, market-based approach continued to promote renewables while reflecting the costs of environmental externalities, and allowing support levels to adapt to market conditions instead of guaranteeing a fixed and permanent subsidy.

Figure 3-10 | Entities Eligible for RPS



6.3.3. Investment Subsidies

In addition to the FIT, between 1993 and 2009 the government provided 142 billion KRW in direct support for the construction and operation of renewable power plants. The government provided the funds required for the construction and operation of facilities for NRE, such as solar thermal and solar PVs. The range of the government's support was up to 100% of the required funds, and the support conditions include 2.0% of the annual percentage rate (APR) and a ten-year redemption period via amortizations after a five-year deferment period. For companies investing in new and renewable power generation facilities, a one-time deduction of 10% of the investment amount could be made from the builder's individual income or corporate tax. In addition, 65% of the customs levied on 26 different items in four categories (solar thermal, solar PVs, wind power and fuel cell) could be deducted.

6.3.4. Regional Deployment Subsidy Program

In an effort to improve the energy supply & demand condition and to promote the development of regional economies by supplying region-specific NREs that are environmentally friendly, the government promoteda regional deployment subsidy program designed to support various projects implemented by local governments. This program, which started in 1996, supported both NRE and energy-saving areas until 2005. However, the two areas were divided in 2005 in accordance with thePromotion Act for NRE Development, Utilization and Deployment. Depending on the support ratio of the government subsidy and the nature of project, subsidies were classified into two categories: for building the infrastructure and for installing NRE systems.

- The subsidy for building the infrastructure: feasibility study, human resources development, and public relations for development and utilization of region-specific energy (supports up to 100%)
- The subsidy for installing NRE systems: deployment of NRE systems such as PV and wind power etc. (supports up to 60%)

6.3.5. Million Green Homes Program

In an effort to encourage NRE deployment, the government initiated a program called the One Million Green Homes Program. This is a subsidy program to facilitate installing NRE facilities in residential areas such as private houses, multifamily houses and public rental houses. This program was launched in 2009 it incorporated the 100,000 Solar Roof Installations Program through which the government supported a portion of total installation cost. Although the 100,000 Solar-Roof Installations Project installed PV

systems in residential houses, the One Million Green Homes Plan focused on a variety of energy options such as PV, solar thermal, geo-thermal, and small wind.

6.3.6. Loans and tax Incentive Program

The government provides long-term, low-interest loans for the customers or manufacturers of NRE systems which have already been commercialized. The objective of the program is to expand the deployment of NRE systems as well as to promote commercialization of large-scale facilities. Installation loans are provided when customers install NRE systems, while operation loans are provided to the manufacturer of NRE facilities or to operate and manage such facilities. Loans are provided for up to 90% of the total cost in the case of small and medium companies and up to 50% for large companies. In addition, about 20% of total investment in installation of NRE systems could be deducted from personal or corporate income tax.

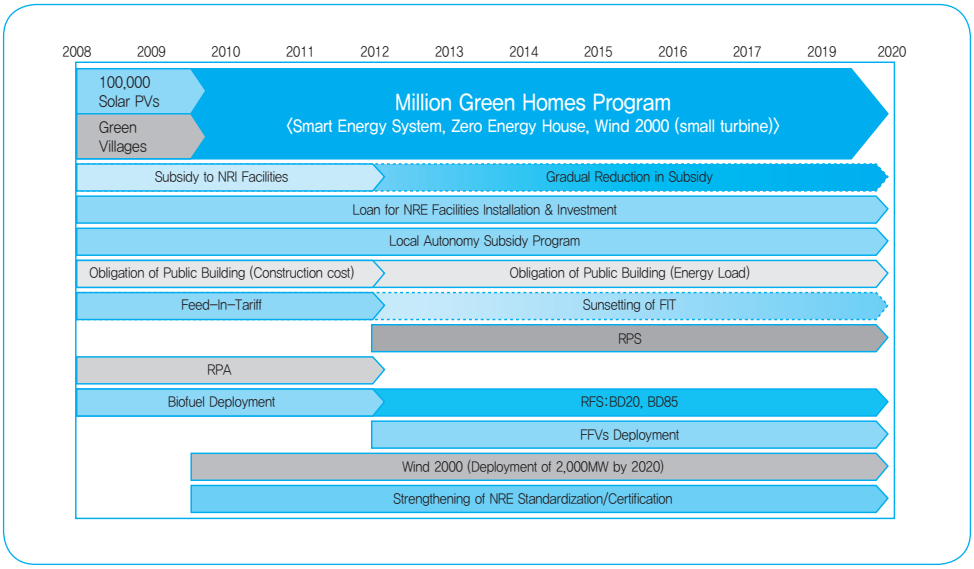
6.3.7. NRE Mandatory Use for Public Buildings

The new building sconstructed by state-owned institutions with floor areas exceeding 3,000 square meters are legally obliged to use more than 5% of their total construction expenses to install renewable energy resource systems. State-owned institutions include state administrative bodies, local autonomous entities, and state-owned companies. Between March 2004 and 2009, state-owned institutions submitted 1,036 installation plans. According to the installation plan, the government invested 483 billion KRW in NRE systems. This amount accounted for just 5.58% of total construction expenses (8,674 billion KRW). Approximately 209.4 billion KRW (50% of all investment) was invested in geothermal systems. Solar thermal energy accounted for 16.6 billion KRW in investment, and photovoltaic accounted for 257.4 billion KRW.

6.3.8. Regional Deployment Subsidy Program

In an effort to improve the energy supply and to boost regional economies by supplying region-specific new and renewable energies, the government promoted a regional deployment subsidy program designed to support various projects carried out by local governments. Starting in 1996, this program supported both NRE and energy-saving schemes until 2005. The two areas, however, were separated in 2005 in accordance with the Act on the Promotion of the Development, Use and Diffusion of NRE. The subsidy for installing NRE systems such as PV and wind power supported up to 50% of the investment outlay.

Figure 3-11 | Policy Roadmap for NRE Development and Deployment



6.4. Policy Assessment

6.4.1. Status of NRE Deployment and Industry

Due to the efforts made by the Korean government and with their strengthened policy framework, the share of NRE in TPES reached 2.75% in 2011 from 1.24% in 2001. However, NRE deployment has been greatly increased in terms of growth rate. Its annual growth rate was 16.0% between 2001 and 2011 which was way higher than that of TPES (5.3%).

Table 3-20 | NRE Share in TPES

	1990	2000	2001	2005	2007	2010	2011	Growth Rate (1990~2011)
TPES (10^3 TOE)	93,192	192,888	198,410	228,622	236,454	262,609	275,688	5.3%
NRE (10^3 TOE)	335.3	2,127.3	2453.3	4,879.2	5,609	6,856	7,583	16.0%
Share (%)	0.40	1.1	1.24	2.13	2.37	2.61	2.75	-

The number of manufacturing companies in the NRE industries increased from 41 in 2004 to 212 in 2010 for an increase of 517% or the annual growth rate of 20%. The number of companies by resource as of 2010 was: 91 PV companies (12%), 46 bio companies (48%) and 32 wind companies (67%) compared to 2009.

As the NRE industry has expanded, employment in theindustry has also increased. In the PV industry, in particular, the employment effect was remarkable due to the increase in the value chain. The number of employees in the PV industry increased from 170 persons in 2004 to 12,000 in 2011. In the case of wind, the workforce in the system area increased from 87 in 2004 to 1,137 in 2011.

The export sales in the NRE industry increased from 64 million USD in 2004 to 4.53 billion USD in 2010 for an increase of 69 times. As the global companies in Korea completed to enter the industry and overseas expansion accelerated, the export sales in 2011 were expected to be 8.7 billion, increasing 91% compared to the previous year. When comparing the two, domestic consumption rate of NRE and its export one, the export ratio has been rapidly increasing from 52% in 2004 to 65% in 2010.

6.4.2. Assessment of Policy Directions and Tools

To date, the government developed and implemented various measures to directly support renewables deployment, including a feed-in tariffs, direct supports, tax benefits and R&D funding. While various measures were often warranted, an ad hoc approach to renewables deployment, where policies were added one by one without co-ordination, often resulted in inefficient government investment. A better approach was a streamlined promotion policy with clearly defined government authority, roles and responsibilities. Establishing an efficient renewables promotion policy also required comprehensive cost-benefit analysis and co-ordination across the Ministry of Knowledge and Economy (MKE), the Ministry of Education, Science and Technology (MEST) and other relevant ministries and entities.

Since 2002, Korea has implemented a series of market creating policy tools, namely, FIT, RPA, and RPS. FIT was an incentive to promote a larger uptake of NRE as well as to foster the NRE industry to make up for the difference between power generation cost and sale prices for NRE technologies. FIT rates were regularly re-evaluated and adjusted downward to encourage continued advancements and cost reduction in NRE technologies. In 2012, the government replaced FIT with the more market-oriented RPS to secure a stable deployment of NRE as specified in the National Basic Plan for NRE. It started with 2% in 2012 towards a 10% target of NRE in electricity supply by 2022.

In addition to RPS, the government decreased subsidies for NREs. For example, the One Million Green Homes program, which was expanded from the 100,000 Solar Roof program in 2009, reduced its subsidies in terms of both the subsidizing ratio and the standard capital costs, set by the government, for a wide range of technologies such as solar PVs, solar thermal, fuel cells, etc. These measures represent solid progress.

The cost-effectiveness of chosen policies and measures needs to be carefully evaluated to ensure that overall NRE objectives were met without placing an excessive burden on consumers through additional taxes or higher tariffs. Particular attention should be given to the cost of each NRE technology. It is important that the government decrease incentives for specific technologies over time, in order to increase market competitiveness. On the other hand, it is also very important to provide a stable, predictable and transparent regulatory framework with a clear timeframe for the reduction and phase-out of support schemes to continue to attract investments in producing new technologies.

6.4.3. The Future of NRE

Owing to geographic and climatic conditions, the resource potential for NRE in Korea is relatively low when compared to other IEA member countries. This adds to the overall cost and challenges of meeting the NRE targets. It is important, therefore, to carefully evaluate the potential of all available technologies and ensure that the most cost-efficient projects were developed. In this regard, a detailed resource map of domestic NREs is currently underway based on full-fledged surveys and analyses of potentials in six NREs, i.e., solar, wind, tidal power, biomass, geothermal, and small hydro, to discover and develop promising projects (project period: December 2004 - June 2012; project money: 2 billion KRW).

Given that the goal of 11% NRE in TPES by 2030 does not distinguish between electricity and other types of energy, Korea should investigate the cost-effective potential for NRE-based heating and cooling as well as for biofuels, and design support schemes to tap into this potential. In this regard, the Korean government will develop a comprehensive NRE strategy, supported by technology roadmaps containing policies and measures based on a technical and economic assessment of potential resources, for the deployment of NRE technologies, including the heating, cooling and transportation sectors.

Problems related to grid access could be a potential barrier to the future deployment of NRE technologies. It is very important to analyze the implications of the large-scale penetration of intermittent renewable energy production in the overall energy system, with regard to cost-efficiency and system reliability. Good coordination between the development of grid capacity and NRE production should be encouraged

NRE offer not only sustainable energy sources but also a new engine to lead green growth in response to climate change while enhancing energy security. It is necessary to expand supply of these new energy sources to increase energy supply capacities in terms of energy security and to contribute to diffusion of environmentally-friendly energy sources in the climate change era. As specified in the third National Basic Plan for NRE, the government set a target of 11% NRE's share in TPES by 2030. The government also drew up road-maps for all 11 new and renewable technologies along with policy roadmap for industrialization

and commercialization of NRE technologies. Recently, the Korean government started working on the fourth National Basic Plan for NRE with a time horizon until 2035. A new approach to industrialization and export for NRE in addition to all the issues above mentioned will be in an in-depth discussion.

7. Environment and Safety

7.1. Eco-friendly Energy Policy

In the energy sector, environmental issues have emerged as a major task amid stronger environmental regulations on a global scale, following the establishment of the 1987 Montreal Protocol and United Nations Framework Convention on Climate Change (UNFCCC) at the global environmental conference held in Rio, Brazil in June 1992. Therefore, Korea has seen increasing needs to build energy systems based on environmental considerations to achieve both environmental conservation and sustainable growth through future energy policies. It is especially crucial in Korea which its economic structure is mainly comprised of massive energy-consuming industries, such as steel, chemicals and cement. Due to these industries' large energy consumption, a large amount of greenhouse gases are emitted by burning fossil fuels which cause environmental problems that could have a major economic impact in Korea.

Based on these reasons, the government executed various energy policies to implement low-carbon-type, eco-friendly energy systems that could appropriately respond to environmental issues and climate change. In particular, policies that utilize environmental measures as a new growth engine for Korea were executed. It could be potentially be a good development model for developing countries faced with environmental problems. This section of the report will examine Korea's environmental policies, supported by energy policies for addressing climate change, and expansion of low-carbon clean energy supply.

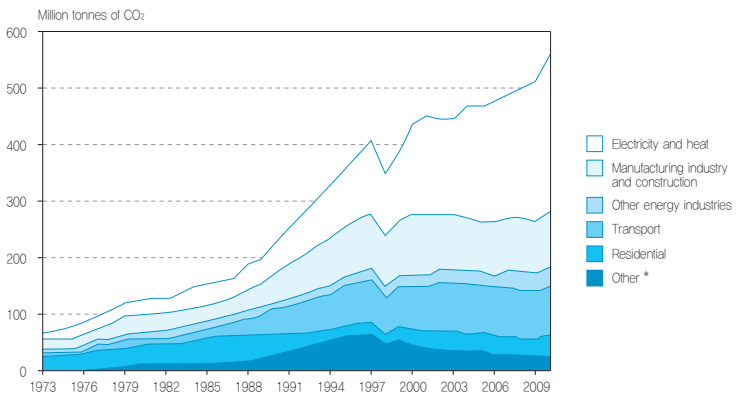
7.1.1. Energy Policies for Addressing Climate Change

a. Background

Climate change policies were introduced amidst potential economic crisis for countries emitting massive amounts of greenhouse gas, after the establishment of the UNFCCC in 1992 and Kyoto Protocol in 1997 that specified binding obligations to reduce greenhouse gas for major industrialized nations. Korea's international competitiveness has been impacted as a number of industries consumed massive amounts of energy. Moreover, the UNFCCC was expected to have a huge influence on the general public, amidst steady rise in energy consumption emitting large amounts of greenhouse gas due to burning cheap oil

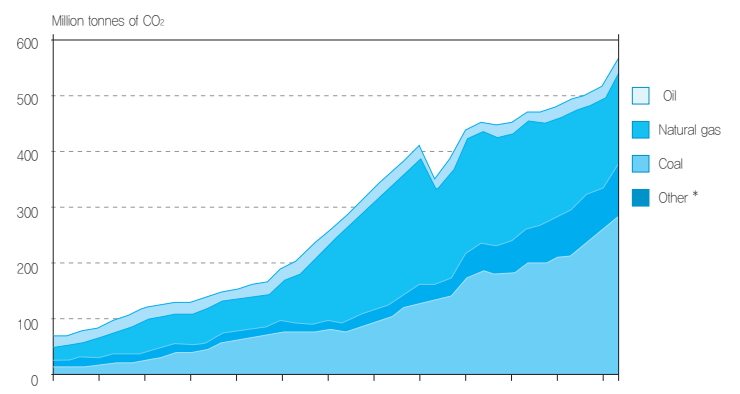
and coal. In fact, Korea's total emission of CO_2 jumped from 283.2 million tons in 1990 to 513.7 million tons in 2000. The emissions in the energy sector represented over 80% of the total emissions amounted to 229.3 million tons in 1990, and 437.7 million tons in 2000.

Figure 3-12 | CO_2 Emissions by Sector, 1973 to 2010



Note: * *Other* includes sectors of commercial and public, agriculture/forestry and fishery
Source: IEA/OECD (2012)

Figure 3-13 | CO_2 Emissions by Fuel, 1973 to 2010



Note: * *Other* includes sectors of commercial and public, agriculture/forestry and fishery
Source: IEA/OECD (2012)

b. Execution System and Policy Measures

In response to the UNFCCC, a government agency was established in April 1998. It was a government-wide task force that included relevant ministries, academia, industries, and research institutions, and executed the first comprehensive measures for response to the UNFCCC in 1999.

In September 2001, a Decree of the Prime Minister was enacted to expand and reorganize the Government Agency for Climate Change Convention as the UNFCCC task force. The task force established the following five sub-task forces: Negotiation Task Force (organizing ministry: the Ministry of Foreign Affairs and Trade), Energy and Industry Task Force (Ministry of Commerce, Industry and Energy), Environmental Task Force (Ministry of Environment), Agriculture and Forestry Task Force (Ministry of Agriculture and Forestry), and Research and Development Task Force (Ministry of Science and Technology). Under the sub-task forces, policy research teams, consisting of non-governmental experts, were established and operated in the following five areas: clean development mechanisms and joint implementation; establishment of greenhouse gas statistics systems; carbon taxes; emissions trading schemes; and compliance with obligations. The task force established the second and the third comprehensive measures for response to the UNFCCC to reflect the establishment of Kyoto Protocol implementation measures (Marrakesh agreement) and the changes in Korea's economic and industrial conditions.

In 2007, the Climate Change Strategy Task Force was created and the fourth comprehensive measures in response to the UNFCCC were announced. Subsequently, the Comprehensive Plan for Combating Climate Change was made in September 2008 with the following goals: 1) fostering climate-friendly industries as new growth engines; 2) improving the quality of people's lives and the environment; 3) leading the efforts of the international community to cope with the climate change. To achieve these goals, the following tasks were selected: 1) improvement of energy efficiency in the industrial sector; 2) securing advanced green technologies with more investment in R&D; 3) fostering and spreading climate-friendly industries and increasing the export; 4) improving the quality of life by mitigating a traffic congestion; 5) creation of green living environment and improvement of social constitution; 6) building a safe society by implementing climate change adaptation measures and expanding public support for low carbon options and lifestyles; 7) substantial enhancement of the ability to monitor and predict climate change; 8) setting goals to reduce greenhouse gas emissions nationwide; 9) actively implementing proactive negotiation strategies; 10) support for developing countries and promoting international cooperation. In February 2009, the Presidential Committee on Green Growth was organized to encompass responses to climate change, sustainable development, and energy policies. In efforts to

systematically respond to climate change, Low-Carbon Green Growth Act was enacted and announced in January 2010.

c. Major Policy Tools and Measures

a) Expansion of Clean Energy Supply

In an effort to reduce the greenhouse gas emissions in the energy sector, which account for more than 80% of the domestic greenhouse gas emissions, the government intensively promoted expansion of clean energy sources, such as renewable energy and nuclear power which emit less carbon dioxide. The UNFCCC stipulated that greenhouse gas emissions which are mostly produced by consumption of fossil fuels such as oil and coal were to be reduced.

Since 1997, the government has implemented a basic plan for developing and providing renewable energy technologies with intensive investment in the three selected fields of solar power, wind, and hydrogen fuel cell technologies with a large market potential. At the same time, higher target for renewable energy supply was set by providing subsidies, financing, tax incentives, and R&D. As a result, Korea's renewable energy penetration, or the share of renewable energy in the primary energy consumption has risen from 1.03% in 1998 to 1.24% in 2001, and 2.61% in 2010. However, one big concern was that wastes and hydropower account for more than 70% of the total renewable energy supply.

b) Energy Conservation and Improvement of Energy Efficiency

An establishment of the UNFCCC in June 1992 triggered a potential crisis that would cause an imbalance in international trade due to an increase in energy import and the consequent decline in industrial competitiveness. Therefore, policies for conserving energy and improving energy efficiency have been actively pursued. The government has implemented the Basic Plan for Rationalized Energy Use since 1993, and National Energy Conservation Promotion Committee was organized in February 1997 chaired by the Prime Minister.

In addition, the policies to reduce energy consumption in the overall economic and social structure and the regulatory measures to strengthen efficiency standards were implemented by increasing support for investment in energy-saving facilities; providing greater supply of collective energy; stimulating energy innovations; improvement of energy pricing system for market-friendly energy conservation; and nurturing energy service companies (ESCOs). As a result, Korea's energy intensity has been in a steady decline to 0.28TOE/million KRW in 2001, and 0.25TOE/million KRW in 2011 since its peak at 0.35TOE/million KRW in 1997.

c) Stimulation of Carbon Market

The government pursed the stimulation of domestic and foreign investments through the clean development mechanism (CDM) which was adopted by the Kyoto Protocol, and introduced an emissions trading market for cost-effective reductions in greenhouse gas emissions. As of May 2011, there were a total of 56 domestic CDM businesses registered at the UNFCCC, reducing greenhouse gas emissions approximately by 17 million tons which ranked fourth in the world after China, India, and Brazil. In an effort to stimulate the CDM businesses, a greenhouse gas emission reductions registry was launched in July 2005, by means of a carbon trading market. Meanwhile, the government executed a variety of support measures, including purchase of Korea Certified Emission Reduction (KCER) at around 5,000 KRW per ton. It was issued as a reward for companies' voluntary efforts to reduce emissions, and it was integrated with the Carbon Neutral Program. Furthermore, the government supported investments in domestic emissions reduction projects, such as solar power generation projects, starting with the support for the launch of private Carbon Fund which was worth approximately 100 billion KRW in 2007. The government has actively promoted the Carbon Fund to be led by international organizations to secure its expertise in operating the Carbon Fund. In 2011, emissions trading pilot projects in the industrial development sector were implemented. Carbon Emission Trading is scheduled to be put into place after 2015, following the Greenhouse Gas Emissions Allocation and Trading Act in May 2012.

d) Strengthening the Response System in the Energy and Industrial Sectors

In an effort to enhance the climate change response system in the energy and industrial sectors, the government began with an overhaul of relevant sectors. In 2003, the Energy Use Rationalization Act was revised, and the Energy Basic Law was enacted two years later in 2005, with stipulations for greenhouse gas emission reduction measures in the National Energy Plan and Energy Use Rationalization Plan. In addition, public-private-academic-research task forces were formed for each of the 12 massive energy consumption industries, and developed a guideline for gas emissions calculation collaboration between the government and industries. Furthermore, industrial, public, and academic forums for climate change response were formed in March 2009. It set the strategies for climate change negotiations, considering the reality of the industries and reflecting the opinions from all walks of life regarding national policies.

In addition, a wide range of incentives have been offered to encourage voluntary reductions in greenhouse gas emissions for all citizens. After May 2009, the Carbon Cash-back Program was implemented. In the program cash-back points are granted for purchase of low-carbon and green products, and the granted points could use to purchase

new products. At the same time, the Carbon Neutral Program was implemented to promote low-carbon green lifestyles.

e) Introduction of Statistics System and Strengthening International Cooperation

The government designated greenhouse gas statistics as the national data to gain international confidence, and has implemented projects to put the statistics in place by establishing legal grounds on the creation, management, and publication of the total greenhouse gas emissions. The information and statistics on energy and industrial processing sectors have been managed by the Ministry of Knowledge and Economy which is responsible for the energy and industrial sectors. In particular, under the Green Growth Basic Law, energy and greenhouse gas statistics of massive gas emissions and energy consumption businesses will be systematically created in consultation with relevant ministries, along with management of greenhouse gas statistics of energy and industrial sectors.

Meanwhile, Korea is expected to become involved in the future post-Kyoto regime, given its substantially high economies of scale and greenhouse gas emissions. As a countermeasure, the government has actively striven to strengthen international cooperation based on more efficient greenhouse gas reduction technologies and to minimize the negative potential on economic growth caused by reduction obligations. In addition, Korea has participated in the Major Economic Forum (MEF) launched by the U.S.A. in 2009, exploring cooperative measures to develop transformational technologies, which could contribute to greenhouse gas reductions, in collaboration with Japan, EU, China, and Brazil.

7.1.2. Low-polluting Clean Energy Supply Expansion Policy

The government policy of low-polluting clean energy supply expansion has been in full-swing since the mid-1980s. Although low-sulfur supply expansion policy had previously been pursued, it remained a passive response measure. However, it has gradually shifted to proactive measures, in accordance with atmospheric emissions regulations policies targeting energy and industrial sectors which allowed it to gain momentum following the Seoul Olympics. First, the LNG plant construction policy in four new metropolitan cities was incorporated into the revision of the sixth five-year plan for power resources development in 1988, expanding the use of natural gas which is a low-emission clean energy source. Second, the nationwide Natural Gas Supply Plan was designed to stabilize the natural gas supply in 1990, and construction of major pipelines for stable power supply to the nation's major cities began. Third, the Collective Energy Supply Plan was made in August 1990 to expand supply of collective energy with a lower environmental load than individual heating systems. As part of system and execution structure repair, the Collective Energy Business Act was enacted in December 1991 and the Korea District Heating Corporation (KDHC) was founded.

As such, government policies have been continuously strengthened to this day amid stronger attention to the environmental issues following the UNFCCC. In particular, greater supply of LNG has been on the top of the agenda leading to an increase in the supply to seven million tons in 1995 from two million tons in 1990. This elevated its proportion among primary energy sources from 3.2% to 6.1%. The LNG supply expansion policy remained in place leading to the rapidly increasing amount of LNG supply of 37 million tons in 2011, with its proportion among primary energy sources rising to 17.2%.

7.1.3. Policy Assessment

a. Assessment of Policy Directions and Tools

As the international environmental regime, such as UNFCCC, intensified in the 1990s, the need to set up an environmentally friendly energy system escalated in Korea. Accordingly, the Korean government took steps to reduce emissions while maintaining economic growth.

The government organized an inter-ministerial UNFCCC joint task force with relevant ministries, academia, industries, and research institutions to devise a policy package. The main contents of this policy package were the active extension of clean energy sources (i.e. renewable energy, nuclear energy and natural gas), energy saving, and energy efficiency improvement. Moreover, the greenhouse gas statistics system, CDM for reducing greenhouse gas, activating a cap-and-trade, and developing energy technologies were in progress. In June 2010, the plan to introduce an energy cost system including the cost of production and environment, market competitiveness, eradication of inefficiency in state-owned sector, and energy welfare was announced.

These policies were evaluated to distil what outcomes had been achieved. Though greenhouse gas emissions in Korea remain high, the rate of increase has been slow. Particularly, as Korea promoted policies that led to national development in a proactive response to the environmental regulations, it would be a good development model for the developing countries facing environmental issues.

b. The Future of Policy Directions and Tools[2]

In February 2009, the Presidential Committee on Green Growth was organized in response to climate change, sustainable development, and energy policies. In an attempt to systematically respond to climate change, the Low-Carbon Green Growth Act was enacted and announced in January 2010. Also, the government committed to reduce its GHG emissions by 30% in 2020 compared to its business-as-usual case (BaU) and integrated this commitment into its Strategy for Green Growth. This strategy was transposed into

2. Refer to IEA/OECD(2012).

law by the enactment of the Framework Act on Green Growth, whose implementation was coordinated by a Presidential Committee. Uncertainty remained, however, as to what this target meant in practice, both in terms of the level of reductions since the BaU case is not firmly defined and in how it will be achieved.

For a mid-term target, an emissions trading scheme (ETS) will be implemented in 2015. This has the potential to provide a comprehensive and economically efficient means of reducing emissions. An ETS could avoid many of the difficulties under the target management approach. The Korean government is working on details of the scheme, including how the interaction between the ETS and the target management system will put into practice. IEA/OECD (2012) suggests that the cost, both to the economy and to emission-intensive industries in particular, is a factor in ETS designs. As an energy-intensive and trade-exposed economy, Korea must ensure that these cost impacts are not over-estimated while taking care to ensure that the negative impacts on certain industries are minimized.

Korea, which is densely populated and heavily reliant on energy-intensive industries, has limited natural resources for new and renewable energy development. Therefore, it is likely that the country will rely on fossil fuels for a substantial part of its energy demand in the foreseeable future. While the government envisions some reduction in the share of coal in the overall energy mix by 2030 (from 28% to 16%), in absolute terms, the use of these fuels is likely to rise. Therefore, deployment of carbon capture and storage (CCS) could be necessary if increased GHG emissions are to be avoided. Also, the implementation of Korea's Strategy for Green Growth could be a big contribution to the country by supporting complementary energy efficiency policies, new and renewable energy measures and a strong research and development sector.

7.2. Energy Safety and Locational Policy

In the energy sector, safety issues have become a major task after a series of energy facility explosion accidents A gas safety management policy was launched after a rise in the number of gas accidents amid increasing supply and use of LPG produced as petroleum byproducts in the early 1960s. Another reason behind the policy enforcement was public sentiment and sense of entitlement for a pleasant and safe environment, due to higher national income after the 1980s. The public anxiety over energy safety led residents to strongly shun energy facilities located in their neighborhoods, which complicated securing locations for energy facilities, as well as to address the safety issues in the energy sector. In particular, the mounting public anxiety over nuclear power plants triggered fierce collective complaints and protests in the areas scheduled for nuclear power plant construction, leading to cancellations of ten locations among 18 newly-scheduled sites.

Amid strong public backlashes, the government implemented a wide range of policies to address energy safety and facility location issues. As Korea's energy safety and facility location policies were relatively effective, it could serve as a good development model for developing countries faced with similar challenges. This section of the report explores Korea's energy safety and facility location policies concerning nuclear power plant safety management policy, gas safety management policy, and power supply location policy.

7.2.1. Nuclear Power Plant Safety Management Policy

a. Background

The nuclear power plant safety management policy was enforced after the nuclear power plant accident at Three Mile Island (TMI) in the U.S.A.in 1979 and the Chernobyl nuclear accident in 1986. Although the Nuclear Energy Act was enacted in 1958 had stipulations for safety management, including nuclear materials management, as the start of the nuclear power plant safety management policy, it remained at superficial. As vigilance over nuclear power safety issues spread worldwide in the wake of the nuclear power plant accidents, Korea overhauled and strengthened its nuclear power safety system.

In addition, the stronger anti-nuclear power plant movement on the domestic front was another factor affecting the nuclear power plant safety management policy in Korea. As the anti-nuclear power plant movement gained its momentum from the late 1980s to the mid-1990s, nuclear power plant safety management system was systematically overhauled.

b. Execution System and Method

In 1981, the government set up a specialized nuclear power plant safety management organization, called the Nuclear Power Safety Center, as an internal organization of Korea Institute of Nuclear Power Research. It provided technical support for safety measures, such as screening the licensing of nuclear facilities, development of technical standards, and safety inspection. After a system overhaul in 1982, a licensing system for supervisors handling nuclear fuel materials was introduced by observing the environmental conservation standards for nuclear power plant operators and education and training for nuclear power plant workers. In 1986, the Ukraine Chernobyl nuclear accident served as a wake-up call for Korea. After then, Korea began to strengthen a nuclear power plant safety management system. The affiliation of the Nuclear Power Committee which was the agency that voted on nuclear power policy, changed from the Ministry of Science and Technology to the Prime Minister who also assumed the role of committee chair. In addition, the Nuclear Power Safety Center was expanded and reorganized into an independent affiliated institution.

The stronger anti-nuclear power plant movement led to a systematic overhaul of the nuclear power plant safety management system. In 1989, the Specialized Nuclear Power

Safety Committee was established under the Nuclear Power Committee for a specialized review of nuclear power plant safety issues. In 1993, the Nuclear Power Safety Center was reorganized into the Korea Institute of Nuclear Power Safety as an independent entity, and establishment of comprehensive nuclear power plant safety information system was started. In 1996, the Specialized Nuclear Power Safety Committee was separated as an independent entity of the Nuclear Power Safety Committee. In 1998, the Civic Environmental Watchdog Agency was founded in Kori Nuclear Power Plant for all-time monitoring of its safety in the presence of resident representatives, followed by another one in nuclear power plant in 1999.

The cost associated with the establishment and operation of the agency was covered by Power Plant Site Community Support Fund. The 2000s saw increasing need for a comprehensive nationwide radioactive disaster prevention system in preparation for a possible accidental radioactive material leak at nuclear power facilities, with participation from all relevant disaster prevention agencies, including nuclear power operators, local authorities and the central ministries. Therefore, the Radioactive Disaster Prevention Plan was incorporated into the National Safety Management Plan (2005~2009), which became a basis for the national radioactive disaster prevention system in preparation for possible radioactive accidents.

c. Main Measures and Evaluation

As a major strategy for nuclear power plant safety, the government executed the following actions. First, it overhauled the relevant organizations and systems. The Nuclear Power Safety Committee for specialized review of nuclear power safety issues, the Korea Institute of Nuclear Power Research as a specialized regulatory agency, and the Nuclear Power Research Institute as a specialized research institute were established. This led to improve nuclear power plant safety through effective relevant policy and technology development.

Second, strict safety management standards were put in place by law for the entire process from selection of location to final disposal. In preparation for earthquakes, the geology of the area around the nuclear power plants was closely surveyed to select locations with no active fault grounds, and earthquake-proof designing was required along with examination of the past earthquake records. In addition, emergency operating system against radioactive material leak accidents caused by earthquake was required.

Third, an environmental impact assessment for the areas surrounding the nuclear power plants was executed. The impact of nuclear power plants on the local residents and the environment was predicted. From prior to the construction to the operation period, a whole range of environmental management activities were conducted to minimize its effects. The low and intermediate level radioactive wastes produced during the power plant operation

were strictly managed through scientific processing. Moreover, radiation monitors were installed around the nuclear power plants for all-time measurement of quantity of radioactivity.

Fourth, a civic environmental watchdog agency was founded along with disclosing nuclear power plant information. The agency was created to fundamentally address the distrust of local residents over safety of nuclear power plants, which could not be solved solely by nuclear power plant operational information and disclosure of evaluation on environmental impact to the public.

Fifth, the Nuclear Power Plant Safety Performance Index was created to allow the public to easily understand the safety of nuclear power plant. Starting with its development in 1995, the current safety performance index system was established in 2002 after cooperation with international organizations, such as the International Atomic Energy Agency (IAEA), the Organization for Economic Cooperation and Development and Nuclear Energy Agency (OECD/NEA). Afterwards, the safety of nuclear power plant has been evaluated through the index since 2005 after verification and improvement process. The results are disclosed to the nuclear power plant safety management information system, along with domestic and foreign nuclear power plant operational status, data on the accidents and faults, and grading results.

Sixth, technology development and human resources training for nuclear power plant safety improvement have been intensively implemented. Nuclear power plant safety-related research and development projects were funded by nuclear power plant operators from nuclear power research and development funding. The Advanced Power Reactor 1400MWe (APR1400) was developed in Korea after ten years of R&D in 2001 by the government, industries and academia. APR1400, a standard advanced light water reactor, has had added to its design significant enhancements in regard to safety as well as increased power capabilities. Currently, New Kori Unit Three and Four and New Uljin Unit One and Two are being built as APR1400.

7.2.2. Gas Safety Management Policy

a. Full-fledged Gas Management Policy Following LPG Supply in the 1960s

Gas safety issues became a major issue in the energy sector after increasing gas accidents following greater supply and consumption of LPG (Liquefied Petroleum Gas) which was produced as petroleum by products in the early 1960s and supplied as industrial energy and public fuel. The LPG explosion accident at an apartment in Seoul in August 1964 made gas safety a social issue. As such, Presidential Decree No. 2878 and the Decree of Ministry of Commerce No. 189 were enacted on July 19, 1967 and August 26 respectively, as a policy to address to put the gas safety issue in full-swing.

b. Establishment of Gas Law 2 System of the 1970s and Gas Safety Management Agency

Afterwards, a gas fire accident at Daeyeongak Hotel (163 deaths) in December 1971 and a gas explosion accident at Daewang Corner (six deaths) in August 1972 triggered the following measures. Gas safety was entirely managed by the Industrial Advancement Administration founded in January 1973, and the Compressed Gas Regulatory Law was abolished; instead, High-Pressure Gas Safety Control Act was enacted in February 1973. It required the establishment of gas providers' safety management regulations and the hiring of safety managers, and introduction of inspection systems for gas production facilities and gas containers. In addition to this, the High-Pressure Gas Security Association, the former body of current Korea Gas Safety Corporation was founded in January 1974, and the Urban Gas Business Act targeting household LPG was enacted in December 1978, setting the initial stage of the current gas safety management system. In February 1979, High-Pressure Gas Security Association was expanded and reorganized into Korea Gas Safety Corporation as part of overhaul of specialized gas safety management system.

c. Establishment of Gas Law 3 System of 1983

Meanwhile, gas consumed by households increased to 1.27 million tons in 1983 from 400,000 tons in 1978, and the government's promotion policy for urban households and commercial fuel gasification was initiated in 1981. It was expected to have a huge increase in gas consumptions, leading the government to revise the relevant gas laws. In February 1983, the gas safety management long-term plan was made, which involved the following measures: 1) local government's intervention to prevent overcrowding by regulating the market entry into the gas market; 2) enforcement of obligatory safety checks on gas businesses and on consumers' facilities as well as subscription to the third party damage compensation insurance; 3) support required capital through gas safety management fund and enforce obligatory modernization of facilities in gas businesses such as LPG stations; 4) unification of ownership and management responsibilities of rechargeable LPG containers to the supplier and registration system for the gas containers.

The Safety and Business Management of Liquid Petroleum Gas Act, which separated LPG from High-Pressure Gas Safety Control Act, was legislated in December same year. Subsequently, the Gas Law Three System was established, which included High-Pressure Gas Safety Control Act, The Safety and Business Management of Liquid Petroleum Gas Act, and the Urban Gas Business Act.

The basic framework of gas safety management system centered on the prevention of gas related accidents was provided, in which approaches by self-safety management system by the private sector rather than the safety management by the government. The frequency of

the accidents decreased from 22 cases in 1983 to 14 cases in 1987 due to the introduction of the Gas Law Three System.

d. Establishment of Gas Safety Management System Improvement Plan in 1995

There were 577 gas accidents by 1995 because the gas facilities expanded quickly whereas improvements in the gas safety management system lagged. Due to the large number of gas explosions in 1994 and 1995, the government established the Gas Safety Management System Improvement Plan in 1995 and discussed various measures to improve the law.

This improvement plan changed the gas policy principles to safety, then, supply system. Also, it executed reform measures to achieve the safety level of the developed world within the next five years. As result of the execution of this improvement plan, the gas safety management system was extensively modified. The occurrence of the gas accidents decreased from 577 cases in 1995 down to 176 cases in 2000.

User and business awareness of gas safety management improved due to changes in the safety management system. But on the other hand, the problem of excessive safety regulation and social demand for alleviation of administrative regulations rose. The government drastically simplified the administrative procedures in 1998 in response as well as alleviating the excessive obligations and regulations. Furthermore, unnecessary regulations in the improved the Gas Law Three System, were removed when it was amended in February 1999. Regulations were changed due to the perception that gas safety management was no longer seen as the subject of legal regulation but as a voluntary private sector obligation. Though the administrative procedure was reduced and administrative regulations were alleviated, the remaining regulations were amended to get maximum benefits.

The High-pressure Gas Safety Management Act and the Urban Gas Business Act were enforced from July 2001 to carry out systematic and efficient safety management. It was done by promoting the transfer of central administrative authority. The authority for the construction plan approval and registration permission of the city gas supply facilities and the high-pressure gas manufacturing facilities which were determined not to have gas safety issues was transferred to primary local authorities. High-pressure gas manufacturing shutdown report system and high-pressure gas pipe construction supervision system were introduced. The construction supervision system regarding high-pressure gas pipes was introduced due to a gas leakcaused by the old pipes and inadequate construction in Ulsan Petroleum Chemistry Complex in March 2001. The enhanced safety management system on gas facilities was introduced as one of the 100 comprehensive measures on safety management in Office for Government Coordination in the next year. The safety management system for gas in urban areas was established through the Urban Gas Business Act Enforcement Regulation Amendment in 2003. In 2006, the safety system was made

because of the necessity of enhancing the safety management of compressed natural gas (CNG) containers was raised.

e. Reorganization of Gas Technology Standards Operation System in 2007 (Coded)

The gas safety related laws required frequent amendments whenever the technology changed making them inefficient and inflexible and revealed problems in preventing accidents without deterring technological developments. This was due to the fact that the laws contained regulations and notifications, mixed with administrative sections as well as technical standards. The government promulgated an Act to reorganize and codify the operating system of gas technical standard on December 21, 2007. The government divided the gas safety technical standards which operated under the Gas Law Three System and notifications into performance standards and detailed standards. The performance standards were regulated under the Act and the detailed standards were regulated and operated by the private sector.

The codification of the Gas Law Three System significantly reduced the standard enactment period, increasing companies' competitiveness as well as facilitating the development and introduction of safety management methods. These methods improved their own efficiency and competitiveness which greatly contributed towards preventing gas accidents. It created an opportunity for administrative efficiency to be utilized in the policy development by transferring the government's authority to the private sector while complying with WTO/TBT by regulating technical standards.

7.2.3. Power Supply Facility Location Policy

The power supply location policy was enforced after residents strongly shunned power facility location since the late 1980s. As negative perceptions of power facility's environmental and safety expanded, local residents filed collective complaints and protested against the construction of power facilities in their area. Even the cooperative local governments started to lessen their support and opposed the plants. The siting of power plant became a huge issue in the power plant development policy due to the adamant rejection of regional residents and so only eight locations were confirmed out of 18 locations planned. It was an issue because ongoing expansion of the power supply facilities was essential for the betterment of the national economic development and citizens' lives.

In order to secure power supply locations, the Power Plant Area Support Act was enacted in 1989, and various support projects have been executed since 1990. The funding was covered by Power Plant Area Support Fund which was created by the Korea Electric Power Corporation by putting in 0.3% of electricity sales revenues every year. In 2005, the relevant laws were revised, paving the way for the areas where nuclear power plants

were located to collect regional support. There was now a legal evidence for development businesses to do regional support business with their own capital, which tremendously increased the support funds in case of the nuclear power station's surrounding area. Also, nuclear development businesses were contributing towards regional development through a regional development tax.

In addition, the information on nuclear power plants was disclosed as part of power supply location policy. In 1990, the guideline of nuclear power data disclosure was announced, which became a basis for Nuclear Power White Paper that has been published every year since then. In March 1992, nuclear power promotion projects were under way along with the foundation of the Korea Nuclear Power Cultural Foundation targeting opinion leaders and local residents. Ultimately, the Civic Environmental Watchdog Agency established in Kori Nuclear Power Plant in 1998 was based on such nuclear power data disclosure policy. The projects were implemented with funding from the Power Plant Area Support Fund, and the amounts were set by the Minister of Commerce, Industry and Energy (currently Minister of Knowledge and Economy) after discussion with Surrounding Area Support Project Review Committee.

The policies have greatly solved the power plant location issues by addressing the concerns of local residents regarding power plant facilities. Such effects were demonstrated by the survey on nuclear power plants conducted by the Korea Nuclear Power Cultural Foundation. The rate of positive response to the need for nuclear power plant skyrocketed to 95% in 2005 from 62% in 1989, while negative response declined from 73% to 29% during the same period. Residence acceptability also jumped to 51% in 2005 from 12% in 1995.

7.2.4. Policy Assessment

After the domestic and international major accidents at nuclear power plants, as the awareness of a good and safe living environment were rising, the safety regulations for the major energy facilities, such as nuclear plants, gas facilities, oil and gas facilities, and pipelines, were implemented. Particularly, after the accidents at the nuclear power plants occurred in succession in 1979 and 1980, demonstrations against nuclear power plants intensified and that led to the difficulty in securing the construction spot for the nuclear power plants.

Therefore, the government pushed the safety standards of nuclear power plants, as well as technology development and raising human resources. Furthermore, to change people's perception of uneasiness over nuclear power plants, environmental assessment of nuclear power plant, disclosure of the safety information on nuclear power plant establishment of private environment monitoring organization, development of the safety index for nuclear power plants, and various support projects in the surrounding areas were implemented.

These policies were assessed as helpful measurements for improving the public acceptance and realizing the difficulty of construction of nuclear power plant. While Korea has made very good progress in many areas with public awareness, the recent events at Fukushima and the need for sites for waste disposal reinforce the importance of these efforts.

2012 Modularization of Korea's Development Experience
Energy Policies

Chapter 4

Policy Assessment and Policy Implications for Developing Countries

Policy Assessment and Policy Implications for Developing Countries

Based on the analysis presented so far, the policies developed and implemented by the Korean government could be assessed to offer several policy implications and possibly make some recommendations for policy makers in developing countries.

1. General Energy Policy Approach

Policy is an organized set of action devised to respond to a problem. When a problem emerges a crisis could result if countervailing policy measures are not adopted. Assessing the agenda and priorities contribute to the policy-making process. Ideally, policy is made before a problem reaches a crisis level by effectively identifying and mitigating risks. However, in Korea's energy policy scene, this ideal has not been attained, and almost all the policies reflected a reaction to an unanticipated problem.

In the Korean energy arena, internal and external energy issues have emerged over time. In the 1940s and 1950s, energy poverty was a top-priority which required a concerted national response. In the 1960s, a sufficient and relatively cheap supply of energy was required to fuel the of nation's rapid economic growth. During the two oil shocksin the 1970s and 1980s, the vulnerability of nation's energy system to external shocks was the major issue. Thereafter, the environmental degradation due to the increasing use of lower-grade fossil fuels ensuedas another priority issue. The internal issue of obsolescent governance structures in the energy industry, caused in part by increasing scale and complexity of energy industries exacerbated pressures. In recent years, the trend of rising oil pricescombined with the escalating global climate change issue has made the sustainability of Korea's energy system a national agenda a top priority.

Similarly, energy policy directions have changed over time. In the 1950s, policies aimedat developing the domestic coal resources were implemented, followed by the policies in 1960s that targeted the increasing use of oil, or "oilization" of the nation's energy system to fuel the successful industrialization of the economy. During the oil shocks in the 1970s and 1980s, stringent policies were executed to enhance the energy security under the three core principles of diversification, conservation and stockpile building. In the 1980s and 1990s, the focus of energy policy was shifted to responding to issues of environmental degradation as a more low-quality fossil fuels were used. At the same time, the policies to reform governance were launched targeting deregulation, privatization and pro-competition, in other words, the increasing the application of market mechanisms in managing the energy industry. In recent years, the policy focus shifted again reflecting the commonly-shared perception that technological breakthrough is the most likely approach to improve the energy system's sustainability.

Having accumulated decades of experience solving energy problems, Korea has emerged as one of the G10 energy economies from the world-poorest one. The once firewood-dominant traditional energy structure has been transformed to a modern structure in which world-top class industries deliver a variety of energy services. This evidence may support the assertion that Korea's energy policy has been at least somewhat successful. Then, what lessons could be learned from history?

First, it could be fairly stated that, in the case of Korea, each policy challenge was met by a corresponding policy action. Sometimes, the policy response was delayed such as in the delayed response to the environmental crisis or that some policies drifted such as the energy security policies during the first oil shock. However, it is important that most problems were eventually met by policies which enabled solutions to proceed. This implies that Korea's energy policy process was kept healthy since it was could be flexible to the changing internal and external variables.

Second, the solutions generated considered the long-term processes of a decade or more. The Korean domestic coal development policy and the oilization policy, for example, each evolved over a decade. The security enhancement policy went through two decades of evolutionary process to realize its goals. The governance reform policy aimed at expandingthe application of market mechanisms was launched more than 20 years ago and is still evolving. This implies that in the real-world, there is no one policy to address all issues. Rather, in order to resolve a problem, policy efforts need to be promoted consistently over a decade or decades with clear a task orientation and ongoing modifications as lessons are learned through implementation.

Third, another important point is that Korea's energy policy process has adopted been a variety of plan systems, such as the previous five-year economic development plan, the current plans for national energy basic and the long-term electric power supply and demand. A plan system is an indispensable tool to organizepolicy efforts and to correct policy errors through feedback mechanisms. More than these, it is a tool that allows for a continuous conversation between the policy and the implementation to allow the policy to evolve.

Fourth, each policy regime was equipped with corresponding institutions and financial mechanisms. Successful policy implementation requires the corresponding institutions such as laws and organizations to be enacted along with adequate financial support.

Fifth, Korea's energy policy history suggests that 'luck' played a significant role in the policy's success. If the price warduring which the crude oil price suddenly dropped to $10/bbl. had not occurred in 1986, Korea's economic challenges might have been prolonged and eventually could have collapsed the energy system. If the first oil shock had occurred in the 1960s instead of 1970s, Korea's oilization policy might have had catastrophic results. However, luck itself was not a decisive factor though it opened the window of opportunity for success. What is ultimately indispensable is clear, task-orientated policy that is fully supported shared among policy actors.

The oilization policy was expected to produce the positive impact of a successful industrialization of the Korean economy however; it also produced a negative impact of increased import-dependency for energy supply. The energy security policy which responded to the first and the second oil shocks led to the Korean energy supply and demand management system including the diversification of energy sources and supply sources, energy conservation, and strategically stockpiling oil. These policies were integrated to improvethe energy supply and demandand to promote relevant energy industries, resulting in a positive effect of strengthened energy security. Entering the 20th century, the environment became a key word in addressing energy policy, resulting in restoration of the environment quality to the level recommended by the World Health Organization.

2. Energy Security

Energy is an indispensable factor to sustain economic growth, industrial activities, and national welfare. In this regard, each country'spolicy aims to supply the energy needed for the national economic stability. As a resource-poor country, Korea's domestic energy resources could not even come close to satisfying the energy demand to fuel the continuous economic industrialization. Therefore, the primary goal of Korea's energy policy has been to ensure a stable energy supply to support economic development. Energy security is always taken as a principle objective of national energy policy.

Specific measures to enhance energy security capability include:

- Diversifying energy sources from oil to coal, natural gas and nuclear
- Expanding energy infrastructure,
- Encouraging overseas energy development projects, and
- Emergency strategic oil stockpiles.

2.1. Policy Implications and Recommendations for Developing Countries

Different countries are endowed with different levels of domestic energy resources. Korea's past experience strongly indicates that the lack of domestic energy resources do not necessarily create a bottleneck for economic development. Korea's energy supply is almost totally dependent on imports from overseas acquired on the international energy market. Korea's openness to the international energy marketwas a key factor in formulating energy security for Korea's economic development process. To minimize the impact of international oil price fluctuation on the Korean economy, Korea considered all possible energy options other than oil, including nuclear, coal, and natural gas, and introduced them into Korea' energy mix system. This diversification contributed to making Korea's economic energy system more robust since the 1960s.

Government leadership was quite important in shaping a sound energy mix on a long-term basis. The government played a key role, particularly in planning and implementing energy policy but also in financing the energy projects and developing and importing energy-related technology. In Korea, the energy security policy included nuclear energy in the energy mix in the early 1970s. Subsequent government support enabled the development of nuclear related technologies and facilitated energy diplomacy with foreign countries with advanced nuclear technology capabilities. Government long-term plans also adopted natural gas for use in urban areas and to generate power. The government initiated the necessary construction of related infrastructure, such as the LNG receiving terminals and nation-wide trunk pipeline system.

An energy crisis couldoccur when a bottleneck emerges in an energy supply system. Short-term energy shortages could be overcome by implementing emergency preparedness system and tapping a nation's emergency oil reserves. In the longer-term, the most effective energy crisis management system is to enhance market mechanisms in pursuing the energy security and to maximize the market transparency in investment in the energy industry and energy pricing system.

3. Fostering the Energy Industry

The Korean government actively fostered the energy industry, and thus the government initiated and helped the industry to expand the production of energy-supply facilities construction, to ensure energy an uninterrupted supply. Examples included projects such as oil refineries and power generation plants which enabled the energy sector become a pivotal driving forcefor Korean economic growth. Since the 1960s, Korea has successfully established an energy production and supply infrastructure system during its rapid economic development.

The energy industry in Korea has successfully developed enabling it to play a significant role as one of the driving forces for economic growth and industrialization. Despite the lack of domestic energy resource reserves, Korea's energy production and supply facilities are among the best in the world, as the most advanced technology was introduced when installing the energy facilities. Korea is home to some of the largest and most advanced oil refineries in the world.

Korea was the world's tenth largest energy consumer in 2010, and with its lack of domestic reserves, Korea is one of the top energy importers in the world. The country is the fifth largest importer of crude oil, the third largest importer of coal, and the second largest importer of liquefied natural gas (LNG). Korea Gas Corporation is the largest single LNG importer in the world. Korea is also the world's third-largest importer of hard coal behind Japan and China.

In sum, the energy industry in Korea has been developed through three major approaches, 1) openness, 2) government's strong leadership, 3) industrial structure based on market mechanisms.

3.1. Policy Implications and Recommendations for Developing Countries

Fostering the energy industry is a prerequisite to industrialize the economy and economic and/or social development in any country. However, it is usually a heavy equipment industry that requires for a huge amount of investment and technology application. Based on Korea's experience, strong government involvement in the energy industry was necessary to foster the energy industry due to shallow domestic capital market sand shortage of technology when economic development commenced.

However, this experience also suggests that the partnership between the government and the private sector was quite essential to establish the energy industry and constructing the energy supply facilities. In Korea, oil, coal and city gas industry have been completely

privatized, so that private companies could freely construct and operatein the industries. This was possible due to the private sector's improved capability to mobilize the required investment capital and technology. The role of the government in the privatized energy industry is to set market rules.

The government remains involved in the energy industry in Korea, particularly in the electricity power industry, the wholesale parts of the natural gas market and the district heating industry. Together these industries represent large investments in equipment, particularly for the transportation network system with the transmission and distribution and pipeline system. They also reflect area of high public concern and interest which may not be best served by monopoly structure in which a market-failure could occur.

Korea's nuclear energy industry is a model for other countries and a commendable achievement, particularly in light of its relative youth. The industry, which started in the mid-1970s, reached full maturity and includes design, building and operation of nuclear power plants, maintenance services, fuel fabrication and radioactive waste management. The nuclear energy regulatory framework implemented by Korea is comprehensive and in line with international best practices. The performance of the units in operation is good, and its safety record is excellent with no nuclear accidents reported at any facility. Furthermore, it has had an average capacity factor over 90% since 2000, which is a notable achievement when the world average of just below 80%.

4. Development of Technology

Taking into account the long-term nature of the energy technology development cycle, it is too early to fully assess the policy outcomes. Work continues towards achieving the objectives set for the next decade. Also, skepticism remains about the feasibility of the long-term roadmap with many experts criticizing the inefficiency of the government R&D budget allocation. However, there are emerging signs that progress towards objectives has been made. For example,the level of overall technological capability was assessed to have risen from 60.2% of the advanced group to 69% during the period 2006 and 2010. Another example is the export of NRE technologies which rose to 4.6 billion dollars in 2010 from 1.9 billion dollars in 2008. Also, it was estimated that a macro-economic effect equivalent of 4,025 billion KRW was created by commercializing innovative R&D products (commercialization ratio 24%: 172 projects among 717 attempted), and a total 5,412 new jobs were created.

4.1. Policy Implications and Recommendations for Developing Countries

What Korea has accomplished in energy technology development to date is remarkable. It is not an overstatement to say that Korea built its current world-classenergy technology from scratch. The Korean government placed technology on the top of the national economic development agenda, proposing that only technology could enable Korea to build an industrial economy to compete in the global market. Since Korea has limited natural resources, and relies on energy supply from abroad, the acquisition or domestication of leading edge technology overcame adversities, to makeit a contender in the global market.

What could developing countries learn from the Korean experience in the development of energy technologies? First, they should start by establishing research institutes specialized in energy technology R&D. The first step is to introduce those technologies that already exist in the local energy market and build capacity so the systems could be produced and installed domestically. By learning and doing, local capacity could be builtto conduct R&D planning and implementation themselves. Second, mid- and long-term goals and strategies need to be established to attain the goals. Detailed action plans or roadmaps are then constructed efficiently and effectively to implement the strategies. In this way, the national task of technology developmentcould be presented in the form of master planthat could be approached systematically with foreseeable outcomes. Third, it is strongly recommended that the master plan should include options for financial sources and legislation without which the whole system cannot last and survive the challenges from other urgent national tasks. Last, even if there are few convincing short-term outcomes, maintaining a long-term vision and perspectivecould show progress.

5. Energy Conservation and Efficiency Improvement

Energy conservation and efficiency improvement policies, initiated in 1970s, were systematic and fully implemented. Right after the first and second oil shocks, the government introduced a series of energy conservation policies which, however, were less efficient and effective in terms of scale and quality. Considerable outcomes followed by promulgating the Act on Rational Energy Utilizationand establishing the Korea Energy Management Corporation (KEMCO) pursuant to the law. Between the 1980s and the early 1990s, there were a variety of policy tools and programs developed and implemented under the auspice of the Ministry of Energy and Resources (now the Ministry of Knowledge and Economy: MKE). From 1990s up to now, three Basic Plans for Rational Energy Utilization have been introduced and implemented in series. Korean energy conservation policy has been firmly established.

Korea has made significant efforts to respond to the increase in energy intensity that has accompanied its rapid economic rise. Most notable and commendable are its effort to develop a public transport system to reduce energy consumption growth from transportation. In addition, Korea's progress in energy efficiency fully supported by the establishment of the General Energy Conservation and Efficiency Improvement Plan to improve Korea's energy intensity and energy efficiency. Korea's mandatory fuel economy standards for vehicles were implemented for the first time in 2005, with higher standards than those in the U.S.A., Australia and Canada. Another commendable policy initiative is voluntary agreements (VAs) with industry which are a critical part of Korea's existing energy efficiency improvement plan. Korea's standards for the efficiency of buildings will also remain in line with other best policy approaches.

5.1. Policy Implications and Recommendations for Developing Countries

Since Korea has very limited the domestic energy resources, the only option for Korea is to make the most of the energy sources available through conservation and improved efficiency in energy use. As fully illustrated in the section of energy conservation and energy efficiency, the Korean government has developed and implemented a variety of policy tools to reduce energy consumption. Those policies have evolved in response to changes in the energy market, resulting in strong infrastructure including the government, state-owned organizations, and financial sourceswithin a clear legal framework. Above all, the Korea Energy Management Corporation (KEMCO) as an implementing public organization has played a central role.

For developing countries that have just started to build their energy supply and demand infrastructure, the early Korean experience could provide model to follow. It is recommended that developing countries establish a policy infrastructure by setting a feasible long-term policy target and developing a set of strategies to attain it. For these policies to be effectively and efficiently implemented, relevant governance as well as an implementing state-owned agency should be created and supported by legislation.

Based on this policy framework, a variety of policy measures could be introduced along with tools to conserve energy and improve energy efficiency based on their specific conditions in terms of availability of energy resources, level of technology, and other socio-economic and cultural factors. First, education and training programs need to be introduced to build the necessary technical and policy expertise. Then, as KEMCO has done, the designated state-owned organization works on specific policy measures and programs to mobilizethis expertise and build the capacity to cope with challenges for energy conservation as well as reduce GHG emissions.

6. New and Renewable Energy

Since Korea has few domestic conventional energy sources, it has focused developing and deploying NRE as a clean, environment-friendly and domestic energy sources. In this context, the first, second and third Basic Plans for Renewable Energy Development and Deployment were established sequentially in which deployment targets and strategies were introduced and implemented to foster relevant industries and create a market. While those basic plans were implemented, the policy infrastructure evolved. Many policy measures and programs have been devised some of which have been made obsolete and replaced by more advanced ones.

Due to the Korean government's unprecedented efforts in terms of organizations, programs and necessary budget to fulfill policy goals and strategies, the NRE R&D activities and deployment of NRE has been successfully executed. As of 2011, deployment of NRE was 7,583 thousand TOE, sharing 2.75% of the TPES which is still below the expectation. However, the hardware as well as the software infrastructure has been firmly established as compared to other countries. In particular, policy tools such as FIT, RPA and RPS are regarded as some of the best mechanisms in the world which have evolved through the years of experience and implementation.

Korea has carefully designed and adjusted its policy measures and programs in order to maximize their effect taking into account natural and economic conditions in Korea. While basic and common policy approaches such as subsidies, low-interest rate finance, tax incentives and other administrative actions were provided. More beneficial incentive systems to promote a larger deployment of NRE have been developed and implemented: FIT and RPS. These two mechanisms adopted different in approach. The one was more market-oriented and the other was more subsidy-oriented. After ten years of implementation of FIT, the Korean government decided to replace it with RPS which was seen as a more cost-effective policy tool.

In recent years, as environmental problems such as climate change and local air, soil, water pollution have become a major issue, NRE is regarded as a core area of low-carbon green growth which is being implemented, domestically as well as globally. In addition, it is to be seen as a new growth engine which will feed the economy in the coming decades. It is highly expected that this industry would become a lucrative export item based on the current technology, industry, and policy infrastructure for other developing countries.

6.1. Policy Implications and Recommendations for Developing Countries

Due to a poor endowment of conventional energy resources, Korea has had to develop alternative energy sources such as NRE which is domestic and free from energy security concerns. Theseissues of energy security and climate change justify the Korean efforts to develop and deploy NRE technologies even though they are more costly than the conventional fossil fuels such as coal and natural gas. The Korean case could be a good policy model for those countries which, like Korea, also have few domestic energy resources with high population density.

Korea has carefully designed and adjusted its policy measures and programs to promote NRE to maximize their effect, taking into account environmental and economic conditions in Korea. Initially, the Korean government focused on its finance-oriented role to provide subsidies to promote NREs.Over time, a systematic and comprehensive approach was needed to encourage a larger uptake of NREs so; the Korean government established a national plan as well as legal system to promote the sector. FIT was a major policy tool to create a market for NRE early in the process. However, as some NRE technologies such as wind and biomass, approached a mature market stage, an innovative, the Renewable Portfolio Standards (RPS) was adopted to provide a more market-based mechanism. This is expected to accelerate the commercialization and industrialization of NRE.

As a whole, most developing countries are not fully equipped with policy infrastructure from legal system to administration. Accordingly, a top priority is to establish the relevant legislation and develop and implement a legally binding national plan. Even if the policy is good, without legal status, it cannot be effectively enforced which requires effective interaction between policy-making and legislation. Through this process, policy infrastructure evolves as demonstrated by the Korean experience.

7. The Environment and Safety

In the 1990s, the Korean government put more stress on environment friendly policies and the policies to secure saftey for energy supply facilities.

The key points of environmentally friendly policies include a larger uptake of clean energy sources (i.e. renewable energy, nuclear energy, and natural gas), energy conservation, and energy efficiency improvement. Moreover, environmental regulation policy also evolved. Environmental impact assessments, various support programs, disclosure of nuclear power plants' safety information, and the establishment of the environment monitoring organization were implemented to secure construction sites and to allay safety concerns.

While work remains, the policies mentioned above are worth an attempt to produce the expected outcomes in the areas of the environment and safety. Though Korea's greenhouse gas emissions remain relatively high, the rate of increase in greenhouse gas production has slowed. Additionally, the survey of public acceptance for the nuclear power plants indicated more encouraging results than that in the past.

7.1. Policy Implications and Recommendations for Developing Countries

As international environmental regulation has intensified, developing countries need to build energy systems in harmony with the environment and safety. In other words, a balance between environmental preservation and sustainable economic growth should be a critical objective.

The Korean government has taken steps to foster eco-friendly energy systems while maintaining economic growth. The Korean case could provide a good model for countries like Korea that have a high population density, rely heavily on energy-intensive industries, and have limited natural resources. The Korean government organized pan-government UNFCCC joint task force, and intensively promoted expansion of clean energy supplies, energy conservation and energy efficiency improvement. Moreover, systems to generate greenhouse gas statistics, CDM for reducing greenhouse gas, activating a cap-and-trade program, and developing energy technologies are in the progress. In June 2010, the plan for the introduction of energy cost system including the cost of production and environment was announced.

Recently, the policies that capitalize on the environment as a new growth engine have been pursued in Korea, which could serve as a good development model for developing countries faced with environmental problems. The Korean government is actively in pursuit of the greening existing industries and promoting green industries. Export of green products in major industries is expected to rise from 10% in 2009 to 22% in 2020. While promoting green technologies, such as NRE, a smart grid, and energy efficiency improvement, the government is also encouraging small and medium-sized enterprises (SMEs) to green their businesses.

As energy infrastructure is expanding, developing countries may face energy safety and facility location issues. The Korean government implemented a wide range of policies to address the issues of energy safety and energy facility location. To secure sites for energy supply facilities, environmental impact assessments and disclosure of the safety information on power plants, establishment of environment monitoring organization and various support programs in its surrounding areas were done. These policies contributed to improving safety

and public acceptance for energy facilities, which could serve as a good development model for developing countries faced with similar issues. While Korea has made a considerable progress in improving public acceptance, the Fukushima nuclear accident reinforces the importance of such policy efforts.

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339-012, Sejong Government Complex, 477, Galmae-ro, Sejong Special Self-Governing City, Korea Tel. 82-44-215-2114 www.mosf.go.kr

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