KNOWLEDGE SHARING PROGRAM

Policy Recommendations for Economic Development in Priority Areas of the Kingdom of Saudi Arabia

2011

MINISTRY OF STRATEGY AND FINANCE

KDI Korea Development Institute

Policy Recommendations for Economic Development in Priority Areas of the Kingdom of Saudi Arabia

Policy Recommendations for Economic Development in Priority Areas of the Kingdom of Saudi Arabia

Project Title	Policy Recommendations for Economic Development in Priority Areas of the Kingdom of Saudi Arabia
Prepared by	Korea Development Institute (KDI)
Supported by	Ministry of Strategy and Finance (MOSF), Republic of Korea
Prepared for	Government of the Kingdom of Saudi Arabia
In cooperation with	Ministry of Economy and Planning, Kingdom of Saudi Arabia
Program Directors	Kwang-Eon Sul, Former Managing Director, Center for International Development (CID), KDI MoonJoong Tcha, Managing Director, CID, KDI Taihee Lee, Director, Policy Consultation Division, CID, KDI
Program Officer	Mikang Kwak, Research Associate, Policy Consultation Division, CID, KDI
Project Manager	Hyung Koo Lee, Former Minister of Labor
Authors	Chapter 1: Hyung Koo Lee, Former Minister of Labor & Dongseok Kim, Senior Research Fellow, KDI Chapter 2: Chang Hwan Kim, Senior Research Fellow, Korean Educational Development Institute & MoonJoong Tcha, Senior Research Fellow, KDI Chapter 3: Jaejoo Ha, Vice President, Korea Atomic Energy Research Institute Chapter 4: Chang Seob Kim, Professor, Kyungwon University
English Editor	Minah Kang, Freelance Editor Eun Hae Kim, Freelance Editor

Government Publications Registration Number 11-1051000-000155-01

ISBN 978-89-8063-537-5 93320

KNOWLEDGE SHARING PROGRAM

Government Publications Registration Number
11-1051000-000155-01

Knowledge Sharing Program

Policy Recommendations for Economic Development in Priority Areas of the Kingdom of Saudi Arabia

2011

MINISTRY OF STRATEGY AND FINANCE

KDI Korea Development Institute

Preface

In the 21st century, knowledge is one of the key determinants of a country's level of socio-economic development. Based on this recognition, Korea's Knowledge Sharing Program (KSP) was launched in 2004 by the Ministry of Strategy and Finance (MOSF) and the Korea Development Institute (KDI). KSP aims to share Korea's development experience and knowledge accumulated over the past decades to assist socio economic development of the partner countries. Former high ranking government officials are directly involved in policy consultations to share their intimate knowledge of development challenges, and they complement the analytical work of policy experts and specialists who have extensive experience in their fields. The government officials and practitioners effectively pair up with their counterparts in development partner countries to work jointly on pressing policy challenges and share development knowledge in the process. The Program includes policy research, consultation and capacity building activities, all in all to provide comprehensive, tailor made assistance to the partner country in building a stable foundation and fostering capabilities to pursue self sustainable growth.

Year 2010 is the first to conduct Knowledge Sharing Program with the Kingdom of Saudi Arabia (KSA). Written demand survey forms were submitted by the Ministry of Economy and Planning of the KSA via official channels throughout 2009. Upon the request, 2010 KSP with the KSA was launched in May 2010 focusing on the following four areas: Enhancing the Effectiveness of the Implementation of Economic Development Plans; Improvement of Primary Education; Nuclear energy development with special focus on institutional and technological capacity enhancement; and Introduction of a Smart Grid System.

I would like to take this opportunity to express my sincere gratitude to Project Manager, Dr. Hyung Koo Lee, and all the fellows including Dr. Dongseok Kim, Dr. MoonJoong Tcha, Dr. Jaejoo Ha, Dr. Chang Hwan Kim, and Dr. Changseob Kim for their immense efforts in successfully completing the 2010 KSP with the KSA. I am also grateful to Managing Director Dr. Kwang-Eon Sul, Program Directors Mr. Taihee Lee, Dr. Wonhyuk Lim and Program Officer Ms. Mikang Kwak, all of the members of the Center for International Development, KDI, for their hard work and dedication to this program. Lastly, I extend my warmest thanks to the Ministry of Economy and Planning of the KSA, related Saudi government organizations, program coordinators and participants for showing active cooperation and great support.

In your hands is the publication of the results of the 2010 KSP with the KSA. I sincerely hope the final research results including policy recommendations on the selected areas could be fully utilized to help the KSA in achieving economic development in priority areas in the near future.

Oh-Seok Hyun
President
Korea Development Institute

Contents

Chapter 02
Improvement of Primary Education of the KSA

Contents

Chapter 03

Sharing of Korean Nuclear Experience for the Introduction of Nuclear Energy in Saudi Arabia -Focusing on the Self reliance Experience of Nuclear Energy in Korea-

Contents

Contents

Chapter 04
Korea's Smart Grid Policy Initiatives

Acronyms and Abbreviations

A/E	Architect Engineering
AEC	Atomic Energy Commission
AECL	Atomic Energy of Canada Limited (Canada)
AERI	Atomic Energy Research Institute (UAE)
APR	Advanced Nuclear Power Reactors
ASE	Atomstoryexport (Russia)
CANDU	Canada Deuterium Uranium (Canada)
CE	Combustion Engineering Company (USA)
CNEPP	Comprehensive Nuclear Energy Promotion Plan
CNNC	China National Nuclear Corporation (China)
CNRF	Cold Neutron Research Facility
CTBT	Comprehensive Test Ban Treaty
ECRA	Electricity & Co-generation Regulatory Authority (UAE)
ENEC	Emirates Nuclear Energy Corporation (UAE)
FTL	Fuel Test Loo
GA	General Atomic (USA)
GCC	Gulf Cooperation Council
GE	General Electric Company (USA)
GGA	Gulf General Atomic Co. (USA)
GNEP	Global Nuclear Energy Partnership
HANARO	High-flux Advanced Neutron Application Reactor
IAEA	International Atomic Energy Agency
IFC	International Finance Corporation
INGS	International Nuclear Graduate School (Korea)
IPPs	Independent Power Producers
IWPP	Independent Water & Power Project
JAEC	Jordan Atomic Energy Commission (Jordan)
JRTR	Jordan Research and Training Reactor (Jordan)

JUST	Jordan University of Science and Technology (Jordan)
KABAR	Korea Atomic Burns and Roe (Korea)
KACARE	King Abdullah City for Atomic and Renewable Energy (UAE)
KACST	King Abdullah City of Science & Technology (UAE)
KAERI	Korea Atomic Energy Research Institute (Korea)
KAIST	Korea Advanced Institute Science and Technology (Korea)
KAU	King Abdul Aziz University (UAE)
KEPCO	Korea Electric Power Corporation (Korea)
KEPCO E&C	KEPCO Engineering & Construction (Korea)
KEPCO KPS	Korea Plant Service & Engineering (Korea)
KEPCO NF	KEPCO Nuclear Fue (Korea)
KEPIC	Korea Electric Power Industry Code (Korea)
KHIC	Korea Heavy Industries and Construction Co. Ltd. (Korea)
KHNP	Korea Hydro & Nuclear Power Co. Ltd. (Korea)
KINAC	Korea Institute of Nuclear Nonproliferation and Control (Korea)
KINS	Korea Institute for Nuclear Safety (Korea)
KIRAMS	Korea Institute of Radiological & Medical Science (Korea)
KMRR	Korean Multi-purpose Research Reactor (Korea)
KNE	Korea Nuclear Engineering Co. (Korea)
KNFC	Korea Nuclear Fuel Co. Ltd. (Korea)
KNFDC	Korea Nuclear Fuel Development Complex (Korea)
KNS	Korean Nuclear Society (Korea)
KOFA	Korea of Fuel Assembly (Korea)
KOPEC	Korea Power Engineering Co. Ltd., presently renamed as KEPCO E&C (Korea)
KRMC	Korea Radioactive waste Management Corporation (Korea)
KSNP	Korea Standard Nuclear Power Plant
KSU	King Saud University (UAE)
LILW	Low and intermediate-level wastes

Acronyms and Abbreviations

MEST	Ministry of Education, Science and Technology (Korea)
MKE	Ministry of Knowledge Economy (Korea)
MW	megawatt
NAA	Neutron Activation Analysis
NPP	Nuclear Power Plant
NPT	Non-Proliferation Treaty
NRF	National Research Foundation of Korea (Korea)
NSC	Nuclear Safety Commission
OAE	Office of Atomic Energy (Korea)
OPR	Optimized Power Reactor
PHWR	Pressurized Heavy-Water Reactor
PWR	Pressurized light Water Reactor
SANCST	Saudi Arabian National Center for Science and technology (UAE)
SEC	Saudi Electricity Company (UAE)
SFR	Sodium Fast Cooling Reactor
TLD	Thermo Luminescence Dosimetry
TRIGA	Training Research Isotope-production General Nuclear
UAE	United Arab Emirates (UAE)
UST	University of Science & Technology (Korea)
VHTR	Very High Temperature gas Reactor
WNA	World Nuclear Association

2010 KSP with the Kingdom of Saudi Arabia

In 2009, Ministry of Strategy and Finance (MOSF) conducted a written demand survey for KSP through the Korean Embassy in the Kingdom of Saudi Arabia (KSA) and the survey was submitted from H.E. Ahmed I. Al Hakami, the Vice Minister of Economy and Planning. Amongst 10 topics in the demand survey, KDI has decided to address, 'Developing the present planning process and mechanisms of the five year plan at the Ministry of Economy and Planning (MOEP) as well as its implementation follow-up.' Based on such a request, the Korean MOSF, a sponsoring organization for KSP, and KDI selected Saudi Arabia as its development partner country for 2010.

The Korean delegation, headed by Former Minister of Labor, Hyung Koo Lee, paid a visit to Riyadh from May 13th to May 19th, 2010 and met with H.E. Khalid Mohamed Al Gosaibi, Minister, and H.E. Ahmed I. Al Hakami, Vice Minister of Economy and Planning, and senior government officials from the MOEP, Ministry of Finance, Saudi Arabian Monetary Agency and other government organizations in order to discuss policy priorities and detailed assignments regarding the above mentioned topics.

During the visit, the Korean Delegation had an in depth discussion with H.E. Ahmed I. Al Hakami, Vice Minister of Economy and Planning and a group of advisors at the MOEP regarding the agendas of 2010 KSP for the KSA. As a result, four agendas were selected which are based on policy priorities and requests submitted by the Saudi side. These four agendas and Korean researchers for each topic are as below.

Consultation Topics	Korean Researcher
Enhancing effectiveness of implementing development plans	Dr. Hyung Koo Lee Dr. Dongseok Kim
Improvement of primary education	Dr. Chang Hwan Kim Dr. MoonJoong Tcha
Nuclear energy development with special focus on institutional and technological capacity enhancement	Dr. Jaejoo Ha
Introduction of a smart grid system	Dr. Chang Seob Kim

The KDI conducted Pilot Study from July 1st to July 7th, 2010 to identify the relevant

research themes and to gather relevant data and information. During the visit, the Korean delegation had working-level meetings at the MOEP with the experts from the Ministry of Education, Saudi Electricity Company, and King Abdullah City for Atomic and Renewable Energy. Participants from both countries engaged in an active discussion about the current state and issues of each topic of the Kingdom of Saudi Arabia and exchanged ideas of how they can be improved.

In September 2010, for the purpose of presenting interim progress findings and sharing ideas for the KSP with the KSA, an Interim Reporting and Policy Practitioners' Workshop was held in Korea. The Saudi delegation, headed by H.E. Bandar A. Alwaily, Assistant Deputy Minister of Economy an Planning, participated in the Interim Reporting & Policy Practitioners' Workshop.

From September 13th to 17th, 2010, a Saudi delegation composed of 10 members from the Ministry of Economy and Planning, Ministry of Education, King Abdulaziz University, King Abdulaziz City for Science and Technology and King Saud University visited Seoul to participate in Policy Seminar and Policy Practitioners' Workshop. Policy Seminar included presentations on the research topics as well as Korea's broad development experience. The seminar fully served its purpose by facilitating active exchange of information and research progress as well as discussion on the research plan for the final consultation report. Furthermore, the Saudi delegation was welcomed by relevant Korean institutions and organizations including the Ministry of Strategy and Finance, KEPCO, Korea Atomic Energy Research Institute, Doosan Heavy Industries & Construction Co., Kori Nuclear Power Plant, Ministry of Education, Science and Technology, and EBS. Those visits enhanced the understanding of the Saudi participants in their respective sectors and Korea's development experience.

As the final stage of 2010 KSP with the KSA, Senior Policy Dialogue and Final Reporting Workshop was held in Riyadh from December 16th to 22nd, 2010. For Senior Policy Dialogue on December 18th and 19th, the Korean delegation headed by Dr. Hyung Koo Lee held meetings with high ranking officials including H.E. Khalid bin Muhammad Al Gosaibi, Minister of Economy and Planning, H.E. Ahmed I. Al Hakami,

Vice Minister of Economy and Planning, H.E. Saleh H. Alawaji, Deputy Minister of Electricity, H.E. Mohammed I. Al-Saud, Deputy Minister of Water, H.E. Faisal Abdulrahman bin Muaammar, Vice Minister of Education, H.E. Waleed Hussain M. Abulfaraj, Vice President of KACARE, and H.E. Khalid M. Al Sulaiman, Vice President of Renewable Energy of KACARE. The Final Reporting Workshop took place at the Ministry of Economy and Planning. The Korean experts presented the final report and policy recommendations, and the local experts from government organizations, public sectors and schools participated as discussants for their corresponding topics.

The Final Reporting Workshop was a great success with nearly 40 people participating from the related ministries and organizations. Furthermore, the policy recommendations for each topic have been well-received by participating Saudi government ministries and agencies.

Mikang Kwak
Program Officer for 2010 KSP with the Kingdom of Saudi Arabia

Hyung Koo Kee (Former Minister of Labor)

Enhancing the Effectiveness of the Implementation of Economic Development Plans

Saudi Arabia has more than four decades of accumulated experience in plan design, implementation and follow up, and the methodology and content of all types of plan have been evolving and improving over time. Sophisticated statistical and econometric techniques are used in formulating the documents, and comprehensive and sophisticated economic models are utilized in Saudi Arabia's development plans. Recently, a computerized web based follow up system has been developed for the operational plans implementation. It is widely evaluated that Saudi's development plans have greatly contributed to the steady economic growth of the nation.

On the other hand, Saudi Arabia's development plans have a few weaknesses in the implementation and follow up sides. In the implementation of projects, not enough objective indicators are set out at the project formulation stage, and it is desired that the plans include concrete and detailed targets, clear time lines, and clear assignment of responsibility. At the project implementation stage, the Ministry of Economy and Planning (MOEP), the planning ministry, cannot act preemptively to prevent deviations from targeted paths, and has neither the mandate nor the resources to check on the accuracy of all progress reports submitted by government agencies.

Second, in the implementation of policies, the Ministry of Economy and Planning cannot make sure that satisfactory implementation of the macroeconomic and sectoral policies are achieved for various institutional constraints;

- The plan does not assign policies to specific government agencies to implement them.
- It is left for government agencies to choose which policies to implement
- The MOEP has no power to assign responsibilities for policy implementation to any government agencies

- It is impossible to hold any government agency responsible for failures in implementing plan policies.

After a thorough review of the general characteristics of economic development plans in market economies and of Korea's experience in comprehensive socio-economic development planning, we provide the following advice and recommendations for enhancing the effectiveness of the implementation of Saudi Arabia's economic development plans.

(1) Strong Implementation of Development Plans: Development plans must be of higher level than all other plans, and effective implementation of development plans is possible when they are assigned high priorities in economic management.

(2) Strong Leadership of the Top Leader: Long-term plans must be executed comprehensively and consistently, but changing circumstances always bring adjustments and changes to the original plan. The most effective way to overcome this problem is a strong leadership of the top leader, who can commit to long term goals of the plan, making it robust and strengthen people's belief in future prosperity.

(3) Strong Position of the Planning Center: It is suggested that a wide consensus be established inside the Saudi government regarding capability and power of the Ministry of Economy and Planning in coordinating and problem solving, and its leadership as the planning center.

(4) Professional Research Institution: Successful preparation and implementation of economic development plans requires a professional research institution with close ties to the government. In the era of global economy, information sharing and dissemination capability is a prerequisite to stay up to date on global current affairs. A professional research institution can provide outcomes that are based on research, analyses and scientific studies, and thus provide solid recommendations, which could be used as policy tools for government officials, who otherwise may not have such access. The Korea Development Institute (KDI) played such role in the Korea's development process.

(5) Enhancing the Functions of Market System: Korea's experience proves that the expansion of the public sector raises substantial inefficiency, and that enormous efforts must be made in providing the market with an efficient incentive system. The oil sector occupies a huge portion in the Saudi economy, and is regarded as a public sector. Considering the fact that one of the major objectives of development plans is to expand the functions of the market system and to develop the private sector, it is suggested that efforts be made in providing the market with an efficient incentive system.

(6) Indicative Planning: Economic development plans in a market economy must be 'indicative,' that is, they must clearly 'indicate' concrete strategies and directions for accomplishing the country's goals. Indicative plans must take into serious consideration the capabilities and expectations of the market at both aggregate and sectoral levels, and provide a grand picture of the economy with an economy wide balance.

(7) Reconciliation of Macro Plan with Sectoral Plans: It is not an easy task to assess, based only on the plan documents, how well the sectoral plans are reconciled with the macro plan. In many countries, macro and sectoral plans are prepared and implemented separately without appropriate reconciliation. It must be stressed that development plans are not fully 'comprehensive' without this reconciliation.

(8) Rolling Plan System: Rolling plan system is one of the solutions for continued implementation of development plans. Rolling plan system can enhance the public awareness on the development plans as well as on the domestic and international environments.

(9) Concrete Plan: Concreteness of the plans also affects the effectiveness of plan implementation extensively. Effectiveness of the implementation of development plans can be maximized only when the plan documents include not only the goals, directions and strategies, but also specific details such as the concrete quantitative targets, specific time lines, implementing agencies, budgets, and so on. Development plans cannot be more effective than political promises without such details.

In the final report of the Knowledge Sharing Program (KSP), a framework for

development planning in Saudi Arabia is suggested, which describes the roles of the top leader, the planning center, research institution and government ministries, and the elements of the preparation and implementation of the plans.

Improvement of Primary Education of the KSA

Economic growth is defined as the increase in the value of final products (including goods and services) in a certain area in a given time. In order for an economy to grow, factors of production should be accumulated, and productivity should be enhanced. Institution is the most important fundamental for an economy to grow, where education system comprises one of the most important parts of institution.

Previous studies indicate that education and human resource development is a common factor of and the most significant contributor to the growth of highly performing East Asian economies. In particular, these economies started with the effort to universalize primary education, and then moved their policy emphasis to more advanced levels of education. Some studies show that contribution of labor to economic growth in Korea ranged from 1.1% to 4%, where the relative contribution of labor quality has increased.

Another important contribution of education, including primary education, is its role of improving human development. It has been found that enhancement of education improves health and life expectancy as well as affecting fertility substantially. These findings imply that the increase in efficiency and effectiveness of education, most of all primary education, will have significant impact to the Kingdom of Saudi Arabia (KSA).

Primary education in Saudi Arabia is six years and children at the age of 6 enter into the first grade of primary education. All national primary schools are day schools and are not co educational. In order to move on to intermediate education, children have to pass the examination at the end of grade 6 of primary school and obtain the Elementary Education Certificate. According to government data, 2,442,482 students (1,255,117

male and 1,187,365 female) are in primary education in 2007 and the number of teachers is 217,555 in total (107,227 male and 110,328 female) in 2007. According to the UNESCO, gross enrollment ratio for boys is 99.9 percent, gross enrollment ratio for girls is 96.3 percent, and gross enrollment ratio for total is 98.1 percent in 2007.

In order to improve the primary education of the KSA, the following strategies could be recommended: First, the KSA is geographically a wide country. It is difficult to manage every school within the country, especially to provide equal educational services including rural areas. Therefore, strategies to increase the accessibility of education services are required. Second, the KSA is a young country. The youth population growth rate is very high (more than 50% of total). This implies that the Kingdom needs to construct many school facilities and hire numerous teachers every year, which are highly costly. In addition, the Kingdom has a lot of small sized schools. Therefore, strategies to increase the efficiency of educational services, such as e-learning and participation of the private sector in building school facilities, are required. Third, quantitative increase in the number of students and teachers requires strategies to improve the quality of education.

Based on these strategies, following policies are recommended: First, the e-learning accounts for significant meaning. The Korean experience in e-learning, especially EDUNET and the Cyber Home Learning System will contribute to expand educational opportunities and educational services of the KSA.

Second, as a public broadcaster, the Educational Broadcasting System (EBS) will help expand the educational opportunities from pre-elementary education to adult education. It is recommended to consider about the introduction of Educational Broadcasting System whether it be TV, radio, or Internet.

Third, dealing with the problem of small sized schools, school network and integrated school management will increase the efficiency of educational services and enhance the quality of education.

Fourth, the growing population, especially the growing birth rate of the KSA requires more school facilities. Therefore, a policy to invite the private sector to invest in school facilities is needed. Build-Transfer-Lease (BTL) projects can meet the demand in a timely manner.

Fifth, the Kingdom of Saudi Arabia is a young country. Because of the high birth rate, the Kingdom needs more teachers every year. Training programs are very important in achieving a high teacher quality. The policy to improve the quality of teacher training program (including overseas training) is highly recommended. In addition, the policy to train the elite bureaucrat groups for quality improvements will be needed.

Sixth, through the establishment of educational think tanks, the KSA will be able to create windows for introducing and learning advanced experience, knowledge, technology, techniques, and so on. With the help of these institutions, evidence based scientific decision making will be improved.

Sharing of Korean Nuclear Experience for the Introduction of Nuclear Energy in Saudi Arabia

Climate change and energy security is one of the top challenging agenda worldwide. Saudi Arabia seriously considers the introduction of nuclear and renewable energy as an option to counter the challenge as well as to diversify the industrial structure for the nation's sustainable development.

However, the employment of nuclear energy, unlike the other industries, needs to address a broad range of issues such as technologies and industries, strong human resource, enormous initial investment, high standard for safety and security, sensitive international non proliferation issues, complicated public acceptance, long term vision and R&D, and so on. Due to such a broad and complicated prerequisite, the decision and strategy for the introduction and development of nuclear technology and energy requires

comprehensive feasibility studies and planning. One of the most effective ways is to benchmark the experience of countries who share some of characteristics of Saudi Arabia and conducted the nuclear program effectively and efficiently, i.e., a successful model that can be applied to Saudi Arabia.

In this sense, Korea is one of the strong candidates of such successful models. Although other advanced countries developed their own technology based on already established industrial infrastructures and technology, Korea started the nuclear program by importing necessary technology in the first stage, localized the technology in the second stage, and further developed innovative technology in the third stage. Such experience and strategy can be commonly adapted to so-called “new-comer” countries.

During the first stage, regarded as a “dawning era”, Korea became a member state to the International Atomic Energy Agency (IAEA) in 1957. Following the promulgation of the Atomic Energy Law in 1958, Korea established the Office of Atomic Energy, the first government organization, and the Korea Atomic Energy Research Institute (KAERI) in 1959 subsequently. After these fundamental setups were enacted, the first research reactor, TRIGA MARK II, was imported from U.S.A. in 1959.

Based on such human resource establishment, the first commercial nuclear power plant, Kori 1 was constructed in 1972 and operated in 1978. Although this was also imported from U.S.A. as a turn-key basis contract, it provided a critical momentum to accelerate in building the broad range of nuclear power industries such as regulation system, heavy component manufacturing, fuel fabrication, design and construction, and education and training system.

The second stage, during the 1980s and 90s, emphasize 'localization' of technologies, in which design, construction and operation as well as domestic supply of equipment were developed by the Koreans. HANARO, a 30 MW multipurpose research reactor, was designed and constructed by the KAERI. As well, CANDU and PWR fuel fabrication facilities and technology were also localized and supplied 100% of nuclear fuel to the domestic NPPs. The conducting scheme of NPP construction project was

changed from a turn key basis contract with foreign vendors to several contracts with domestic companies by separating design, construction, and equipment supply, but with direct project management by the utility, the Korea Electric Power Company (KEPCO). This changed scheme has continued to this day, and enabled the entities to focus on becoming technologically self sufficient in their specialized areas.

As a result, Korea ranks as the world's 6th in total nuclear power generation using 20 units totaling 17,716 MWe, which supplied 38.6% of the total electricity demand. Currently 8 units are under construction, and 10 more units are to be constructed by 2030 to increase its share up to 60% of the total electricity demand.

In the current stage, Korea is actively participating in the international nuclear power market as well as the future innovative technology. In 2009, Korea succeeded in exporting a research reactor to Jordan and power plants to the United Arab Emirates. This achievement is not just from its experience and technology, but also from the strong emphasis on the importance of partnership that Korea has learned from the past experience. This is especially important to new comer countries that are eager to localize technology.

To employ nuclear technology, there are many considerations such as government leadership and policy, manpower buildup, international relations, comprehensive promotion plan, legal structure, technology selection and self reliance strategy, and so on. However, based on Korean experience, the followings are specifically recommended to Saudi Arabia for the introduction of nuclear technology.

First, government plays important role in nuclear technology, since it is a long term, politically sensitive, multi disciplinary and industrially fusion critical infrastructure, and also requires large investment. The King Abdullah City for Atomic & Renewable Energy (KACARE) seems to have the very essential approach to establish such a government's role not just as “control tower”, but also as “acting agent”. The project should not necessarily large, but easier such as a research reactor construction and utilization. Through such a tangible, result oriented project, the necessary infrastructure

and human resource can be naturally established.

Second, in technology selection, economics and performance are usually key factors. However, if the country has a long term vision for the sustainable development of nuclear technology, the consideration of sincere partnership and technology transfer/cooperation scheme should not be overlooked. In Korean experience, joint design and on the job training in a real project under the Technology Transferring Agreement (TTA) played a key role in achieving technological self reliance.

Third, human resource development is crucial to any aspect, and takes very long time. The education and training is essential to create the critical mass.

Fourth, developing and incubating technology in a technology warehouse shall be a crucial role for achieving technological self reliance. The relevant research institute should be established and supported.

Since Saudi Arabia has the potential to perform the nuclear program economically and academically, taking advantage of Korea's experience and a close cooperation with Korea, will effectively promote the introduction of nuclear energy in Saudi Arabia.

Korea's Smart Grid Policy Initiatives

Korea and Power Industries

Using 2009 standard, Korea's generation capacity stands at 73,470 thousand kilowatt. And The demand for electricity is expected to increase 3% annually and by 2024, peak electricity will be up to 107,437 megawatt. In response to growing needs of electricity, Korea is in the process of establishing a smart electric grid to efficiently produce and distribute energy.

The total length of transmission line is 29,929 c km. Outage time in Korea is

14.29min/year. Other countries that show longer outage time than Korea are: 57min/year in France, 68min/year in UK, 122min/year in USA. The loss rate of transmission/distribution in Korea is about 4% which is lower than other countries of 9% in UK, 7% in USA, 5% in Japan.

These numbers indicate that Korea's electricity grid is already smart due to automated distribution and operation of innovated technologies. Regardless, Korea is dedicated to develop and implement smart grid technologies.

Why Smart Grid?

The age of post petroleum calls for a shift in the current development paradigm. The need for a change in energy resource is urgent. Fossil fuel dependent growth will need to be replaced with renewable energy and nuclear energy dependent growth. As a result, Korea plans to have 8.8% from the total energy generation percentage from renewable energy sources and 47.7% of energy generated from nuclear energy by year.

Additionally electric vehicles, energy storage system, AMI and smart appliances are expected to be key green technologies; Smart grid will provide the necessary platform for development and application of innovated green technologies

Smart grid is anticipated to play a major role in inducing development of other green innovated technologies. It will also play the role of an incubator to help foster green growth development. There is no doubt that early deployment of smart grid will bring Korea economic benefits as the world marches towards a green growth society.

Due to climate change, establishment of a smart grid platform is unavoidable in order to achieve low carbon green growth, the new national vision of Korea, which the President puts forth. To address climate issues, Korea set a goal to increase energy efficiency by 46.7% compared to 2006 standard. Korea also plans to supply 2.4 million electric vehicles by 2030. These goals are impossible to achieve without a new platform called the smart grid.

Smart Grid Demonstration Overview of Korea

There are 5 different domains under the smart grid test bed project. For example, there is Power Grid that acts as an intelligent power system. There is Power Place, which is the base for efficient energy use in homes and buildings. There is Smart Renewables that allow stable connection distribution of renewable energy. Then there is a Smart Transport, which will test electric vehicles. Finally, there is a Smart Power market, which provides price signals and acts as smart grid control center.

The Jeju test bed consortia, which are organized with Korea's major companies, have been chosen based upon a competitive bidding process. There are four companies for smart place, three companies for smart transport, three companies for smart renewables and so on.

Strengths of Korean Electricity

Korea is one of the biggest energy consuming countries in the world, based on new power infrastructure and superior ability of operation. Korea prides itself in globally competitive skills for power infrastructure development and possesses optimal conditions to deploy the smart grid. Under such smart grid appropriate conditions, Korea is proceeding with the Jeju smart grid demonstration which incorporates industries from various fields, such as electricity, telecommunication, appliances, construction and transportation. In the long run the smart grid will induce a smart industry.

In addition, Korea is in the process of establishing and operating highly sophisticated telecommunicative infrastructure. Through such integration and incorporation of various infrastructure, Korea aims to develop innovated smart grid technology. What we anticipate is to include a smart grid ubiquitous city, which surpasses the function of intelligent grid.

There are currently 168 companies participating in the Jeju smart grid demonstration. Consequently, there are several challenges that result from working together with so

many companies. Regardless of unavoidable trial and errors, the government has remained dedicated to implementing the smart grid and has shown robust leadership in the field.

Suggestion for Saudi Arabia

Korea is already in the process of establishing and operating a globally competitive and highly sophisticated electric grid. Additionally, Korea is in the process of developing new technologies, services and infrastructure all in connection with telecommunicative infrastructure.

There is a need for Saudi Arabia to proceed with an automated electric grid as a priority. In this regard, Korea's technological experiences and technologies currently under development will guide Saudi Arabia with the help it needs.

Last but not least, Korea values collaboration between telecommunication industries and electricity company, and it is expected that intimate collaboration between these industries will bring forth productive outcomes.

In closing, incorporating greenhouse industry by using PV panels to help produce lacking vegetables in Saudi Arabia can be an ideal case to implement the smart grid in place like Saudi Arabia.

Policy Recommendations for Economic Development
in Priority Areas of the Kingdom of Saudi Arabia

Chapter 01

Enhancing the Effectiveness of the Implementation of Economic Development Plans

Chapter 01

Enhancing the Effectiveness of the Implementation of Economic Development Plans

Hyung Koo Lee (Former Minister of Labor)
Dongseok Kim (Korea Development Institute)

1. Brief Review of Saudi Arabian Economy

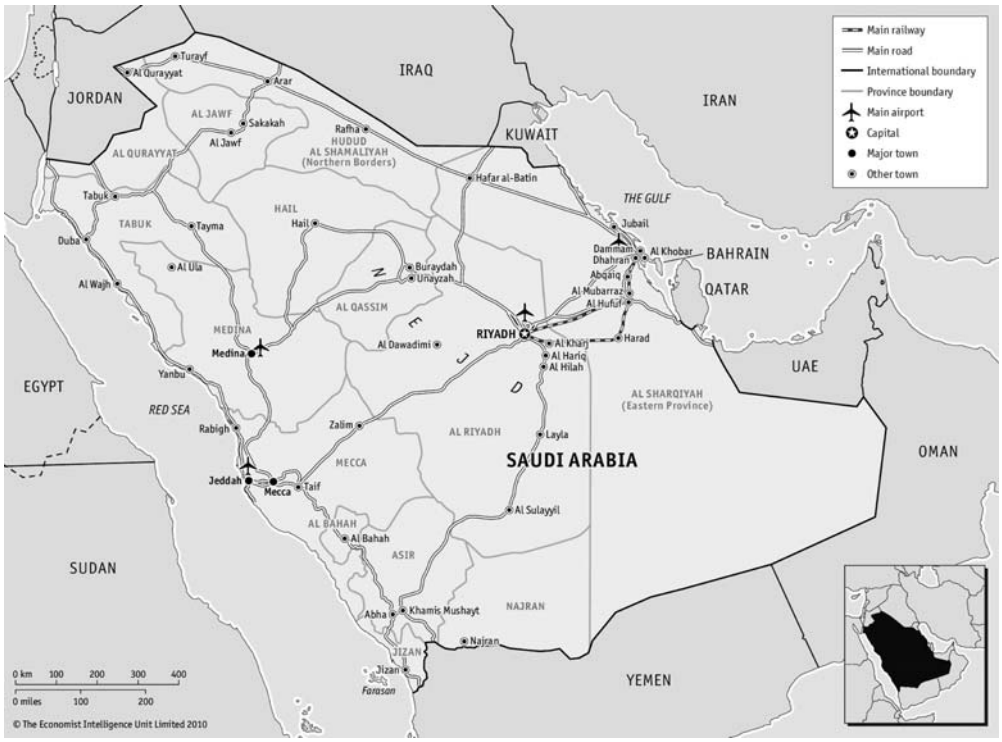
1.1. Territory and Population

The Kingdom of Saudi Arabia is located in the Arabian Peninsula, with the territory of about 2.15 million ㎢, ranking the 14th in the world in terms of landmass. Saudi Arabia is located between the Gulf in the East and the Red Sea on the West, and shares its borders with eight countries-Jordan, Iraq, Kuwait, Bahrain, Qatar, United Arab Emirates, Oman and Yemen. Most of its territory consists of deserts and dry areas. It is reported that about 20% of the worlds' confirmed petroleum reserves is in Saudi Arabia.

Two holiest mosques are in Saudi Arabia, in Mecca and Medina, and, for this reason, the King of Saudi Arabia is called 'the Custodian of the Two Holy Mosques.' The current kingdom was built by the King Abdul Aziz bin Saud in 1932, and is an Islamic absolute monarchy.

The population in 2010 is estimated at 27.1 million (including 8.4 million resident foreigners), ranking the 41st in the world. Most of Saudi Arabia's population consisted of nomads until 1960, but its share rapidly decreased to under 5% due to rapid economic growth since the 1970s.

Figure 1-1| Location of Saudi Arabia



1.2. Economic Growth

Saudi Arabia achieved a remarkable economic growth in the 1970s with average annual growth rate of over 13%, mainly due to the rapid rise in oil price during the first Oil Shock. Rapid economic growth in the 1970s laid a foundation for continued growth in the next decades.

Current GDP of Saudi Arabia increased from about 23 billion Saudi Riyals (SR) in 1970 (USD 5 billion)[1]1,754 billion SR (USD 468 billion) in 2008, while constant GDP (at 1990 price) from 134 billion SR (USD 30 billion) to 765 billion SR (USD 204 billion) during the same period. Average annual growth rate of the Saudi Arabian economy during 1970-2008 was 4.7%.

1) The exchange rate between Saudi Riyal and US dollar has been fixed at 3.75 SR/USD since 1987.

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
SR/USD	4.50	4.49	4.14	3.71	3.55	3.52	3.53	3.53	3.40

Year	1979	1981	1982	1983	1983	1984	1985	1986	1987~
SR/USD	3.36	3.33	3.38	3.43	3.45	3.52	3.62	3.71	3.75

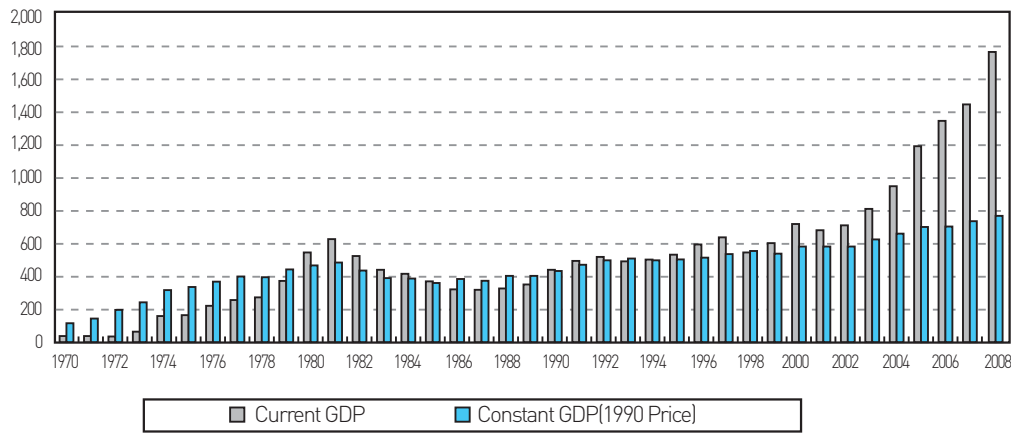
Per capita GDP of Saudi Arabia was 3,928 SR (USD 873) in 1970, which jumped to 23,185 SR (USD 6,531) in 1974 and 61,014 SR (USD 18,038) in 1981, mostly thanks to the two oil shocks in these two years.

Stabilization in the international oil price in the 1980s, however, resulted in the decrease in per capita GDP, recording the lowest 21,997 SR (USD 5,866) in 1988. Also, the rapid population growth was another cause for the decrease in per capita GDP in the 1980s, compared to the growth of the national GDP. Growth rate of Saudi Arabia's population recorded over 4% in 1970s and 1980s although it entered a downward trend in 1980s.

Steady rise in the international oil price since the 1990s and, in particular, the sharp rise in the late 2000s caused the second surge of Saudi's per capita GDP, as can be seen in Figure 1-4. Per capita GDP in Saudi Arabia in 2008 was 69,582 SR (USD 18,555), surpassing the previous highest level, 61,014 SR (USD 18,038) in 1981.

Figure 1-2| Current and Constant GDP

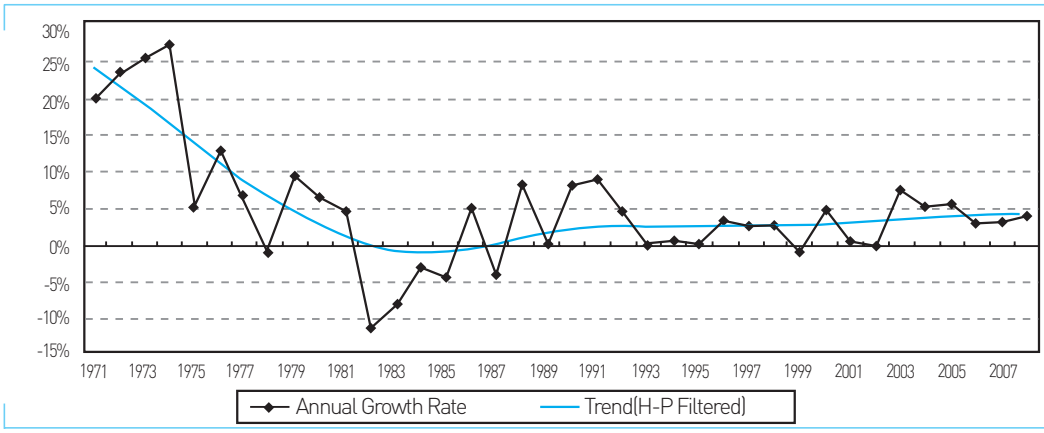
(Unit:billion SR)



Source: UNSD Statistical Databases.

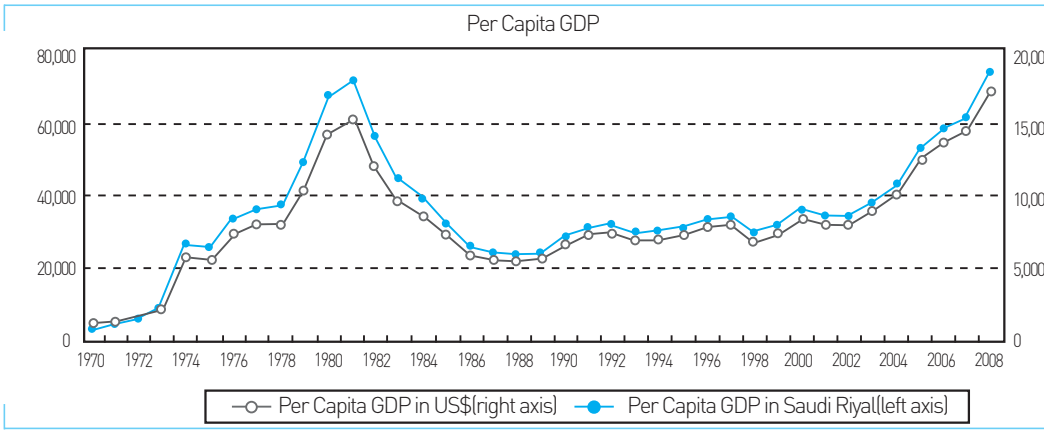
Figure 1-3| Annual Economic Growth Rate

(Unit: %)



Source: UNSD Statistical Databases.

Figure 1-4| Per capita GDP



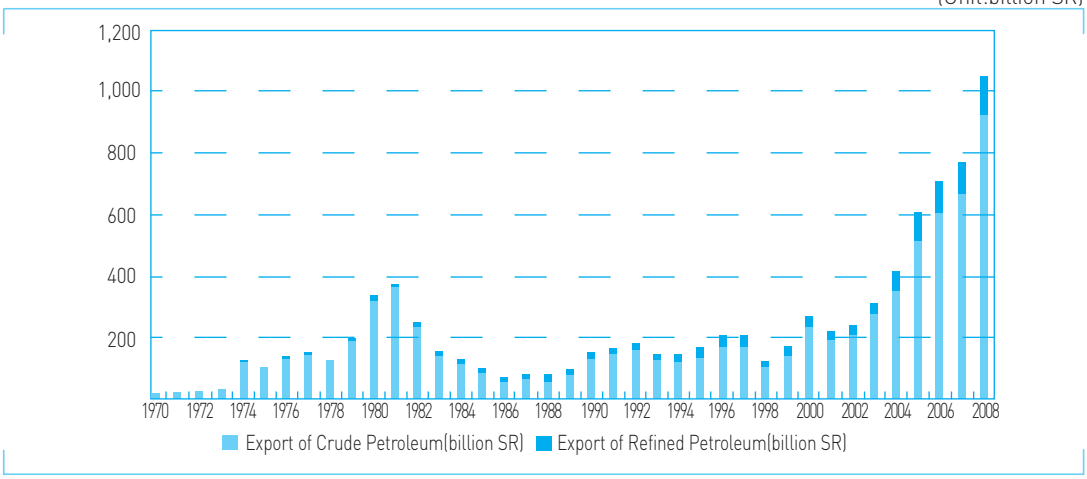
Source: UNSD Statistical Databases.

The most conspicuous characteristics of the Saudi Arabian economy is its high dependence on the oil sector, and the trends of the Saudi Arabian economy since the 1970s is highly correlated with those of the international petroleum price and Saudi's oil production. Saudi's export of petroleum, both crude and refined, was only about 11 billion SR (USD 2.4 billion) in 1970, which, after the two Oil Crises, jumped to 377 billion SR (USD 111.5 billion) in 1981.

Saudi's petroleum export stayed under 200 billion SR (USD 53.4 billion) in the 1980s and 1990s due to international economic recession and stable oil price, but increased rapidly again since the late 1990s due to rapid rise of international oil price ('Second Oil Boom'), recording over 1 trillion SR (USD 266.7 billion) in 2008.

Figure 1-5| Export of Crude and Refined Petroleum

(Unit:billion SR)



Source:IMF Data and Statistics.

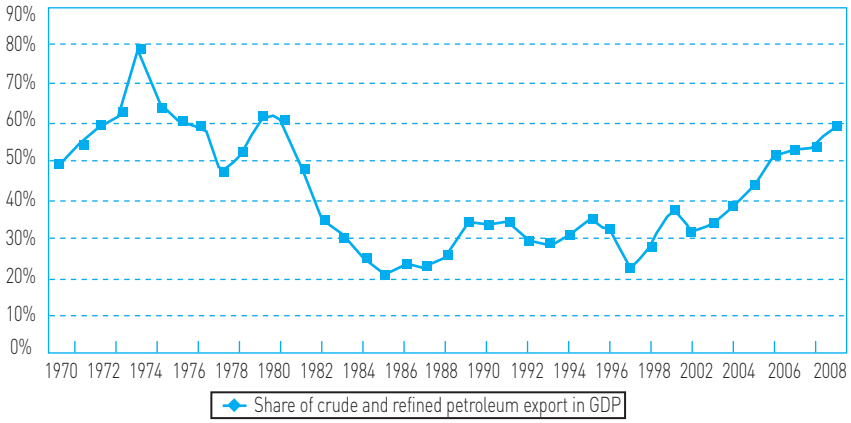
Saudi's export of refined petroleum has stayed under 40 billion SR (USD 10.7 billion) until the 1990s, but steady construction of refining facility since the 1990s caused substantial increase in refined petroleum export, which first exceeded 100 billion SR (USD 26.7 billion) in 2007. Saudi's daily petroleum export peaked at 9.2 million barrels in 1980, decreased to 2.2 million barrels in 1985, but has stayed between six and seven million barrels since 1990.

Saudi Arabia's high dependence on petroleum export can be easily confirmed through its share in GDP, which rose from 48.2% in 1970 to 79.2% in 1974 (the First Oil Crisis), and steadily decreased after the Second Oil Crisis in 1980, but has recovered since the late 1990s, remaining at around 60%. Saudi Arabia's high dependence on petroleum export can also be confirmed through the trend of international oil price. Saudi's average annual growth rates were 13.3% in the 1970s, -0.6% in the 1980s, 2.7% in the 1990s, and 3.7% in the 2000s, which also shows its high dependence on the oil sector.

In 1970, Saudi Arabia ranked 52nd in the world in terms of total GDP, but the ranking soared up to between the 10th and 20th in the mid-1970s, and has stayed in the 20th since the mid 1980s. Since the 1990s, Saudi Arabia has ranked around 50th in terms of per capita GDP.

Figure 1-6| Share of Crude and Refined Petroleum Export in GDP

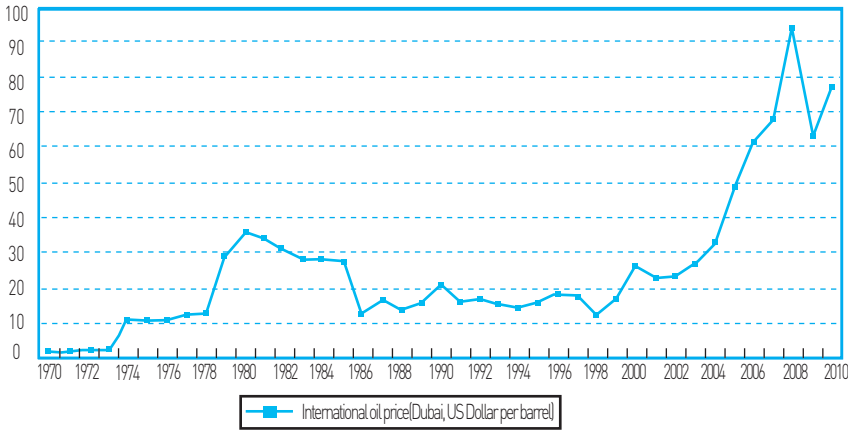
(Unit: %)



Source:IMF Data and Statistics.

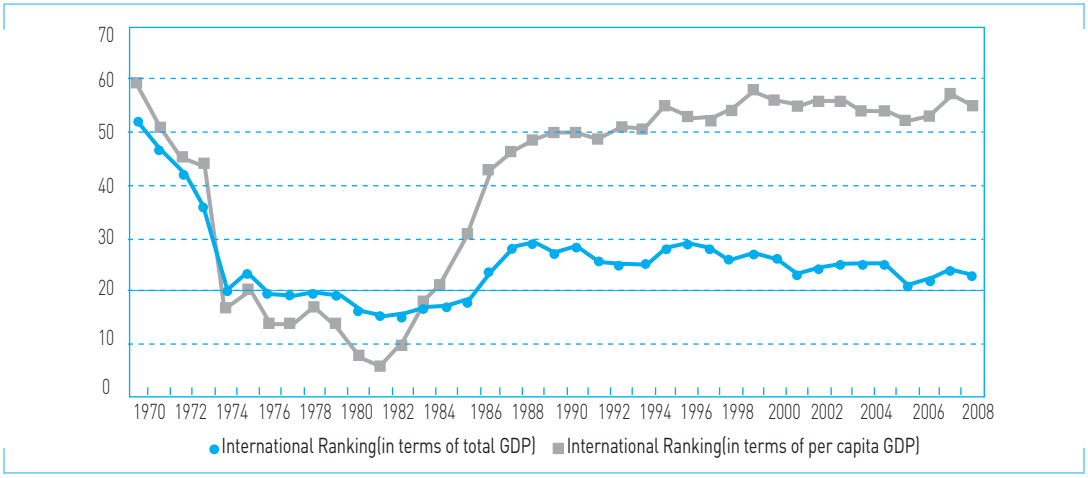
Figure 1-7| International Oil Price

(Unit:US Dollar per barrel)



Source:Korea National Oil Corporation.

Figure 1-8| International Ranking



Source:UNSD Statistical Databases.

1.3. Industrial Structure

High dependence on the oil sector implies that Saudi Arabia's industrial structure is centered on the mining sector. The share of mining sector in terms of total value added sharply increased from 47.1% in 1970 to 75.6% in 1974, steadily falling down to 20% in the mid-1980s, but has recovered since then, reaching 60% in recent years.

The share of agricultural sector (including forestry and fishing) had risen to 6% in the 1990s owing to government efforts in water supply, but has fallen to 2% in recent years, while that of the manufacturing sector has maintained 8~10% since the late 1980s. The construction sector recorded a rapid growth in the 1970s and its share once reached 10%, but has shown a steady downward trend.

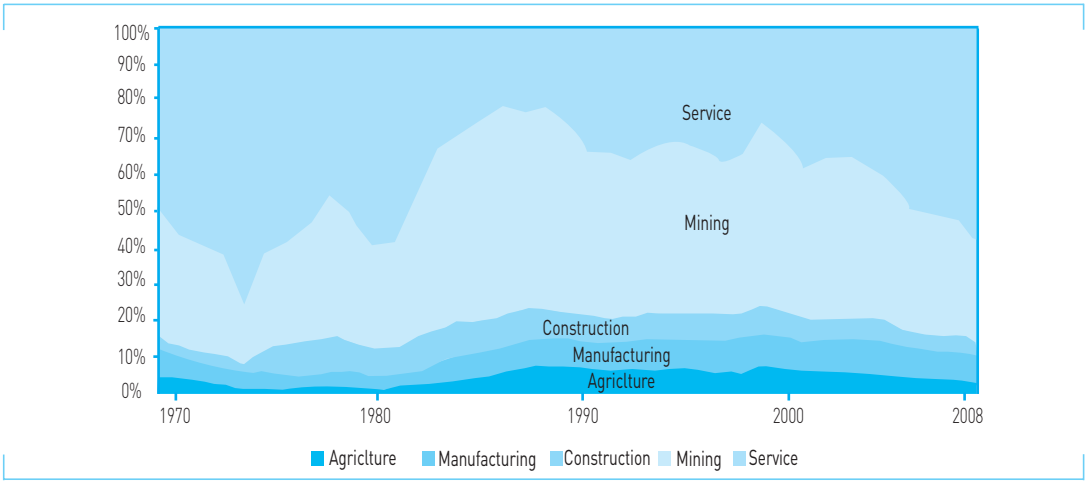
Table 1-1 | Industrial Structure of Saudi Arabia

(Unit:%)

	1970	1975	1980	1985	1990	1995	2000	2005	2008
Agri., forestry & fishing	4.3	0.9	1.0	3.6	5.7	5.9	4.9	3.2	2.3
Manufacturing	8.3	5.0	4.1	7.9	8.6	9.6	9.6	9.3	8.3
Construction	3.5	6.3	7.5	8.8	6.5	6.8	5.9	4.6	4.0
Service	36.8	27.3	27.8	55.2	45.7	45.5	41.5	33.9	27.5
Mining	47.1	60.5	59.6	24.5	33.5	32.2	38.1	48.9	57.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: UNSD Statistical Databases.

Figure 1-9| Industrial Structure of Saudi Arabia



Source:UNSD Statistical Databases.

Analyzing the industrial structure and sectoral dynamics through the composition of value added by sectors is neither easy nor appropriate in Saudi Arabia's case because of the dominant share of the oil sector and its high dependence on international oil price.

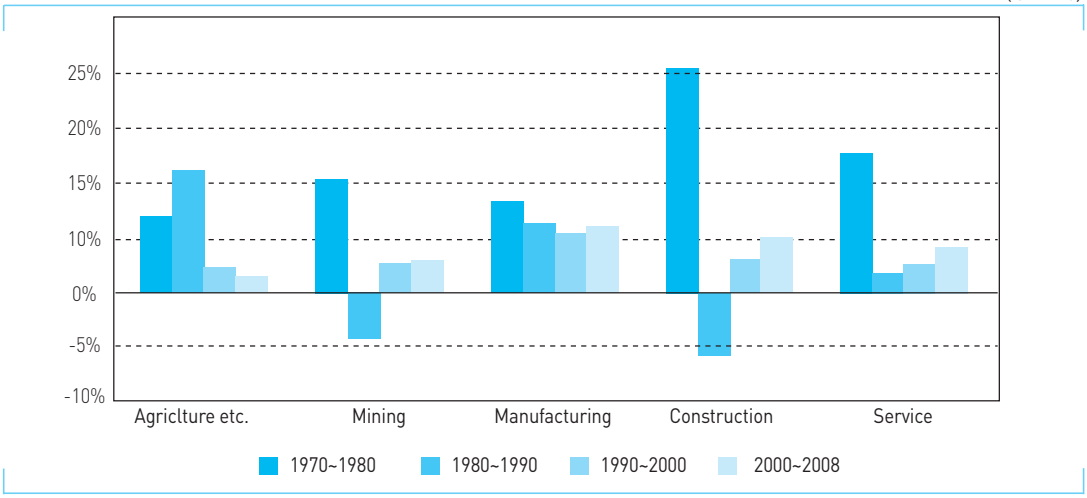
Average annual growth rates of real value added by sectors can be found in Figure 1-10. The agricultural sector (including forestry and fishing) recorded considerably rapid growth rates in the 1970s and 1980s, 6.6% and 10.9%, respectively, but the rate has been stabilizing at 1-2% since the 1990s. Both the mining and construction sectors experienced rapid growth in the 1970s but severe slowdown in the 1980s, followed by a mild recovery thereafter, showing a trend similar to that of the entire economy.

The service sector has shown a similar trend, while it recorded a mere 1.5% growth in the 1980s. Average annual growth rates of various service sectors during 1970-2008 were 7.7% in wholesale and retail trade, restaurants and hotels, 6.0% in transport, storage and communication, and 4.7% in other service activities.

On the other hand, Saudi Arabia's manufacturing sector has achieved extremely steady growth, recording about 6% over the entire period, and 6.3% even in the 1980s, which can be contributed to the Saudi government's continuing efforts toward the diversification of economic base.

Figure 1-10| Annual Average Growth Rate of Real Value Added by Sectors

(Unit:%)



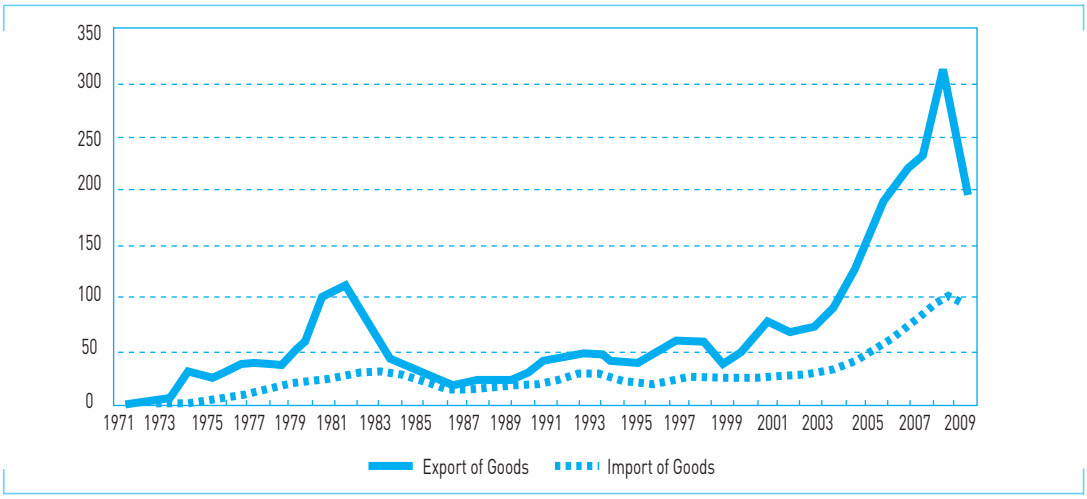
Source: UNSD Statistical Databases.

1.4. External Transaction

While the export of goods has showed fluctuations similar to those of petroleum export, the import of goods has showed a more stable trend. Saudi Arabia's import of goods surpassed 50 billion SR (USD 13.3 billion) for the first time in 2005 and 100 billion SR (USD 26.7 billion) in 2008. For the entire period 1970-2009, Saudi Arabia has recorded surplus in balance of goods.

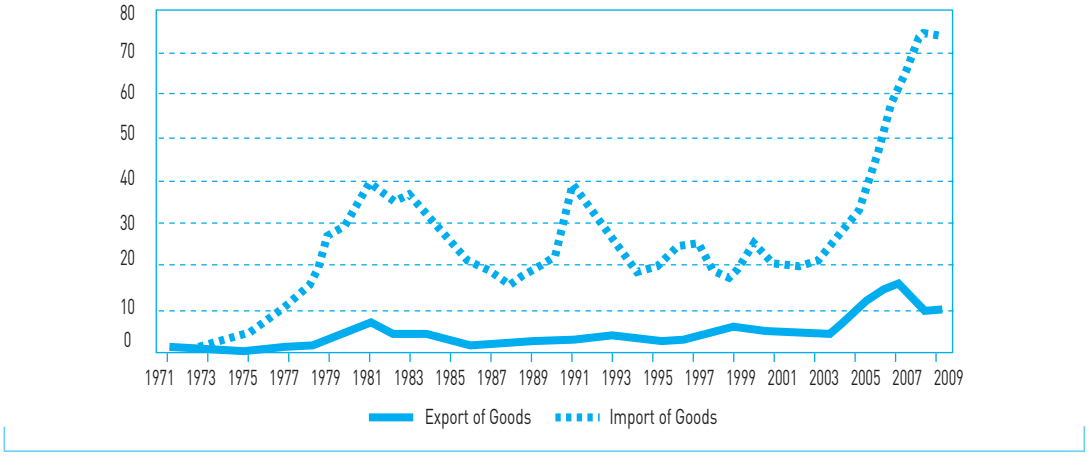
Figure 1-11| Export and Import of Goods

(Unit:billion SR)



Source: IMF Data and Statistics.

Figure 1-12| Export and Import of Services (Unit:billion SR)



Source: IMF Data and Statistics.

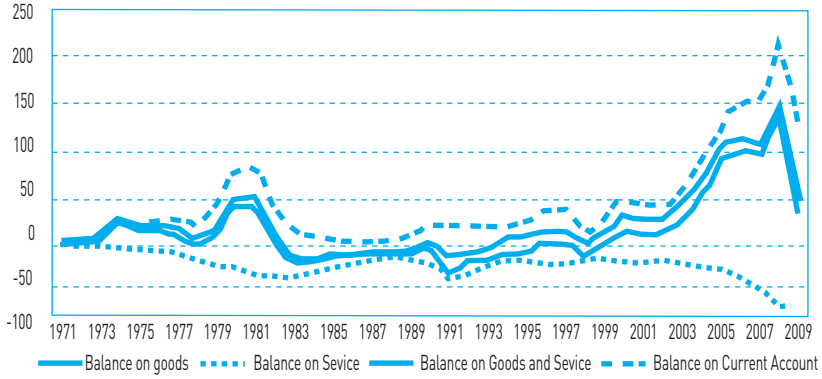
International competitiveness of Saudi Arabia's service sector has been considerably low, and the service export exceeded 10 billion SR (USD 2.7 billion) only in 2005. Import of services, on the other hand, shows a trend similar to that of oil export, which implies that much of Saudi Arabia's service import is linked with the oil sector. For the entire period 1970-2009, Saudi Arabia has recorded deficit in balance of services.

Surplus in goods balance has exceeded the deficit in service balance, except in the 1980s, and the surplus in the balance of goods and services increased rapidly in the 2000s, exceeding 100 billion SR (USD 26.7 billion) since 2005.

Income and transfer balance (current balance less goods and service balance) has experienced a deficit, except during 1983-1988, which steadily increased since the 1990s, recording about 19 billion SR (USD 4.9 billion) in 2009.

Figure 1-13| Current Accounts

(Unit:billion SR)

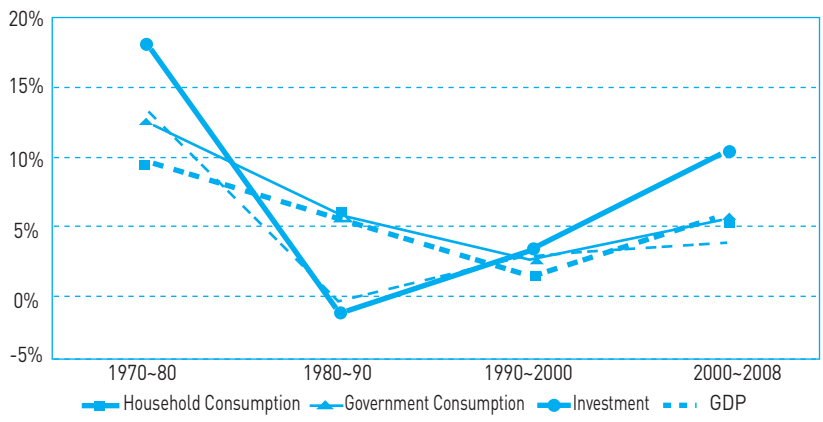


Source: IMF Data and Statistics.

1.5. Consumption and Investment

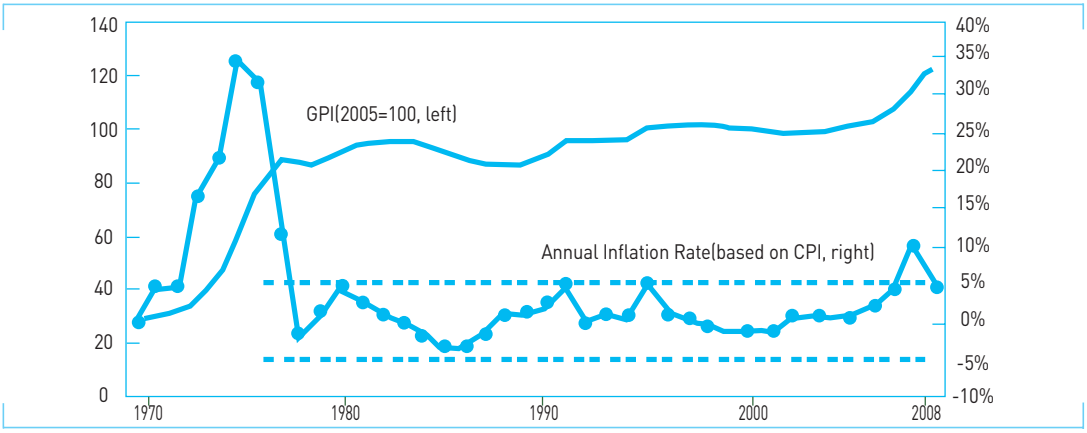
Average annual growth rates of private and government consumption expenditures and investment (fixed capital formation) by decade can be found in Figure 1-14. It can be seen from this figure that both private and government consumption expenditures show less fluctuation than real GDP, implying 'consumption smoothing.' This contrasts with investment, which has shown more fluctuation than real GDP with higher growth rate during the period of boom and lower growth rate during recession, implying that investment has been pro-cyclical. Average annual growth rates of these three expenditure terms during 1970-2008 were 5.5%, 6.5% and 7.2%, respectively.

Figure 1-14| Average Annual Growth Rates of Expenditures on GDP



Source: UNSD Statistical Databases.

Figure 1-15| CPI and Inflation Rate



Source: IMF Data and Statistics.

1.6. Inflation

Saudi Arabia experienced a severe inflation in the years around the first Oil Shock in the mid 1970s caused by the increase in aggregate demand and liquidity, the rise in the price of imported goods, and so on. Record breaking international oil prices in 2008 and 2009 also caused a considerably high inflation. Except these two periods, Saudi Arabia has been able to successfully control the inflation rate under 5%, mostly below 3%.

2. Development Planning in Saudi Arabia

2.1. Brief History

Saudi Arabia started development planning in 1970, which was the beginning of rapid economic growth, in the form of 'five year development plans.' Eight five-year plans have been established, and the Ninth has just been approved by Shura (Council of Ministers) and the King, and will soon be in effect. Table 1-2 summarizes the years of planning, target periods and the planning ministries of these nine five year development plans. Saudi Arabia's development plans have improved in terms of planning methodology and they basically comprise of principles, objectives and strategies, cross-sectoral plans, sectoral plans, and growth targets during the target period. Objectives and strategies have evolved reflecting the socio-economic development stages and domestic and international environments, and can be summarized as follows:

The First Development Plan: The objectives of the First Plan were (1) to maintain the religious and moral values, (2) to raise the living standards and welfare of the people, and (3) to

provide for national security and to maintain economic and social stability. Strategies selected to achieve these objectives were (1) to increase the economic growth rate, (2) to develop human resources, and (3) to diversify the sources of national income and to reduce oil dependence.

Table 1-2 | Nine Development Plans

	Year	Target Period	Planning Ministry
1st	1970	1970~1975	Central Planning Organization
2nd	1975	1975~1980	Ministry of Planning
3rd	1980	1980~1985	"
4th	1985	1985~1990	"
5th	1990	1990~1995	"
6th	1995	1995~2000	"
7th	2000	2000~2004	"
8th	2005	2005~2009	Ministry of Economy and Planning
9th	2010	2010~2014	"

Source: 「Development Plan (1st~8th)」, Kingdom of Saudi Arabia.

The Second Development Plan: The goals of the Second Plan were expanded compared with those of the First Plan, which were (1) to maintain the religious and moral values of Islam, (2) to assure the defense and internal security, (3) to maintain high growth rate, (4) to reduce economic dependence on oil export, (5) to develop human resources, (6) to enhance the well-being of all groups within the society and to foster social stability, and (7) to develop physical infrastructure. For these goals, the Second Plan adopted the following three strategies; (1) to diversify the economic base, (2) to rapidly develop human resources, and (3) to develop economic regions.

The Third Development Plan: The Third plan was established in 1980, at the beginning of economic slowdown, and the goals and strategies adopted were in line with previous plans.

The Fourth and Fifth Development Plans: The Fourth and Fifth Plans also adopted similar goals and strategies of the previous plans while the Fourth Plan emphasized the importance of cultural standards, quality of development, and cooperation among the GCC (Gulf Cooperation Council) countries, and the Fifth Plan emphasized the importance of enhanced information provision, strengthening the role of private sector, and balanced regional development.

The Sixth Development Plan: The Sixth Plan came with various methodological improvements; such as (1) to emphasize the coordination between the five year plans and national budgets, (2) to include long-term forecasts in the plan, (3) to emphasize the coordination between five year plans and long term forecasts, project evaluation, and database

and information system, and (4) to emphasize the cooperation between the government and private sector in the implementation stage. Goals and strategies of the Sixth Plan were also in line with those of the previous plans.

The Seventh Development Plan: Various methodological improvements were made also in the Seventh Plan; (1) procedures for systematic plan preparation were established, including Plan Documents, Operation Plans, Regional Reports, and Follow up Reports, (2) emphasis was given to 'strategic, indicative and directive' planning, and (3) econometric methodologies were improved. While the general principles of the Seventh Plan were similar with those of the previous plans, it incorporated the economic and social developments in the previous decades and placed high priorities on (1) enhancing defense capabilities and to deepen citizens' loyalty and sense of belonging, (2) to rationalize government expenditure and to make the national economy more dependent on private sector activities, (3) to address the constraints which impede the development and employment of Saudi human resources, and (4) to continue the expansion and maintenance of infrastructural facilities.

The Eighth Development Plan: The Eighth Plan adopted the general principles similar with those of previous plans, while it emphasized the importance of manufacturing sector, tourism industry, information industry, and water resource development. Key objectives of the Eight Plan were (1) to increase economic growth, (2) to increase employment opportunities and to reduce unemployment, (3) to provide care for poor and needy families, (4) to diversify economic activities and sources of national income, (5) to expand and develop public services, (6) to emphasize regional development, (7) to improve productivity and competitiveness, and (8) to promote export and to enhance balance of payments. The Eighth Plan included specific infrastructure and public service targets for the 13 regions for the first time. The Eighth Plan is organized as follows:

(1) General summary (Chapters 1-4 and 34): achievements of previous development plans, goals and strategies of the current plan, mid and long term forecasts, and planning methodology

(2) Cross sectoral plans (Chapters 5-10): institutional and administrative development, private sector, investment, manpower and employment, population and standard of living

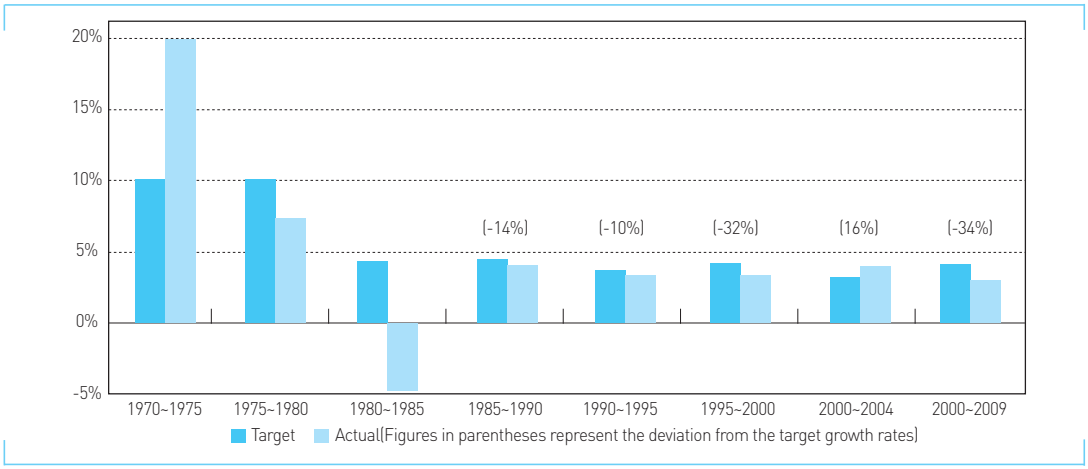
(3) Sectoral plans (Chapters 11-33): regional development, construction, environment and sustainable development, tourism, trade, financial service, family and society, women and development, housing, science and technology, human resource development, health, ICT, water, oil and natural gas, mineral resources, agriculture, industry, electricity, transportation, municipal and rural affairs, culture/information/youth services, religion, statistical data and information services

The Eight Development Plan has the following four characteristics: First, it is an 'integrated

strategic plan' encompassing the development plans of all ministries and government agencies and the long term forecast of the entire country. Second, it is an 'indicative plan,' providing guidelines for the private sector. Third, it is a 'directive plan' which emphasizes the roles of implementing agencies. Fourth, it is a 'regional plan' which contains development plans for the regions.

Saudi Arabia's development plans provide growth forecasts for the target periods based on economic environments using various econometric methods, and Figure 1-16 summarizes the forecasts contrasted with actual growth performance. It can be found from this comparison that these forecasts have been quite realistic, if slightly conservative, with sufficient accuracy, except those forecasts made during the period of severe fluctuations in the international environment (First through Third Plans). Saudi Arabia's recent development plans also provide long term (20 years) growth forecasts, and the long term average annual growth rates in the Seventh and Eighth Plans were 4.2% (2000-19) and 6.6% (2005-24), respectively.

Figure 1-16 Average Annual Growth Rates for the Target Periods



Source: UNSD Statistical Databases, 「Development Plan (1st~8th)」, Kingdom of Saudi Arabia.

2.2. Evaluation of Saudi Arabia's Development Plans

Over the last four decades, Saudi Arabia's development plans have evolved with new changes, but at the same time, with continuity. They have continuously adopted a set of common objectives; diversification of economic base, human resource development, economic growth, and so on. Also, new objectives have been added reflecting environmental changes; for example, regional development, science and technology, information and communications technologies (ICT), etc.

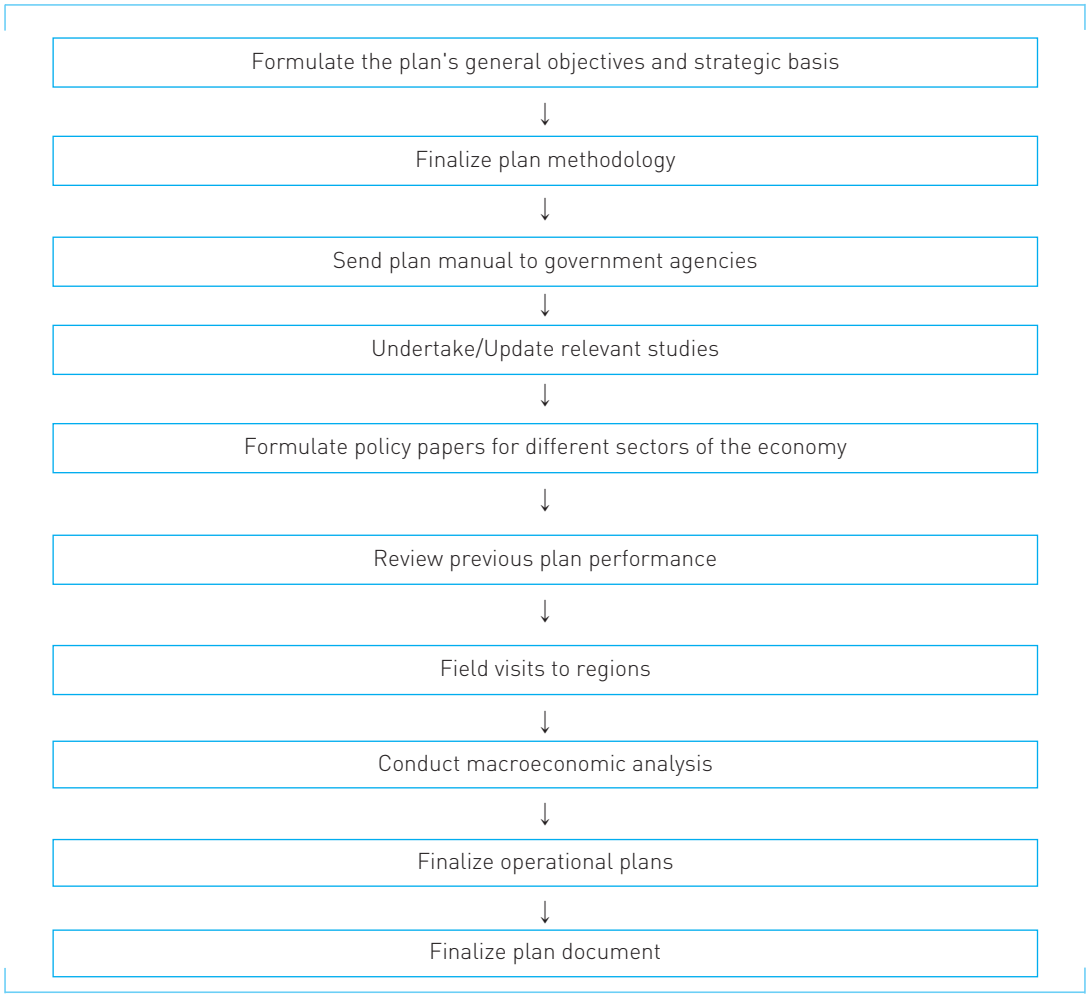
Methodology of the plans has also evolved dramatically. For example, (1) Saudi Arabia's development plans switched from project based to program based since the Fourth Plan, (2) the

Fifth Plan initiated 'indicative planning, (3) long-term perspective was first adopted in the Seventh Plan, (4) vision driven, policy based strategic planning has been emphasized since the Eight Plan, and (5) the Ninth Plan adopted the Outcome Performance Indicators System (OP).

Recently, Saudi Arabia developed a new web based plan follow up system in which (1) follow ups are reported on real time basis, (2) weights are given to objectives, (3) outcome performance indicators and failure indicators are employed, and (4) comparing performance among government agencies is possible.

The collection of plan documents has become more comprehensive, and the documents of recent plan include the Development Plan Document, Operational Plans of government agencies, Regional Plans, Yearly Follow-up Reports, and Yearly Achievement Reports. Figure 1- 17 is a brief description of Saudi Arabia's current planning process.

Figure 1-17| Current Planning Process



Here, we attempt to evaluate the strengths and weaknesses of Saudi Arabia's development plans, which will contribute to improving the effectiveness of Saudi Arabia's development plans facing these new challenges. First, the strengths of Saudi Arabia's development plans can be summarized as follows: (1) Saudi Arabia has four decades of accumulated experience in plan design, implementation and follow up, and the methodology and content of all types of plan have been evolving and improving over time. (2) Sophisticated statistical and econometric techniques are used in formulating the general document. (3) Comprehensive and sophisticated economic models are utilized; century model (long-term), selection model (mid-term), oil model (mid-term) and implementation model (annual). (4) Computerized web based follow up system has been developed for the operational plans implementation.

The main weakness of Saudi Arabia's development planning lies in the implementation and follow-up sides. First, in the implementation of projects, not enough objective indicators are set out at the project formulation stage, and it is desired that the plans include (i) specific and sufficiently detailed targets, (ii) specific and clear time-lines for project implementation, and (iii) clear assignment of responsibility. At the project implementation stage, furthermore, the Ministry of Economy and Planning (MOEP) cannot act preemptively to prevent deviations from targeted paths, and the MOEP has neither the mandate nor the resources to check on the accuracy of all progress reports submitted by government agencies.

Second, in the implementation of policies, the MOEP cannot make sure that satisfactory implementation of the macroeconomic and sectoral policies are achieved since (i) the plan does not assign the policies to specific government agencies to implement them, (ii) it is left for government agencies to choose which policies to implement, (iii) the MOEP has no power to assign responsibilities of policy implementation to any government agencies, and (iv) as such, it is impossible to hold any government agency responsible for failure in implementing plan policies.

Currently, Saudi Arabia faces various challenges both domestic and international. First, the population is growing rapidly at 2.4%, and 50% of the population is below 15 years of age, which causes the need for significant increase in education, housing and health services, and at the same time, the need to facilitate job opportunities. Second, Saudi Arabia still needs to diversify its economy. While it is true that oil continues to be the major asset, Saudi Arabia needs to take full advantage of this asset and to expand its sources of economic income into non-oil sectors, to foster SMEs and to develop various regions of the country in order to sustain its development. Third, Saudi Arabia needs to have a secure investment policy and attract both domestic and foreign investment by removing administrative hurdles for investors. Other challenges remained are the issues of job creation, transforming the economy into knowledge-based economy, and so on.

Considering these new challenges and the weaknesses of previous planning scheme, it is

desired to update and improve planning methodology so that new mechanism could contribute to successfully solving the challenges and to spreading the benefits of development to every region and every group in the country. Major elements of the improvement would be a numerical follow-up of the General National Objectives (GNO), a system to quantitatively relate the GNO to sectoral objectives, a system to link follow-up plan implementation and budget allocation, a follow up mechanism between the MOEP and other government agencies, a system for dealing with unfulfilled objectives, and so on.

3. Significance and Characteristics of Economic Development Plans

3.1. Economic Development Plans in Market Economy

Economic development plans were first introduced in planned economies including the Soviet Union after the Second World War. Development plans in planned economies basically were 'control plans,' in which target and means were clearly specified, and the policies and projects were accomplished under the control of the central government.

Development planning, as a way of efficient use of resources, attracted the attention of many developing countries with poor natural resources and insufficient development experience. Advancement in econometric and statistical methods after the War, which enabled long term forecasts, in particular, enhanced the attractiveness of development planning among newly developing countries with a market economy system.

Development plans in market economies drastically differed from those in planned economies in nature. In market economies, the central government does not have total control over the implementation of the targets since most transactions occur in the market, hence the development plans in market economies had to be initiated as 'indicative' plans.

Indicativeness of development plans in market economies was clearly stated in the Fourth Five Year Economic Development Plan of Korea (Economic Planning Board, Republic of Korea, 1976);

"This development plan, as an indicative plan, has been designed to provide information to support national economic activities based on market economy system."

An indicative plan can be translated as the central government's vision and objectives, which might possibly differ from those of the private sector, the major player in the market. Also, it is possible that the incentive system provided by the plan might not be attractive enough for some companies. It is for these reasons that a considerable discrepancy can occur between the goals

and the actual outcomes.

3.2. General Characteristics of Economic Development Plans in Market Economies

It is impossible to make a generalization on the characteristics of economic development plans in market economies because the forms and contents of the plans largely depend on traditional and cultural factors as well as on the capabilities and the will of the government. The complicatedness of the plan implementation process also adds to the diverse characteristics of economic development plans in market economy. This section attempts to summarize the changes and problems observed in the course of development plan implementation in market economies.

3.2.1. Discrepancy in Perception among Economic Agents

A common problem of economic development plans in market economies arises from the discrepancy in perception regarding the contents of the plans among various economic agents and from the difficulty in orchestrating the opinions and inducing concerted efforts to solve problems.

Facing insufficient resource endowments, knowledge and information, most developing countries cannot afford enough time on the preparation stage. The development plans are mostly prepared by government officials with limited knowledge or experience, or by outside consultants, which could result in low level of perfection in the former case, or lack of sincerity in the latter. In both cases, consensus build-up among various economic agents or among government agencies is unsatisfactory in plan preparation, which frequently makes if difficult to acquire understanding and cooperation with the players in the market, and leads to ineffective implementation.

3.2.2. Discrepancy in Perception inside the Government

Discrepancy in perception regarding the contents of the plans can raise serious problems not only between the market and government but also within the government. Even when the plans are prepared by a planning authority within the government, development strategies or policies of mechanically prepared plans may not be easily accepted by other government agencies because the considerations and intentions underlying the plan documents cannot be easily understood by other agencies. Government agencies responsible for plan implementation, furthermore, tend to think that they have more expertise in the relevant areas, and are reluctant toward outside intervention that points out weaknesses and criticizes the plan.

3.2.3. Discrepancy between Aggregate and Sectoral Plans

The following two characteristics are frequently found in the economic development plans of many developing countries. First, the plan is often not a comprehensive development plan, but a list of strategies in specific areas without concrete projects or realistic policy means, close to platforms or public commitments of modern political parties. These plans usually consist only of targets and promises, and the implementation is not given much attention.

Second, these plans sometimes lack consistency and integration between aggregate and sectoral plans and among sectoral plans, often resulting to low level of achievement or affecting effectiveness at the implementation stage.

3.2.4. Discrepancy between Plan and Implementation

Discrepancy between plan and implementation is a general and pervasive phenomenon. The cause of discrepancy is not only by the quality of the plan or the capability of the government, but also by the changes in domestic and international environments. Hence, a discrepancy between plan and implementation is a natural consequence.

It must be pointed out that the discrepancy between plan and implementation does not undermine the significance of economic development plans nevertheless. While it is also true that development plans can be utilized politically, development planning also has an 'enlightening' function: many developing countries are still attracted to development planning since it can contribute to enhancing the efficiency of resource allocation, especially when the market mechanism has not reached a mature stage.

The discrepancy between plan and implementation does not justify the irresponsibility or negligence in the implementation stage since the success of the plan still depends on the efforts and the will of the government and economic agents.

A number of historical examples show that a greater discrepancy between plan and implementation results when the plans were utilized as political propaganda, thus neglecting the goal of the plans. More prevalent problems in many developing countries are the planning authority not functioning properly and/or the government not paying sufficient attention to the implementation stage.

4. Implementation of Development Plans

Successful implementation of a development plan depends on several factors such as its legal status, implementation governance, implementation scheme, and the coordination between

the plan and annual budget.

4.1. Legal Status of Development Plan

Legislating a development plan guarantees its continuity and practicability and it complies with the principle of market economic system, while on the other hand, it might cause rigidity in the plan. An alternative is for the government and the top leader to place highest priority on implementing the plan and make utmost efforts to ensure the leadership of the top leader, cooperation from the interest groups and political parties, and so on. Korea followed the latter case.

4.2. Implementation Governance

Implementation of the plan must be carried out by the relevant government agencies; e.g., plans for the agricultural sector by the agriculture ministry, plans for the industry by the ministry of industry, plans for the financial sector and public finance by the finance ministry, and so on. The key to effective implementation of development plans lies in the implementation governance. Here, the major questions one should address are ‘will there be a ministry or an agency responsible for coordinating and assessing the implementation of detailed plans, policies, programs and projects?’ and ‘which ministry will be responsible for this task?’ The answers to these questions depend on the tradition and political situation.

4.3. Implementation Scheme

Another key to effective implementation of development plans is an implementation scheme that includes for example, implementation and adjustment frequency (entire target period vs. annual), mechanism and the extent of adjustment, the degree of directiveness/ indicativeness, etc. The implementation scheme requires an active interchange of ideas and the strong will of the government/top leader.

4.4. Coordination between Plan and Annual Budget

Most countries compile annual budget, which is a numerical representation of the government's annual management plan. Annual budget is legally binding, and is a blueprint for public expenditure. For this reason, it is desired that the annual budget reflect the development plan as much as possible. The effectiveness of the plan implementation greatly depends on the extent to which the annual budget reflects the plan especially in the case of an annual implementation scheme.

Experiences of many countries teach us that the coordination between development plan and annual budget can be difficult for several reasons: First, the government might not have

sufficient resource to plan implementation due to the constraints of tax revenue. Second, and more importantly, the priorities of the annual budget can be different from those of the development plan, and important projects are not given sufficient resource. Solutions for tackling these difficulties depend on the situation of each country. Korea merged the functions of planning and budgeting into one ministry, which is contrasted with Saudi Arabia where the finance ministry consults with the relevant implementing agency and the planning ministry at the final stages of annual budgeting. In some other countries, annual budget is compiled independent of development plans. While this is an extreme case, it must be pointed out that a full coordination between development plan and annual budget is imperative to maximize the effectiveness of the implementation of economic development plans.

5. Korea's Development Plans

First commenced in 1962, Korea's six 'Comprehensive Five-Year Economic Development Plans' ran until 1991. Additionally Korea launched a 'Five-Year Plan for the New Economy' for 1993-1997, which was not part of a comprehensive economic development plan, but rather a president's comprehensive plan during his term, prepared by the President's Office out of accordance with previous plan preparation process.

However economic development plan disappeared from the Korean economy since 1998. This was not the result of changes in political situations or in the government's priorities, but the need for long-term development weakened over time as the economy reached certain development stage and the speed of technology development accelerated. For these reasons, it would be proper to regard the years 1962-1991 as the period of comprehensive economic development plans in the history of Korean economic development.[2)]

It should be noted that the Sixth 'Five-Year Economic and Social Development Plan' with the target period 1986-1991, although prepared with previous plan preparation process, could not be properly implemented due to a nation wide social turmoil and large-scale illegal labor disputes, and resulted in a huge discrepancy between the plan and implementation.

The goal of this section is to summarize and draw lessons from Korea's experience in economic development planning. To this end, this section begins with a chronological review of Korea's development plans and their key strategies, and then moves on to discuss the Korea's implementation scheme.

2) The Condition of Prosperity (in Korean), Hyung Koo Lee, Pakyoungsa, 2008, p.276.

5.1. Chronological Review of Korea's Economic Development Plans

5.1.1. The Situation before the Economic Development Plan (1945-1961)

Shortly after Korea achieved independence from the Japanese colonial rule in 1945, a government was established in Korea and the elements of a country started to formulate. However, the Korean War from 1950 to 1953 almost completely wiped out the country's fledgling production facilities and administrative system, and it was only in 1953 when a normal economic system could resume. Economic situation since 1953 until the early 1960s can be summarized as follows:

Scarce Production Capabilities and Infant Industrial Structure

The Korean War almost completely destroyed the country's production facilities, and few that survived the war could not be operated due to the lack of materials and industrial technology. The war also destroyed major infrastructures such as roads, bridges and harbors. This situation, combined with other social problems resulted in an extremely low economic growth at 4% per annum for the period 1954-1961, entirely depending on the agricultural sector for this growth.

Economic Instability and Development by Foreign Aid

What followed the war was a sharp inflation, caused mainly by large scale money supply during the war. The money supply and the price level increased 18 times compared to that of before the war.[4] Since 1954, foreign aids from Korea's ally countries made possible a number of economic reconstruction projects. According to the statistics by the Korea Development Bank, the total foreign aids from the allies and international organizations during 1954-1959 amounted to USD 2.7 billion, which explained 70% of the Korea's total investment for the period.

Rapid Migration and Increased Unemployment

With a great number of casualties, the Korean War also displaced a large number of citizens from North Korea to South Korea, amounting to 650 thousands after the war. This sudden movement raised various social and economic problems in South Korea, including a sharp increase in demands for consumption goods, housing shortages, unemployment rate, and political instability. Concentration into urban areas also appeared during this period, resulting in high unemployment rate in urban areas.

3) The Korean Economy, Hyung Koo Lee, State University of New York, 1996, pp.2 5.
4) Korea's National Income 1953 1963, Bank of Korea, 1965, p.4.

Equal Income Distribution in Poverty and Strong Will to Educate

In an extreme poverty in the 1950s, the income distribution of the most Koreans was equal. In an attempt to achieve a more equitable distribution of wealth, the Korean government began a farmland reform in 1949 by which each farmer could own only three jungbos (30 thousand square meters) of farmland. This combined with the destructiveness of the Korean War led to the more even income distribution among the population although most Koreans were in an extreme poverty.

In the midst of turmoil, many Koreans sacrificed everything they had into educating their children, determined not to hand down their poverty to the next generation. Due to this endeavor, Korea could be able to generate a high quality labor force, which became the driving force behind its remarkable economic growth in the coming decades. Thus, the economic situation around the end of 1950s could be described as 'extremely poor but highly potential.'

5.1.2. Launching the Economic Development Plan (1962-1971)

To launch a comprehensive economic development plan in the 1960s, the Korean government devoted tremendous amount of discussion and research to set the most appropriate economic goal and proper strategies. First of all, the government declared that the goal must be placed on pursuing the establishment of a 'self reliant economy' to get people out of poverty. Under this clear goal, the government established three major development strategies as follows:

Outward looking Development

First, Korea adopted bold export oriented, outward looking development policies as the key strategy[5]. In 1961, per capita GNP was mere USD 82, and 43.1% of GNP and 63.1% of employment were attributed to the agricultural sector. The domestic market was narrow and underdeveloped. On the expenditure side, 97.1% of GNP was spent on consumption, and the domestic savings rate was only 2.9%. Total annual export, mere USD 41 million, covered only 14.4% of the total import and shortage in goods and materials had to be met by foreign aids.

Korea faced a choice between a slow development based on the narrow domestic market, and an aggressive outward looking development. The Korean government chose the latter, i.e., an export oriented outward looking development strategy by utilizing high quality fast learning manpower, rapidly enhancing productivity, and concentrating on the areas with comparative advantage in the world market.

5)The Condition of Prosperity (in Korean), Hyung Koo Lee, Pakyoungsa, 2008, p.282.

Developing Labor intensive Light Industry

The share of manufactured goods in total export was only 21.9% in 1961, while the rest were the products of primary industries such as agriculture, forestry and fishery. Korea tried to expand its export of manufactured goods, especially in the sectors where Korea had comparative advantage based on its high-quality manpower, and rapid productivity growth was possible. Considering the problems of limited capital, low technology and high unemployment, Korea focused on the development of labor intensive light industries such as textile, plywood, footwear and wig manufacturing which were based on the technologies that were easy to learn and could maximize employment. At the same time, the Korean government made extensive efforts on building social infrastructure, such as electricity, roads, railroads and harbors, which were essential for industrial development.

Promoting Investment

The most serious problem for Korea in pursuing the development plan was the limited resource for investment. Domestic savings rate was only 2.8% in 1961, and inducing investment resource was one of the most urgent missions for the Korean government.

Facing this challenge, the Korean government placed high priorities on domestic savings expansion and foreign capital inducement. To expand domestic savings, the government adopted a high interest rate policy to promote domestic savings, and modernized the nation's tax system and administration.

Introducing foreign capital raised enormous debate and resistance. The theory of imperialism was prevalent world wide in the 1960s, and the government had to face violent opposition and resistance from those worried about the ‘dependency’ on foreign capital. Despite these obstacles, the Korean government made persistent efforts to induce foreign capital; for example, the government enacted the ‘Foreign Capital Inducement Act,’ and founded a new department, 'Foreign Capital Inducement Committee' for fluent foreign investment inflow.

5.1.3. Establishing a Self Reliant Industrial Structure (1972-1979)

In the 1960s, the Korean economy was able to lay a foundation for further development; outward looking industrialization strategy led to enormous increase in export, mostly of light manufacturing goods. The economy recorded a rapid growth, with 8.8% annual average growth rate during 1962-1971 when the world economy was growing at an average of 5%.

The growth of the Korean economy in the 1960s, on the other hand, created various side effects and aggravated structural imbalances, and the nation was suffering from conflicts among various economic and social entities, such as between manufacturing and agricultural business,

urban and rural areas, and large and small companies.

In the beginning of 1970, the Korean government faced the following four problems. First, it was urgent to adjust the industrial structure. Industrialization strategy in the 1960s enabled a fast growth of the manufacturing sector, but the rural area remained in a relatively slow development. Also, fast growth in light manufacturing was followed by the rapid increase in demand for intermediate goods and materials, mostly imported, which necessitated the development of heavy and chemical industries for their fluent supply.

Second, increase in export of goods from labor intensive light industries based on low wage led to increase in wage and deteriorating advantage, and it was necessary to upgrade into a more technology-intensive production system which still could absorb enough employment.

Third, it was necessary to promote more domestic investment resource by raising domestic savings rate, and to pursue balanced international payments.

Fourth, improving the income distribution became one of the major economic policies in the 1970s, both primary income redistribution policy in the fields of employment, health, education and housing, and secondary income redistribution policy by improving the income tax system.

To tackle these structural problems, which required persistent efforts and gradual structural adjustment, the Korean government concentrated on the modernization of the rural areas and the development of heavy and chemical industries.

Modernization of Rural Areas

Korea utilized two approaches for modernizing the rural areas: the first was to strengthen the agricultural sector by improving water resource development, paddy area rearrangement, etc., and the second was the ‘Saemaul Undong (New Village Movement)’ initiated by the top leader, the late president Jung Hee Park, focusing on modernization of the agricultural sector and building the spirit of diligence, self reliance and cooperation among the Koreans.

Korea’s Saemaul Undong is said to have much in common with the ‘will to economize’ suggested by W. Arthur Lewis. The Saemaul Undong began with improving the environments of rural areas, and further developed into productivity growth by cooperation and modernization of production. As it became popular, the Saemaul Undong spread into urban areas and industries, focusing on the improvement of productivity and efficiency, and finally became a nation-wide movement.

Development of Heavy and Chemical Industries

Development of light industries in the early stage of economic development substantially contributed to the expansion of production and export, but a decade long industrialization also led to various economic issues. First, increase in the import of raw materials and intermediate goods intensified dependence on the foreign sector. Second, newly developing countries with low wage advantage started threatening Korea's comparative advantage, which necessitated the development of more skill-and technology-intensive industries. Facing with these issues, the Korean government oriented policies to intensively foster heavy and chemical industries.

While the development of heavy and chemical industries is more capital intensive and riskier, and requires more advanced technologies than light industries, the Korean government determined that this would contribute to expanding the nation's exports and to reducing production costs by substituting imported raw materials and intermediate goods. In other words, the focus of this policy was placed more on import substitution than on export promotion. The Korean government carefully selected six heavy and chemical industries as the 'national strategic businesses' as in Table 1-3.

While these industries became Korea's major growth engines in later decades, various structural problems had emerged in the course of implementation. Government's support and incentives attracted enormous investment in a number of projects without sufficient economic and technological examination, which later became a big burden on the Korean economy.

This led to over investment and excess capacity in these industries and weakened corporate financial structures, but the solutions had not been prepared by the government yet. This strategy, which was originally intended to pursue a balance among sectors and import substitution, resulted in over-investment and a more imbalanced development.

Table 1-3 | Strategic Industries in the 1970s

Industry	Large factories and industrial sites
Steel	Pohang Iron and Steel Company (established in 1973)
Machinery	Changwon Machinery Industrial Complex (established in 1974)
Ship Building	Hyundai Shipbuilding Company (established in 1973)
Petrochemicals	Ulsan Petrochemical Industrial Complex (completed in 1972)
Electronics	Kumi Electronic Industrial Estates (established in 1971)
Automobiles	Hyundai Automobile Company (established in 1972?1976)

5.1.4. Economic Stabilization Policy (1980 -1987)

This period covers the last phase of Korea's economic development planning, which can also be regarded as the beginning of a true market economy system. During this period, a tremendous transformation occurred in Korea; not only in terms of economic system, but also political and social circumstantial changes took place.

Since the late 1970s, the Korean economy faced high inflation, decrease in international competitiveness and low growth rate caused by economic mal management in the 1970s, such as a failure in liquidity control and over-investment in heavy industries. To break through this critical economic circumstance and restore growth potential and enhance industrial efficiency, the Korean government adopted the 'Comprehensive Stabilization Policy' with the goals of price stabilization, balance of payment surplus, and high growth. The Korean government adopted 'Stabilization, Autonomy, and Open Market' as its slogan.

The Comprehensive Stabilization Policy was a strategy to transform the Korean economy into a more open and market oriented, and to convert the economic policies from 'government - guided' into 'business oriented.' The government also pursued such policies with liberalization, market opening, and fair trade in mind. This aggressive market-opening program has become a backbone of the country's economic management policy after the late 1980s to present.

Major contents of 'Stabilization Policies' were:

1) Financial liberalization, squeezing liquidity, and finance sector reform
2) Strengthening national budget structure and expanding the role of public finance
3) Upgrading import liberalization policy
4) Activating a fair trade system
5) Manpower development
6) More efficient changes in industrial incentive systems
7) Stabilizing real estate prices

In the late 1980s while the government was extensively pursuing its 'Stabilization Policies' to stabilize domestic price level, the external economic environments had changed to become more favorable to the nation. Weak dollar rates, low oil prices, and low global interest rates in the international environment contributed to Korea's remarkable economic performance. In 1986, the country's current balance of payment account was moved to the surplus side for the first time in the modern history of Korea, registering high annual growth rate of 12%.

5.2. Implementation and Execution

The period of economic development planning, 1962-1991, was not always successful, and Korea experienced various trials and errors. The Korean economy, however, recorded rapid

economic growth during this period, at 8% per annum on average and acquired a sound foundation for market economy.

During this period, Korea gradually transformed from a traditional agricultural society into an industrial society based on the strong manufacturing sector, and into a post-industrial society. Currently, Korea is passing the era of knowledge based economy with flourishing contents industry and the convergence of industries.

Project-based economic development plans in the initial phases gave way to comprehensive aggregate level indicative plans in later phases. Currently, Korea does not have economic development plans any longer, but only a few inheritances from the periods of economic development plans.

This section summarizes Korea's economic development plans in terms of its implementation governance and scheme.

5.2.1. Implementation Governance

Economic Planning Board (EPB)

In June 1961, the Ministry of Reconstruction was dissolved, and the Economic Planning Board (EPB) was established, which initiated its active work from June 1962 at the announcement of the First Five Year Economic Development Plan. The EPB was responsible for the entire width of the Plan, including preparation, implementation and execution, and monitoring.

The minister of EPB was appointed simultaneously as the Deputy Prime Minister (since December 1962), and the EPB was a planning center and a super ministry in charge of the national budget and foreign investment inducement. The Second Economic Development Plan stated that "the EPB is responsible for the management, implementation and coordination of the Plan."[6)]

Plan Units

After the announcement of the plans, the plan units within the government agencies and local governments that participated in the preparation of the plans remained involved to ensure the effectiveness of the plans. They were responsible for the implementation of the plans and were in close cooperative relation with the EPB. The EPB also formed the Investment

6) The Second Five Year Economic Development Plan, Economic Planning Board (Republic of Korea), 1966, p.124.

Coordination Committee along with the government agencies, where the issues regarding the Overall Resources National Budget, follow up of the plans, private investment promotion, and so on, were discussed.[7)]

Korea Development Institute (KDI)

During the mid 1960s, while complementing the First Plan and preparing the Second Plan, the Korean government felt the need for an expert group who could conduct more intense studies on the economic development plans. The idea materialized further in the Second Plan, which explicitly stated that, "a research institute will be founded in a near future in order to strengthen professional and methodological capabilities of the government on economic development planning."[8)]

The Korean government founded the Korea Development Institute (KDI) in March 1971 under the EPB as a partner in the fields of intense research on economic policy studies and economic development planning, and also as a window for international networking with foreign experts.

The Korean government placed a strong emphasis on strengthening the government's research and statistical functions and on close cooperation with academia and research institutions. In particular, the Korean government emphasized that "the plans must be prepared in a rational way, based on basic and applied researches on practical economic policies, short and long term forecasts, various statistical analyses, etc., by fully utilizing KDI."[9)]

Consulting Committee for Economy and Science

The Consulting Committee for Economy and Science was founded based on the Article 118 of the Constitution' in order to provide advice to the president on policy issues regarding national economic development and science promotion.' The late president Jung Hee Park appointed ten or so experts from academia and expert group as the committee members, and the committee made regular reports to the president on the status and assessment of the plan implementation. The committee members were also asked to attend various meetings related with development plans or other urgent economic issues to share their professional opinions.

7) op. cit., pp.123-125.
8) op. cit., pp.123.
9) The Third Five Year Economic Development Plan, Economic Planning Board (Republic of Korea), 1971, p.122.

5.2.2. Implementation Scheme

Rolling Plan System: 'Overall Resources National Budget'

In order to reconcile with the weakness of long term plans, Korea adopted the rolling plan system, in which adjusted plans, reflecting the changes in the economic environment, were announced at the end of every year and used as the basic framework for economic policies in the next year. The next five years became the target period of the adjusted plan.

The Second Economic Development Plan provided a clear description of the Overall Resources National Budget as the main implementation scheme of the plan:[10)]

Overall Resources National Budget includes the assessment of the past performance, analysis on general economic trends for coming years, estimates of available resources, yearly targets and specific policy tools, magnitude and details of annual budget, sectoral investment plan including the private sector, major financial indicators including money supply and principles in the financial sector, magnitude of foreign capital and the government'guarantee plan, demand for and supply of major items, other activities of the private sector, and so on.

Individual plans, such as plans for annual budget, foreign exchange, international trade, comprehensive cash flow, etc., had to comply with the Overall Resources National Budget, and a close cooperation must be maintained between the offices of EPB and corresponding government agencies.

The Overall Resources National Budget and individual plans must be prepared in a timely manner considering the times required for legislative and administrative procedures.

Improving National Statistics

The Korean government continuously complemented, expanded and refined national statistics which were crucial in the effectiveness of the plan preparation and implementation. The functions of Statistics Bureau inside the EPB were strengthened in order to enhance the comprehensiveness and precision of the statistics. On the other hand, national account statistics have been produced by the Bank of Korea. The Korean government introduced and made effort to increase the quality of various new statistics, including national census.

10) *The Second Five Year Economic Development Plan*, Economic Planning Board (Republic of Korea), 1966, p.125.

Plan Implementing Review Session

The EPB organized the monthly meetings that lasted until the late 1970s. These meetings, which later called the 'Plan Implementing Review Sessions,' were held in the EPB building and were attended by ministers, congressmen, politicians, members of the Consulting Committee for Economy and Science, and business representatives, etc., and most importantly, the president.

In these meetings, the EPB made comprehensive reports on the status and progress in major projects of the development plan, obstacles and potential solutions, and current domestic and international economic trends. Since most of the issues discussed in the meeting could be settled right away by top decision-makers presented, the sessions provided a very efficient, time saving decision making process to the government. At the same time, these sessions provided a venue for encouraging planning experts to share opinions and perceptions on plan implementation.

Monitoring and Evaluation

Monitoring and evaluation of plan implementation of individual projects was accomplished by the Planning and Coordination Officer in each government agency, while the EPB was responsible for professional monitoring on the key projects. Summary of monitoring and evaluation on overall plan implementation was reported to the president in regular meetings attended by the members of Consulting Committee for Economy and Science.

Project Evaluation System

As the size and complexity of the investment projects increased, the government felt the need to strengthen the investment assessment system, which led to a professional organization inside the EPB for improving and disseminating investment assessment system. The Third Plan emphasized that 'the new investment assessment system must be further improved in implementing the Third Plan, and be disseminated to the private as well as public sectors.' It also declared that 'investment assessment system consists of economic and technological reconnaissance and financial profitability analysis. Economic reconnaissance consists of 'economic' benefit-cost analysis of individual projects followed by the analysis of their effects on international payment, value added and employment.' The Korean government improved the investment assessment manual and established an organization responsible for the dissemination and education to the private as well as public sectors.

6. Advice and Recommendations

Korea's experience in economic development cannot directly provide implications for effective implementations of development plans in Saudi Arabia. Above all, Saudi Arabia's

socio economic situations drastically differ from those of Korea; Saudi Arabia possesses enormous natural resource endowment, strong social cohesion, leading position among Arabic countries, and four decades of experience in development planning. In addition, the goals and policies largely depend on the tradition and culture of individual countries, all of which made it difficult to apply development experience of one country to another.

One of the authors of this chapter, however, participated in the entire phases of the Korea's development plans from the preparation, implementation and follow up since the Second to the last plan. His first-hand experience in the formation of major economic policies during the period, at various levels in the EPB as the Director General for Planning, the Deputy Vice Minister, the Vice Minister and the Minister provides useful insights into enhancing the effectiveness of plan implementation. The following advice and recommendations are based on Korea's experience, and partly on his personal experience inside the Korean government.

6.1. Strong Implementation of Development Plans

Having experienced the implementation of eight development plans and the preparation of nine such plans, the planning center of Saudi Arabia is well aware of the major obstacles in effective plan implementation.

Korea's experience suggests that comprehensive economic development plan be of higher level than all other plans. Experiences of other countries can be found where comprehensive development plan is in parallel with other sectoral plans, each with its own implementation scheme, thus becoming only one of many plans without strong implementation. Effective implementation of development plans is possible when they are assigned high priorities in economic management, while the legal status of the development plan is not crucial.

6.2. Strong Leadership of the Top Leader

Long-term plans must be executed comprehensively and consistently, but environmental changes always ask for adjustments and changes from the original plan. The most effective way to overcome this problem is by strong leadership of the top leader, which makes the long term goals of the plan robust and strengthens people's belief in future prosperity. It is every Korean's belief that the strong leadership of the late president Chung Hee Park in the execution of Korea's economic development plans was the foundation for economic development in Korea.

6.3. Functions of the Planning Center and its Strong Position inside the Government

In Korea, the first action made while preparing the First Plan was to establish the Economic Planning Board (EPB) as the planning center. As mentioned previously, the Deputy Prime

Minister of the Korean government also held the position of EPB Minister, implying that the EPB was at a higher level than other ministries. The EPB was responsible for national budget compilation and foreign capital inducement in addition to plan preparation and implementation, and was the organizer of the Ministers' Meeting in Economic Affairs. In addition, the EPB had the full support from the president and professional assistance from the Korea Development Institute (KDI), which greatly contributed to enhancing the effective implementation of the development plans.

Considering Korea's experience, it is suggested that a wide consensus be built up inside the Saudi government regarding the capability and power of the Ministry of Economy and Planning in coordination and problem solving and its leadership as the planning center.

6.4. Professional Research Institution

Successful preparation and implementation of economic development plans in the era of global economy asks for a professional research institution inside the government. The current global economy requires more professional information and its structure becomes more and more complicated. Professional research institutions can provide professional research and analysis and scientific forecasts and recommendations, which is usually difficult for government officials to access.

KDI played this role in Korea. KDI was responsible for intense research on economic policy studies and economic development planning, especially on macroeconomic analysis and forecasts of the development plans. KDI also played the role of window for both domestic and international research networking, and played a significant role in consensus building among government officials and interest groups on development plans.

If Saudi Arabia has interests in establishing a research institution like KDI, our research can be extended to the detailed frameworks as to the institutional aspects and its role in plan preparation and execution, and, in particular, in implementing rolling plan system. Korea's experience in launching KDI can be utilized for this work.

6.5. Enhancing the Functions of Market System

Expansion of the public sector was inevitable in the early stages of the Korean economy, while the private sector grew continuously in later stages. Korea's experience proves that the expansion of the public sector raises substantial inefficiency, many trials and errors, and enormous efforts must be made in providing the market an efficient incentive system. Oil sector occupies a huge portion in the Saudi economy, and is regarded as a public sector. Considering

33) www.kats.go.kr

the fact that one of the major objectives of development plans in market economies is to expand the functions of market system and to develop the private sector, it is suggested that efforts be made in providing the market with an efficient incentive system.

6.6. Indicative Planning

Economic development plans in market economies must be ‘indicative,’ that is, they must concentrate on 'indicating' the strategies and directions for accomplishing the country's goals. Although Korea's constitution defined the economic system as market-based, Korea experienced frequent conflicts between individuals' interests and the government intervention in the early stages of economic development.

Indicative plans must take into serious consideration the capabilities and expectations of the market at both aggregate and sectoral levels, and provide a grand picture of the economy with economy-wide balance. This requires advanced knowledge at macro level.

6.7. Reconciliation of Macro Plan with Sectoral Plans

Usually, it is not an easy job to assess, based only on the plan documents, how well the sectoral plans are reconciled with the macro plan. In many countries, macro and sectoral plans are prepared and implemented separately without appropriate reconciliation. It must be stressed that development plans are not ‘comprehensive’ without this reconciliation.

In Korea, such reconciliation was not possible in early years; the reconciliation was not even attempted in preparing the First Plan, and in the Second Plan, a macro model was utilized in preparing the macro plan, and the input output tables were used in the sectoral models to calculate sectoral investment demand. The following box describes the conceptual framework for reconciling the macro and sectoral models in the later plans.

(Working Process for Plan Preparation)

1) Review of macro basis economic performance and future perspectives
   - Checking the major national account in recent years
     • Y = C + I + (X-M)
     • growth rate, marginal propensity to consume, marginal propensity to invest, share of trade (export and import) to GDP, fixed capital formation, employment, balance of payment, etc.
   - Review of changes in international economic situation
     • perspectives on international trade and capital markets
   - Macro perspectives of plan period with macro model
     • Finding factors of advantages and disadvantages for development
     • What will be the key issues to achieve the goal?
2) Setting up goals and strategies for the plan
   - Continuous discussions, consuming enormous amount of time and energy, are necessary for the settlement of goals among the government and various professional groups.
   - Strategies should be elaborated by the planning center and ministries concerned to achieve these goals.

3) Allocation of investment resources
- Calculate the figure of the value added and total fixed capital formation during the plan period by macro frameworks
- Decompose the value added by industries in a target year; primary industry, manufacturing, services, etc.
- Calculate the investment requirement by industries based on the value added volume and the past trend of capital output ratio (ICOR).
  • ICOR = I / V, I = ICOR * V
- Feed back to the total fixed capital formations and investment requirement.

4) Preparation of major policies and projects
- Ministries concerned start to prepare major policy direction and formulate major projects cooperating with private sectors.
- Examine the major projects' rationality through input output table
- Discussions with planning center

5) Reconcile macro plan with sectoral plans
- Finalizing macro frameworks
- Setting up major policy directions
- Fixing up priorities for strategic major projects

6.8. Rolling Plan System

Rolling plan system is one of the solutions for continued implementation of development plans, if not guaranteed. Korea adopted the rolling plan system, the so-called 'Overall Resources National Budget,' and could achieve considerable continuity in plan implementation. Rolling plan system could enhance the awareness of the public on the plans themselves and on domestic and international environments.

6.9. Concrete Plan

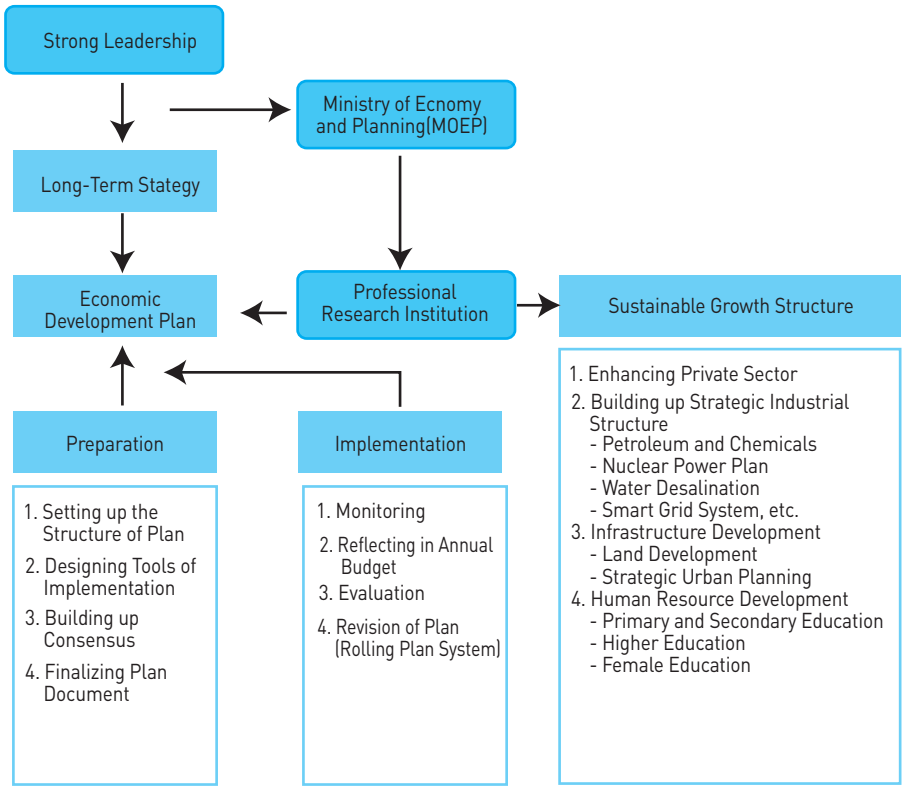
Concreteness of the plans also affects the effectiveness of plan implementation extensively. Effectiveness of the implementation of development plans can be maximized only when the plan documents include not only the goals, directions and strategies, but also specific details such as the quantitative targets, implementing agencies, budget, and so on. Development plans cannot be more effective than political commitments without such details.

Korea’s five year development plans consisted of macro and sectoral plans, and each sectoral plan considered current situations and issues, objectives and policy directions, strategies and investment plan required to accomplish each objective. In particular, the goals and investment plans were prepared in a very concrete and quantitative manner. Each sectoral plan was prepared by a task force, usually a team of 10 to 20 members from the implementing agencies and the EPB.

On the other hand, many sectoral plans of Saudi Arabia's development plans, even the recent ones, are not satisfactory in terms of concreteness. Although they do consider current situations, issues and challenges, objectives and policy directions, they do not provide detailed quantitative targets, implementing agencies, budget, and so on.

Figure 1-18 depicts the basic framework for development planning in Saudi Arabia summarizing the above advice and recommendations for enhancing the effectiveness of economic development plan implementation.

Figure 1-18 | Framework for Development Planning in Saudi Arabia



References

Ahn, Jongjik, *Directions of the Korean Economy* (in Korean), Dong Ah Publishing, 1962.

Bank of Korea, *Korea's National Income* 1953-1963, 1965.

Economic Planning Board (Republic of Korea), *The First Five Year Economic Development Plan*, 1962.

_____, *The Second Five Year Economic Development Plan*, 1966.

_____, *The Third Five Year Economic Development Plan*, 1971.

_____, *The Fourth Five Year Economic Development Plan*, 1976.

_____, *The Fifth Five Year Economic and Social Development Plan*, 1983.

_____, *The Sixth Five Year Economic and Social Development Plan*, 1986.

Lee, Hyung Koo, *The Korean Economy* (in Korean), Pakyoungsa, 1982.

_____, *The Korean Economy*, State University of New York, 1996.

_____, *The Condition of Prosperity* (in Korean), Pakyoungsa, 2008.

_____, *Directions of Korea Kazakhstan Knowledge Sharing Program*, 2010.

http://unstats.un.org/unsd/databases.htm, UNSD Statistical Databases.

http://www.imfstatistics.org/imf/, International Monetary Fund (IMF) Data and Statistics.

http://www.mofa.gov.sa, Ministry of Foreign Affairs, Kingdom of Saudi Arabia.

http://www.planning.gov.sa, Ministry of Economy and Planning, Kingdom of Saudi Arabia.

Chapter 02

Improvement of Primary Education of the KSA

Chapter 02

Improvement of Primary Education of the KSA

Chang Hwan Kim (Korean Educational Development Institute)
MoonJoong Tcha (Korea Development Institute)

In order to improve primary education a demand survey was conducted in the Kingdom of Saudi Arabia (KSA). The Ministry of KSA expressed a strong interest on the Korean educational development hoping to resolve some education issues of the KSA. During the meeting, which took place in July 2010 in the KSA, education issues and problems of both countries were discussed. In the following conference, which was held in September in Korea, the issues became more refined and focused as follows: 1) The relationship between economic development and education, in particular, in the context of Korea's experience; 2) The educational development and strategies of Korea; and 3) The education issues and interests of the KSA. Based on these survey and conference outcomes, means to improve primary education of the KSA will be discussed.

1. Education and Economic Development

1.1. How does Education Affect Economic Growth?

1.1.1. The Mechanism of Economic Growth

Education affects economic growth through various channels. This mechanism should be understood in an economy-wide view. For this, the mechanics of economic growth must be taken into consideration first.

Economic growth is defined as the increase in the value of final products (including goods and services) in a certain area in a given time. When GDP is used as a measure of scale of an

economy, growth is understood as the increase in the value of final products in domestic market in a given time (usually one year). Consequently, in order for an economy to grow, factors of production should be accumulated, and productivity should be enhanced, to produce more value added, as shown in Figure 2-1.

Both factor accumulation and productivity have close relationship with the openness and economic institution of the economy. In fact, openness is a kind of nation's institutions related with its attitude, regulation and policy towards foreign countries. Therefore, economic institution is the most important infrastructure of economic growth. The failure of communist economies is largely due to their economic institution, which does not allow private ownership and people's right to seek profit.

Acemoglu (2002) points out that institution and economic growth have strong correlation. He argues that the miraculous growth of Korea in the 1960s and 1970s heavily relied on the excellent institution that Korea had, which encouraged incentives to work, invest and innovate. In the case of Korea, it should be noted that two important things that significantly contributed to economic growth were declared in the first constitution promulgated in 1948: protection of private ownership by the government, and compulsory primary education for all people. With this institutional preparation, which was rare for a country with the level of per capita GDP as Korea's at that time, Korea could lay foundation for future growth. This is why such a large number of economists, including Rodrik et al. (2004) argue that the quality of “institution” is the most important and fundamental factor of economic growth, as summarized in Figure 2-2.

Figure 2-1 | Determinants of Economic Growth

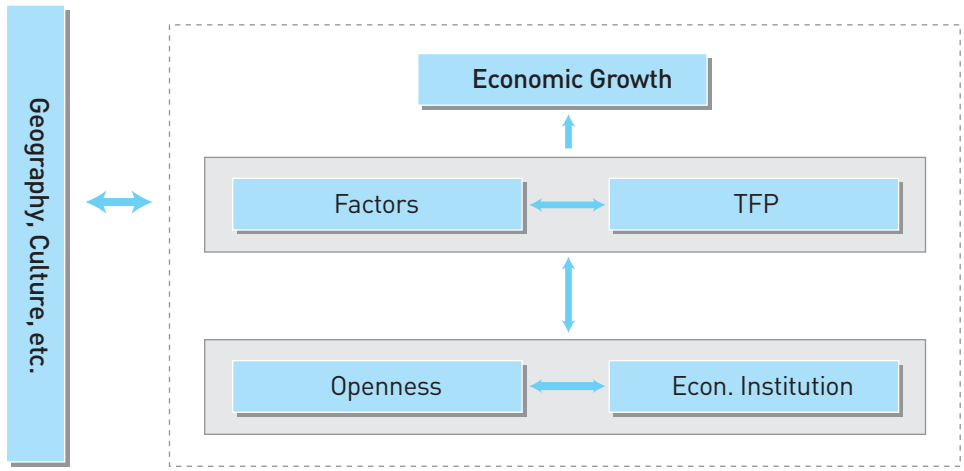
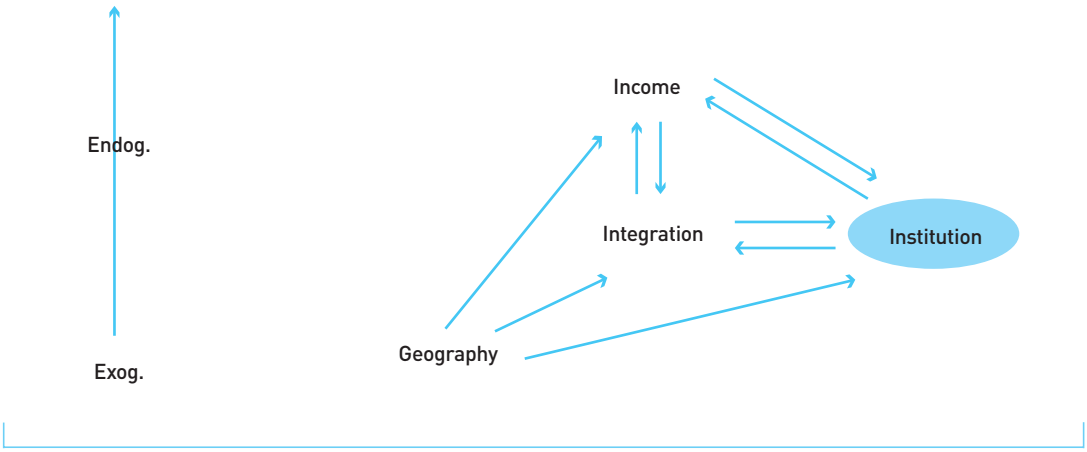


Figure 2-2 | National Income and Institution



Geography is also very important and fundamental for economic growth, however, it is given exogenously, and one cannot change this factor. In contrast, "institution" is what one can control, although it is affected by some exogenous variables such as geography, and at the same time substantially affect integration and income. This is why institution should receive serious attention from policy makers aiming economic growth.

Institution encompasses a number of contents as it virtually covers all the customs, ethics, laws, governance and trustiness. To have an education system is also included in institution. As discussed earlier, compulsory and universal primary education was a critical part of Korea's first constitution, which encouraged investment in people. These well educated labors later became the important source of growth when Korea commenced its development since the early 1960s.

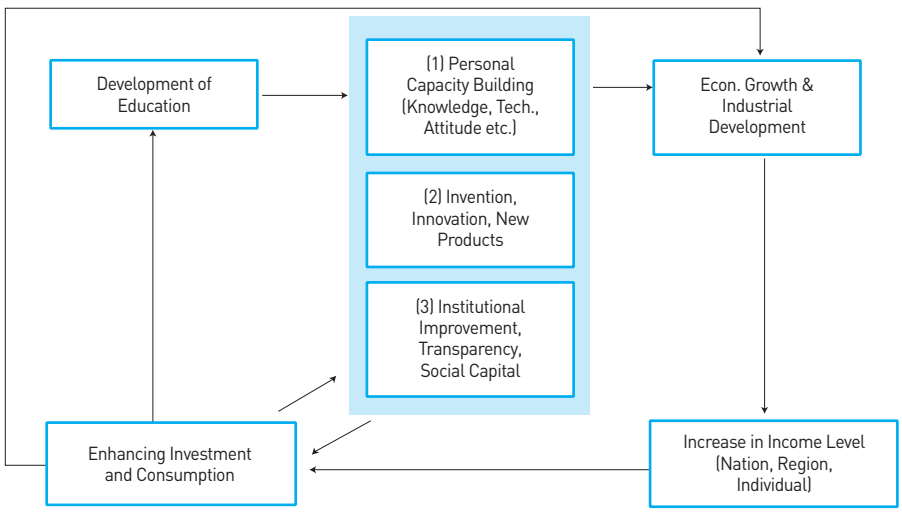
1.1.2. Channels Education Affects Economic Growth

Education can affect factor accumulation in two aspects. First, it increases the number of labor who can be employed for productive economic activities. Second, it increases the quality of labor or the level of human capital. The original idea of economic growth uses two distinctive production factors: capital and labor. Later, economists found that wide spectrum of labor productivities were prevalent; one labor in the USA could produce about 34 times what one Bangladeshi labor can produce. They analyzed this and concluded that as more capital is invested into human, this labor's productivity increases. This human where capital is invested mostly through education is labeled as human capital. They can enhance their personal capacity by accumulating more knowledge and learning new technology through education.[11] Considering this concept of human capital, as well as factor accumulation, the first channel through which education can affect growth is labeled as (1) in Figure 2-3.

Education, particularly when it is carried out in a proper way, improves people's ability on invention and innovation, through learning how to think and extend logic. A very strong drive of Korea in providing education and investment in research and development has allowed Korea to be ranked the 4th in the world recently, in terms of the number of patent application. This effect is labeled as (2) in Figure 2-3.

In spite of its importance, the effect of education on building up social capital is ignored frequently. Social capital is an intangible asset in a society, which consists of explicit and implicit institutions including laws, acts, ethics, norms, networks and trustiness. Previous studies found that social capital significantly reduces social costs, particularly transaction costs that might incur when social capital is insufficient. For example, a society with a very low level of trustiness should pay high cost in making contracts to prepare all the legal means to keep each party's interest. One of the most important goals of modern education is to educate people to have good personality and open mind, and respect the rules. An appropriate education can improve the level of social capital in a society. This is shown as (3) in Figure 2-3.

Figure 2-3 | The Effects of Education on Economic Growth



1.1.3. Education Reducing Social Costs from Conflicts

Modern industrialization first occurred in Western countries since the 18th century, and

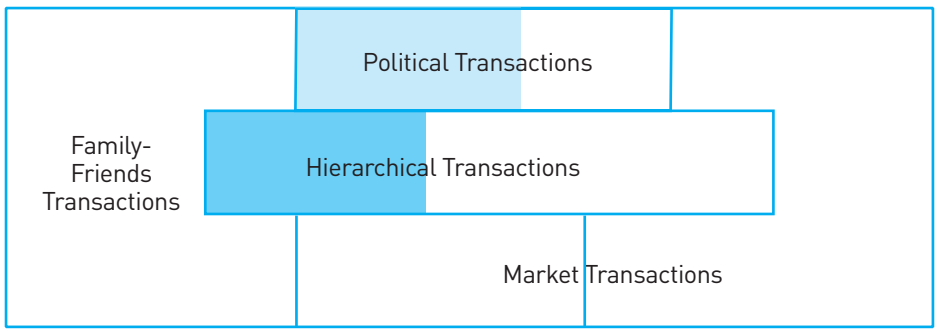
11) This capacity building can be achieved by school education or/and on the job training.

continued to progress in European and North American countries. As industrialization of these Western countries spread to other developing countries, it has been observed in many developing countries that modern technology and skills moved in accompany with Western culture. In many developing countries, in consequence, cultural shocks and social conflicts took place as newly incoming Western cultures and values were not consistent with domestic ones. Social and cultural conflicts incur a lot of cost and deter economic development unless they are very wisely harmonized and coordinated.

The OECD-Weber model uses Figure 2-4 and explains how original and incoming cultures and norms clash. People's activities are categorized into four transactions: (i) family-friends transactions, (ii) political transactions, (iii) hierarchical transactions, and (iv) market transactions. While the original and traditional norms and values in most developing countries belong to the family-friends transactions, the newly incoming norms and values emphasize the role of the other three. The relations, transactions and values they used to regard family and friend-oriented and rather informal, are now regarded as political, hierarchical or market ones, which are more formal and official under the new cultural influence. The colored areas in Figure 2-4 represent the vague areas where the nature of some activities is interpreted differently by different cultures. Developing countries experience this confusion. As a country experiences a rapid westernization together with industrialization, these areas become larger and social conflicts or confusion will be serious.

More systematic education that teaches the importance of different cultures, the skills of negotiation, the value of harmony and the respect for its own culture and value can resolve these problems. Korea is not satisfactorily successful in implanting this kind of education system. As entrance examination for higher levels of school was regarded important, students could not have sufficient opportunities to learn the art of living together, or resolving conflicts and tensions through discussion and compromise. This incurs a high level of social cost. A good education system is needed to minimize the cost from social and cultural conflicts.

Figure 2-4 | OECD-Weber Model for Social Conflicts



Also, a higher level of social mobility always enhances people's incentive to work, invest, learn and create. This will help stabilize and secure economic growth. This is also one of the most efficient ways to resolve conflicts among social groups or classes. Society becomes dynamic yet stable and healthy when education and social mobility are combined.

1.2. Contribution of Education to Growth

1.2.1. Contribution of Education to Growth - the US Case

It is very difficult to find how much education contributes to growth, while there has been consensus that it "is" important. In discussing the effect of education on growth, two things should be investigated. First, it should be considered how spending on education increases school quality (and quantity), and how this influences returns to schooling for students. Second, how human capital or education contributes to economic growth should be investigated on a more aggregated level.

The first type of questions has been answered by a large number of labor economists, and their answers are substantially different. The answers using the Korean experience is to be discussed in the next section. For the latter, the Bureau of Labor Statistics of the U.S. reported that (due to more investment in schools) U.S. labor quality grew by 0.22%p per year and this explains about 13% of the growth in U.S. labor productivity between 1967 and 2000. Namely for these years, annual growth of the U.S. labor productivity was 1.66%, and 0.22%p was due to the improvement in quality of labor. However, this may miss out a significant part of labor quality growth (see Table 2-1).

Table 2-1 | Growth Accounting for Private Business Sector (the USA, '67-'00)

	Y/L	TFP	S_K * K/L	S_L * H
Annual Growth Rate	1.66	0.66	0.77	0.22
Contribution (%)	100.0	39.8	46.4	13.3

Note: Y is total product, L total number of labor, TFP total factor productivity, Sk the share of capital, K, capital, L labor, S_L the share of labor and H human capital.

You (2008) suggests that the improvement in quality should be divided into two: First, the increase in quality of labor, and second, the increase in mean school years. Therefore, as can be expected, an increase in expenditure in schooling should have the two effects: quality improvement of human capital due to better equipment, better student-teacher ratio, and better curriculum and material development. At the same time, the mean years of schooling will also increase due to more schools and teachers. According to You (2008), with different assumptions on the model, the contribution of education has increased as shown in Table 2-2.

Table 2-2 | Growth Accounting of the U.S. Growth

Year	Y/L	TFP	$S_K \times K/L$	$S_L \times H$	
				$S_L \times Hq$	$S_L \times Hc$
Traditional Model					
1967-2000	1.66	0.67	0.77	..	0.22
1967-1984	1.43	0.50	0.81	..	0.12
1984-2000	1.90	0.85	0.72	..	0.32
Baseline Model					
1967-2000	1.66	0.39	0.77	0.19 (0.08)	0.31 (0.00)
1967-1984	1.43	0.14	0.81	0.19	0.29
1984-2000	1.90	0.54	0.72	0.20	0.34
Skill Premium Model					
1967-2000	1.66	0.46	0.77	0.12 (0.05)	0.31 (0.00)
1967-1984	1.43	0.28	0.81	0.11	0.23
1984-2000	1.90	0.66	0.72	0.12	0.40

Source: You (2008).
Note: Hc is the mean years of schooling, and Hq is the improvement in quality of human capital.
Numbers in parentheses stand for standard errors.

With the Baseline model where human capital improved by 0.5% every year, improvement in human capital (both quality and mean schooling) explains 0.5%p of 1.66% of growth, which is some 30% of contribution. When skill premium is considered, the contribution of human capital is slightly lower than the baseline model, explaining 0.46%p. If the two different kinds of human capital are investigated, the contribution of Hc (the mean years of schooling) appears higher than Hq (the improvement in quality of human capital).

1.2.2. Contribution of Education to Growth - Many Country Cases

Including the schooling years into the growth accounting can reveal the effect of primary and secondary education's contribution. The exact effect of education on economic growth varies according to the periods, countries analyzed and quantitative methods adopted. Nevertheless, it is commonly discovered that education has positive effects on economic growth.

Table 2-3 and Table 2-4 show the results of regression analyses to explain the determinants of growth provided by the World Bank (1993). Table 2-3 presents 113 countries for the period of 1960-1985. Three things should be discussed. First, the primary enrollment rate significantly and positively affects economic growth. An increase of 10 percentage points means that primary school education would increase per capita income growth by around 0.3%p. Second, the effect of secondary enrollment is not significant. Third, the High Performing Asian Economies

(HPAEs) performed better than the remaining countries.

Table 2-3 | Basic Cross-Economy Regression Results
(dependent variable: average rate of real per capita income growth, 1960-85)

Variable	*113 observations*	*113 observations*	*113 observations*
Intercept	-0.0070 (0.0079)	-0.0034 (0.0075)	0.0042 (0.0081)
Relative GDP to U.S., 1960	-0.0430** (0.0118)	-0.0293* (0.0115)	-0.0320** (0.0110)
Primary enrollment, 1960	0.0264* (0.0065)	0.0233** (0.0062)	0.0272** (0.0065)
Secondary enrollment, 1960	0.0262 (0.0139)	0.0160 (0.0132)	0.0069 (0.0131)
Growth of population, 1960-85	0.1015 (0.2235)	0.0201 (0.2095)	0.0998 (0.2023)
Average investment/GDP, 1960-85	0.0578* (0.0224)	0.0455* (0.0211)	0.0285 (0.0207)
HPAEs[a]		0.0230* (0.0056)	0.0171** (0.0056)
Latin America			-0.0131** (0.0039)
Sub-Saharan Africa[b]			-0.0099* (0.0041)
Adjusted R^2	0.3480	0.4324	0.4821

* Statistically significant at the 0.05 level.
** Statistically significant at the 0.01 level.
Note: Standard error is in parentheses.
a stands for High Performing East Asian Economies. b also includes Tunisia and South Africa.
Source: World Bank staff estimates.

Table 2-4 shows the elasticity of economic growth with respect to capital, labor and human capital for both full sample of 87 economies and selected high-income economies. Elasticity of growth with respect to human capital for full sample appears to be 0.154, indicating that when human capital increases by 1%, the economy's output grows by 0.154%. This figure is rather small compared to that for capital elasticity and labor elasticity. However, for high-income countries, human capital elasticity appears as 0.269, which is comparable to labor elasticity.

Barro and Sala-I-Martin (1995) also investigate the growth rate (in terms of per capita) for various countries for over prolonged period and derive important implications of education for growth. With 87 countries for 1965-75 and 97 countries for 1975-85, they quantitatively analyze the growth by applying diverse regression methods with a large set of independent variables, including various ones for education.

They find that average years of male secondary and higher schooling and average years of

female secondary and higher schooling tend to be significantly related to subsequent growth (at the start of each decade, 1965 and 1975). More specifically, from the estimation, it is derived that a one-standard-deviation increase in male secondary schooling (0.68 years in this case) for 1965-75, raises the growth rate by 1.1%p per year. A one-standard-deviation increase in male higher schooling (0.091 years in this case) raises the growth rate by 0.5 percentage points per year for the same period.

Table 2-4 | Basic Cross-Economy Regression Results

	No. obs.	S_K	S_L	S_H
Full Sample	2093	0.178 (10.895)	0.669 (6.411)	0.154 (1.49)
High-income ctr.	460	0.399 (10.237)	0.332 (1.679)	0.269 (1.476)

Source: Barro and Sala-I-Martin (1995).
Note: S_K, S_L, and S_H means elasticity of output with respect to capital, labor and human capital respectively. Numbers in parentheses are t values.

The effect of female secondary schooling and higher schooling turns out to be mixed. They are negative but insignificant respectively, however, negative and significant when joint. They explain that less education attainment of female signifies more backwardness, which accordingly indicates higher growth potential. It is true that a large spread between male and female attainment is a good measure of backwardness. Their empirical results also indicate that it is not appropriate to leave education variables out of quantitative analysis.

The effect of education can be also measured by investigating public spending on education. The amount (GDP share) of spending can complement schooling years, as the latter is about 'quantity' of education while the former is about quality as well. Barro and Sala-I-Martin (1995) use the average value over each 10-year period of the ratio of nominal government spending on education to nominal GDP. They find that a one-standard-deviation increase in the public education share (by 1.5%p for 1965-75) raises the growth rate by 0.3%p per year.

Nevertheless, it should be pointed out that the effect of primary schooling on growth does not appear significant in their regression analyses. While insignificant, the magnitude of coefficient is also small, which might indicate the convex relationship between education or human capital and return to schooling or GDP.

Overall, when school enrollment rates are also included, the effects from attainment still remain similar. In addition, it is found that the male coefficients are positive, the female coefficients are negative and the magnitude of the effect from higher schooling is greater than that for secondary schooling. These results are substantially analogous to those for schooling attainments.

1.2.3. Education and Socio-economic Variables

Education may affect important socio-economic variables through various channels. Such variables as fertility, life expectancy and mortality are very crucial for welfare of people and also have strong implications for sustainable economic growth. Table 2-5 shows the results of quantitative analyses investigating the effects of education on these variables.

Table 2-5 | Regressions for Fertility and Health

	(1)	(2)	(3)
	Log (fertility) 1965, 1985	Log (life expectancy) 1965, 1985	Infant mortality 1965, 1985
Log (GDP)	0.93 (0.31)	0.603 (0.099)	-0.134 (0.028)
Log (GDP) squared	-0.070 (0.020)	-0.0330 (0.0064)	0.0071 (0.0018)
Male primary education	0.094 (0.036)	0.0163 (0.0118)	-0.0071 (0.0033)
Female primary education	-0.194 (0.038)	0.0225 (0.0123)	-0.0034 (0.0034)
Male secondary and higher education	-0.191 (0.060)	0.0288 (0.0180)	-0.0054 (0.0050)
Female secondary and higher education	0.155 (0.067)	-0.0215 (0.0201)	0.0032 (0.0056)
R^2 (number of observations)	0.68 (90) 0.81 (102)	0.77 (89) 0.84 (99)	0.73 (88) 0.82 (100)
Serial correlation coefficient	0.61	0.43	0.43

Note: Estimation is by the SUR technique. Standard errors of coefficients are shown in parentheses. The variables are observed (where data are available) in 1965 and 1985. The dependent variable in column 1 is the log of the total fertility rate. In column 2, it is the log of life expectancy at birth, and in column 3, the infant mortality rate. The serial correlation coefficient is the AR (1) value in a regression of the residuals for 1985 on those for 1965.

Source: Barro and Sala-I-Martin (1995).

The estimated effects of education on fertility depend on gender and the level of schooling. For males, the coefficient on primary education is significant and positive, but that on higher education is significant and negative. The pattern is reversed for females. The effect of primary education on fertility is significantly negative, while that of higher schooling is significantly positive.

Barro and Sala-I-Martin (1995) interpret these results that women typically play the key role in child rearing, especially in developing countries. According to them,

> "The effects from primary schooling suggest that more female attainment affects primarily the value of time devoted to raising children; hence, the effect on

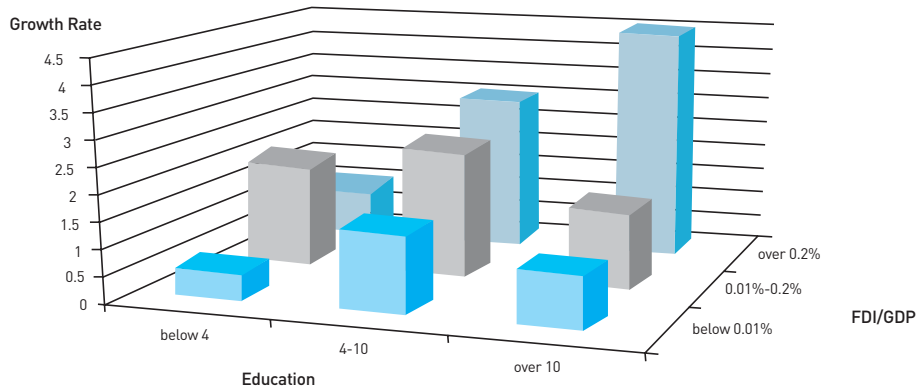
fertility is negative. In contrast, an increase in male primary attainment has mainly a positive income effect on the demand for children; therefore, the effect on fertility is positive." (Barro & Sala-I-Martin, 1995, p.454)

Table 2-5 also provides important findings on the relation between education and health. The main effect of primary education on life expectancy appears to be positive. More primary schooling goes along with greater life expectancy. However, secondary and higher level of education turns out to be insignificant. The similar results are found for infant mortality. There is negative relation between infant mortality and primary education. However, higher level of education only has insignificant effect on infant mortality.

These findings indicate that, in general, education provides mixed effects on fertility, and primary education increases life expectancy and reduces child mortality. It is noteworthy that secondary or higher education does not significantly affect life expectancy or infant mortality.

The last effect to be introduced is the effect of education or human capital on economic growth, combined with Foreign Direct Investment (FDI). There are numerous researches on the effect of FDI on economic growth. Borensztein, Gregorio and Lee (1998) extend this issue and analyze the effect of human capital (education attainment) on growth, combined with FDI (see Figure 2-5). They find that the countries with FDI/GDP ratio higher than 0.2%, in general, show higher growth rates, where those with higher level of education reveal higher growth rates. For those with mediocre level of FDI (0.01-0.2%) and low level of FDI (below 0.01%), about secondary level of education (4-10 years) most contribute to economic growth. For any level of FDI, countries with a very low level of education always show very low growth rate.

Figure 2-5 | Relation between Education, FDI and Economic Growth



Source: Borensztein, Gregorio and Lee (1998).

1.3. Education as a Factor of the Asian Miracle

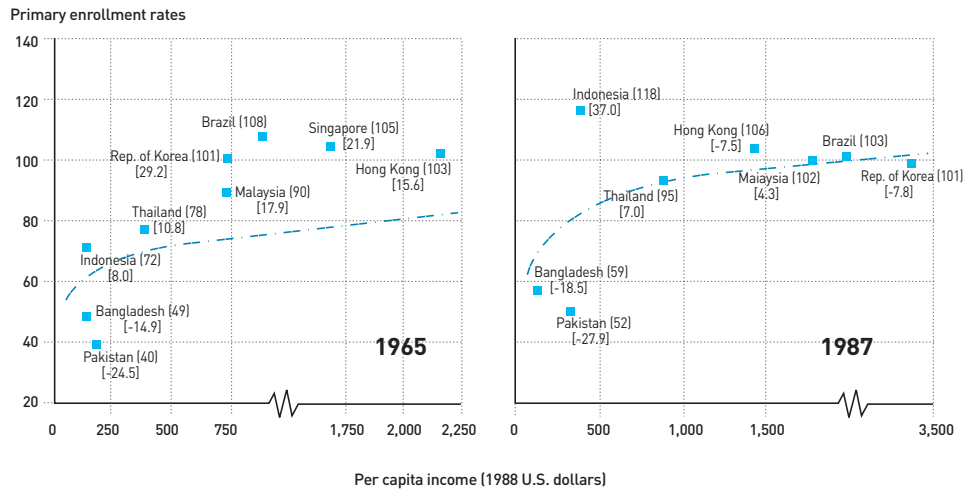
1.3.1. The East Asian Miracle and the Importance of Education

The World Bank (1993) illustrates the common characteristics of the High Performing East Asian economies (HPEAs) which might be the main contributors of rapid economic growth as follows: (i) market conforming public policies, (ii) macroeconomic stability and export growth, (iii) building institutional basis for growth, (iv) efficient allocation of resources, and (v) accumulating human capital and physical capital.

It is pointed out that in the 1960s, levels of human capital were already higher in the HPAEs than in other low-and middle-income economies as shown in Figure 2-6. The World Bank (1993) argues that governments built on this base by focusing education spending on providing universal primary education.

Economies such as Korea, Singapore and Hong Kong already showed the primary school enrollment rate higher than 100% in 1965. The figure also shows that the second group of development in the region, Thailand and Malaysia also reached ‘universal’ primary enrollment in 1987. The World Bank (1993) indicated that real expenditures per pupil at the primary level rose by 355% in Korea between 1970 and 1989, while in Mexico and Kenya, they rose by 64% and 38%, respectively.

Figure 2-6 | Primary Enrollment Rates ('65-'87)

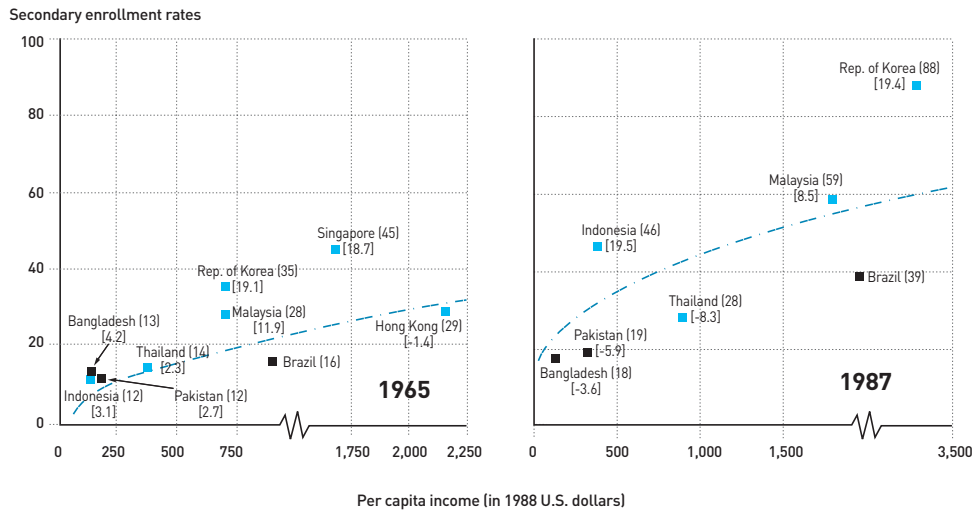


Source: The World Bank (1993).
Note: Figures in parentheses are enrollment rates; bracketed numbers show residuals.

Enrollment rates for secondary education in the region also reveal implicative features. Figure 2-7 shows that the enrollment rates for secondary education in Singapore, Korea and Malaysia were all higher than the trend line in 1965. The rate for Hong Kong was slightly lower than the regression line but the gap is not substantial. The figures for 1987 indicate huge changes; the enrollment rate for Korea reached 88%, which is far higher than the trend line, as the nation's policy focus moved from primary to secondary education.

Malaysia and Indonesia also demonstrate higher enrollment rates than the trend. Compared to these countries, Thailand was not very successful in secondary education interns of enrollment rates. It is noteworthy that for very successful countries in secondary education such as Korea, Malaysia and Indonesia, the enrollment rates in 1965 were already higher than the regression line while that for Thailand was just on the line.

Figure 2-7 | Secondary Enrollment Rates ('65-'87)



Note: Figures in parentheses are enrollment rates; bracketed numbers show residuals.
Source: Behrman and Schneider (1992).

1.4. Education and Growth - The Korean Case

1.4.1. Correspondence between Development and Education

As discussed, human resource development, or education has been illustrated as one of the most important contributors to the economic development of Korea. In particular, it has contributed to not only quantitative growth such as an increase in the level of GDP per capita,

but also qualitative development such as democratization and advancement in institution and governance. Education, which made Korea's development growth distinctive from other developing economies, has some key features that are noteworthy.

One of the most important aspects of the relationship between education and economic growth of Korea lies in the consistency between the goal of education policy and the nation's development goal over time (See Table 2-6). For the period of 1945-1960, the Korean economy did not record a high rate of economic growth. Most of the U.S. aid, which explained the largest source of foreign currency, was used to buy consumption goods, which was always regarded as the most important function of the government.

Surprisingly, Korea launched its first six year plan for free compulsory education in 1954, right after the Korean War. By the enactment of the Education Tax Act in 1958, more resources were invested in education. The share of education budget out of total government budget increased from 4.2% in 1954 to 14.9% in 1959. Bae (2007) pointed out that most of the education budget was allocated to build more schools and reduce the number of double shift schools, particularly in primary education. This period was, therefore, known as the period of universalization of primary education, though primary education became free to all eligible school aged children in the late 1960s.

Table 2-6 | Economic Development and Education Policy in Korea

National Development Phase		Economic Development	Education Policy
Phase 1 (1945-1960)		Agriculture Society, Postwar Reconstruction, Period Export-Centered Industrialization	Establishment of Basic Education System, Universalization of Primary Education
Phase 2	1960s	Labor-Intensive Industrialization Centered on Light Industry	Expansion of Secondary Education
	1970s	Heavy and Chemical Industrialization, Fostering Large Companies	Training and Expansion of Vocational Technology Education
Phase 3 (1980s-1990s)		Technology, Knowledge, Information-Intensive Industrialization	Expansion of Higher Education
Phase 4 (2000-present)		Entry into Globalization, Informationalization, Knowledge-Based Economy	Popularization of Higher Education, Educational Informationalization, Lifelong Learning, National Human Resource Development

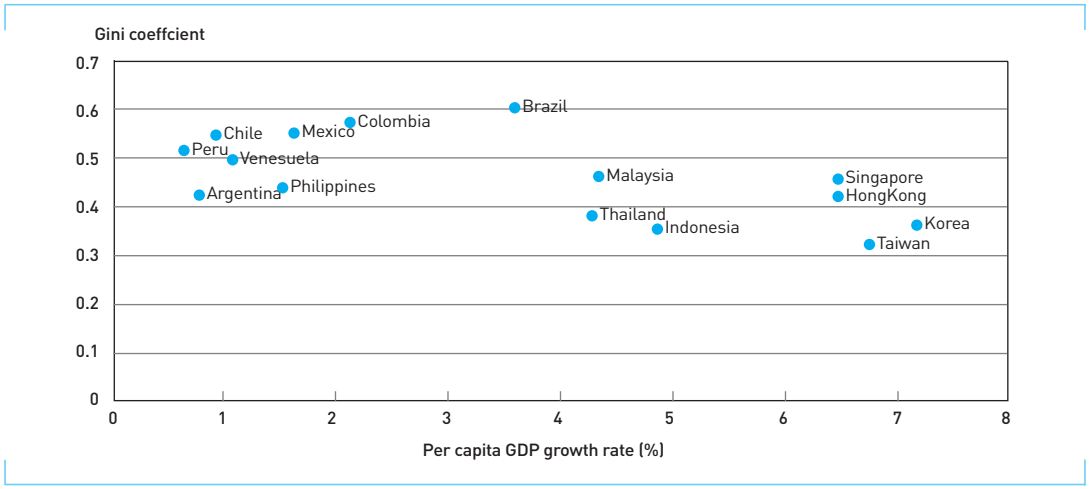
As well-known, more active history of economic development of Korea began in 1962 when the first 5-year economic development plan was established. Since then, the plans were prepared and implemented 7 times until 1996, and played a key role in industrializing the

economy of one of the most devastated countries in the world into one of the most successful countries that achieved both economic growth and social democratization. In implementing development plans, the government has formulated human resource development policies to provide well-educated and trained workers.

As mentioned earlier, a very high rate of literacy, in particular among the young workers, due to the effort for universalization of primary education since the nation's independence, contributed to the emergence of labor-intensive industries as a growth engine in the 1960s. During the 1960s, the primary goal of education policies was to provide properly educated and trained workforce for the light and labor-intensive industries. As a result, the major emphasis of education was on the practicability, anticommunism and moral development (Bae, 2007).

Starting with labor-intensive industries was wise as it was consistent with comparative advantage of the nation. However, there is another important merit which is also extremely implicative for many developing countries. Universalizing primary education and beginning economic growth with labor-intensive industries contributed to the "pro-equal" economic growth as shown in Figure 2-8. Since 1965 to 1990, the Gini coefficient of Korea was one of the lowest, while its growth rate for per capita GDP was the highest among developing countries. It is noteworthy that most East Asian countries that emphasized primary education at the beginning achieved better Gini coefficient than other developing countries.

Figure 2-8 | GINI Coefficients and Economic Growth ('65-'90)



Source: KDI (2006).

Table 2-6 also shows how readily the focus of education moved to keep consistency with its industrial transformation. Due to domestic and foreign circumstances, Korea had to move to pursue the Heavy and Chemical Industries (HCI) Drive in the 1970s, where six industries-iron

and steel, electronic and electric, shipbuilding, automobile, machinery and petro-chemical-were focally emphasized. This HCI-Drive required skilled workforce, and the Korean government prepared for this change since the late 1960s. After achieving universal primary education, the nation moved its emphasis on secondary education, and also strongly pushed vocational and technological high schools since the late 1960s. These technology and vocational high schools aimed to train-middle level engineers, who became a great asset when the nation began the HCI Drive in the 1970s. Throughout this period, school education was discipline-oriented, where major emphasis was on science and technology, in particular vocational skills and engineering. The government even implemented a policy to keep the number of students in vocational and engineering high schools above a certain level.

The 1980s is the period that Korea has deeply engaged with the HCI development and the whole industry has experienced a sea of restructuring. The share of light industry has decreased remarkably, and the HCI replaced it. As the HCI expanded rapidly, and the industries developed to produce more elaborated products, the emphasis of education policy again moved to produce more highly educated human capital. In 1981, the quota of new entrants to universities was largely expanded, and the government allowed more universities to be established.

While it is still controversial whether this sudden increase in the number of universities and university students was beneficial in terms of the entire nation's efficient allocation of labor, it is still clear that those who were educated in universities became the crucial manpower leading the evolution of industrial development and economic growth.

Nowadays, more than 80% of high school graduates enter into universities, which is the highest figure among the OECD economies. Regardless of whether this is proper for the economy, the emphasis of education policy is now moving to lifelong learning and human resource development consistent with the national strategy. This is crucial for Korea that faces a large number of challenges ahead, in particular, continuously facing series of globalization and rapidly aging society.

1.4.2. Contribution of Education to GDP Growth

While the method You (2008) used is very rigorous, the data restriction does not allow application of similar analyses for other countries' experience. Nevertheless, the contribution of education or the quality of human capital to economic growth can be estimated using various methods. Table 2-7 summarizes the results of previous studies on the growth contribution of labor (both quantity and quality) to economic growth of Korea for each period. The total number of labor in Korea has been rapidly increasing, though it is facing the problems of aging society and declining population at present. The table shows that the contribution of labor to economic growth reached its maximum during 1966-1970, explaining 3.84%p where the contribution of quantitative increase in labor explained 3.13%p and qualitative increase in labor

explained 0.71%p. It should be noted that education contributed to both quantity and quality increase of labor.

As the overall growth rate has been decreasing, the figures representing the contribution of overall labor has been also declining. However, if we compare the contribution of quantity and quality, the former has decreased rapidly while the latter, in fact, has increased with fluctuation. The quality's contribution sharply decreased in 1996-2000, however, its share in total labor's contribution has increased significantly. This period should be interpreted as the period of restructuring the Korean economy around the Asian crisis period. Virtually, the contribution of labor quality is, at least, as important as that of labor quantity since 1996.

Table 2-7 | Growth Contribution of Labor in Korea (%)

Period	Labor-Quantity	Labor-Quality	Labor-Total
1945-75*	2.13	0.71	2.84
1966-70**	3.13	0.71	3.84
1970-75**	2.68	0.68	3.36
1980-94**	1.7	0.79	2.49
1996-00***	0.5	0.6	1.1
2001-05***	1.0	1.0	2.2

* Mcginn et al. (1980), ** Choi (1997), *** KDI (2007).

1.4.3. How to Increase Investment in Education?

It was shown that human capital has become more important in achieving economic growth. Improvement in human capital through education enhances labor's knowledge and capacity. It also increases ability of pupil to innovate and invent new products or improve managerial skills and production procedure. Finally, it can strengthen social capital of the society, which emerges as one of the most important factors of growth in recent years.

To improve human capital through increased mean school years and quality of teaching, it is necessary for the government to regard education as the most important area for budget expenditure. Furthermore, it is also important that people are willing to invest their time and physical capital in education.

While the Korean government wisely approached education and invested substantial amount of budget, Korea has been regarded as the nation with the highest expenditure ratio (of income) for out-of-school private education. Intuitively, people invest more when they expect higher return from investment. The same logic can be applied to investment in education. Table 2-8 summarizes the marginal rate of return to investment in education (schooling) in Korea. It is

shown that initially the marginal rate of return to middle school was the highest, and then high school and college/university. Since the 1970s this trend has changed, and marginal return was the highest in high school education, and then college/university. The trend changed again in 1977, where marginal return to college/university was the highest, and then high school and middle school.

While the estimation methods and data sources could be different, these results are consistent with intuition. In the early stage of development when labor intensive light industries played key roles in the economy, there was strong demand for relatively simple and cheap labor. As the economy grew and matured, the demand for labor with higher education increased. In summary, while the government emphasized specific levels of education with the future industry in mind, the marginal return from the real world changed in a way to encourage people's investment into higher education.

It is not desirable for the government to distort marginal return to education for certain purposes. Many times it is not possible either. If market works fairly and information is shared to a sufficient extent, instead, people will react to the signal from the market. In the case of Korea, the signals from the market and government were harmonized, and people reacted to these signals properly in their investment in education.

Table 2-8 | Returns to Schooling in Korea

	Base Year	Middle School	High School	College/University
Kwang-Suk Kim	1967	12	9	5
Florida Stat Uni.	1969	20	11	9.5
Chang-Yong Chung	1971	8.2	14.6	9.4
Jong-Kun Bae	1977	2.8	9.9	13.8
Se-il Park	1980	2	8.1	11.7
KEDI	1982	9.5	12.3	13
KEDI	1994		7.3	7.2

Source: Kim (2007).
Note: Returns to schooling imply the rate of income increase due to additional schooling.

1.5. Implication for the KSA

It has been found from previous research and many countries' experiences that education or human resource development increased labor productivity for each person, and contributed to the whole economy's growth. The experience of Korea shows how strategically the government allocated its national investment in education to support the economic growth, which enabled industrialization to be completed in one generation.

There is a wide consensus that investment in education at the national level was one of the most important factors for the economic development of Korea. The modernization and democratization of the society also went hand in hand with educational development. However, there is no 'iron rule' for certain education policies applicable to any countries, even when these policies were really helpful in achieving economic development for a certain nation.

Bae (2007) points out that this kind of ‘Korean Model’ of education may well fit for

(i) Countries which have few natural resources such as oil and natural gas, and therefore have to rely on human resources as the foundation of economic development;
(ii) Countries which retain a Confucius cultural legacy which is more likely to have a centralized governance system; and/or
(iii) Developing countries where highly advanced systems may not work well.

The KSA does not perfectly fit into any category mentioned above, however, the nation contains the characteristics of, at least, parts of each category. The KSA is very affluently endowed with natural resources, particularly petroleum, but still needs human resources for its future as well as current development. While it does not have a Confucius cultural legacy, it also has an excellent religious and cultural legacy and a well established central governance system. Also, as its history of economic development is relatively compact and its culture is quite different from Western advanced countries, it needs an education system suitable for 'intensive' economic growth.

The question is whether the KSA has sufficient time to progressively pursue education policy as Korea has done for the last 50 years. As aforementioned, Korea spent first ten years (or even longer, considering its effort right after the Korean War in 1954) in the 1960s for primary education. In the 1970s, the nation put its stress on secondary education with strong emphasis on vocational and technical high schools. It was not until the 1980s when tertiary education emerged as the most important policy target, with the introduction of a knowledge based economy.

While it may be possible for the KSA to commence its policy efforts to strengthen all levels of education from primary to tertiary simultaneously, and it may be also possible for the nation to finance sufficient budget for this, it is still questionable whether the nation can achieve what it aims from policy efforts; the well-educated high quality workforce that will be responsible for further growth of the country. The major problem is it takes time to have high quality workforce as individuals should receive good education from primary schooling.

Bearing this in mind, it is noteworthy that the experience of Korea provides the following implications for the KSA.

1) *Strong leadership*

The experience of Korea indicates that strong political support is necessary for the national education development, particularly at the early stage. The national education development plans always need strong financial support, where all the budget items compete to acquire their share in the government budget. For Korea, the leaders with strong leadership and integrity understood the importance of education, and tried to allocate substantial amount of financial resources at the expense of other fields demanding government budget. This enabled continuous reforms and improvement in education system and facilities.

2) *Systematic approach consistent with economic development*

It was pointed out that the educational emphasis and the economy's comparative advantage came together in Korea. It is striking to many countries that the nation established a six-year plan for free compulsory education in 1954, which was just one year after the Korean War was over. Later, education and human resource development plans were harmonized with the five year economic development plans, serving for the national agenda of economic development. Accordingly, educational development plan moved from the most fundamental and basic primary education to more advanced and higher levels.

With more affluent budget owing to the continuous economic growth and continuous aspiration for better education, the nation has dealt with all levels of education, simultaneously. For example, since 2001, the National Human Resource Development Plan was commenced to allow primary and secondary students to develop basic knowledge and attitudes for social activities. At the same time, two prominent plans for higher education, Brain Korea 21 (BK 21) and the New University for Regional Innovation (NURI) began to strengthen the competitiveness of universities.

Recent changes in the name of the ministry that is in charge of education indicated how much effort the nation exerted to combine education with the most effective and imminent national agenda. The names changed from the Ministry of Education, to the Ministry of Education and Human Resource Development and then to the Ministry of Education, Science and Technology.

In addition, it is noteworthy that one of the most crucial factors contributing to enhancing efficiency of education is an active introduction of IT into education. Due to its strong and well -equipped Internet system, Korea has used a variety of education methods both in and out of classroom teaching. Internet teaching is also widely used for private tutoring.

3) *Education and comparative advantage*

The KSA is a resource abundant country where its comparative advantage lies in resource intensive industries such as petro-chemical. The aim of education should be set on educating and training those who can create value-added in these industries. Unfortunately, most industries in these fields have lost their capacity to absorb labor, as capital and technology have replaced labor rapidly. Therefore, education focusing on workforce for these fields will produce two problems: (i) the unemployment rates will remain high, and (ii) the inequality of income distribution will not be improved.

A variety of policy approaches to resolve these problems are available, however they will not be very successful if they are based on simple 'income redistribution' scheme. More fundamental and effective policy is needed. The experience of Korea indicates that the best method to reduce the unemployment rate and improve income equality is to provide more jobs. Korea achieved this goal through specializing in labor intensive industries. Education development plans were also formulated and implemented with this in mind. However, the KSA is completely different from Korea.

As the KSA has its comparative advantage in widely defined HCI, it is neither plausible nor efficient for the nation to create and encourage labor intensive manufacturing industries. It would be proper for the nation to utilize comparative advantage and specialize in HCIs, importing those goods that the nation does not have comparative advantage. In this regard, the most proper solution to create more jobs and improve income inequality is to develop service sectors.

The major difference of developed countries from developing countries is that the former has larger service sector in terms of both employment and value-added, and their productivity is far higher than that in developing countries. Service sector provides a large number of jobs. Many subfields in the service sector are in fact labor-intensive. Further, most of service is untradable and still very directly and closely related with the welfare of people. Consequently, there are so many justifiable reasons to encourage service sectors in the KSA.

4) *Social mobility through education as an incentive*

It is one of the invariable premises in economics that human beings respond to incentives. It is clear that expected marginal return to education is the product of probability to be employed after education and the return when employed. This opportunity to be employed or to move up in the social ladder is labeled as 'social mobility'. If it is important to raise the level of education, the social system should promise higher return to higher level of education.

Incentives also work in investing in education. The case of Korea clearly shows that

marginal return to education went along with the duration of education. As the marginal rate of return increased, average schooling years of youth increased, since people respond by investing into education more when the expected marginal return to education is high. In this regard, one more devise to increase education investment is to improve social mobility.

2. Korean Educational Development and Its Strategies

2.1. Historical Development

In this paper, we attempt to organize the period and phase for educational development by following the classification method, which mainly combined economic and educational development phases: Phase 1 (1945-1960): Liberation, Reconstruction, and Establishment of Postwar Korea; Phase 2 (1961-1980): Export-oriented Industrialization and High Development; Phase 3 (1980-2000): Economic Reconstruction and Stable Growth; and Phase 4 (2001-Present): Reconstruction Period Following a Knowledge-based Society. A summary of the peculiarities for each national and educational development phase and central education policy is the same as Table 2-9 to Table 2-13 below.(Korean Educational Development Institute, 2007: Vol.5, p.15~16)

Table 2-9 | Stages of Korean Education Development

Development Phase	1st Phase	2nd Phase	3rd Phase	4th Phase
Period	1945~1960	1961~1980	1981~2000	2001~Present

Table 2-10 | 1st Phase

Period	1945~1960
Main Economic Development Specialties	•Reconstruction after Liberation •Establishment of Postwar Korea
Challenges to Education	•Compulsory Education
Major Concerns	•Access to Opportunity
Main Educational Development	•Basic Educational Systems •Universalizing Primary Education
Policy Choice	•Universal Compulsory Education •Reconstruction of Educational Infrastructure

Table 2-11 | 2nd Phase

Period	1961~1980
Main Economic Development Specialties	•Export-Oriented Industrialization and High Development
Challenges to Education	•Secondary Education for All •Supply for Technical Manpower
Major Concerns	•Growth of Quantity •Efficiency •Control
Main Educational Development	•Expansion of Secondary Education •Amplification of Vocational Education and Training
Policy Choice	•Expansion and Equalization of Secondary Education •Technical Vocational Education & Training

Table 2-12 | 3rd Phase

Period	1981~2000
Main Economic Development Specialties	•Economic Reconstruction and Stable Growth
Challenges to Education	•Universalization of Higher Education
Major Concerns	•Quality •Autonomy •Accountability
Main Educational Development	•Growth of Higher Education
Policy Choice	•Decentralized local Autonomy of Education •Expansion of Higher Education •Quality Improvement

Table 2-13 | 4th Phase

Period	2001~Present
Main Economic Development Specialties	•Knowledge-based Society & Economy
Challenges to Education	•Lifelong Learning •Human Resource Development
Major Concerns	•Competitiveness in Globalized Knowledge-Society
Main Educational Development	•Enforcement of Education Reform and competitive Power
Policy Choice	•Restructuring Higher Education •HRD & Lifelong Learning Quality Improvement in Public

2.2. Development Strategy

2.2.1. The Expansion of Educational Opportunities and Quantitative Growth Strategy

2.2.1.1. Universal enrollment achieved in 50 years

Under Japan's illegal occupation, educational opportunities for Koreans were severely limited. At the end of the colonial rule, only 64.0% of primary school aged children were enrolled in school; this percentage drastically dropped to 3.2% for secondary education and 0.18% for higher education. Defining universal enrollment as attaining a 90% enrollment rate, Korea achieved universal primary education by 1957, middle school education by 1990, and high school education by 1999. In 1979, more than 90% of primary school graduates entered into middle school, and in 1985 more than 90% of middle school students entered into high school. In 1995, more than 50% of high school graduates entered into higher education. Universal enrollment of primary and secondary schools was achieved within 50 years of liberation from colonial control in 1945.(Korean Educational Development Institute, 2007: Vol.5, p.27)

Table 2-14 | The Years of Attainment of Universal Enrollment

Year of attaining 90% in entering into a school of higher level		Year of 90% Enrollment rate	
		Primary	1957
Pri.- → Middle	1979	Middle	1990
Middle → High	1985	High	1999
High → Ter-*	1995	Tertiary	2000

* In tertiary education, an enrollment rate of 50% is applied.

2.2.1.2. Eight key factors in the quantitative expansion: (Korean Educational Development Institute, 2007: Vol.5)

(1) The achievement of universal access to primary education in the beginning stage of educational expansion.
(2) A sequential bottom-up approach that expanded primary education, followed by the expansion of middle school and high school education.
(3) A low cost approach was implemented to expand access to education without reducing its quality.
(4) Private schools contributed to the expansion of access to secondary education to achieve targeted enrollment.

(5) An egalitarian approach to expand access to education. An egalitarian approach is implemented with “Abolition of Entrance Examination to Middle Schools" and "High School Equalization Policy”. The affirmative action programs were also applied in financing and providing free textbooks.

(6) Legal provision was made to secure funding for education. The 'Law of Grants for Local Education Financing’ set aside 12.98% of total domestic tax revenue for elementary and secondary education.

(7) Parents’ strong aspirations for their children's educational success built up strong demand for education even in the period of low per capita income.

(8) Korea’s education owes much of its rapid expansion to economic growth which provided financial resources and job opportunities for graduates.

2.2.2. Low-Cost Approach

An approach which brings quantitative expansion in education at the expense of qualitative conditions is defined as a “Low Cost Approach”(Korean Educational Development Institute, 2007: Vol.5). The expansion of primary education was made possible through this Low-Cost Approach. The forced expansion of enrollment in primary education resulted in large class sizes and the use of multiple shifts in classrooms.

Table 2-15 | Quality Index of Primary Education

	Student (Per Thousands)	Student Per Class (Per Persons)	Student Per Teacher (Per Persons)
1965	4,941	65.4	62.4
1970	5,749	62.1	56.9
1975	5,599	56.7	51.8
1980	5,658	51.5	47.5
1985	4,857	44.7	38.3
1990	4,869	41.4	35.6
1995	3,905	36.4	28.2
2000	4,020	35.8	28.7
2005	4,023	31.8	25.1

Source: The Statistical Yearbook of Korean Education.

2.2.3. Egalitarian Approach

In the process of expanding access to education, the government implemented an equity oriented-policy framework. This policy aimed to reduce the gaps in the enrollment ratio, school -quality conditions and student achievements between regions and family-backgrounds by

supporting the least favored areas and social classes (Korean Educational Development Institute, 2007: Vol.5).

It was set out to abolish entrance examinations for middle schools and high schools in urban areas, replacing them with lottery assignment of students to schools within school districts, to allocate more resources to schools in regions with poor school conditions and finally to implement programs for low-income areas as well as to families free of charge, covering textbook costs and tuition fees.

2.2.4. Planning of Centralized Education Policy

2.2.4.1. Centralized Development Strategies

Korea's high growth is the result of a strong 'big push' strategy from the top, based on a centralized execution power. The nation (government) took on the role of top commander, establishing and executing growth strategies. Local self governing systems and local self governing education systems also were reserved for their execution for an extended period of time (Lee , 2008).

2.2.4.2. Centralized Education Policy

Education systems have also nationally oriented and centralized characteristics. Even though local governments (public) and private foundations (private) are the founders or managers of schools, it was premised that teachers who are public workers basically operate the national curriculum. Establishment and advancement of centralized education policies through an 'administrative management model' with a nation oriented-education system and top-down method widened educational opportunities within a short amount of time. Centralized education policy has contributed to the improvement of educational environment by raising the effectiveness of school systems.

It also secured a nationwide minimal, common education level by standardizing contents of school education in each level, which advantageously ensured quantitative equality among regions and classes.

2.2.5. Political Leadership

In terms of educational development in South Korea, political leadership played an important role. The leadership of the late President Park Chung Hee deserves special attention for his role in the remarkable economic growth, which, in turn, provided resources for educational development. The national goals of President Park's government were national defense and economic development. Major educational development projects were framed in

the context of educational contribution to the national tasks. Special attention was made to enact laws that secured the financing of educational development.

3. The Educational Interests and Issues of the KSA

3.1. Primary Education of the KSA

3.1.1. Overview of Education of the KSA

When the Kingdom of Saudi Arabia was founded in 1932, education was not accessible to everyone and was limited to individualized instruction at religious schools in mosques in urban areas. These schools taught Islamic law and basic literacy skills. By the end of the century, Saudi Arabia had a nationwide education system providing free training from preschool through university to all citizens.

The primary education system began in Saudi Arabia in the 1930s. By 1945, King Abdulaziz bin Abdelrahman Al Saud, the country's founder, had initiated an extensive program to establish schools in the Kingdom. Six years later, in 1951, the country had 226 schools with 29,887 students. In 1954, the Ministry of Education was established, headed by then Prince Fahd bin Abdulaziz as the first Minister of Education. The first university, now known as King Saud University, was founded in Riyadh in 1957.

Today, Saudi Arabia's nationwide public education system comprises twenty-eight (28) universities, more than 24,000 schools, and a large number of colleges and other educational and training institutions. The system provides students with free education, books and health services and is open to every Saudi. Over 25% of the annual State budget is for education including vocational training. The Kingdom has also worked on scholarship programs to send students overseas to the United States, Canada, France, the United Kingdom, Australia, Japan, Malaysia, Spain, Germany, China, Singapore, South Korea and other nations. Currently, tens of thousands of Saudi male and female students are being sent to higher-education programs every year under the King Abdullah Scholarship Program

3.1.2. Education Management System

The education system in Saudi Arabia is primarily the responsibility of the Ministry of Education, the Ministry of Higher Education and the General Organization for Technical Education and Vocational Training. Other authorities such as the Ministry of Defense and Aviation; the Presidency of the National Guard; and the Ministry of the Interior provide their affiliates and children with kindergarten, elementary, intermediate, secondary and adult education as well, following the educational ladder, study plans and curricula formulated by the

Ministry of Education.

The highest authority that supervises education in Saudi Arabia is the Supreme Committee for Education Policy, established in 1963 (UNESCO IBE, 2005, 2007). According to the World Bank database, public spending on education is 6.8 percent of GDP (Korea 7.3% in 2006, OECD Average 5.8% in 2006), and public spending on education as percentage of government expenditure is 27.6 percent in 2004 (World Development Indicator/Edstats). Education spending as a proportion of overall spending tripled from 1970 to 2000 and neither economic growth nor the price of oil had much impact on this trend in Saudi Arabia (World Bank , 2008a).

3.1.3. Primary Education of the KSA

The duration of primary education in Saudi Arabia is six years and children at the age of 6 enter into the first grade of primary education. All national primary schools are day schools and are not co-educational. In order to move on to intermediate education, children have to pass the examination at the end of grade 6 of primary school and obtain the Primary education Certificate.

According to government data, 2,442,482 students (1,255,117 male and 1,187,365 female) are in primary education in 2007 and the number of teachers total 217,555 (107,227 male and 110,328 female) in 2007. According to UNESCO, gross enrollment ratio for boys is 99.9 percent, gross enrollment ratio for girls is 96.3 percent, and gross enrollment ratio for total is 98.1 percent in 2007 (UNESCO IBE, 2005, 2007).

3.1.4. Private Education

In the KSA, private education is to be considered one of the elements supporting public education at all education levels. The General Department for Private Education at the Ministry of Education supervises private schools for boys and girls and government provides private schools with free textbooks and an annual financial aid. The government also appoints and pays for competent director in every private school (UNESCO IBE, 2005, 2007). According to UNESCO, in 2007, 48.9 percent of children enrolled in pre-primary private schools, and 8.2 percent of children enrolled in primary private school. As for the intermediate education, 6.4 percent of students enrolled in general programs are in private schools and 70.3 percent of students enrolled in technical and vocational programs are also in private schools. As for the secondary education, 13.4 percent of students enrolled in general programs are in private schools and 61.6 percent of students enrolled in technical and vocational programs are in private schools (UNESCO IBE, 2005, 2007). According to the World Bank, in 2004, 7.4 percent of students in tertiary education enrolled in private schools (World Bank, 2008b).

3.1.5. Literacy

According to the results of the demographic survey conducted by the Department of Statistics and Information, Ministry of Economy and Planning in 2007, the incidence of illiteracy among the Saudi population is 13.7%. The illiteracy rate stood at 1.4% for the age group 10 to 14 years, while the highest level in the age group between the ages of 65 and more than 509,573 people to the rate of 73.9%.

3.1.6. Education Policy of the KSA

As in the case of Korea, the KSA achieved already universal enrollment of primary and secondary schools. Improving the quality of school education could be a new challenge in the future. To meet this challenge the Ministry of Education developed "The Ministry of Education Ten-Year Plan 1425-1435 (2004-2014)" which set the following goals for that ten year period:

1) The education of 4-6 year-old children and the consideration of kindergarten as an independent stage in terms of its buildings and syllabi from other education stages
2) Accommodation of all age categories from 6-18 year old at various stages of education
3) Deepening the spirit of loyalty and integrity of the country through intellectual awareness based on recognizing issues of the country
4) To prepare students academically and culturally at a local and international level to be able to achieve advanced posts internationally in the fields of mathematics and sciences for various age categories, taking into account international test standards
5) To organize girls' technical education
6) To develop the educational system for students with special needs
7) Development and growth of the Ministry's personnel educational and administrative training
8) Improvement of internal and external sufficiency for the educational system
9) To develop syllabi based on Islamic values leading to the development of male and female students' personality and to their integration in society as well as to the achievement of scientific and thinking skills and life characteristics resulting in self-education and lifelong learning
10) To improve the quality of male and female teachers and to increase the citizens' rate in the education sector to achieve the full use of the Saudi human resources
11) To develop the educational structure and to update the school map to meet the expected quantitative and qualitative changes in the next stage
12) To develop the infrastructure of information and communication technology and its employment in education and learning
13) To develop male and female adults' education and to eradicate illiteracy
14) The Ministry's comprehensive administrative development
15) Expansion of social participation in education

16) To establish integrated systems for accountability

3.2. Improvement of Primary Education of the KSA

3.2.1. Improvement Strategy

In order to improve primary education of the KSA following strategies could be recommended. First, the KSA is geographically a wide country. It is difficult to manage every school within the country, especially to give equal educational services including rural areas. Therefore, strategies to increase the accessibility of education services are required.

Second, the KSA is a young country. The youth population growth rate is very high (more than 50% of total). That means the Kingdom needs to construct a great number of school facilities and hire numerous amounts of teachers every year, which are very costly. Also, the Kingdom has many small-sized schools. Therefore, strategies to increase the efficiency of educational services, such as e-learning and participation of the private sector in building additional schools are required.

Thirdly, a quantitative increase in the number of students and teachers requires strategies to improve the quality of education.

3.2.2. Interests and Issues of the KSA

3.2.2.1. ICT in Education

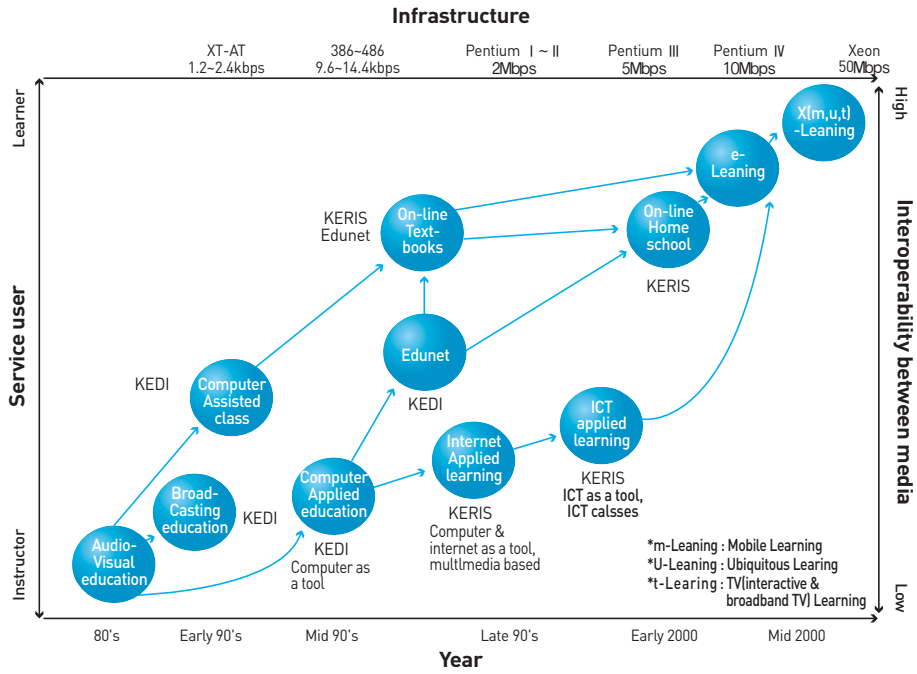
A. Korean Experience

A. Development of ICT in Education

From the latter part of the 1990s, information and communication technology in South Korea entered a new level of development. The information and communication technology (ICT) has been widely used for school management and in the instructional program development.

In the education sector, the educational information support system made its greatest contribution to school education with the establishment of (1) NEIS, (2) EDUNET, (3) Cyber Home Learning System, and (4) EBS. See Figure 2-9 for additional information.

Figure 2-9 | Development Diagram of ICT in Education



B. National Educational Information System (NEIS)

The National Educational Information System (NEIS) has been in operation since 2003. It brings all administrative authorities and schools into an information network whereby the agencies concerned share information with regard to students, administration, academic affairs, school management, and education financing.

C. EDUNET

It is the national teaching-learning center in Korea. It was launched on July 11, 1996 and has been operated by the Korea Education and Research Information Service (KERIS).

1) Overview

EDUNET is an educational information service and the nation's largest education portal that supports the distribution and utilization of a diverse range of high quality educational contents to all educational service users online.

2) Purpose

EDUNET aims to improve the quality of education for elementary and secondary school students through its teaching and learning center. It also has the objectives of improving the professional capabilities of teachers and eliminating the educational divide, which is the main factor responsible for social polarization, and supporting innovations in teaching and learning at schools.

3) Roles & Structure

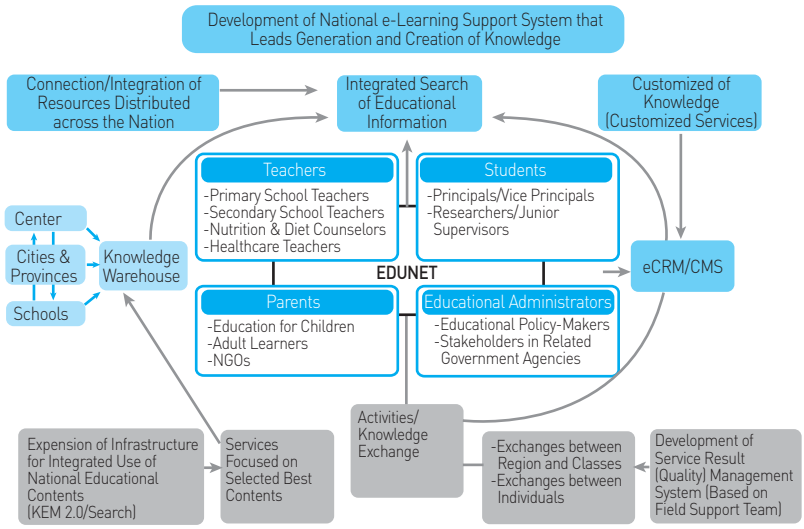
EDUNET is developing national standards, models, and guidelines by working in close cooperation with educational organizations of cities and provinces, as well as individual schools. The learning centers of each city and province are developing and distributing contents based on these national standards, models, and guidelines, and are sharing diverse educational information and contents through the national information sharing system. Each school uses the teaching and learning contents provided by the central and local teaching and learning centers through the learning support center, and is working to improve its teaching and learning environment.

4) Contents Service Process

Based on the national standards, EDUNET is building a knowledge warehouse with the outputs created through the central and local teaching and learning centers, diverse contents, and research conferences. The collected knowledge is being provided to the central and the local teaching and learning centers, as well as the teaching and learning support centers of each school.

EDUNET is being developed into an educational contents platform, in which contents are expanded, re-created, and shared by offering an improved community solution with advanced features, such as the web 2.0-based RSS feed and notes. See Figure 2-10 for diagram of the EDUNET system.

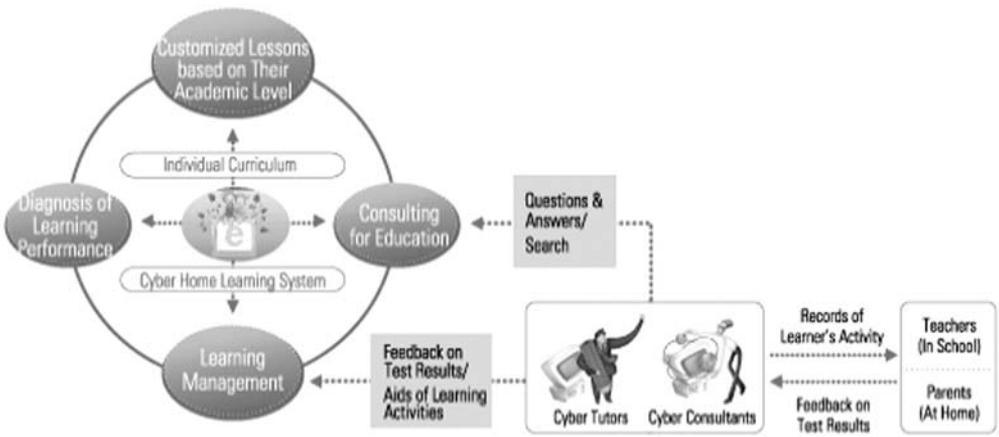
Figure 2-10 | Diagram and EDUNET System



D. Cyber Home Learning System

The Cyber Home Learning System (http://www.edunet4u.net/) is an on line learning service to support students for self-study through the Internet.

Figure 2-11 | Flow Diagram of Cyber Home Learning System



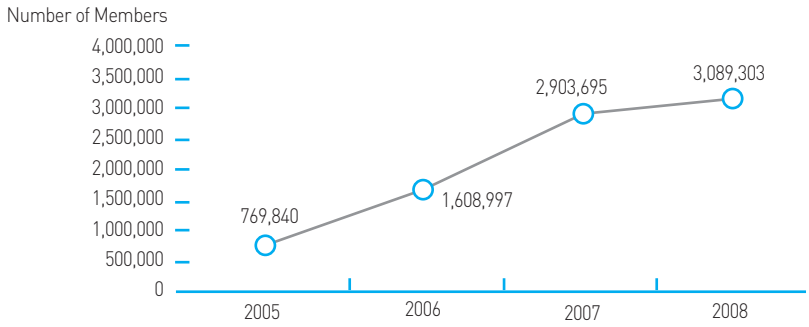
〈Flow Diagram of Cyber Home Learning System〉

The Cyber Home Learning System is used by 3,089,303 students and is supported by 60,891 cyber teachers and parent tutors (See Figure 2-12) .

Figure 2-12 | Numbers of EDUNET Members by Year

[As of August 2008
unit: Person

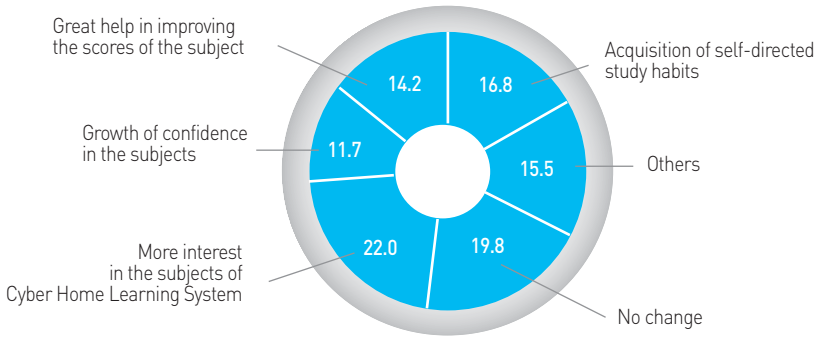
Description	Total No. of Members (Acc.)	No. of Cyber Teachers	No. of Parent Tutors	Average No. of daily visits
Total	3,089,303	60,891	4,508	304,236



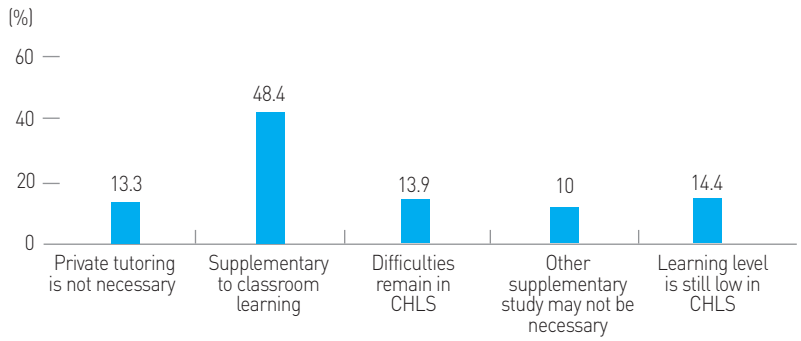
Number of Members bu Year

80.2% of students who use the Cyber Home Learning System responded that the Cyber Home Learning System is helpful in their learning and 71.7% of students answered that the Cyber Home Learning is more helpful than supplementing classes provided in school alone (See Figure 2-13).

Figure 2-13 | The Learning Effectiveness of Cyber Home Learning System



〈The Learning Effectiveness of Cyber Home Learning System〉



〈Benefits of Cyber Home Learning System〉

* Source : Research into the effectiveness and benefits of Cyber Home Learning System in 2007
-Korea Education & Research Information Service(2007)

E. Educational Broadcasting System (EBS)

The EBS TV channel was established in the 1980s to broadcast educational programs, which are directly corresponded to materials taught at the elementary and middle school levels. Between 1980 and 1995, as excessive private tutoring became a social problem, the EBS began to provide supplementary tutoring programs as an alternative to private tutoring.

The EBS offered TV programs as low-cost substitutes. In 2004, when private tutoring re emerged as a social issue, the EBS provided on-line supplementary programs.

B. Policy Recommendation

The KSA is geographically very wide. Therefore, educational service per e-learning will have a significant meaning. The Korean experience in e-learning area, especially EDUNET and the Cyber Home Learning System greatly contributed to expanding educational opportunities and educational services. It is, therefore, highly recommended to take into account the Korean e-learning system (EDUNET and the Cyber Home Learning System) for improving the e learning system of the KSA.

As a public broadcaster EBS (Educational Broadcasting System) helped to expand life long educational opportunities from pre-primary to adult education. It also contributed in reinforcing e-learning and the realization of equal rights to education. It is, therefore, recommended to discuss further about the introduction of an Educational Broadcasting System whether by utilizing TV, radio, or Internet.

3.2.2.2. Small-sized School

A. Korean Experience

A. Main Cause of Small-sized School in the Rural Area

Due to the low birth rate the number of students rapidly declined in Korea. At the same time, many young adults are moving from agricultural areas to large cities, exacerbating population decline in the rural area.

B. Problem of Small-sized School

There are a number of problems in operating small-sized schools. First, it is very costly. Although it is a small-sized school, it needs basic educational settings including school facilities and staffs. It is not easy to manage education finance efficiently.

Second, a combined class is an alternative for a small number of students, but it could deteriorate the quality of education.

Third, because a small-sized school does not have enough number of teachers, one teacher teaches several subjects. This results in discordance with teacher's certification subject and the subject that they actually teach, and this hardly guarantees quality of education.

Fourth, the insufficient number of teachers lays greater burden on teachers who are forced to deliver more lessons and work. It could also deteriorate the quality of education.

C. What do we do for Small-sized Schools in Korea?

We try to build a school network. One stronghold school (a benchmark) and many small satellite schools could integrate school management. We also try to combine 2 to 3 classes into one class. In addition, we operate a system of peripatetic teachers (e.g. many schools can only afford to employ peripatetic music teachers). Finally, we use ICT in education to reduce the educational gap between large sized and small sized schools.

D. Standard for Closing Schools

It varies from each school district. However, schools being closed usually have students ranging from 15 to 180 in a school.

E. Government's Position on Closing Schools

The Korean government decides to close a school if the school in question has shown difficulty maintaining finance and quality of education. When a school is closed the Korean government assists the parents in selecting other schools for the students and also providing transportation to schools for students. Unlike the government's position most residents do not wish for school closure in their district, especially in the rural areas, because school plays an integral part as a regional center and has integrated functions.

F. Model Case of Maintaining Small-sized Schools
(Primary School in Jincheon gun, Chungcheongbukdo Province)

The regional governments were successfully soliciting industrial waste sanitation facilities and were granted USD 10 million by the central government. With this money local governments founded scholarship committee. It awards scholarships to all primary and secondary school students in that region, gives opportunity to all university students who come from that region to apply for scholarship, and also supports the students who go abroad to study. With this effort the regional governments can increase the number of students and keep the schools open.

B. Policy Recommendation

The Kingdom of Saudi Arabia has many small-sized schools. Therefore, strategies to increase the efficiency of educational services and to enhance the quality of education are needed.

The KSA could try to build a school network. One stronghold school (a landmark) and many small satellite schools could share integrated school management including teacher training. The

KSA could also try to combine 2 to 3 classes into one class. In addition, the KSA could operate a system of peripatetic teachers. Finally, the KSA could use ICT in education to reduce the educational gap between large sized and small-sized schools.

E-learning comprises all forms of electronically supported learning and teaching. The information and communication systems, whether networked or not, serve as specific media to implement the learning process. The Cyber Home Learning System is an on-line learning service to aid students to self-study through the Internet. E-learning (in-classroom and out-of-classroom) can help to reduce the high cost of teacher recruiting. E-learning can also help to reduce the educational gap between large-sized schools (in urban areas) and small sized schools (in rural areas).

3.2.2.3. Building Schools

A. Korean Experience: BTL Project

A. What is BTL?

The Build-Transfer-Lease (BTL) is a type of private investment where private companies construct public facilities using their own capital and then transfer the ownership to the government, and in return they are granted the right to lease the facilities back to the government and to provide maintenance and operation service, thereby recovering the investment costs with profits.

B. BTL Project

Table 2-16 | BTO and BTL

Form of Business	Target Facilities	Investment recovery	Business Risk
BTO (Build-Transfer-Operate)	Facilities which makes possible to recover the investment through collection of user fees (e.g. expressway, harbor facilities)	user fees	high (fluctuation of earnings rate according to the actual use of facilities)
BTL (Build-Transfer-Lease)	Facilities which makes impossible to recover the investment through collection of user fees (e.g. school, welfare facilities)	rents from the government	low (government guarantees the earnings rate)

C. Goals and Features of BTL Projects in Educational Facilities

1) Mitigation of fiscal burden in Education/Early supply of Services

BTL project can timely respond to demand for new schools in developing areas. It could also improve the educational environment in advance through rebuilding (remodeling) old schools and expanding gymnasium (auditorium), etc.

2) Restructure School Facility Projects

BTL project authorizes the private sector to conduct a series of activities such as financing of school facilities, designing, and supervision on construction work and maintenance.

3) Specialization and Privatization of Facility Construction Work & Operation and Maintenance

Instead of regional education offices a specialized supervision company can oversees the construction work of building school facilities. The regional education offices can also authorize private companies to operate cleaning/security/facility maintenance.

D. Why do we Introduce BTL Project?

Many Korean education facilities are old. In 2005, 23.4% of school buildings are more than 30 years old. We needed more school buildings in urban areas because of the exodus of young adults from the agricultural areas to large cities. Compare to the OECD countries, Korea still has large number of schools with large sized classes. But the government has restricted financial resources. Hence, the Korean government is putting efforts to attract more private investment in constructing new schools.

E. Characteristics of BTL

The government can provide school buildings at an early stage. The service provider can securely recover the investment through renting the facility to the government.

B. Policy Recommendation

A. Initiation of BTL Project

The growing population, especially the growing birth rate of the KSA requires more school facilities. However, national financial resources are limited. Therefore, policies to invite the private sector in investing in school facilities are much needed. The BTL project can meet the

demand in a timely manner.

Hybrid school facilities, in addition to school facilities, can provide such facilities as sports, childcare, cultural activities, vocational training, parking lot, etc. These facilities when built by the private sector could also take on the form as the BTL projects and receive rental income.

B. Establishing Private Schools

In Saudi Arabia, private education is considered as one of the elements supporting public education at all education levels. The General Department for Private Education at the Ministry of Education supervises private schools for boys and girls and government provides private schools with free textbooks and an annual financial aid. The government also appoints and pays for competent directors for every private school. According to UNESCO, in 2007, 48.9 percent of children enrolled in pre primary schools, and 8.2 percent of children enrolled in primary schools. The government of KSA supports the private sectors to participate more actively in founding schools.

3.2.2.4. Teacher Policy

A. Korean Experience

A. Strong Drive of the National Government in Developing and Enforcing Teacher Policy

Korea is a highly centralized country by tradition and such heritage is reflected well in the distribution of authorities and responsibilities between the central and local education administration organizations. Policies on teachers are also developed and enforced at the initiative of the central education administration authority, namely the Ministry of Education, Science and Technology (MEST). In other words, all policies pertaining to teacher whether training, qualification, employment, status and compensation fall within the jurisdiction of the national government and the room for leverage of each office of education or school is very limited.

Such centralized governance structure enables the central government to drive strict teacher policies in terms of development and enforcement, with strong initiative. Even after the 1990s when local education autonomy was allowed for the 16 municipal and provincial offices of education, policies on teachers are still administered by the central government to a large degree.

B. Gradual Shift of Policy Priority from Supply Increase to Quality Assurance

Following the liberation from Japan's illegal occupation, the teacher recruitment policy of

Korea simply focused on meeting the growing demands for more teachers to improve public access to learning opportunities. It was only in the mid-1980s that serious discussion began on policies to improve the quality of teachers and enhance their professional development. The evaluation system for quality control of initial teacher education institutions was introduced as late as in the mid-1990s.

Discussion for such quality improvement took the main stage almost upon completion of the unification of primary and secondary schooling services. Such policy approach is indicative of the government's attempt to achieve two different objectives-increasing the supply of teachers and improving their quality-in phases rather than concurrently.

It was an effective approach when demands for education grew explosively. As quality improvement requires much more time and cost, it needs persistent commitment and it is strategically important to focus on competing objectives selectively, depending on their priorities.

C. Competitiveness of Teaching Profession

The teaching profession in Korea is one of the most competitive jobs. The most compelling strength of the Korean schooling system is that traditionally teachers and the teaching profession have a positive image and their social status and expectations are high. Teaching profession is a highly secure job, as it guarantees mandatory retirement age. Most teachers are employed as permanent employees, allowing them to devote themselves to teaching without worrying about job security. They also work under unconstrained working conditions, enjoy stable business hours, and have access to adequate welfare systems such as extended leave. In comparison with other countries, teachers have advantages in terms of salary and pension.

Table 2-17 | International Comparison of Teacher Salaries (2007)

(Unit: US(PPP)$)

	Elementary School Teachers		Middle School Teachers	
	First Year	15 Year	First Year	15 Year
Korea	31,717	54,789	31,590	51,470
France	23,640	31,800	26,019	34,179
U.S.A	35,907	43,633	34,519	44,015
Germany	43,387	53,345	47,936	57,978
OECD	28,687	39,007	31,000	41,993

Source: OECD (2009), Education at a Glance.

As teacher selection and employment processes are managed at the municipal/provincial level, equality and efficiency can be promoted and additional credit, teacher rotation and teacher

circulation systems are well established to ensure availability of teachers in underprivileged areas.

The ICT infrastructure available in schools is close to the world's best level and designed to assist with class preparation and provide a wealth of teaching/learning materials that can be utilized in class. Thanks to such strengths of the teaching profession, the turnover rate of teachers is very low.

B. Policy Recommendation

A. Teacher Training Program

The Kingdom of Saudi Arabia is a young country. Because of the high birth rate, the Kingdom needs more school facilities and teachers every year. In order to have high quality of teachers training programs are very important. The policy to improve the quality of teacher training programs is highly recommended. Teacher training and promotion per ICT and in overseas will help the capacity improvement.

B. Training of Elite Educational Bureaucrat Groups

To heighten the central or local government's accountability on education policy and its proper management, capable administration and bureaucrats are needed above all. For any form of organization, the most basic and necessary requirement for composing a capable government or effective policy system is the training and securing of elite bureaucrat groups. Government's support policies such as overseas dispatching or training for quality improvement will also be very helpful.

3.2.2.5. Establishment of Educational Think Tank

A. Korean Experience

A. Government funded Research & Development institutes

The late President Park appreciated the need for national think tanks for national development. From the latter part of the 1960s, the government began to establish national research and development institutes.

The Korean Institute of Science and Technology (KIST) was established in 1964. The Korean Development Institute (KDI) and the Korean Educational Development Institute (KEDI) followed later. The number of research and development institutes increased to 43. These institutes have played important roles in research and development. The German Max

Plank Institute stands as a reminder of their pioneering role in research and development.

B. Educational Institutes

Korea has now a variety of educational institutes:

- Korean Educational Development Institute (KEDI, 1972): Educational Policy
- Korean Institute for Curriculum and Evaluation (KICE, 1997): Curriculum
- Korea Research Institute for Vocational Education & Training (KRIVET, 1997): Vocational Education & Training
- Korea Education and Research Information Service (KERIS, 1999): ICT in Education
- National Institute for Lifelong Education (NILE, 2008): Lifelong Learning

B. Policy Recommendation

In Korea's educational development process, the role and contribution of those research and development organizations were substantial. Through the establishment of such think tanks, the KSA will also be able to create windows for introducing and learning advanced experience, knowledge, technology, techniques, and so on. The KSA could utilize these establishments for research, analysis, and evaluation activities along with diverse educational support projects as well as research and development on education policy. With the help of these institutes an evidence based scientific decision making will be improved.

References

Acemoglu, D. (2002). "Reversal of fortune: Geography and institutions in the making of the modern world income distribution." *The Quarterly Journal of Economics, vol. 117, pp. 1231-94.*

Bae, S. H. (2007). "Education as the key to national prosperity: Korea's experience." Ch.2 in *Education and Korea's Development, Korea* Education Development Institute, pp.111-30.

Ban, Sang-Jin (2008). *Understanding Korean Education Policy Vol.3: Efficient Management of Educational Finance*, Seoul, Korean Educational Development Institute.

Barro, R. and X. Sala-I-Martin (1995). *Economic Growth*. McGraw-Hill: New York.

Becker, G. S. (1964). *Human Capital-A Theoretical and Empirical Analysis with Special Reference to Education.* New York: National Bureau of Economics Research.

Borensztein, E., Gregorio, J. D., and J. Lee (1998). "How does foreign direct investment affect economic growth?" *Journal of International Economics*, Vol.45, pp.115-36.

Choi, K. (1997). "An analysis of the effects of education to economic growth." *The Korean Journal of Finance and Economy I Education*, vol. 6(1).

Denison, E. F. (1984). "Accounting for Slower Growth: An update", in J. W. Kendrick (ed.). *International Comparisons of Productivity and Causes of Slowdown*, Massachusetts: Ballinger, Cambridge.

Huh, Kyung-Chul (2007). *Understanding Korean Education Vol.1: School Curriculum in Korea, Seoul, Korean* Educational Development Institute.

Huh, Kyung-Chul (2009). *Understanding Korean Education Policy Vol.4: Universalization of Elementary and Middle School Education, Seoul, Korean* Educational Development Institute.

Huh, Kyung-Chul (2009). *Understanding Korean Education Policy Vol.7: Curriculum and Textbook Policy*, Seoul, Korean Educational Development Institute.

Kim, Ee-Gyeong (2009). *Understanding Korean Education Policy Vol.87: Teacher Policy: Procurement and Disposition of Qualitative Teachers*, Seoul, Korean Educational Development Institute.

Kim, S. B. (2007). "The growth of education and Korean Economy." Ch.3 in *Education and Korea's Development*, Korea Education Development Institute, pp.131 56.

Kim, Young-Chul (2008). *Understanding Korean Education Policy Vol.2 : Universalization of Tertiary Education*, Seoul, Korean Educational Development Institute.

Kim, Young-Hwan (2007). *Understanding Korean Education Vol.2: ICT in Korean Education*, Seoul, Korean Educational Development Institute.

Korea Development Institute (2006). Internal Research Material.

Korean Educational Development Institute (2007). *Understanding Korean Education Vol.3: School Education in Korea*, Seoul, Korean Educational Development Institute.

Korean Educational Development Institute (2007). *Understanding Korean Education Vol.4: Higher Education and Lifelong Learning in Korea*, Seoul, Korean Educational Development Institute.

Korean Educational Development Institute (2007). *Understanding Korean Education Vol.5: Education and Korea's Development*, Seoul, Korean Educational Development Institute.

Lee, Sang-Jin (2008). *Understanding Korean Education Policy Vol.1: National Development Strategy and Education Policy*, Seoul, Korean Educational Development Institute.

Lee, Young-Hyun (2009). *Understanding Korean Education Policy Vol.5: Vocational Education and Training in the Process of Industrialization*, Seoul, Korean Educational Development Institute.

McGinn, N. F., Kim. S. B. (1980). *Education and Development in Korea*, Cambridge: Harvard University Press.

OECD, Education at a Glance: OECD Indicators, each year.

Park, Se-II (2000). *Managing Educational Reform. Lessons from the Korean Experience: 1995~97*.

Permani, R. (2008). *Education as a Determinant of Economic Growth in East Asia: Historical Trends and Empirical Evidence (1965-2000)*. Paper presented at the Asia-Pacific Economic and Business History Conference, University of Melbourne, 13-15 February.

Rodrik, D., Subramanian, A., and F. Trebbi (2004). “Institutions rule: the primacy of institutions over geography and integration in economic development.” *Journal of Economic Growth*, Vol. 9, pp.1331 65.

Schultz, T. W. (1971). *Investment in Human Capital The Role of Education and of Research*. New York: The Free Press.

Son, Byung Gil (2009). *Understanding Korean Education Policy Vol.6: Informatization of Education*: ICT Use in Education, Seoul, Korean Educational Development Institute.

The World Bank (1993). *The East Asian Miracle*. The World Bank: Washington D.C.

UNESCO IBE (2005, 2007). “Saudi Arabia”, World Data on Education.

World Bank (2008a). 2008 Education Flagship Report.

World Bank (2008b). Edstats Database.

You, H. M. (2008). “The contribution of rising school quality to US economic growth.” Ch. II-1 in *Enhancing Productivity and Sustaining Growth*, Korea Development Institute, pp.121-58.

Chapter 03

Sharing of Korean Nuclear Experience for the Introduction of Nuclear Energy in Saudi Arabia

-Focusing on the Self reliance Experience of Nuclear Energy in Korea -

Chapter 03

Sharing of Korean Nuclear Experience for the Introduction of Nuclear Energy in Saudi Arabia

-Focusing on the Self reliance Experience of Nuclear Energy in Korea-

Jaejoo Ha (Korea Atomic Energy Research Institute)

1. Introduction

Securing energy sources is one of the top priorities of many countries because of the rising cost of fossil fuels, attributable to high international oil prices in the world. Growing concerns over the global warming and greenhouse effects have raised an issue that calls for immediate attention of all nations. Accordingly, it is essential to establish and conduct cooperative systems among countries, including the developed and developing countries, in dealing with climate change and energy security matters.

It is clear that nuclear energy, an alternative energy source, has an important role in helping to reduce greenhouse gases. Under these circumstances, it is advantageous to extend nuclear energy in many countries, and some international organizations have expected an increase in the nuclear power generation.

Recently, Saudi Arabia has tried to make efforts to transform the current economic system, which heavily relies on crude oil production, into a more sustainable economic system. In addition, the demand for electricity has been sharply rising due to the rapid economic development, population growth, growing tourism, and so on. Moreover, Saudi Arabia has already experienced a limited transmission and shortage of electricity and is considering the introduction of nuclear power generation as a national long term strategy.

This report introduces Korea's current state of nuclear energy and its self-reliance experience of nuclear technology so that Saudi Arabia may organize its own effective nuclear program

policies when introducing nuclear power plants (NPPs) to the nation, making use of the lessons learned from Korea.

2. History of Nuclear Development in Korea

2.1. The Introduction Period of Nuclear Energy (1950-1960)

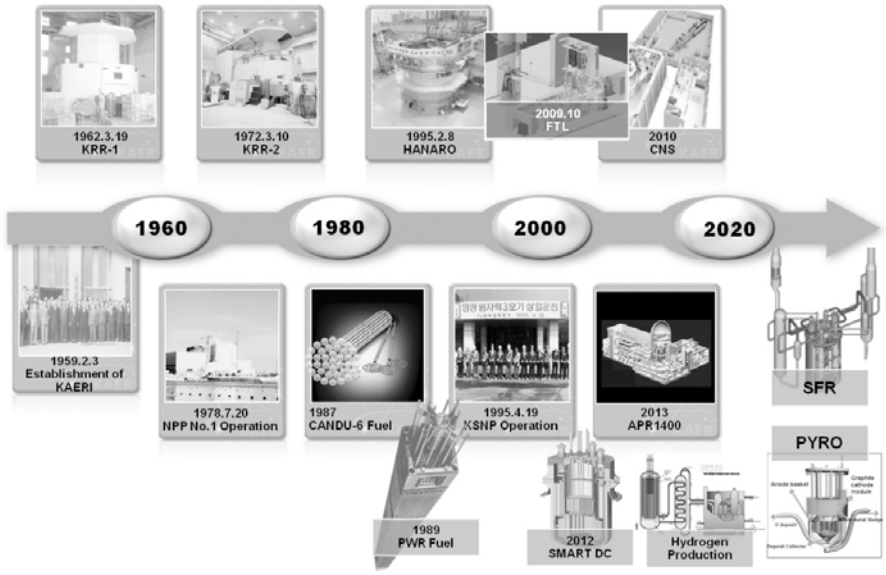
Commercial nuclear research & application was initiated by U.S. President Eisenhower in December 1953. Korea started the peaceful use of nuclear energy in 1955 by means of the ratification on nuclear technology cooperation agreement between Korea and the USA for the same purpose.

The Nuclear Office was founded in March 1956, to deal with administrative procedures for nuclear policy and research within the Ministry of Culture and Education of Korea. Korea joined the International Atomic Energy Agency (IAEA) in 1957 and made immediate efforts to benefit from nuclear power, since fossil fuel resources available in the country are very limited. The Atomic Energy Act was promulgated in March 1958. In 1959, the Office of Atomic Energy (OAE) was established under the direct control of the President with the committee of nuclear energy and the nuclear administrative organization was set up in Korea. The Korean Atomic Energy Research Institute (KAERI) was built in February, along with the nuclear engineering department in Seoul National University in March 1959.

A contract for TRIGA Mark-Ⅱ was made between Korea and General Atomics (GA) in the USA in December 1958, and the groundbreaking ceremony for a research reactor took place in July 1959. Hanyang University (established February 1958) and Seoul National University (established March 1959) opened their respective department of nuclear engineering, to nurture highly professional elites on the nuclear energy. The TRIGA Mark II, the first research reactor achieved criticality in 1962.

The Radiological Medical Institute (December 1963) and the Radiological Agriculture Institute (November 1966) were separated respectively from the Korea Atomic Energy Research Institute. In March 1969, the Korean Nuclear Society (KNS) became a bridge between the Korean nuclear industry and nuclear academic circles.

Figure 3-1 | Past and Future of Korean Nuclear Programs



2.2. Technological Self-reliance of Nuclear Energy (the 1970s-1990s)

In preparation of the nuclear fuel production and its fuel cycle, the Korean Nuclear Fuel Development Complex was founded in December 1976 and began to implement its related research and operation. Commercial-scale nuclear power generation started at the Kori-1 NPP in 1978, marking a nuclear era of the Korean nuclear history. The first generation of nuclear plants in Korea was built almost entirely by foreign contractors. Since then, the domestic industry has advanced significantly. Further reactors have been built using a mixture of CANDU (Canada Deuterium Uranium) and PWR (Pressurized Water Reactor) technology. The nuclear fuel manufacturing and production of CANDU and PWR types could be almost accomplished around 1988.

The High-flux Advanced Neutron Application Reactor (HANARO), a research multi-purpose reactor, achieved initial criticality in February 1995. The HANARO project called for a combination of various indigenous technologies ranging from design to commissioning including the radioisotope production and irradiated material examination. It is one of the world's best research reactors that is capable of undertaking all the functions that a research reactor can carry out. Korea has attained the technological self-reliance not only in the research reactor but also in the NPPs. With the construction of the Younggwang-3 NPP, the degree of technological self-reliance practically reached from 60% to 95%. Since 1995, nuclear plants in

Korea have been built using 95% or more indigenous technology. Korea plans to become fully self-sufficient in terms of nuclear technology by 2012.

2.3. Highly Advanced Technology of Nuclear Energy (the 2000s)

In late 2009, Korea won its first export order; four APR-1400 reactors for the United Arab Emirates. Beyond this, the Generation III Advanced Pressurized Reactor 1400, the development of the next generation reactor has also been started from 2001, seeking the fourth nuclear generation system, Gen IV. By means of international cooperation and joint R&D, Korea has participated in SFR (Sodium Fast cooling Reactor) and VHTR (Very High Temperature gas Reactor) projects, preparing for the future nuclear technology.

Low and intermediate level wastes (LILW) are now stored at each reactor site in Korea. Finding repository sites and a disposal facility will be subject to "The Act for Promoting the Radioactive Waste Management Project and Financial Support for the Local Community" 2000. In November 2005, after considering the four candidate cities, Kyongju on the east coast 370 km from Seoul was designated as the site. It is close to Wolsong NPPs.

The consortium of the Korea Atomic Energy Research Institute (KAERI) and Daewoo engineering won the bid to build the 5 MW (megawatt) reactor at Jordan University of Science and Technology (JUST) in Irbid in 2009.

Recent achievements of HANARO include the installation of a Fuel Test Loop (FTL) and a Cold Neutron Research Facility (CNRF). The fuel test loop in HANARO enables a simulation of the thermal-hydraulic conditions of the power reactor. A commissioning test including test fuel irradiation was successfully completed in 2010. With the introduction of the fuel test loop, Korea can now conduct the whole production process of reactor fuel from designing and fabricating to testing new power reactor fuels.

2.4. The Merge and Spin off of Nuclear Energy Activity

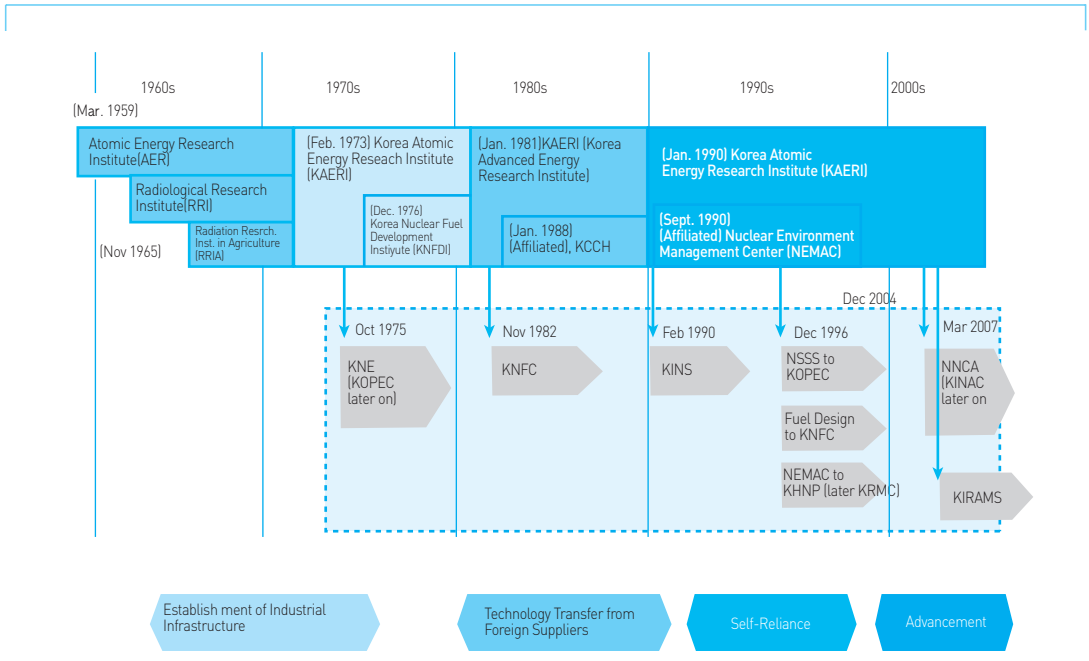
The Korea Atomic Energy Research Institute has played an essential role in promoting nuclear energy since it was first established in February 1959. As some functions of KAERI were divided into independent entities as a result, the most representative organization, KABAR (Korea Atomic Burns and Roe), a joint corporation with equal share (50-50percent) between KAERI and Burnes & Roe in the USA for a local architectural engineering, was founded in 1975. In following year, Burnes & Roe transferred ownership interests to KAERI, and the name was changed to the Korea Nuclear Engineering Co. (KNE). Later this organization became the Korea Power Engineering Co. Ltd. (KOPEC) in 1982.

For the purpose of developing nuclear fuel technology for the PWR (Pressurized Light-Water Reactor) and the PHWR (Pressurized Heavy-Water Reactor), the Korea Atomic Fuel Development Public Complex under the KAERI's organizational structure set up the Korea Atomic Fuel Corporation in 1981 to localize nuclear fuel cycle in Korea. KAERI also established the Nuclear Safety Center in 1982 in order to deal with nuclear regulatory operations and safety. The relative laws and regulations were approved in 1989, constituting the Korea Institute for Nuclear Safety (KINS).

Many businesses operated by KAERI were listed: nuclear power plant design, radioactive waste management, nuclear fuel manufacturing, and nuclear safety and regulation. The division of work has given birth to some nuclear entities present in Korea. In addition, KAERI produced the Korea Institute of Nuclear Nonproliferation and Control (KINAC) in 1994, which would be responsible for compliance with international treaties and regulatory trends, and inspections by the IAEA.

In 1962, the Radiation Medicine Research Lab within KAERI was founded. This organization became the Korea Institute of Radiological & Medical Science (KIRAMS) in 2006, specializing in cancer treatment.

Figure 3-2 | The Merge and Spin-Out Case of Korea's Nuclear Energy



3. Current Status of Nuclear Energy

3.1. National Nuclear Policy

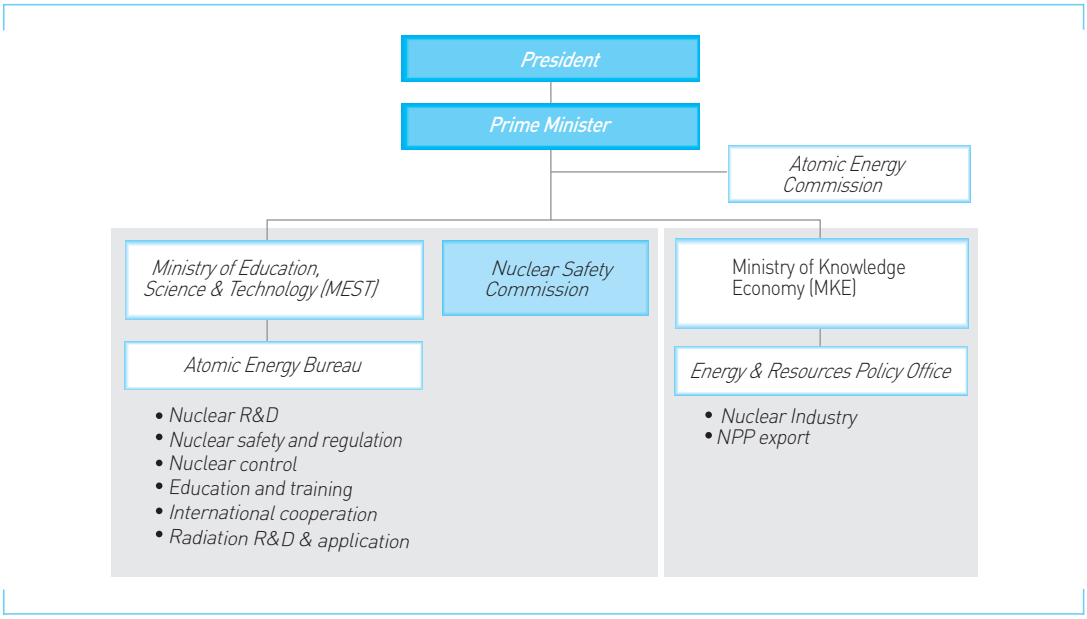
The basic direction of the national nuclear policy in Korea is to promote the peaceful uses of nuclear energy, enhancing nuclear safety, securing nonproliferation, and maintaining transparency of nuclear activities.

In 2004, the Korean Government announced four principles on the Peaceful Uses of Nuclear Energy: (1) no intention to develop and possess nuclear weapons, (2) adherence to the principles of nuclear transparency, (3) compliance with the international norms of nonproliferation, and (4) expansion of the peaceful uses of nuclear energy.

3.2. Administration System of Nuclear Energy

The Nuclear Energy Bureau has an extensive responsibility for national nuclear energy research & development, safety regulation within the Ministry of Education, Science and Technology (MEST) and makes nuclear policies through 'The Comprehensive Plan of Nuclear Energy Promotion' with its relevant laws. As of June 2010, the Nuclear Energy Bureau consists of six departments.

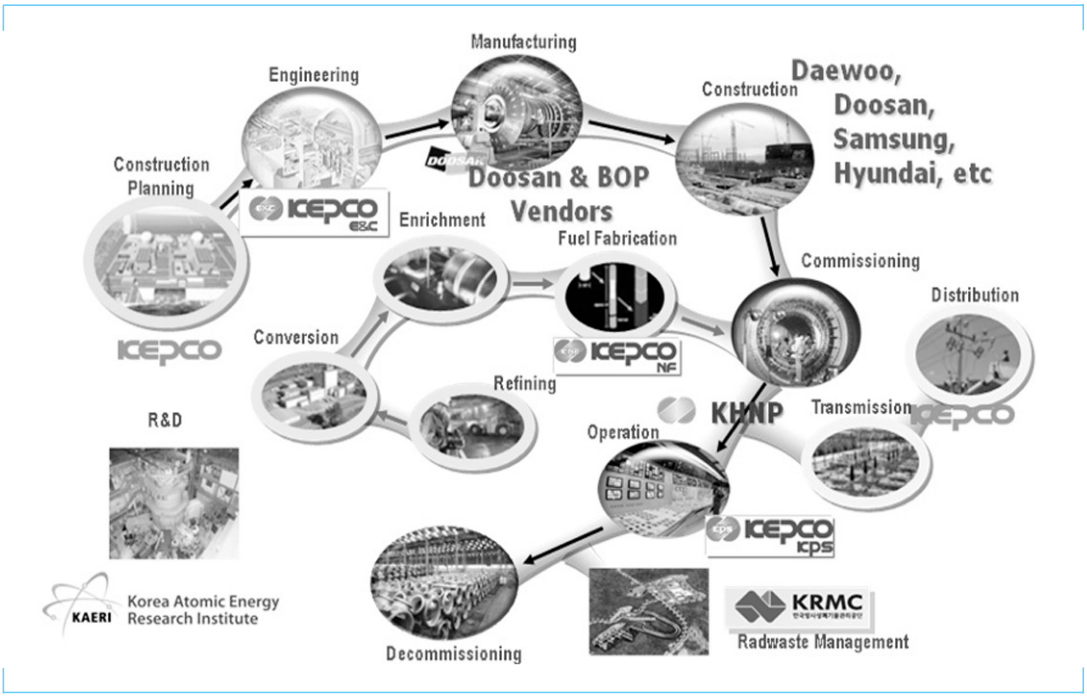
Figure 3-3 | Nuclear related Governmental Organization Structure in Korea



The Atomic Energy Commission (AEC), the top decision making body for national nuclear policy, reviews and addresses such essential issues as nuclear energy directions and nuclear initiatives under the Prime Minister. The Nuclear Safety Commission (NSC) under the Minister of MEST is in charge of reviewing safety matters and can make decision separately on nuclear safety issues.

The Energy Resource Office under the Ministry of Knowledge Economy (MKE) takes responsibility of the Korean nuclear industry planning and coordination on the nuclear power generation as well as radioactive waste disposal management.

Figure 3-4 | Industries and Supply Chain in Korea



There are several other nuclear energy-related organizations. KAERI is a government funded research institute, which belongs to the National Research Foundation of Korea (NRF), carrying out fundamental nuclear R&D activities. The KIRAMS performs R&D on the medical use of radiation under the MEST. The KINS implements inspections on the safety of nuclear energy facilities such as nuclear power plants and radioactive waste disposal sites. The KINAC takes charge of non proliferation and controlling of nuclear materials.

There are some companies on the nuclear industry side involved in the construction and operation of nuclear power generation: KEPCO (the Korea Electric Power Corporation), Construction Planning (KHNP, the Korea Hydro & Nuclear Power), Nuclear Fuel Production

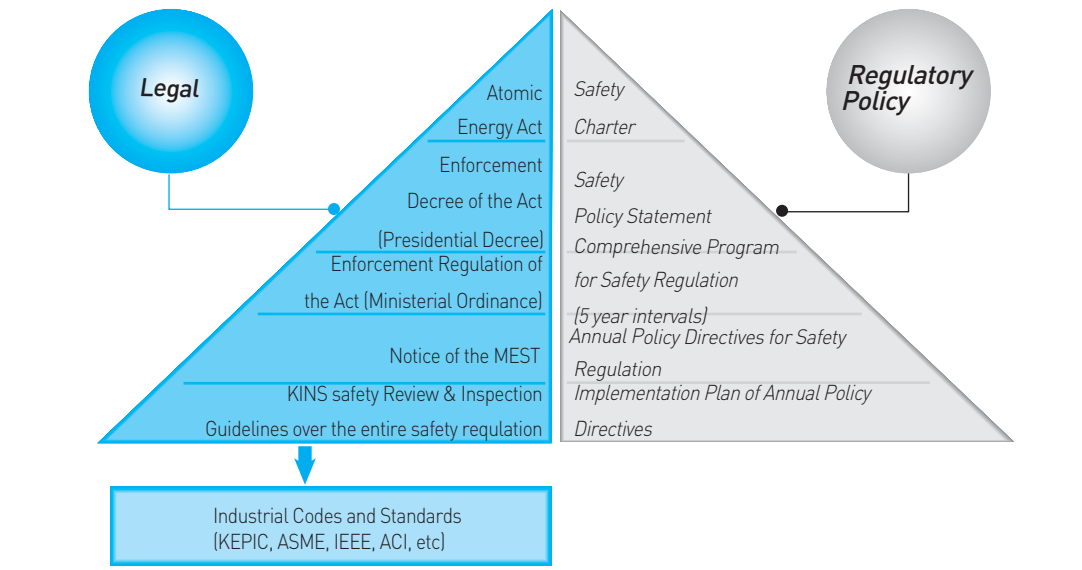
(KEPCO NF, the KEPCO Nuclear Fuel), Architect Engineering and NSSS (Nuclear Steam Supply System) design (KEPCO E&C, the KEPCO Engineering & Construction), Maintenance (KEPCO KPS, the Korea Plant Service & Engineering), Radwaste Management (KRMC, the Korea Radioactive waste Management Corporation) and Nuclear Key Component Production with Steam generator, reactor vessel head etc. (Doosan Heavy Industrial and Construction).

3.3. The System of Nuclear Energy Regulation

The Atomic Energy Act was enacted in 1956 and relevant regulations have been sequentially followed by one after another. There are five regulatory categories concerning nuclear activities: Atomic Energy Act, Enforcement Decree of the Act (Presidential Decree), Enforcement Regulation of the Act (Ministerial Ordinance), Notice of the MEST, and KINS Safety Review & Inspection Guidelines over the entire safety regulation.

The Atomic Energy Act is the prime law on the use and development of nuclear energy, regulations on safety and other important procedures. This law includes the operation of the Committee of Nuclear Energy, Committee of Nuclear Safety, and the Comprehensive Program for Safety Regulation.

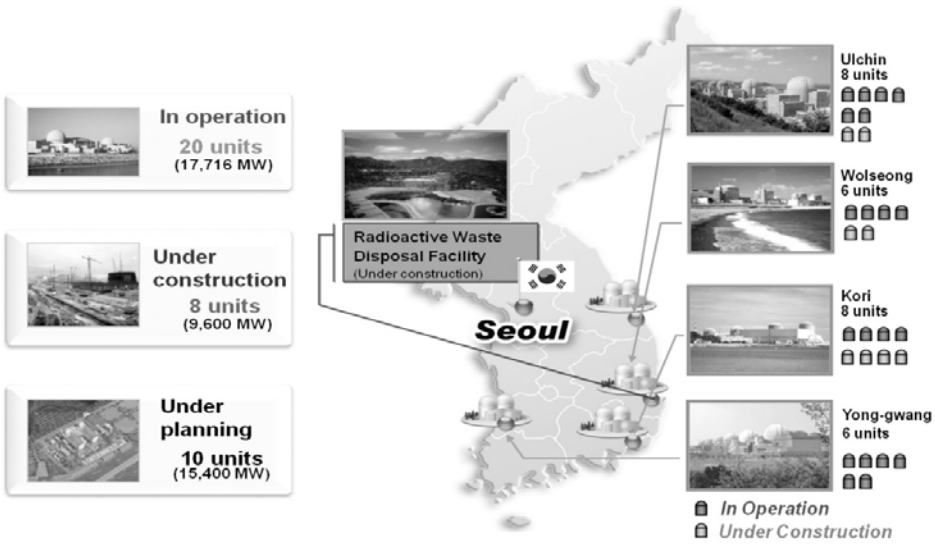
Figure 3-5 | Legal and Regulatory Policy Structure in Korea



3.4. Current Status of Nuclear Power Plants

The first nuclear power plant (hereinafter NPP) in Korea, Kori Unit 1, has been operating since 1978. The country now has twenty nuclear power plants. 16 units of PWR (Pressurized light Water Reactor) and 4 units of PHWR (Pressurized Heavy Water Reactor) are commercially in operation. As of 2010, Korea ranks as the world's 6th in total nuclear power generation using 20 units totaling 17,716 MWe, which supplied 38.6% of the total electricity demand. Korean NPPs have been successfully operating with the highest average availability factor (93.22%) and capacity factor (90.83%) in the world between 2001 and 2006. the Korean government has recently decided to expand its nuclear power program as a part of a longrange plan to further reduce energy import and greenhouse gases. By 2030, nuclear power is expected to supply 59% of total electricity demand.

Figure 3-6 | Location of Nuclear Power Plants in Korea



Upon the construction of the first three NPPs on a turnkey basis and the next 6 NPPs on a non-turnkey basis, the Korea's nuclear industry had successfully localized most of technology to build NPPs with its own designs, namely OPR 1000 and APR 1400. Currently, six nuclear power plants are under construction. Shin-Kori Unit 1 and 2 and Shin-Wolsong Unit 1 and 2 are being built in OPR 1000 type. Shin Kori Unit 3 and 4 and Shin-Ulchin Unit 1 and 2 have adopted APR 1400 type, each unit having a capacity of 1400 MW.

Table 3-1 | Status of Nuclear Power Plants in Operation (end of 2010)

Plant		Reactor Type	Capacity (MW)	NSSSSupplier	PlantA/E	CommercialOperation
Kori(KRI)	#1	PWR	587	W/H	Gilbert	Apr. 78
	#2	PWR	650	W/H	Gilbert	July 83
	#3	PWR	950	W/H	Bechtel/KOPEC	Sep. 85
	#4	PWR	950	W/H	Bechtel/KOPEC	Apr. 86
Wolsong (WSN)	#1	PHWR	679	AECL	AECL	Apr. 83
	#2	PHWR	700	AECL/ Doosan	AECL/KOPEC	Jul. 97
	#3	PHWR	700	AECL/ Doosan	AECL/KOPEC	Jun. 98
	#4	PHWR	700	AECL/ Doosan	AECL/KOPEC	Sep. 99
Yong-gwang (YGN)	#1	PWR	950	W/H	Bechtel/KOPEC	Aug. 86
	#2	PWR	950	W/H	Bechtel/KOPEC	Jun. 87
	#3	PWR	1,000	Doosan	KOPEC	Mar. 95
	#4	PWR	1,000	Doosan	KOPEC	Jan. 96
	#5	PWR	1,000	Doosan	KOPEC	May. 02
	#6	PWR	1,000	Doosan	KOPEC	Dec. 02
Ulchin(UCN)	#1	PWR	950	Framatome	Framatome	Sep. 88
	#2	PWR	950	Framatome	Framatome	Sep. 89
	#3	PWR	1,000	Doosan	KOPEC	Aug. 98
	#4	PWR	1,000	Doosan	KOPEC	Dec. 99
	#5	PWR	1,000	Doosan	KOPEC	July 04
	#6	PWR	1,000	Doosan	KOPEC	Apr. 05
Total	20		17,716			

Table 3-2 | Status of Nuclear Plants under Construction (end of 2010)

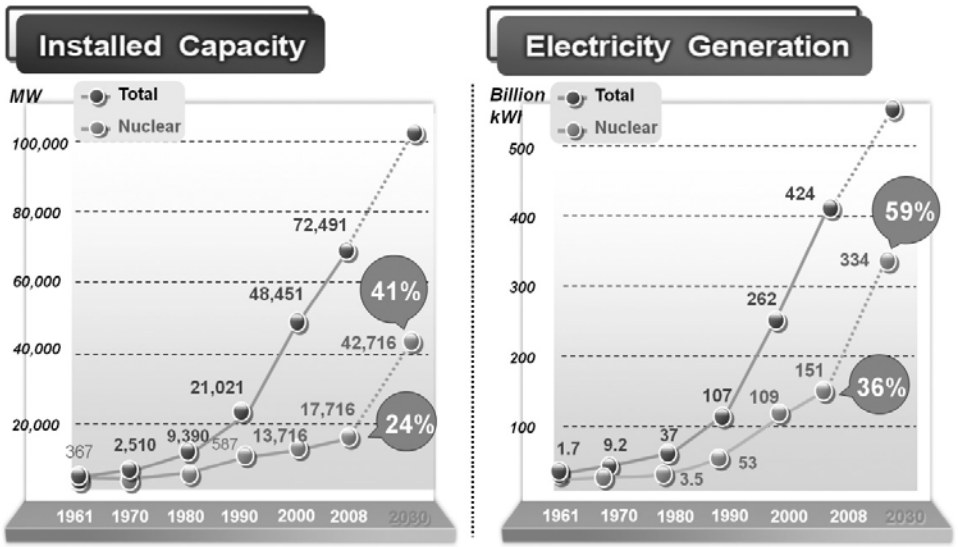
Project		Reactor Type	Capacity (M/W)	Plant Type	Commercial Operation
Shin-Kori	#1	PWR	1,000	OPR1000	Feb. 2011
	#2	PWR	1,000	OPR1000	Dec. 2011
	#3	PWR	1,400	APR1400	Sep. 2013
	#4	PWR	1,400	APR1400	Sep. 2014
Shin-Wolsong	#1	PWR	1,000	OPR1000	Oct. 2011
	#2	PWR	1,000	OPR1000	Oct. 2012
Shin-Ulchin	#1	PWR	1,400	APR1400	Dec. 2015
	#2	PWR	1,400	APR1400	Dec. 2016
Total	8	-	9,600	-	-

The nuclear power plants in Korea are currently operating at a rate of 93.4 percent of capacity factor (the global average of 76.0%), recording the lowest rate of emergency shutdowns in the world, a record due in large part to highly standardized design and operating procedures. Since 2000, the rate has become even lower recording below 0.5 (less than one incident) per plant per year. In 2010, only 2 incidents were recorded among twenty fully operating power plants.

3.5. Energy Prospect for Long-Term Period

The First National Energy Basic Plan, which was the long-term energy plan consisting of 20 years from 2008 to 2030, was first established in August 2008 in Korea. It incorporated the vision of energy policy in long-term basis focusing on low carbon production and green energy technology growth.

Figure 3-7 | The First National Energy Basic Plan



Reducing greenhouse gas emission, nuclear energy is an environmentally friendly resource economically and efficiently compared to the other energy resources. The nuclear power generation in Korea accounted for 36% in 2008 and will increase up to 59% in 2030.

The capacity of the nuclear power generation facilities has increased each year whereas coal, LNG, oil facilities will maintain their current levels by 2020. Moreover, coal, oil and natural gas are limited by its exploitable deposits and will be used in specific areas. But the uranium, the fuel for nuclear power generation is found evenly throughout the world and has more stability of fuel supply.

3.6. The Comprehensive Nuclear Energy Promotion Plan (CNEPP)

To establish a national long-term nuclear development plan, the nation's economy, available resources, technical capability must be thoroughly studied. Nuclear Energy Utilization and Development Plan is aimed at accomplishing the objectives of nuclear energy policies and effectively establishing detailed implementation plans that will promote the current nuclear energy as well as the prospect for nuclear safety management by the Atomic Energy Act. The Comprehensive Nuclear Energy Promotion Plan (CNEPP) has been set up since 1977 and propelled to systematically drive the national policy every five years thereafter. The 3rd NCNEPP was fixed in January 2007.

The CNEPP is the highest form of implementing the national nuclear policy, practically promoting the peaceful use of nuclear energy as well. The subordinate laws are as follows: "Radiation and Radioactive Isotope Utilization Act" and "the Act on Physical Protection and Radiological Emergency".

The CNEPP consists of three major phases: the first phase (1997-2001) includes the technological self-reliance on nuclear power plants, construction of NPPs, basic guidelines for nuclear regulation. The second phase (2002-2006) dealt with a high level of NPP technology, basis for exporting nuclear energy, advanced regulation policy, and a balance of nuclear and radiation technology development. The third design (2007-2011) is incorporating to secure nuclear technology, nuclear product development & export, advanced radiation technology.

4. The Experience of Technological Self reliance

4.1. Technology Development of Research Reactor

4.1.1. Introducing Research Reactor

The construction of TRIGA (Training, Research, Isotopes, General Atomics) Mark- II, the first research reactor, took place in 1959 and the operation of the reactor started in 1962 with 100kWt power. The project of TRIGA MARK-II power upgrading began from 1967 and succeeded in the power generation of 250kWt in 1969.

By the decision of the Atomic Energy Committee, a contract on introducing TRIGA Mark-III was made with the GGA (Gulf General Atomic Co.). The ceremony of laying the foundation stone was held in April 1969. It achieved criticality successfully in April 1972, generating the capacity of 2MWt.

These two research reactors have greatly contributed to training researchers and operators of nuclear facilities, enabling Korea to take the next steps for commercial scale reactors later.

4.1.2. Technological Self-reliance of Research Reactor

The feasibility studies on designing the multipurpose research reactor and its construction was carried out in 1983. The decision to build a multipurpose research reactor was determined for the level of 30 MW power generating. According to the decision, the type of the reactor has a 20% enriched uranium fuel and open pool type, using heavy water as coolant. In order to fulfill various objectives, this project was called as KMRR (Korean Multi purpose Research Reactor). The conceptual design was pursued with the cooperation of the AECL (Atomic Energy of Canada Lionited) in 1985.

The basic design of the research reactor and cooling systems was jointly performed by the AECL and Korean designers while the detail design works were carried out by KAERI and other nuclear engineering and design companies in Korea. The construction of the new research reactor was completed in 1995, renamed as HANARO (Highly Advanced Neutron Application Reactor).

4.1.3. Utilization of HANARO

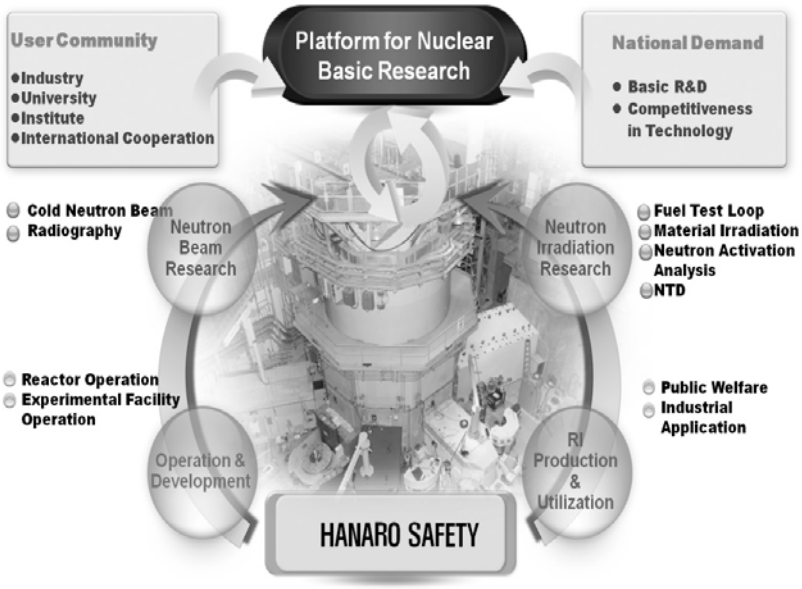
In 2010, KAERI added the CNRF (Cold Neutron Research Facility) on HANARO, effectively producing cold neutron for the first time in Korea. Also, the installation of FTL (Fuel Test Loop) equipment made it possible to test and validate the performance of nuclear fuel.

Since the HANARO reactor achieved initial criticality in February 1995, it has been used for various purposes, having the Radioisotope Production Facility, the Irradiated Material Examination Facility, and the Cold Neutron Laboratory.

It has such various functions for researches: neutron science, reactor material and fuel irradiation, radioisotope production, neutron transmutation doping, neutron activation analysis, and neutron radiography. Particularly the fuel test loop in HANARO enables a simulation of the thermal-hydraulic conditions of the power reactor. With the introduction of the fuel test loop, Korea can now conduct the whole process of reactor fuel production from designing and fabricating to testing new power reactor fuels without recourse to foreign assistance. HANARO's production of cold neutron provides a tool for research on biomaterials and nanomaterials.

4.1.4. Export of Research Reactor

Figure 3-8 | R&D of Research Reactor (HANARO)



In 2009, the Jordan Atomic Energy Commission invited KAERI to participate in the bidding for a 5MW multipurpose research reactor, called the Jordan Research and Training Reactor (JRTR). The KAERI-Daewoo Construction consortium was selected as the preferred bidder, its proposal was finally accepted. JRTR is the first nuclear system to be built in Jordan. For Korea, it marks the first turnkey reactor export in history.

The JRTR project consists of the following operations: construction of the research reactor, training & education for the operator, radioactive isotope production, and neutron science research by 2014.

In the JRTR bidding, three other prominent competitors participated in the process: Argentina's INVAP, China's CNNC (the China National Nuclear Corporation) and Russia's Atomstroyexport. The Korean consortium edged out three other international companies to be named by the Jordan Atomic Energy Commission (JAEC) as the preferred bidder for the project. This is a remarkable achievement so far in the 50 year history of the Korean nuclear industry, giving a chance to step up as a big three producer of research reactors along with Argentina and Russia.

The research reactor site is at the Jordan University of Science and Technology (JUST) in Irbid, 70 km north of Amman, with construction expected to be completed around 2014. Based on the conceptual design, the detail design of the reactor will be completed within 2 years after the contract.

KAERI is in charge of the design of the reactor and its systems, and Daewoo Construction is responsible for the construction and licensing, and project management.

The reactor in JUST will be used for producing radioisotopes for industrial, agricultural and medical purposes, training local engineers and scientists. Jordan also expects the research reactor to contribute to building its first nuclear power plant.

4.2. Technological Self-reliance of Nuclear Fuel

4.2.1. Technological Self-reliance of Nuclear Fuel with Heavy Water Reactor

The localization of the nuclear fuel for the light water reactor was approved in 1979 with the Korea Nuclear Fuel Development Complex (KNFDC) intention of developing it by means of related technology import. However, the nuclear fuel for the heavy water reactor was excluded because economic potentials were relatively considered insufficient. As a result, the KNFDC decided to separate the plan for developing of the PHWR fuel technology.

After all, the Ministry of Science and Technology approved the exploration of the PHWR fuel as a national agenda in December 1980. The research was commenced with the government support in 1981. The full-scale developmental activities occurred in various fields: the fuel design and manufacture, UO_2 powder processing, QA/QC, reactor core operational management & safety, ex-core tests, evaluation and validation methods for the fuel.

In order to verify the nuclear fuel, KAERI made a contract with the AECL of Canada for the nuclear fuel evaluation and inspection technology in October 1982 and the design of the nuclear fuel was approved by the Ministry of Science and Technology in January 1984.

To test the domestic nuclear fuel for commercial use, the Wolsong Unit 1 was chosen for a testing bed and loaded the fuel. KAERI decided to take mass-producing technology from 10 ton to 100 ton yearly in the production of the nuclear fuel fabrication and processing facility. The contract of nuclear fuel supply to Wolsong Unit 1 was concluded between KAERI and KEPCO in 1985. The nuclear fuel assembly was provided to Wolsong Unit 1 and went through the tests and validation processes for a year. The consequence revealed that the loaded nuclear fuel, manufactured by Korea, had as a high quality as Canada's fuel product.

The contract of technology transfer for PHWR nuclear fuel manufacturing on a large scale was made with the AECL in January 1986. The PHWR fuel production and technology was almost completed in 1987 and supplied the whole fuel package to the Wolsong Unit 1 at the end of the year. Technological independence of the PHWR nuclear fuel made possible to incorporate the stabilization of fuel manufacturing processes and the improvement of related equipment.

4.2.2. Technological Self reliance on PWR fuel

'The Basic Plan of Localizing the nuclear fuel of the PWR' was approved by the Government in September 1979 with the recommendation of KEPCO's involvement into it. The construction of a PWR fuel manufacturing facility was finished in July 1981 and could furnish the capacity of 200 ton U production each year. This capability covered the full demand of the PWR fuel in Korea from the year of 1988.

The Korea Nuclear Fuel Company was founded in November 1982 for the purpose of fulfilling the complete localization of nuclear fuel field. Then KAERI was in charge of the management of the Korea Nuclear Fuel Co. Ltd. (KNFC) and revised a localization action plan to concentrate on technology introduction from abroad and to renounce the joint manufacturing aim with foreign companies. In other words, KAERI would take charge of nuclear fuel design and KNFC would take responsible for the manufacturing side.

In 1985, KAERI signed a contract with Siemens-KWU of Germany to introduce the technology for the PWR fuel. The contract became effective in 1986 with the governmental agreement between Korea and Germany and an international loan arrangement from a financial bank of Germany, KfW.

There was a remarkable feature of this joint project. The Siemens-KWU had participated the Korean researchers and fuel designers in almost all areas of design works and engineering from the very beginning of the project in order to reduce the cost and duration of training Korean participants. Therefore, the most of design was jointly done by both sides and Siemens-KWU took all responsibility of the outcomes of design in accordance with the article of the contract.

A fabrication factory of the nuclear fuel was built in June 1988, and producing six mock fuels out of three types, 17×17, 14×14, and 16×16 one after another. The production of the nuclear fuel for Kori Unit 2, the 16×16 type, began in October 1988 and the first of this kind came out in Korea in December of this year.

The Korea Fuel Assembly (KOFA), consisting of 52 fuel bundles, was loaded at Kori Unit 2 in February 1990. The nuclear fuel of Younggwang Unit 3 was loaded in September 1994 and the same one of Younggwang Unit 4, in June 1995 respectively, and each one successfully went

into commercial operation.

The nuclear fuel design of the Korean standard nuclear power plant was independently conducted by Korean engineers with a little consultation from CE (Combustion Engineering Co.). This fuel is being used for Ulchin Unit 3 and 4.

4.2.3. Technological Self-reliance of Research Reactor Fuel

KAERI launched a technology development research on localization of the multipurpose research reactor's fuel in 1987 and established the relevant procedures of manufacturing, securing quality, technology development for the research reactor fuel. The fuel performance test of the localized fuel rod for HANARO was conducted twice and the capacity was evaluated to identify the safety of fuel performance by burning the fuel in the HANARO.

The U3Si/Al fuel, manufactured by KAERI and using the centrifugal separator technique, proved its quality more or less similar and much better one, compared to the fuel made by Canada. Especially, the Korean fuel had outstanding physical features such as thermal conductivity and tensile properties.

For the purpose of commercial application, a facility with processing and fabrication capability was needed to adopt the HANARO fuel technology and centrifugal scattering methods. The installment site was designated at the new Saebit Fuel Science building in July 1998 with the approval and inspection of KINS. In January 2004, the HANARO fuel was produced.

Although the HANARO fuel had been provided five times by the AECL in Canada since May 1994, the HANARO fuel assembly with 32 bundles began to be loaded in the reactor core in November 2007, which was manufactured by Korea only.

4.3. Technological Self-reliance of Nuclear Power Plant

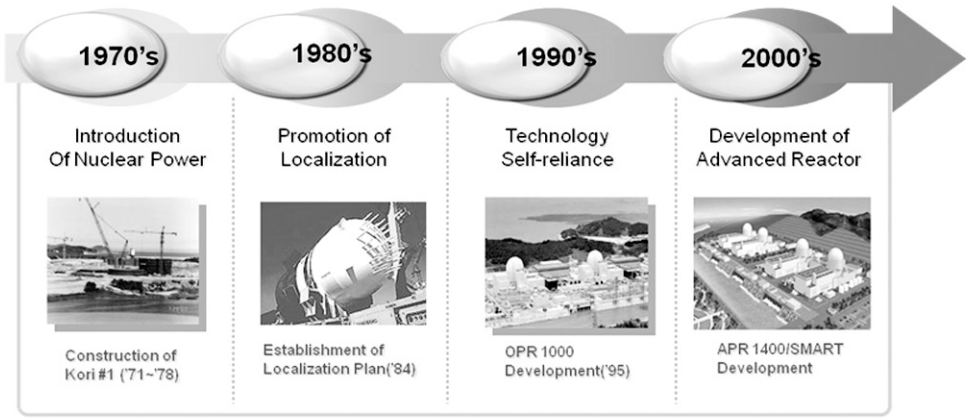
4.3.1. Introduction of Nuclear Power Plant

In 1962, the Korean government organized the Committee of Nuclear Power Development to enhance the implementations of nuclear power generation. Owing to the success of the 5-Year National Economic Development Plans the demand of electricity in Korea had been sharply increasing every year in the middle of economic growth.

In 1968, the Government decided to designate Kori, located in Yangsan-kun, the first construction site of the NPP with KEPCO leading the entire project.

Kori Unit 1 was the first nuclear power plant that had a capacity of 587MWe, built by the turn-key basis. The main contractor was Westinghouse, responsible for the NSSS and fuel supply. The General Electric Company (GE) in the UK was in charge of the turbine generator components and the construction supervision overall. The Hyundai and Dong-A construction companies, as subcontractors, partly participated in the construction of the reactor building and the turbine generator building.

Figure 3-9 | Localization History of Korean Nuclear Power Plants



** OPR1000 (Optimized Power Reactor 1,000) is renamed from the former KSNP*

Frequent construction changes had the original plan delayed about 27 months, but the first nuclear power plant was successfully built in July 1978. The construction of Kori Unit 2 was decided in July 1973 in the midst of the oil crisis. The contract to build the CANDU reactor was made in January 1975 for Wolsong Unit 1.

The contract was concluded on the turn-key basis which the AECL was the main contractor, in charge of supplying the primary system and construction management. In addition, the AECL accepted a full guarantee on the operation and performance of the plant after its construction. Parsons supplied the turbine and auxiliary systems, and the G.E.C provided generator system and electrical equipment. The groundbreaking took place in June 1977 and the completion of construction was in April 1983.

The construction of Kori Unit 3 and 4 was pursued on the basis of non-turnkey. KEPCO was in charge of the project management, promoting Korean companies participation in architect engineering, component and equipment manufacture, and construction.

As a result, KOPEC (Korea Power Engineering Co. Ltd., presently renamed as KEPCO E&C) took part in the detail design of Bechtel's Architect Engineering (A/E) work and accumulated the A/E experience of nuclear power plants. Also, the Hyundai Construction gathered its know-how in the field of construction and building.

Taking advantage of the experience of Kori Units 3 and 4, Korea has effectively reduced the period and cost for building NPPs. Ulchin Units 1 and 2 was a PWR type, a capacity of 950 MWe which Framatome was responsible for the primary system with Alstom in charge of the secondary system. Ebasco in the USA participated in design work as a subcontractor, Dong-A Construction in civil engineering, and Korea Heavy Industries and Construction Co. Ltd (KHIC, now changed to Doosan Heavy Industries) in electric power system facilities.

4.3.2. Technological Self-reliance and Korea Standard Nuclear Power Plant (KSNP)

The Korean government set the nuclear power plant standardization as the national policy project in accordance with 'Technological Self reliance Plan for Nuclear Power Plant Construction'. KEPCO led the entire project management, selecting a local company as the main contractor with foreign company's involvement in specific areas as sub-contractors.

Achieving nuclear technology independence of Korea can be laid out in 4 phases: total dependence on foreign technology, semi self-reliance of technology utilizing foreign technology, the self-reliance stage, and the advanced stage. Through the experience and technology accumulated from Yonggwang Unit 3 and 4, these NPPs became the reference plants for the Korean standard nuclear power plant, achieving 95% competence in the construction field. Ulchin Unit 3 and 4 was the first Korean standard nuclear power plants.

Self-reliant portion of the nuclear technology increased from 60% to 95% after the construction of Yonggwang Unit 3 and 4. The localization was achieved from 40% to 79%. Based on its domestic success, Gaining independence capability in nuclear technology and construction enabled Korea to pave the way for nuclear power plant export afterwards.

As of 2010, Korea has 17,716 MWe nuclear power generation capacity with 20 NPPs providing almost 40 percent of national electricity generation. This is the world's sixth largest nuclear generating capacity.

Given the fact that Korea introduced its first commercial nuclear power plant in 1978 as a developing country, the construction of Younggwang Unit 3 and 4 was a major milestone in the history of Korean nuclear development that boosted a certain confidence in the capability of localization of the nuclear technology. The construction of Ulchin Unit 3 and 4 opened the new page of Korean standard nuclear power plants.

Korea accelerated the construction of Younggwang Unit 5, 6 and Ulchin Unit 5, 6 based on the experience of Ulchin Unit 3 and 4. The construction of Younggwang Unit 5, 6 had improved the performance of the KSNP.

The Korea Electric Power Industry Code (KEPIC) for nuclear power plants was firstly applied to the construction of Ulchin Unit 5, 6 officially. The Korean Standard Nuclear Power Plant (KSNP) and KSNP+ have been renamed as the OPR 1000 (Optimized Power Reactor 1000). In summary, the OPR 1000 is a 1,000 MWe capacity PWR that optimizes the KSNP design utilizing proven, state-of-the art technologies.

Table 3-3 | Technological self-reliance of primary component of nuclear power plant

Primary components	Yonggwang #1·2 (Jun 1987)	Ulchin #1·2 (Sep.1989)	Yonggwang #3·4 (Jan.1996)	Ulchin #3·4 (Dec.1999)	Yonggwang #5·6 (Dec.2002)	Shin-wolsong #1·2 (2012)
Reactor pressure vessel	×	▲	◎	◎	◎	◎
Steam generator	▲	▲	◎	◎	◎	◎
Pressurizer	▲	▲	◎	◎	◎	◎
Primary piping	▲	▲	◎	◎	◎	◎
Reactor coolant pump	×	×	▲	▲	▲	◎
Reactor internal constriction	×	×	×	×	◎	◎
Control rod	×	×	×	×	◎	◎
secondary system (turbine)	×	▲	◎	◎	◎	◎

(× : import, ▲ : partial localization, ◎ : technological self-reliance)

4.3.3. Development of APR-1400

The APR 1400, an advanced light water reactor, was developed based on the experience and technology of OPR1000. The APR 1400, a Generation III reactor, represents evolutionary improvements in safety, performance, and environmental impact, meeting the highest international standards for safety and performance. The plants to be built in the UAE are APR 1400s.

The Shin-Kori Unit 3 and 4, the first APR 1400 NPPs, are currently under construction in Korea, providing excellence in terms of both safety and economics to meet the energy

requirements of the 21st century. The development project was initiated by the KHNP's (Korea Hydro & Nuclear Power Co., Ltd) strategy for the next generation reactor type plan. It was also selected as one of G-7 projects in June 1992.

The APR 1400 has been developed for 10 years by the tripartite collaboration of the Korean nuclear industry, universities, and national R&D institutes. Its design certification was approved by KINS in May 2002.

The APR 1400 adopted various safety design features such as digital plant protection system and hot-leg temperature reduction to increase safety margin. In order to mitigate severe accident, reactor cavity flooding system and direct vessel injection of emergency core cooling water was applied in the APR 1400. The reactor coolant system of the APR 1400 utilized a well proven 2-loop/4-pump configuration with a large pressurizer, pilot-operated safety relief valves, and proven components for improved safety and reliability.

Major characteristics of the APR 1400 are as follows:

- Type: Pressurized Light Water Reactor, capacity of 1400 MW, designed life-time of 60 years, seismic design SSE 0.3g
- Increasing safety margin: thermal margin 10% or higher, large pressurizer to enhance transient response, the safety injection system with four independent trains to take suction from the in-containment refueling water storage tank and to discharge it directly into the downcomer of the reactor vessel.
- Improving economic benefits: Simplified design, increased capacity, operational convenience, maintenance availability, and the integrated head assembly
- Mitigating severe accident: Reactor cavity flooding system, multiple safety injection systems, safety shut-down system, four-train arrangement technology, ex-vessel reactor vessel cooling system
- Advanced control room design: improving man-machine interfaces, digital control system, installing redundant compact workstations, displaying plant status monitoring of critical safety functions.

Shin-Kori Unit 3 and 4 are scheduled to be completed in 2013 and 2014, respectively. Shin-Ulchin Unit 1 and 2 are now preparing for the construction, targeting the completion dates of 2015 and 2016, respectively.

Besides the UAE's first nuclear power plants export, Korea Hydro & Nuclear Power Co., Ltd. is turning its eyes to overseas markets with the APR 1400 model. It is expected to participate in Europe, Southeast Asia, and the Middle East. Korea is now in preparation for applying design certificate of the APR 1400 to the NRC of the USA to gain access to the U.S. market in the future.

4.3.4. Enhancing Technology Competitiveness (Nu-Tech 2012)

The Korean government published the green road map called “National New Growth Engine” in August, 2008. The road map includes various innovation programs to foster green growth until 2012, thereby further developing the economy. The national green growth engine program selected nuclear power as the most workable source of the diverse renewable and low carbon energy.

The Korean government’s nuclear technology development strategy, called “Nu Tech2012,” concerns the localization of key technologies such as nuclear reactor design computer code, reactor coolant pump and man-machine interface system. The rate of the nuclear technological self-reliance is currently about 95%. With effective fostering of the Nu-Tech2012 projects, it will be possible to achieve 100% self-reliance until 2012. Now The Korean nuclear industry led by the KHNP is endeavoring to export the APR1400 (Advanced Nuclear Power Reactors 1400MW class).

The major directions of Nu-Tech2012 are as follows:

- Standard design for license approval and construction period in terms of cost and time
- Simplified design for operation availability and abnormal accident mitigation
- High operating availability (87-90%) and long plant design life (over 60 years)
- Prevention of the reactor core melt-down and other severe accident mitigation
- Structural resistance for aircraft collision to the containment building
- High quality nuclear fuel in terms of efficiency and nuclear waste management
- Extension of refueling cycle up to 18-24 months

4.3.5. Research and Development on APR+

KHNP and its partner companies are currently developing a more advanced reactor, called APR+, consisting of 100 percent Korean technology. The APR+ Technology Development Project was launched on Aug. 1, 2007. APR+ will be developed as a kind of Generation III+ reactor type with improved safety and economic efficiency.

The APR+ Technology Development Project will be carried out in three phases and completed by 2015 with support from the Ministry of Knowledge and Economy. The APR+ project is designed to overcome export constraints by localizing essential design computer codes, reactor cooling pumps, and man-machine interface system. The project aims to further advance the existing nuclear technologies to the level of major nuclear vendors by introducing sophisticated and competitive nuclear technology to the global market.

The success of the APR+ project is essential for the Nu-Tech2015 strategy to work. Korea will be able to emerge as one of the best nuclear reactor exporting countries by 2015 when these

technology development projects bear fruit.

The APR+, the next 1,500 MWe evolutionary nuclear power plant model (the capacity is 100 MW more than APR1400) is expected to remove obstacles to nuclear power plant export. The KHNP has a plan to obtain the ownership of design computer codes by 2012. Acquiring design computer codes is one of the obstacles when exporting nuclear power plants due to the dependency on foreign programs. Only Westinghouse and Areva have their own design computer codes. However, it is possible for Korea to export the NPPs by getting rid of this constraint with the APR+ project objectives.

KHNP will complete the standard APR+ design by 2012, and will receive design certificate on it. The KHNP is planning on the first commercial operation of APR+ around 2022, and will apply APR+ technology to the future ten NPPs by 2030 according to the National Energy Basic Plans.

One of the purposes of the APR+ project is to gain independent patents and know-how on the APR+. The APR+ is anticipated to produce a capacity of 1500 MW. In terms of economic competitiveness, it will be increased up to more than 20% compared to that of the domestic coal power generation of 1000 MW, and the construction period will be reduced to around 36 months.

KHNP takes part in the project as comprehensive project management and leadership; Nuclear Engineering and Technology Institute of KHNP in experimental test and evaluation including verification; KEPCO E&C in the NSSS and BOP design; KEPCO NF in nuclear fuel design and related the reactor core research; Doosan heavy industries in the main equipment and turbine design.

The APR+ will have 257 fuel bundles to the fuel assembly, which 17 fuel bundles are added compared to that of the APR1400, producing more thermal output. The operating average availability will be over 92%, and an unplanned manual reactor scram frequency will be less than 0.2 times per year. The seismic design basis will be 8.0 (0.3g).

The progress of the APR+ project is presently about 50%, and the planned schedule will be completed by 2012. Its design certificate and license application will be done by 2015.

4.3.6. Export of Nuclear Power Plants

On December 27, 2009, A Korean consortium's winning of the USD40 billion nuclear power contract with the United Arab Emirates was the nation's the first and largest order for the Korean nuclear industry. Korea thus has become the world's six exporter of nuclear power plants.

The Emirates Nuclear Energy Corporation (ENEC) had announced that the consortium of KEPCO was selected to participate in the UAE bid to build NPPs. To win the massive project, the Korean consortium competed with two other bidders-a consortium of General Electric-Hitachi and a French consortium including Areva.

The value of the contract for the construction of the four nuclear power plants is worth approximately $20 billion, and an additional $20 billion can be expected from the operation and other supporting activities related to the operation of the completed four units for the next sixty years.

Some reasons of Korea's winning the UAE contract are based on the following facts. Korea has localized over 95 percent of the technologies needed to build and operate nuclear power plants with a wide experience of 30 years in NPP construction. The ARP 1400's overnight capital cost is USD2,300 per kilowatt, which is about 20 percent lower than nuclear power plants in other nations, according to the World Nuclear Association. In addition, the construction period is relatively short and the plant operation record was 93.3 percent as of the end of 2008, 14 percentage points higher than the world's average of 79.4 percent.

The APR 1400, which will be installed in the UAE, is Korea's unique, large capacity 1400 MW nuclear reactor model. The reactor offers markedly enhanced safety, technology, and economy. The plant design life time is also extended from 40 years to 60 years compared to OPR-100. The construction of four 1400 MW APR 1400 NPPs with a total capacity of 5,600 MW is scheduled for completion by 2020. The construction work will begin in 2012, and one nuclear power plant should be ready for operation each year starting from 2017.

The WNA anticipated that the nuclear market would grow in a trillion dollar scale with new 430 nuclear power plants all over the world until 2030. The UAE project will certainly promote Korea’s superior nuclear engineering and technology and its outstanding operating plant experience globally. After winning the UAE's bid, Korea will seek other opportunity in the world market with the local nuclear industry's higher rate of operation, price competitiveness and short construction time.

4.4. Education and Training for Human Resources Development

4.4.1. History of Education and Training

In the beginning of 1960s, there were almost no experts and researchers on radiation protection and application in Korea besides the nuclear physics and engineering. The introduction of nuclear power plants from other nations was a key national project requiring a vast investment and a long-term human resource development.

The Korean government recognized the importance of competent manpower for the nuclear power programs to provide experts and specialists to national nuclear activities. With the limited human resources on various nuclear fields, it was difficult to launch domestic education systems on the nuclear physics and radiation management.

First of all, the Government attempted to encourage nuclear research in universities in an effort to attract the entire academic world to the national nuclear programs. The Government decided to establish the nuclear engineering departments, for this purpose, in Hanyang University and Seoul National University in 1958 and 1959, respectively. The subjects of natural science, physics and radioactive isotopes were taught to the students.

After the completion of Kori Unit 1 in 1978, human resources development became one of the top priority tasks of the Korean nuclear industry in need for nuclear technology and engineering in such field as construction, operation, and design of nuclear power plants.

To fulfill these needs for the industry, the Nuclear Training & Education Center of KAERI as well as the Nuclear Power Education Institute of KHNP started to develop the related curricula and learning materials for operators, engineers, manufactures in NPPs and nuclear fuel production, research reactor and medical facilities. The other nuclear entities in Korea also made efforts to educate their own workers for the assigned functions.

As Korea's nuclear energy program continued to progress and became more self reliant, the education and training on manpower was also beginning to be independent from the foreign partners' assistance. In parallel with the development of Korean standard nuclear power plants and incremental technology transfer in the 1990s, Korea was able to run its diverse training courses in the major fields of technology and maintenance & operations.

Considering the rapid expansion and diversification of nuclear technology, Korea tried to analyze and verify whether or not the safety level of nuclear facilities was sustained at the standards of advanced countries. Since the 1990s, Korea has been emphasizing the importance of education on the safety side, building the safety culture among all personnel engaged in the operation of nuclear facilities. Therefore, the basic educational policy was particularly called for pursuing such training courses as radioactive materials management, securing safe operation of equipment and components for the NPPs.

In order to support human resources development infrastructure of developing countries intended to introduce nuclear energy programs to their home, Korea has taken part in multilateral collaboration projects organized by the IAEA, WNU (the World Nuclear University), and GNEP (the Global Nuclear Energy Partnership), providing international nuclear energy training courses for trainees from developing countries including Vietnam, Egypt, Turkey, Thailand, and the Republic of South Africa.

Though foreign nuclear companies played an important role in the education and training of Korean personnel in the implementation stages of technology transfer, the Korean nuclear energy programs and educational strategy were also a very aggressive one and it was one of the more forward looking policy and programs in the world.

4.4.2. Human Resources Development System

Establishing national nuclear energy programs requires considerable time and concerted efforts by the government, industries, universities and research institutes. Multilateral cooperation based on a shared human resource development philosophy will be much better. The cooperation among the Ministry of Education, Science and Technology, the Ministry of Knowledge Economy, universities, and R&D laboratories across the country has to be integrated for achieving the HRD's goals.

The universities having the nuclear science and engineering department are as follows: KAIST (Korea Advanced Institute Science and Technology), Seoul National University, Hanyang University, Kyunghee University, Chosun University, Jeju National University. In particular, KAIST and the UST (University of Science & Technology) provide highly qualified students of master and doctorate degree in their graduate school.

In 2012, The KEPCO International Nuclear Graduate School (INGS) will be opened to provide competent leadership professionals for planning, design, construction, operation, maintenance and management of nuclear power plants. K-INGS will be located at the Kori Nuclear Power Complex.

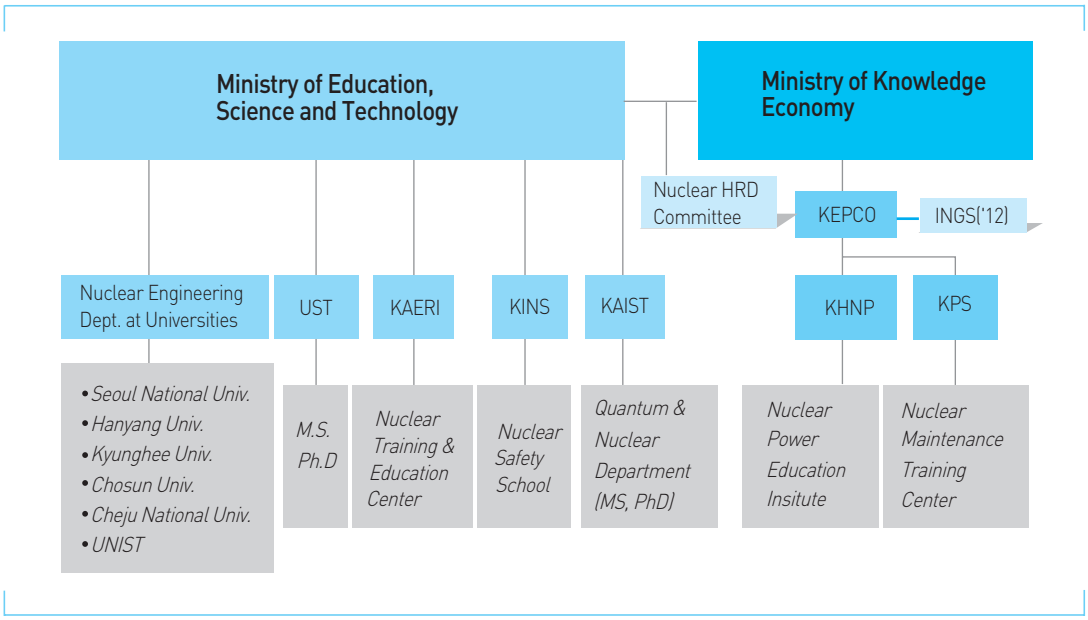
The Nuclear Training & Education Center of KAERI has general training courses in research reactor, nuclear fuel disposal management, radiation management and its techniques including the international nuclear power project policy and management in cooperation with the IAEA. The Nuclear Safety School of KINS has special training courses in nuclear safety review and evaluation, safety inspection, and nuclear regulatory research.

Under the Ministry of Knowledge and Economy, the Nuclear Power Education Institute of KHNP set up the training courses in project of management and NPP operation & controls. The Nuclear Maintenance Training Center of KPS provided training courses in NPP maintenance, repair, and equipment replacement and management. Also, KEPCO has the international nuclear graduate school which is the world's first graduate school focusing exclusively on the nuclear power plant studies.

It is possible to achieve the national goals of nuclear energy programs and self reliant capabilities, only if each participant in the government, industries, universities and research institutes countrywide do its best in performing its share of the human resource development

duties, bearing in mind that they all must be dedicated to cultivating young students and junior experts on the long-term basis.

Figure 3-10 | Nuclear Education / Training Organizations in Korea



5. Lessons Learned from the Korean Nuclear Power Program

5.1. Firm National Commitment under Strong Leadership

With a strong national consensus and under the tutelage of governmental commitment, Korea has implemented nuclear energy program as a vehicle for introducing advanced science and technology as well as meeting the demand of electricity.

The Office of Atomic Energy (OAE) was established in the Korean government directly under the President with the authority to plan and to promote the program without major administrative obstacles.

Since the national nuclear program has diverse objectives to pursue in the long term basis, a strong government determination with the national consensus is a prerequisite part for its successful implementation. As the OAE became the corner stone of national nuclear program, Korea has stepped up the capabilities of nuclear safety, economy, and technology with supports and commitment of the government.

5.2. Synergy with Other National Development Program

National nuclear power program is a part of the nation's economic development plan. Financing for the nuclear power plant construction is generally in parallel with economy growth rate.

Korea has continued its NPP construction in parallel with the national economic development plan. The stable electricity supply with reasonable price led to heavy industries steadily burgeoning out, stimulating the other industrial sectors. This virtuous cycle, in turn, enabled to invest in additional NPP construction with earned capital.

5.3. Continuous Investment under the Government Guarantee

The Korean government guaranteed loans, ensuring of their payment and interest because financial trust and investment principles was an essential part for the next nuclear program. In developing countries, taking control of private companies was not suitable for the construction of NPPs because of large capital investment and high uncertainly arising from the long payback period. The financial risk and uncertainty were the major obstacles to overcome at the early stage of Korean nuclear power program.

Therefore, the success of nuclear power program in the developing countries imperatively depends on the strong commitment of the government with high priorities. The Korean government put emphasis on nuclear power as a high priority for economic development, together with steel, petrochemical, ship building industries.

The government launched the national nuclear power program in good recognition of the fact that financial institutions are typically reluctant to take on big financial risks for a single grand project in the long term. Accordingly, the government's financing policy and commitment had to be settled in advance to reduce the difficulties associated with securing necessary investment funds.

With the solid determination and guarantee of the government, foreign companies as well as national companies voluntarily entered in the Korean nuclear program.

5.4. Strategies for Securing Manpower and Proper Education and Training System on Technological Self-Reliance

Securing high-quality manpower and overseas education and training courses in collaboration with the IAEA and other nuclear advanced nations was aimed at human resource development. The government provided various incentives such as high positions and salaries to qualified specialist and professionals. International experts have also been invited at a high level

expertise required.

In the early stages of the first NPP construction, the government began to send young talented researchers and engineers to nuclear advanced countries for the overseas education and training.

The Korean government has founded undergraduate nuclear engineering departments in universities, allowing students to cope with related theories and technical changes.

As part of basic management system, the consistent support for radiation applications in agriculture, health and biology has been stressed for a distinct kind of skill and special knowledge.

Great emphasis was put on the importance of education and training as a means to keep the national nuclear program on the right track.

5.5. Efficient Localization Policy through Technology Transfer from Partners

The Korean government decided to build the first series of NPPs on a turnkey basis , which had restricted domestic roles to non-safety areas such as civil engineering and construction work only.

Korean companies involved with the projects in the form of “On the Job Training (OJT)”and “On the Job Participation(OJP) with technology transfer in mind.

KEPCO began to concentrate on nuclear localization aim from the fourth NPP construction by a non-turkey basis contract and finally took on the main contractor's role for the tenth NPP in 1987.

Adherence to the localization policy made it possible to gradually manufacture components in local suppliers and to upgrade plant construction. Through this experience, the Korean nuclear industry became better able to keep pace with the growth of nuclear technology and its various complexities.

Table 3-4 | History Overview of Technology Development and Human Resource Development of Nuclear Energy in Korea

	Status of Nuclear Energy Technology	Status of HRD	Major Products	Main Training Organization	
1960s	Preparation for Nuclear Energy	Overseas Training		Universities	NTC/ KAERI
1970s	Introduction of Nuclear Power	Basic Training	Construction of Kori #1		
1980s	Promoting Localization	Advanced Training	Establishing Localization Plans	Utilities	
1990s	Technology Self-Reliance	On-the-Job Participation	OPR-1000, HANARO Development		
				KINS	
2000s	Advanced Technology Development	Experience Sharing	APR-1400 Development	UST	INTEC/ KAERI
2010s	Technology Innovation	Global HRD	SMART	Networks	

*NTC (Nuclear Training Center), INTEC (International Nuclear Training & Education Center).

5.6. Feedback of Evaluation and Viewpoint

Some reviews and comments on the Korean nuclear energy plan were made by domestic experts and foreign specialists from the IAEA and the USA, and all results were incorporated into the next NPP development plan to realize the plan's aims and refinement.

Planning and implementing a nuclear power plant construction is very complicated process. There should be also clear reviews and evaluation after this process for a country to formulate the common goals and consensus of projects. The processes of multiple confirmations and verifications are instrumental tools to prevent and reduce failures and errors of the next planning and implementations, accomplishing the better achievements in the next cycle.

Korea took advantage of in-depth reviews and feedbacks from diverse knowledge and experience pools in the planning and decision-making process.

5.7. Preparation of Safety Regulatory System

After the first NPP construction, the Korean government contemplated shaping the nuclear safety regulatory framework. Since most technical guidelines and principles of nuclear safety were taken from those of the USA, Japan, and France. It caused some confusion and misleading at various levels of interpretations on regulatory laws and rules. .

Arising from these kinds of conflict, the procedures for the NPP's licensing and the work processes of construction at the initial stage were pursued separately, more or less, not in sequence and without adequate interfaces.

In this regard, the Korean lessons learned from its experience showed that a country which introduces the nuclear energy for the first time has to establish, in early stage, the nuclear regulations and licensing system required to secure nuclear safety considering implementation processes for the construction, operation, decommissioning of NPPs, and the spent fuel management.

5.8. Duplicate Efforts by Pursuing Two Different Types of Plants

One of the unique features of Korea’s nuclear energy program is that it is operated two completely different nuclear technologies: Pressurized light water reactors (PWR) and pressurized heavy water reactors (PHWR). The AECL brought its heavy water CANDU system in Korea. In 1976, the AECL signed its first contract to build a CANDU 6 nuclear power plant unit at Wolsong. Korea has taken a very unique approach by mixing and diversifying its nuclear energy technologies, not putting its eggs all into one basket but two baskets.

As Korean nuclear program became more self-reliant, these two different types of NPP technologies require the division of resource allocation and R&D investment, and different regulation. This led KEPCO to pursue a standard NPP model in the PWR. However, the resource allocation was not as adequate in the PHWR as in the PWR case, which often became a controversy over the PHWR.

5.9. Difficulties in Selecting Radwaste Disposal Site

With the increase of the nuclear power generation and use of the radioactive isotopes, the increase in accumulative volume of radioactive wastes called for expansion of storage capacity. The Korean government made efforts to find waste disposal sites in the 1980s. The 20-year long efforts to find a site for the Low and Intermediate of Level radioactive Waste (LILW) and interim storage of the spent fuel were confronted with the oppositions of local residents and environmental activities groups.

The government has tried to improve the public acceptance for nuclear power plant and radwaste. In 2004, the Korea Atomic Energy Commission established the basic principles for the radioactive wastes management. The government and the utilities have made numerous efforts to select the sites of radioactive wastes repository. In 2005, a LILW disposal site was selected with the support and consent of local residents. But the prospect of the public acceptance for the spent fuel management is not optimistic.

Along with the improvement of living standard, it becomes difficult to find the radwaste disposal sites, especially in countries with high population densities. So it is recommended that the early preparation for the environmental impact assessment of radioactive wastes be considered with potential disposal sites and public acceptance.

6. The Current Status of Saudi Arabia

6.1. The Economic Status

Saudi Arabia faced the challenge of low oil price from late 1997. It was due to the East Asian economic crises, a warm winter in the West caused by El Niño, and an increasing of production in non-OPEC countries.

However, countries in the Gulf area including Saudi Arabia met economic growth in 2010 with the world recovering from the economy recession and international oil price increase. As of August 2009, it was reported that Saudi Arabia is the strongest Arab economy according to the World Bank. In October 2010, the IMF expected that the Gulf area economies of the Middle East would record 4% of GDP growth which exceeded the world average growth.

Saudi Arabia's population as of July 2010 is estimated to be 25,732,000 including 5,576,000 non-nationals. It is one of the largest among 6 nations in the Gulf Cooperation Council (GCC). The population growth is about 1.95% from 2010 to 2015, nominal GDP is USD 374 billion, and GDP per capita is USD 23,255 which is the lowest among the GCC. In 2009, owing to the decline of international oil price, the real GDP growth recorded -0.9%, the consumer price growth was 5.5%, and the balance on current account was -USD 680 million. Oil production in the second quarter of 2009 was 7,950 thousand barrels per day, accounting for 56% of the GCC.

Despite the rapid expansion of revenues in the 1970s, during the first Oil Boom the economy of Saudi Arabia increased rather slowly and sporadically because of expanding expenditures in the national welfare, consumption, and military defense to maintain the country. These made the national growth engine weakened to cause the rising unemployment, low motivation to work, and the strain of public expenditure and national debt between the 1980s and 1990s with low oil prices. However, Saudi Arabia has seen the second era of the Oil Boom in the beginning of the 2000s and felt the need for a future economic strategy without dependence on oil export.

Saudi oil reserves are the largest in the world, and Saudi Arabia is the world's leading oil producer and exporter. Oil accounts for more than 90% of the country's exports and nearly 75% of government revenues. As of 2007, non oil manufacturing contributed 10% to Saudi Arabian GDP and less than 6% of total employment.

Now the Saudi government has sought to allocate its petroleum income to transform its relatively underdeveloped, oil-based economy into that of a modern industrial state. The economy has progressed rapidly. Oil wealth has increased the standard of living of most Saudis. However, significant population growth has strained the government's ability to finance further improvements in the country's standard of living.

Saudi Arabia is currently encouraging private sector growth to lessen the kingdom's dependence on oil and increase employment opportunities for the swelling Saudi population. The government has begun to permit private sector and foreign investor participation in the power generation and telecom sectors. The economy diversification is so vital that the country is also seeking for nuclear energy program.

6.2. Current Status of Electric Power

By the 2009, the electricity generation capacity of Saudi Arabia reached 41,000 MW. The electricity generation presently depends entirely on the thermal power generation such as petroleum (51%) and gas (49%). The annual electricity demand is approximately 4-6%, meaning the country's economic growth is steadily increasing with stable momentum. It is expected that the demand of electric power capacity would reach approximately 60,000 MW by 2020.

The electric power generation in Saudi Arabia is expected to be double by 2023. According to the Electricity & Co-generation Regulatory Authority (ECRA), which regulates the national electric power generation from the viewpoint of the electricity's demand and supply, about 82% out of the total electricity of 37,154MW in 2007 was generated by the Saudi Electricity Company (SEC), the national power generation company.

Arising from the economy growth rate and swelling Saudi population, the electricity demand is rapidly increasing. The electricity demand per person in 2008 is 7,229kW/h, comparing to that in 2005, augmented by 13%. According to estimated statistics of the Saudi Arabian Electric Power Department, the Saudi Arabian population by 2023 will expand to 50%, reaching nearly 38 million, and the electricity demand will increase to 4.5% each year, requiring the total electric power demand will reach up to 60,000 MW.

On the other hand, the progress of the electric supply has slowly moved to the power generation enlargement. The ECRA had once tried to take action by increasing the electricity price with the advice of consultants in 2005, but the situation made it impossible to realize this recommendation. The government has been boosting up the other private sectors involvement to give benefits to Independent Power Producers (IPPs) and Independent Water & Power Project (IWPP). The purpose of this policy is to bring out the private capital and to promote the supply of electricity.

The GCC has taken account of the introduction of nuclear energy to the Middle East region to solve similar difficulties that the countries have in common, reducing dependence on oil and preparing for the future economy.

6.3. Current Status of Nuclear Energy Progress

Most of countries in the Middle East had not considered the nuclear option seriously because of abundant oil and gas reserves and low population status but the fast growing economies and incremental populations in this region have presented different situation with a shortage of electricity supply, making the nations reconsider using nuclear energy.

Other reasons have to be factored in this region are: Concerns over the exhaustion of oil and gas reserve in the future, the environmental impacts of the fossil fuel, and the need for an alternate energy source.

Saudi Arabia plans to invest USD 53,400 million in electricity enterprises until 2019, having a keen interest in nuclear power generation as an alternative energy. Saudi has been researching into the introduction of nuclear power plants since the mid-1980s, and spontaneously taken part in the nuclear energy on a GCC level review since 2006. After the UAE's independent decision to build nuclear power plants, the GCC's common goal of the nuclear option has become a little weakened. After all, Saudi Arabia starts to make way for nuclear energy for its own good.

The Saudi Arabian government conducted a feasibility study in March 2010, and has launched an independent nuclear power generation strategy and plans to address the electricity supply.

The King Abdullah City of Science & Technology (KACST) has been assigned to tackle this task. The followings are the major scope of this feasibility study:

- Research on the demand & supply of electricity and freshwater in the future
- Investigation on potential nuclear power plant sites
- Policy and scenario on the introduction of nuclear power plants
- Reviews on the nuclear power reactor technologies
- Long term strategy on nuclear energy

This study lasted from June 2010 to December 2010 (25-26 weeks), and the official announcement of the results is supposed to be released in early 2011, including nuclear power plant construction plans.

In April 2010, the King Abdullah City for Nuclear and Renewable Energy was newly established for the peaceful use of nuclear energy and renewable energy resource. Another

purpose of this organization is not only to supply electricity and freshwater needed for the economic growth and increasing population but also to gradually reduce the dependence of fossil fuels.

The King Abdullah City for Atomic and Renewable Energy (KACARE) is composed of the chairman (the King), the vice chairmen (2 Deputy Prime Ministers), and members (13 Ministers in the government). As body of policy making, this organization is to deal with the feasibility study on nuclear power generation, initially carried out by the KACST and to promote relevant R&D in the private sector.

Furthermore, it will decide the implementations of the national policy relating to nuclear power and new-renewable energy and will monitor nuclear activities on its commercial use and radiation waste management. This decision confirmed that Saudi Arabia has show a keen interest in nuclear power generation, while looking closely into the other alternative energy resource as solar power.

Saudi Arabia has sought advices from a consulting firm in Finland to formulate strategies on nuclear power and renewable energy. Such consultation resulted from the concern over unstable natural gas supply of the Middle East which is used for generating electricity and seawater desalination.

The Saudi Arabian Cabinet conference approved the agreement on the peaceful use of nuclear energy between Saudi Arabia and France on 5 July, 2010. Hashim Yamani, the director of KACARE, did not definitely mention the prospect date of signing it. According to officials familiar with this matter, it would be signed when the King Abdullah visits France in mid-July (Presently, his visit is indefinitely postponed).

The draft of agreement was completed by the negotiations of two countries. The proposal of the agreement had been initiated by France. The Cabinet's approval was delayed by the influences of Saudi Arabia’s reviewing on the nuclear power plant policy in 2009 and to the establishment of the KACARE in 2010.

Although Saudi Arabia does not have a nuclear power plant yet, it is obvious that Saudi Arabia still has the nuclear power on mind in the context that Saudi signed the agreement on nuclear energy cooperation with the USA in 2008, and the negotiations had been made with France for two years.

If Saudi Arabia decides to move on to nuclear power generation, Saudi Arabia would be the forth country in the Middle East that has opted for a nuclear power program.

6.4. Current Status of Nuclear Energy-related Organization

There are several organizations related with nuclear energy in Saudi Arabia. They include King Abdul Aziz University, King Abdulaziz City for Science and Technology (KACST), King Abdullah City for Atomic and Renewable Energy (KACARE).

6.4.1. King Abdul Aziz University (KAU)

Located in Jeddah, the KAU was established in 1967. Now the university is consisted of 40,000 undergraduate students, 2,000 graduate students, 900 doctorate students with 2,300 employees including the faculty. The related to nuclear science in this university is nuclear engineering department.

● **Nuclear Engineering Department of KAU**

The nuclear engineering department was founded in 1977 in order to educate students in the application of radioactive isotope and health physics. Recently, two programs are made for medical-physics engineering and radioactive protection engineering. Thanks to the program courses, many experts in these fields have been trained. There are nuclear energy engineering, medical-physics engineering, and radioactive protection engineering in the undergraduate studies. And, there are medical-physics engineering and radioactive protection engineering in the master's course. In addition, the undergraduate course has been guaranteed from the America Engineering Technical Institute since 2003. The nuclear engineering department consists of a dean, two professors, four associate professors, seven assistant professors and two instructors.

The nuclear engineering depart has following facilities:
- Radiation Detection Laboratory
- Health Physics Laboratory
- Low Level Counting Laboratory for Internal Contamination
- Low Level Counting Laboratory for Environmental Radioactivity
- Non-Destructive Testing Laboratory
- Radioisotope Application Laboratory
- Nuclear Computation & Reactor Simulation Laboratory
- Radioanalysis Laboratory

6.4.2. King Saud University (KSU)

King Saud University (KSU) is a public university located in Riyadh, Saudi Arabia. It was founded in 1957 by King Saud bin Abdul Aziz as Riyadh University. The first university in the kingdom was not dedicated to religious subjects. It was renamed to King Saud University in

1982.

The student body of KSU today consists of about 52,000 students and 5,000 staff members. The university offers departments in natural sciences, humanities, and professional studies without tuition fees for students. The subjects in the engineering and medical disciplines are taught in English with the rest of subjects lectured in Arabic.

- **Nuclear Engineering Laboratory**

The nuclear engineering laboratories consist of Measure Lab, Health Physics Lab, Neutron Activation Facility, and X-ray Fluorescence Lab.

The laboratories meet many kinds of under-graduates studies as well as graduate ones including other research works. In the Measurement Lab, all types of experiments related to Alpha, Beta, Gamma and Neutron Spectroscopy are carried out. The Health Physics Lab contains a complete unit of Thermo Luminescence Dosimetry (TLD). The Neutron Activation Facility is to activate target samples in preparation for radio isotopes experiment and Neutron Activation Analysis (NAA).

6.4.3. King Abdulaziz City for Science and Technology (KACST)

The Saudi Arabian National Center for Science and technology (SANCST) was founded in 1977. The name of SANCST changed to KACST in 1985. KACST issued a project bid for the feasibility study on nuclear energy in Saudi Arabia in March 2010. The scope of the feasibility study includes: ① electricity and seawater desalination needs; ② research on nuclear power plant construction sites; ③ scenario and policy on introduction of nuclear energy; ④ reviews on nuclear reactor technologies; ⑤ establishment of long-term nuclear energy strategies.

The project period is about 25-26 weeks starting from June to December. In the beginning of 2011, the nuclear power plant construction plan will be officially announced based on the feasibility study results. Under KACST, there are other bodies related to nuclear energy: The Nuclear Science and Technology Sector, Nuclear Regulatory Unit, National Center for Radioactive Waste Management, and so on.

- **Atomic Energy Research Institute**

In order to protect health and environment from ionized radiation, the Atomic Energy Research Institute (AERI) supports and develops nuclear energy researches in the fields of agriculture, industry, health, relevant radiation prevention, and protection technologies.

The main tasks of this institute are as follows:

- Establishment of regulation systems for the application of nuclear energy and technology with other authorities in the government
- Protection of human and environment from ionized radiation
- Enhancement of nuclear energy science & technology, related knowledge
- Coordination of nuclear activities with international organizations and Arab countries
- Recommendation of nuclear experts to the King for consult and advisory purposes.

6.4.4. King Abdullah City for Atomic and Renewable Energy (KACARE)

KACARE was founded in April 2010 in order to promote the peaceful use of nuclear and renewable energy. The supreme council of KACARE consists of the chairman (the King), the vice chairmen (2 Deputy Prime Ministers), and council members (13 Ministers in the government). The president of KACARE is Dr. Hashim bin Abdullah Yamani, the former Minister of Commerce. The responsibility of this institution rests with policy-making, decisions on the course of implementations for national energy program. It is expected to follow up the project of the feasibility study on nuclear energy.

7. Basic Considerations for the Introduction of Nuclear Power Plant

7.1. Phases and Milestone for the Introduction of Nuclear Power Plant

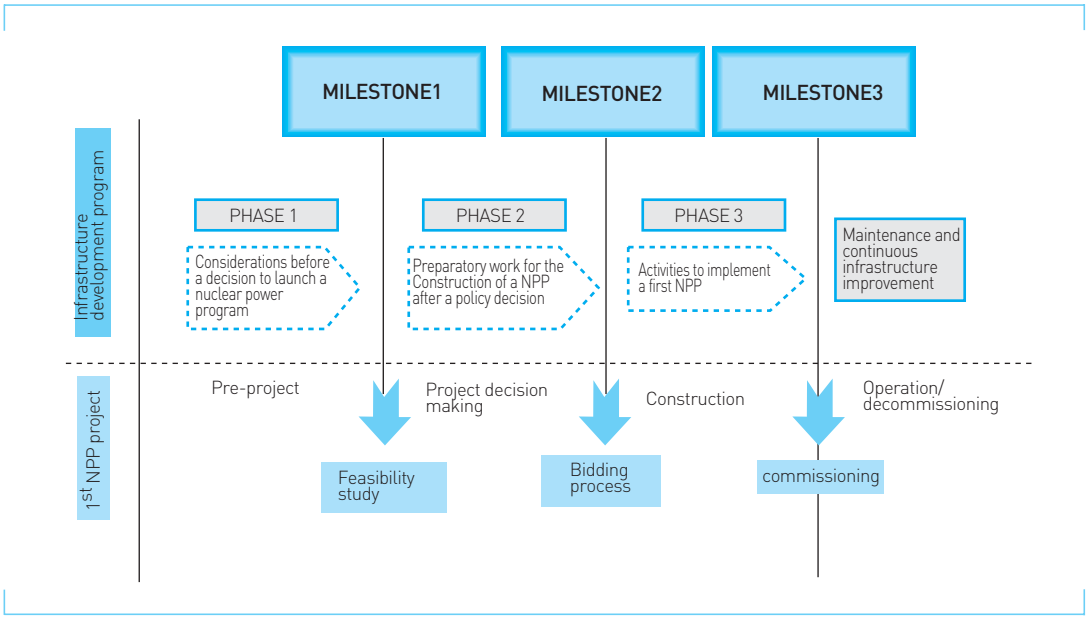
To introduce the first nuclear power project, there are several activities that can be split into three progressive phases of development. Those phases refer to the conditions necessary to demonstrate that each phase has been successfully completed. It should be noted that decisions in the early process can greatly affect the resources needed for the required infrastructure.

The three program phases of development are as follows :
- Phase 1: Considerations before a decision-making;
- Phase 2: Preparatory work for the construction after a policy decision has been taken;
- Phase 3: Activities to implement a project.

The completion of each phase is marked by a specific milestone at which the progress of the development effort can be assessed and a decision made to move on to the next phase. These milestones are:
- Milestone 1: Ready to make a knowledgeable commitment to a nuclear program;
- Milestone 2: Ready to invite bids for the first nuclear power plant;
- Milestone 3: Ready to commission and operate the first nuclear power plant.

A schematic representation of the phases and milestones is given in Figure 3-11.

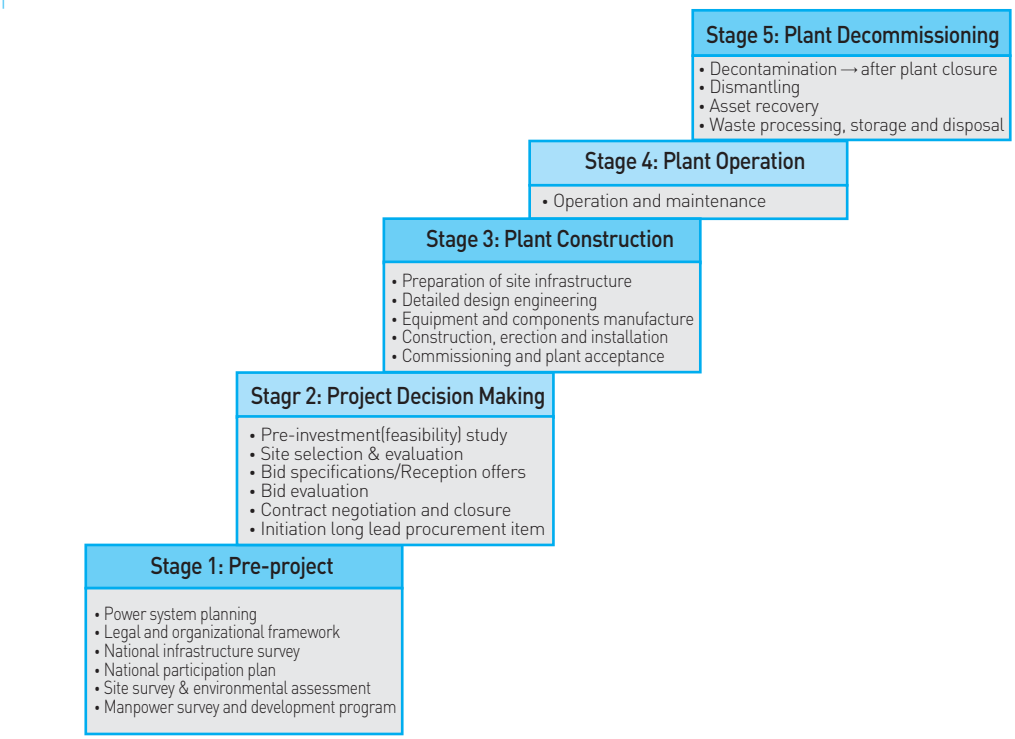
Figure 3-11 | A schematic representation of the phases and milestones of the nuclear power project



Typically three major organizations involve in the program: the government, the owner/operator of the nuclear power plant and the regulatory body. Each has a specific role and responsibility in the program.

The government may organize the activity for its own customs and needs. The owner/operator organization may be state owned, be part of a utility or be another commercial entity. The regulatory body is independent from the owner/operator and other government agencies responsible for nuclear safety, but may exist within the government.

Figure 3-12 | A Generic implementation stages of a nuclear power plant project



7.2. Project stages

The implementation stages of a NPP project planning is shown in Figure 3-12. All these activities are normally performed by several different private and public (government-regulated) organizations with a limited group of activities for the program objectives.

These activities can be regrouped in five distinct stages which makes the NPP project. Each activity corresponding to different stages may often be done in parallel.

7.2.1. Stage 1: Pre-Project

Stage 1 is defined as the period from the decision to consider nuclear energy to launching a pre-investment (feasibility) study for the first NPP project. This initial stage concerns with conceptual preparatory activities embracing all technical-economic-regulatory investigations for the project

On a long-term basis, it is necessary to consider specific new requirements on the country's infrastructure. The activities performed during the Pre-project stage are mainly related to:

- National energy supply planning
- Nuclear power program planning & cost estimation
- International conventions and agreements
- National infrastructure survey
- Sites survey & environmental assessment
- Reactor technology survey

The overall manpower needs for this stage are relatively modest, mostly oriented at directing, coordinating and registering data, but do involve a large number of organizations (private and public). For this reason, senior governmental directions are required to insure full participation and cooperation of all entities invested in the stage.

7.2.2. Stage 2: Project decision-making

This stage deals with the initiation of a pre investment study and the closure of a contract for the purchase of a NPP.

This stage entails preparatory activities to create a national infrastructure to support the launching of the project, leading to the decision making to go forward with it.

It is essential to establish and maintain a clear communication at the decision making level of the specific aspects of nuclear power, and a thorough knowledge of the tasks and activities for requirements, responsibilities, and commitments. The activities for the project decision making stage are mainly related to:

- Site evaluation and qualification
- Evaluation of the nuclear power supply market
- Implementation of the conformity plan related to legal framework
- Regulatory requirements
- Selection of a contractual approach
- Preparation of bid invitation specifications
- Bid evaluation
- Negotiation and closure of contracts
- Technology transfer and training requirements

The overall manpower needs for this stage are relatively few (50 to 100) but highly qualified professionals in need. The relevant staff should preferably have professional experience in complex interdisciplinary studies. The involvement of a knowledgeable consultant is recommended.

7.2.3. Stage 3: Plant construction

Following the closure of a purchase contract for a NPP, this stage continues to operate until the completion of the commissioning stage of the plant. This stage can be described as project oriented activities leading to the successful construction, commissioning and acceptance of the first NPP

The activities for this stage are mainly related to:

- Project management
- Plant safety
- Project engineering
- Procurement of equipment and materials
- Manufacturing of equipment and components
- Plant construction, erection and installation
- Plant commissioning and acceptance
- Turnover to operation
- Safeguards and physical protection

The overall manpower needs for this stage are higher than for any other stages. Within this stage, the activities of manufacturing and construction call for the largest manpower, requirements, of the order of 6000 people during its peak period. Most of these (about 85%) will be technicians and craftsmen. The prefabrication and modularization of sizable part of a nuclear plant will greatly reduce manpower at a site. In the nuclear power industry, the requirements for unskilled labor are generally very low (of the order of 10%).

Professionals are needed primarily for project management and engineering (250 to 350) at design and construction periods. Other supporting activities are included among : NPP project planning and coordination, regulatory and licensing, fuel cycle, research and development, and education and training.

7.2.4. Stage 4: Plant Operation

This stage begins from the plant commercial operation and ends at the decision to decommission the plant, including such activities as the safe and reliable operation and life management of the plant. Considering the actual expectation of the plant life (40 to 60 or more years), this represents the most extensive endeavor in the NPP project.

The activities for this stage are mainly related to:

- Operation and maintenance management

- Technical support
- Plant life and fuel cycle management
- Waste management
- Emergency plan
- Radiological protection and environmental surveillance
- Safeguards
- Physical protection
- Licensing and regulatory surveillance
- Public information and public relations

The overall manpower requirements for this stage are much directed by the policies regarding the uses of external contractors for preventive maintenance and planned shutdown. For guidance, the manpower requirements can be defined as an average of one worker for one megawatt electrical of gross capacity of the plant (680 MWe gross capacity would require approximately 680 workers).

This average can vary significantly with the experience of the operating utility and also when more than one plant is located on the same site. This average value of workers per MWe is not linear and tends to be as low as 0.7 as the plant gross capacity increases especially for multi-units station.

7.2.5. Stage 5: Plant decommissioning

This stage can be described as post operation activities leading to decommissioning of the plant and management of the waste within the frame of the country's long term waste management program.

The plant life could be extended beyond its duration with suitable life management programs that include control of degradation processes, maintenance, repair and refurbishing and replacement of plant components.

Deferred dismantling and entombment strategies allow for the processing and removal of some radioactive material from the facility. The costs of decommissioning NPPs including disposal of wastes usually do not exceed 2% of the total costs of electricity generation. Some countries collect fees in their pricing structure to cover the estimated cost of decommissioning.

The overall manpower requirements for the stage are directly related to the strategy selected. Either one will require highly qualified staff with similar qualifications as the one used in the implementation stage. Depending on the strategy, the manpower requirements range from a few hundreds to more than 1000 people.

7.3. Financing for Nuclear Power Plant Construction

There are uncertainties still remained since the NPP construction requires substantial amount of financing and the recovery of investment takes a long time. And since a developing nation usually does not have a prime credit rating, there are substantial difficulties in securing financing from external institutions.

To securing necessary financing required for the NPP construction in time is one of the critical factors to success of the project. Advance countries that lead the export of NPP technologies provide loans to promote the sale of their products. But keep in mind that there are significant difference in the loan conditions depending on the external credibility of the importing country and its utility. Accordingly, the importing countries of the NPP are required to make considerable efforts to secure as much financial resources as possible from its equity capital, national budget or banks of respective country.

There are also innovative concepts to consider like the Build-Operate-Transfer (BOT), Build- Own-Operate (BOO), Counter Trade or others. But keep in mind that with consideration for investment scale and risk, it is still a tough choice.

If the NPP construction is undertaken with private capital, with a private company undertaking the project alone, it would be too difficult and too risky for the investors. Shareholders prefer government participation in any possible way. Even when fully financed with the private capital, it is recommended that NPP project be carried out as PPP (Public Private Partnership) type with the participation of the government or public institutions and the government should contribute to the financing, regardless of scope of its participation.

Characteristics related to financing for the nuclear power plant construction are classified into four categories: size of vast investment amount, long construction period, uncertainty of construction costs and construction period, and public acceptance.

To minimize the uncertainty and risks related to the financing characteristics of the NPP, the following efforts have to be provided for securing financial credibility of external institutions.

The investment cost of power plant is classified into direct construction costs and indirect construction costs. The direct costs mean the expenses required for plant engineering, equipment purchase, licensing and installation, etc. The indirect construction costs include the support of head office for the project management, price increase during the construction period and interest expenses. In general, land purchase cost for the site, taxes, fees, development cost for infrastructure and initial core loading are not included in the investment cost of the project.

A financing plan starts with the collection of relevant data on the following project factors :

the total capital investment, the nuclear fuel cycle costs with front end and back end components, the respective local and foreign portions, the establishment of debt/equity targets and the assessment of potential financing sources.

7.3.1. Financing sources

Financing of a NPP project is typically underway through multi sourcing, a combination of export credits, commercial loans and owner's resources. For a conventional financing arrangement in the NPP construction, the principal sources of local financing may include:

- Owner’s resources
- Domestic bonds issues
- Domestic loans from local banks credits
- Credits from public entities
- Funding from local government budget
- Local suppliers

For the foreign scope, the principal financing sources are:

- Export credit agencies
- Commercial banks
- International development agencies
- International bond markets
- International suppliers

7.3.2. Owner’s Resource

The readiness of financing package arrangement will depend on the level of financial resources available to the owner. The resources may take the form of owner's equity, loans or appropriation from the national budget. In general, the World Bank regards that as a rule the owner's equity should be in the range of 20-30% for the power sector.

The International Finance Corporation (IFC), a member of the World Bank group, usually requires a minimum owner's equity of 30%. The amount of equity which the financial institutions require in a project is estimated at a function of the debt service coverage ratio.

In principle, local costs should be covered by domestic funds. Experience shows that raising enough money for local financing from foreign sources, local capital markets or government budgets has often proved to be difficult, being the main reason for delays in project construction.

8. Necessary Conditions to Establish a Nuclear Power Infrastructure

8.1. Developing a Nuclear Power Policy

8.1.1. Establishing a Nuclear Power Policy

In general, the construction process of the nuclear power plants takes approximately 10-15 years from the time of decision to commercial operation. It is a project that requires vast amount of investment and may significantly influence the national economy. In doing so, introducing the nuclear energy program requires also proper nuclear policy making and acceptance of the general public. In order to determine the nuclear policy, it is necessary to consider the electricity demand, the industrial infrastructure, environmental impacts, and the cost and period of construction.

8.1.2. Modifying Nuclear Power Administrative System

In order to implement the national policy for the nuclear power plant introduction, a comprehensive strategy has to be developed for evaluating the power demand and reactor technology, responsibilities of works, and legal systems related with nuclear power.

The government's administrative system should be considered for these functions. It is desirable that the government institutions involving in nuclear power should be directly under the sovereign entity such as the King, the President, and strong decision makers in its initial stage. This will ultimately influence the consensus of public acceptance, orientation of policy, and good project management.

The governmental ministries and departments have to be set up in accordance with relevant legal system and its procedure in order to address the nuclear power issues such areas as the safety, security, and radiation protection along with regulatory laws.

The legislation and its structural framework on all nuclear power-related activities provide also responsibility, licensing, compensation, regulation, and R&D program with respect to nuclear power and its administrative structure.

8.1.3. Establishing a National Nuclear Power Implementation Agency

Upon the completion of nuclear power policy making, there should be the establishment of a nuclear power implementation agency within the government at the initial stage, which is recommendable for a country that introduces the first construction of NPPs with the support of the government.

This agency will take roles of surveying the electricity demand & supply, evaluating economic assessment for the NPP and its reactor technology, and requiring the relevant legislation. By the operation of NPPS, this agency will have dealt with various implementations of national policy. This organization can be replaced by another institute after the operation of NPPs.

8.2. Nuclear Regulation Body

8.2.1. Enactment for Nuclear Power Safety

The nuclear regulations and licensing system is necessary for a country to build nuclear power plants at its preparatory stages because these legislation are mandatory for securing nuclear safety, evaluating the environment impact, licensing the construction and site, and the operation and maintenance for nuclear facilities.

The following scopes are responsibility of the regulatory body:
- Safety principle (protection and prevention)
- Security principle (the peaceful use of nuclear energy)
- Legal responsibility principle (utilities, operator, and licensee)
- Licensing principle (review and license)
- Control principle (inspection and monitoring)
- Compensation principle (nuclear accident damage liability)
- R&D (technology and technique related with review and inspection)
- Compliance principle (international treaties, convention, and agreement)
- Independence principle (separated from other implementation organizations)
- Transparency and information principle (notify the public of all nuclear activities)

8.2.2. Necessary Conditions for Nuclear Regulatory Body (NRB)

To establish a regulatory agency, the followings should be considered:
- Nuclear safety regulation, guidelines, rules, and related criteria by the NRB
- Review, evaluation, decision, and licensing procedure by the NRB
- Environmental requirements to electricity suppliers by the NRB
- Transparency policy and information sharing by the NRB

8.3. Major factors for a Nuclear Power Generation Project

Nuclear power implementation agency (NPIA) conducts economic evaluation on nuclear power, comparing it with other energy resources in terms of cost and efficiency and provide basic principles of decontamination, radiological materials waste disposal, funds for the spent fuel management, governmental compensation for nuclear accident, business transactions with

utilities on the produced electricity.

Electricity providers (utilities) definitely define the project cost, risk, financial reserves, and liabilities for nuclear accident aside from the government's support and liability scope.

8.4. Selecting Nuclear Power Technology and Project Implementation

The government officially announces the national nuclear power generation plan. In response of the government decision, the electricity providers prepares the project document of its purpose, scope, financial security and distribute it to companies that intend to participate in. The companies submit bids to the electricity providers. After the process of review and evaluation on proposed bids, the contract is concluded finally.

8.5. Fuel Supply, Radioactive Waste, Spent Fuel Management

To secure the stable supply of nuclear fuel for NPPs, the most important factor for the government and the electricity provider to consider is correctly estimating the demand of nuclear fuel in long term basis along with uranium enrichment and fuel fabrication capability. Both of them have to prepare for the radioactive waste disposal and the spent fuel management.

8.6. Human Resource Development

The professions needed for engineering, construction, operation and management of nuclear facilities are an essential part of national nuclear program. Particularly nuclear safety & regulation and radiation protection require advanced skill and experience in safety analysis, engineering and design, and nuclear materials treatment areas.

To take control of nuclear energy and power generation, at least, 200-1000 specialists are needed in R&D, operation and maintenance of nuclear facilities. The required subjects for this purpose are rather in the wide range of: Mechanics, chemical engineering, electricity, electronics, physics, civil engineering, medical physics, nuclear science and engineering, including the special fields of the accelerator and radiation utilization.

It is suggested that universities provide basic education on nuclear physics and natural sciences, R&D institutes on application of nuclear sciences, and industries on engineering, design, maintenance and operation for their peculiar objectives.

8.7. Enhancing International Cooperation

First of all, it is important to declare a country's transparency policy on the peaceful use of

nuclear energy to the international community and to lead the country to importing technology and the fuel supply from nuclear advanced countries.

For the country that intends to bring in nuclear power plants, it is of great advantage to join the international treaties and conventions such as the NPT (Non-Proliferation Treaty) and CTBT (Comprehensive Test Ban Treaty). International cooperation with the IAEA, OECD/NEA is also crucial to gain support and consultation from international organizations. Collaboration with neighboring countries in the same region will create a synergy effect that will raise the technological level for the nuclear power plant operation. Cooperation in the nuclear power industry can be categorized into two aspects: Nuclear power operation and nuclear power safety. Taking for an example, World Association of Nuclear Operators (WANO) and Institute of Nuclear Power Operations (INPO) provide various reports on NPP related accidents and prevention measures.

9. Recommendations for Nuclear Policy

With its steady economic growth and swelling population, Saudi Arabia is now facing with substantial electricity demand. There has been serious discussion on the nuclear energy introduction and its utilization in response of energy security and reduction of greenhouse gases from the government perspectives. In as much as Saudi Arabia contemplates the nuclear option and its program, it is necessary to consider what should be prepared and how to implement the nuclear program effectively.

The recommendations discussed in this report are based on Korea's experience.

9.1. Establish Firm Direction and Efficient Government Structure

In order to introduce the nuclear power generation for the first time, first of all, the firm resolution of the national leader is an essential part to coordinate many controversial views at the early stage and to resolve conflicts among the branches of the government for the concentrated efforts. To this end, formulating sound government administrative structure is important to efficiently pursue the national nuclear program. Suggestively it strongly determines the effectiveness of implementation in all aspects of the project.

Steps and measures taken by the authorities to examine the nuclear reactor technology and the forms of technology transfer should be integrated into one government agency as a window, which will negotiate with foreign nuclear reactor vendors and can ask for the self-sufficient technology transfer for its national interests.

From this point of view, it seems that the KACARE has adequate capabilities to take up the roles of surveying the national nuclear program and coordinating its implementation plan. Seeing that nuclear energy development planning should be laid out discreetly, promoting the fittest ways in which to complete the plan faithfully one phase after another, it is desirable that the KACARE takes the lead on the direction as a central point or the control tower for the national nuclear program.

9.2. Set up Effective Implementation Strategy

Driving strategy varies in the orientation of national nuclear policy and its objectives of implementation plan. To execute with the national nuclear planning in the way in which to accomplish effectively without much difficulties lies in two approaches to strategy. One strategic approach to the stable supply of electricity generation is to be geared to a priority on the efficient construction of nuclear power plants. Therefore, the point of negotiation with foreign reactor vendors may be aimed at the favorable conditions of construction and operation for NPPs.

The other strategic approach to the self reliance technology for nuclear energy is targeted to accomplish the infrastructure of nuclear R&D and technology-oriented projects along with the construction of NPPs. It implies that the government lays out research reactors, R&D institutes, education and training centers for nuclear science and its applications. To fulfill this strategic approach at an early stage, it is required to acquire highly qualified experts and to establish human resources development plan on the long-term.

For the establishment of the long-term nuclear development plan, there has to be national level of mid to long term goals to ensue. It is advisable for the government to formulate a Comprehensive Nuclear Energy Promotion Plan (CNEPP), which Korea devised for this purpose, so as to implement its national nuclear policy consistently and systematically.

Nuclear energy is not so much a mere generating power as it is an important lever of national economy and security. Therefore, any country looks upon the introduction of nuclear power as the standing highest on the list of its visions and policies. As a result, the government is able to give priority to the direction of its policies so as to support the R&D projects and their implementing subordinate research projects.

9.3. Focus on the Infrastructure for Human Resources Development from the beginning

The early human resources development in particular should be reflected to successfully undertake a nuclear project from the planning stage to the completion of it. In spite of budget constraints, Korea made efforts to send as many students and experts as abroad for study and

when returned, they took the leading roles in the success of R&D activities and the construction and operation for NPPs.

Special emphasis must be placed on establishing the infrastructure for education and training, accordingly, the network of human resource development should be formed for this purpose. While R&D institutes set up education centers for basic science and technology, for the purpose of nuclear power plant construction and operation, the utilities should lead the way to secure and develop the necessary human resource by their own education and training systems.

The universities with a department of nuclear engineering have to focus their attention on such nuclear fields as nuclear physics, radiation applications, and basic nuclear engineering in close cooperation with industries and R&D institutes. To foster innovative experts and specialists, it is recommended that providing expectant researchers with many opportunities in education and training as well as encouraging them to participate in international R&D programs is regarded as an excellent vehicle for improving the researcher's morale and expertise.

As a key element to national education for nuclear science and engineering, Saudi Arabia already owns good universities that have a nuclear engineering department. Only a further direction of education would be given to the aspect of that Saudi Arabia should seek the increase of relevant R&D facilities and the betterment of R&D ambiance.

Additionally, Saudi Arabia should dispatch students and researchers involved in nuclear R&D activities to professional education centers or special R&D institutions at home and abroad to directly learn the current trends of nuclear safety, system design, and application of research reactors by means of on the job training or joint research for the purpose of their capability enhancement.

9.4. Harmonize with International Frameworks for Technology Transfer

Owing to the consequence resulted from those concerns over nuclear weapon expansion and illegal uranium enrichment, nuclear advanced countries tend to avoid technology transfer to other countries that have not signed the NPT. Being fully recognizant of such circumstances and international practices, the emphasis for national policy should be placed on the more securing nuclear technology internally without a friction with other countries. As for obtaining technological self reliance, the government should continuously develop the joint R&D opportunities for technology acquisition under the principles of reciprocal cooperative relationship with nuclear advanced countries.

It is essential to secure the trustworthiness and the transparency of national nuclear activities

on the peaceful uses of nuclear energy by actively joining all the international conventions and agreements such as NPT and CTBT for nuclear nonproliferation such as NPT and CTBT. The importance of bilateral cooperation with regional states and nuclear advanced countries cannot be overemphasized.

It is possible to achieve the national goal of nuclear energy development, only if each participant in their functions-the government, industries, universities and research institutes countrywide-do its best in performing its share of the duties, bearing in mind that the country can also broaden its international cooperation activities with appropriate partnership.

9.5. Build Efficient Technology Incubator and Warehouse

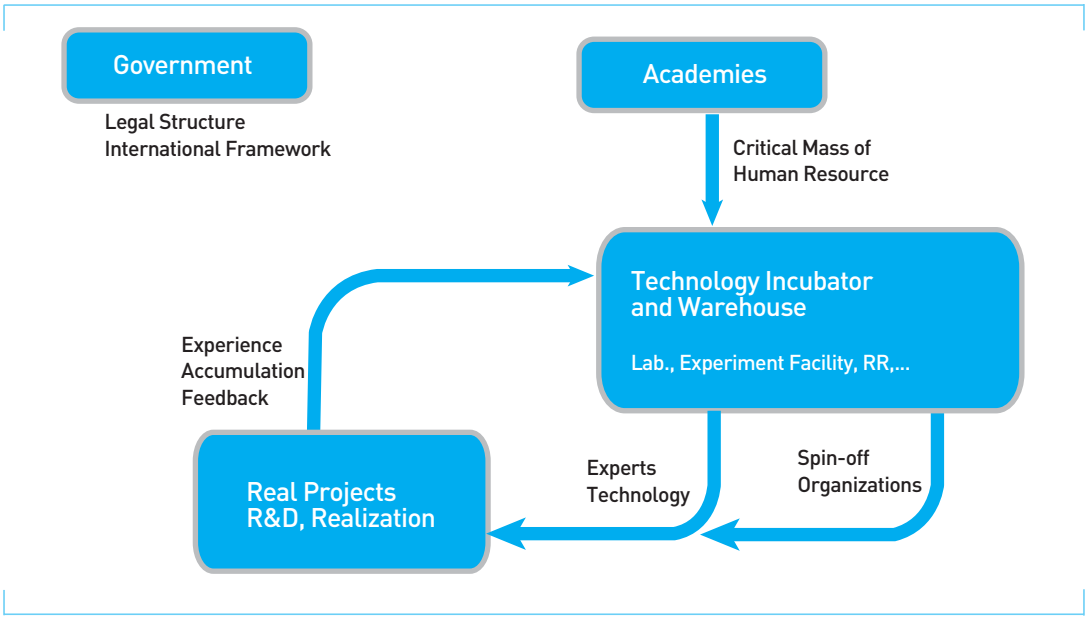
What is important in introducing nuclear technology is for the government to formulate its government administrative structure with a strong commitment to national nuclear policy, nuclear legal system for regulation and safety, international cooperation models, long term human resource development plan. However, the most important point of all is that establishing a nuclear R&D institute as a technology incubator or a technology warehouse is the key to supporting all of these elements.

KAERI played such R&D institute's role so that the necessary infrastructure was successfully and effectively established. Although technology transfer is usually conducted through engineering company and industries, KAERI as a technology transfer center played significant role as a technology incubator, sharing the technology to the relevant industries when they were ready. It is worthwhile to benchmark Korea's approach especially those countries, which have to import, localize, and further enhance the technology.

The results of R&D activities should be transferred to a document record system to allow the participants of the next project to take advantage of the previous data and to gain further perspective on their specific research directions.

Accumulated R&D results and practical technology developed in the process are being merged into a form of package and a follow-up technology transfer to industries and other R&D institutes can be expedited for national interests.

Figure 3-13 | The Schema of the Organization Structure for Nuclear Program



References

International Atomic Energy Agency, *Basic Infrastructure for a Nuclear Power Project*, IAEA-TECDOC-1513, June 2006.

International Atomic Energy Agency, *Lessons Learned from the Development of the Korean Nuclear Power Program*, December 2008.

International Atomic Energy Agency, *Managing the First Nuclear Power Plant Project*, IAEA-TECDOC-1555, IAEA, Vienna (2007).

International Atomic Energy Agency, *Milestones in the Development of a National Infrastructure for Nuclear Power*, IAEA Nuclear Energy Series No.NG-G-3.1, IAEA, Vienna (2007).

KAERI & MEST, 50 Years of Nuclear Energy-50 Years of Prosperity, January 2008.

Korea Atomic Energy Research Institute, 50 *Years Story of Korea Atomic energy Research Institute*, April 2009.

Korea Atomic Society, 50 Years Story of Korea Atomic Power, May 2010.

MEST, A Five-Year Plan for Nuclear Research and Development, 2007.

MEST, The 3rd Comprehensive Nuclear Energy Promotion Plan, 2007.

Ministry of Education, Science and Technology, *Nuclear White Book* 2010, June 2010.

Ministry of Knowledge Economy & Korea Hydro & Nuclear Power Co., Ltd, *Nuclear Power White Book* 2010, June 2010.

MKE, The 4th Electric Power Supply and Demand Master Plan (2008-2022), December 2008.

http://en.wikipedia.org/wiki/King_Saud_University.

http://ksu.edu.sa/AboutKSU/Pages/History1.aspx.

http://sau.mofat.go.kr/kor/af/sau/main/index.jsp, Embassy of the Republic of Korea in the Kingdom of Saudi Arabia.

Policy Recommendations for Economic Development
in Priority Areas of the Kingdom of Saudi Arabia

Chapter 04

Korea's Smart Grid Policy Initiatives

Chapter 04

Korea's Smart Grid Policy Initiatives

Chang Seob Kim (Kyungwon University)

1. Korea and Power Industries

1.1. South Korea Overview

South Korea, officially called the Republic of Korea (ROK) and sometimes simply referred to as Korea, is an East Asian country, located on the southern part of the Korean Peninsula. Its capital is Seoul. South Korea lies in a temperate climate region with a predominantly mountainous terrain. Its territory covers a total area of 99,392㎢ (115th in the world) and it has a population of 48 million (26th in the world). South Korea has a market economy which ranks in 14th in the world by nominal GDP, USD 929.1 billion, and 10th in the world by trade, USD 950 billion, identifying it as one of the Group of 20 (G 20) major economies as well as a member of OECD. South Korea is the only developed country to have been included in the group of Next Eleven (N-11) countries so far. South Korea had one of the world's fastest growing economies from the early 1960s to the late 1990s, and South Korea is still one of the fastest growing developed countries in the 2000s, along with Hong Kong, Singapore, and Taiwan, the other three members of Asian Tigers. The key industries and global ranking of Korea are shown below.

Figure 4-1| South Korea Key Industries and Global Ranking

Source : Korea Smart Grid Institute.

1.2. Climate Change and Energy Solution

People have realized that environmental crisis is getting serious than before. The US makes 25% of greenhouse gases which equal to greenhouses from 4% of the world's population. Most of electricity in the US are stick to burning coal because of sufficient resource. Once people attempt to reduce carbon footprint and stake a claim to global environmental leadership, renewable energy sources like solar, wind and geothermal could expand to worldwide. In order to develop renewable energy, implementing technologies linking them to the grid are necessary, even if their potential will not be fully realized.

Korea is one of the biggest energy consuming countries in the world, but with the condition of 97% foreign energy dependency. Energy imports of USD 91.2 billion in 2009 was much higher than the exports of semiconductors, autos, and mobile phones combined (USD 87.4 billion). Why is Korea striving for green growth? i) Climate impact. Average temperature rises by 1.7˚C which is twice higher than world average. ii) Energy security vulnerability. iii) Economic slow-down. Korea must have a brand new path to move forward.

1.3. Korea Electricity Industry

Reliability and efficiency with operating of 60,269MW facilities satisfy the demand for electricity in Korea. Through the experience of establishing and running those facilities, Korea has developed its own technologies as well as accumulated extensive knowledge which can be readily tailored for various customer needs worldwide. Korea has made great efforts to achieve an optimization of generation resources since the oil crisis in 1974. Especially, Korea Electric Power Corporation (KEPCO)’s dependency on oil for power generation, which reached around

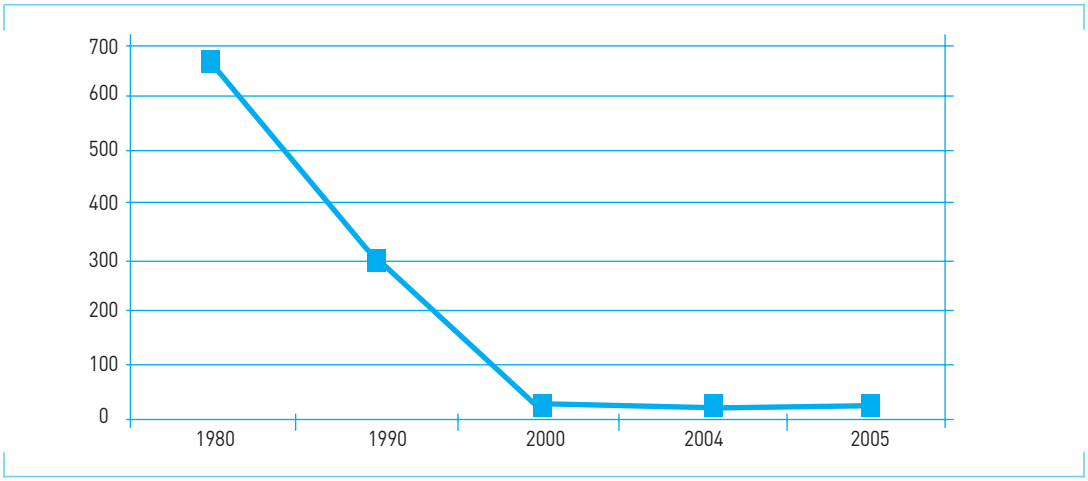
90% in the 1970s, is now about 7%, whereas dependency on nuclear and coal energy has greatly increased. Meanwhile, in response to strengthened environmental regulations and a rapidly growing demand for electricity, Korea has focused alternative energy source including combined cycle power plants. Most combined-cycle power plants were constructed near metropolitan areas in the 1990s and have been displaying outstanding performances. In particular, the Seoinchon Combined-Cycle Power Plant (3,600MW installed capacity) was awarded the 1993 Power Plant Award for its operational excellence in achieving the highest thermal efficiency (49.58%) and the lowest emission of NOx (below 50ppm).

Metropolitan area needs more than 40% of total load demand and only 20% of total generation capability inherently requires a large volume of power transfer from other regions. Most of generating units with low generation cost are located in non-metropolitan areas. With the aim of economic operation, generators in the non-metropolitan region mainly take charge of the base load and then generators in the metropolitan region is operated to meet the demand increase in peak time. This also makes power transfer increase toward the metropolitan region. Therefore, these interface lines, six routes, from the non metropolitan regions to the metropolitan region are heavily loaded. The total length of transmission line is 29,929 c-km.

1.4. Comparison of Power Infrastructure

Korea’s power IT infrastructure is young but already smart. Other advanced countries' power infrastructure becomes superannuated, but Korea has a relatively new power infrastructure and superior operation ability. Korea has world's best power qualities; the outage hour of Korea is just 14.29 min/year (i.e. France is 57 min/year, UK is 68min/year, USA is 122min/year (2008)).

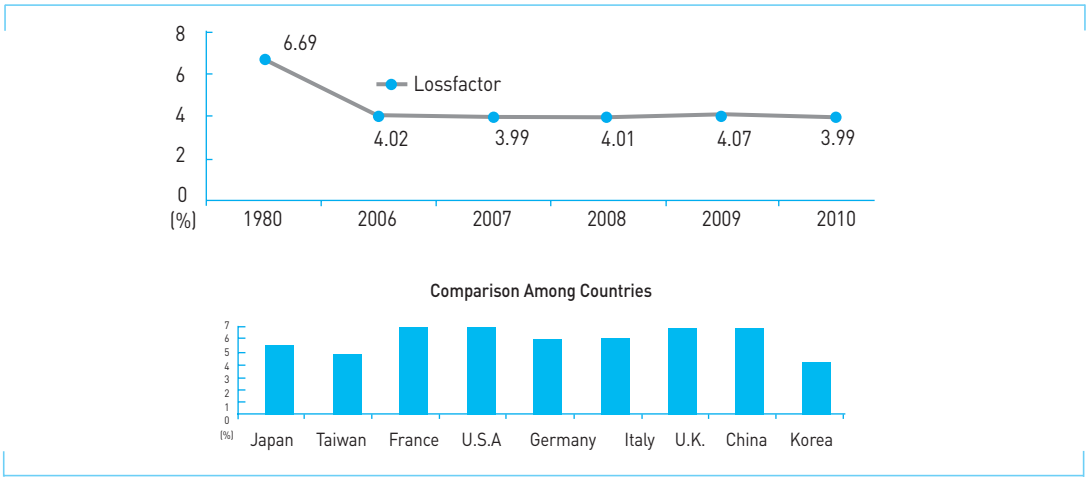
Figure 4-2| Outage Hours of Korea



Source: KEPCO.

Another example is the loss rate of transmission and distribution. In Korea, the loss rate is just about 3.99% in 2001, but in the U.S., the loss rate is more than 6.8%.

Figure 4-3| Loss Rates of Transmission and Distribution



Source: KEPCO.

Today, many countries recognize the necessity of enhancing energy efficiency, tackling climate change, and triggering a green energy revolution. Korea believes that energy efficiency is resolution to overcome energy crisis in future.

2. Why Smart Grid?

2.1. Core Engine of Green Growth

Korea aims to build the world's first nationwide Smart Grid system to reduce its CO_2 emissions by monitoring energy use more carefully. Unlike conventional electricity grids, Smart Grid allows two-way communication between electricity suppliers and consumers, as well as enabling more dispersed generation and storage of power. According to a government-led committee, South Korea could lower its greenhouse gas emissions by 40 million tonnes annually with a national Smart Grid. The committee's findings estimate that Smart Grid would reduce overall energy use by 3% and lower the peak load for electric power by about 6 percent. The electricity savings would be equal to the output of seven 1GW nuclear power reactors. The committee comprises government officials, company executives and representatives and researchers. It did not provide a cost estimate for the project yet. Consumers could reduce their electricity bills by an average of 15% by charging their appliances and cars during off-peak hours, as indicated through the use of smart meters.

The general concept of Smart Grid is core engine of green growth. A smarter grid makes this transformation possible by bringing the philosophies, concepts and technologies that enabled the internet to the utility and the electric grid. More importantly, it enables the industry's best ideas for grid modernization to achieve their full potential. It would act as a Test-bed for the nationwide initiative. The grid will incorporate two 10MW substation transformers and four power distribution lines located near an area with 3,000 households, commercial districts and green energy facilities that include a wind farm. The US has similar plans for a nationwide Smart Grid, with $4.5bn earmarked for investment in related technologies.

2.2. Smart Grid Construction of the World

Different countries deploy Smart Grid to meet their different situations and needs. In the United States, the reliability of the electrical system (due to under investment in the infrastructure), growing demand and the increasing difficulties of building new transmission infrastructures are the primary drivers for Smart Grid.

The operational status of Smart Grid of major countries in the EU is as follows: The British Department of Energy and Climate Change (DECC) has published a Smart Grid roadmap comprising a high level description of the way in which a U.K. Smart Grid System could be delivered to contribute to the realization of government carbon targets and end customer benefits. In France 78% of power produced is from nuclear power. In addition, coal, natural gas, bio meth and wind power are all various methods used to produce power.

Given the potential benefits of Smart Grid systems, the Japanese government has decided to launch a verification test for the Smart Grid as early as fiscal 2009. The Federation of Electric Power Companies of Japan is to develop a Smart Grid System that incorporates solar power generation; this is to be completed by 2020.

Between eastern and western regions of China, it is important to reduce the power generation gap. China established five independent electricity generating companies and several transmission companies. The five generators have an equal share of the assets.

The Indian government announced the Electricity Act; this aimed to improve the efficiency of the existing power distribution networks and add capacity for power generation. With an energy growth rate of 12% per year, power distribution has been a key issue in India and the Electricity Act was the first step towards reformation.

The Essential Services Commission of Victoria, Australia (ESC) released its changes to the Electricity Customer Metering Code and the Victorian Electricity Supply Industry Metrology Procedure to implement its decision to mandate interval meters for 2.6 million Victorian electricity customers.

Hong Kong has a high population density, and Electric Vehicles (EV) and renewable energy will reduce such contamination occurs.

2.3. Background

Korea needs the Smart Grid for several reasons. First of all, continuous increase for power demand is expected. People's demand for an increased quality of life requires for an increased energy demand. At the same time, demand is transferring from primary energy to secondary energy (price distortion). Secondly, the condition for building power transmission facilities is deteriorating. There are severe constraints to construct power line towers because of the 'NIMBY' phenomenon. In addition, an unavailable operating situation causes some problem which happens to build power transmission facilities after constructing power generation equipments. The third, a tighter regulation for CO2 is expected. The Korean government announced its CO2 reduction target by 2020. Among the three options it had considered, Seoul chose the most stringent goal of cutting greenhouse gas emissions by 4% from 2005 levels. Therefore, it is time to require a serious commitment from the public. Besides, it is visualized as allocation between parts due to management by objective (MBO), emission trading (ET) and so on. Moreover, early distribution is made as a result of renewable energy. The Renewable Portfolio Standard (RPS) introduction and the demand response is vitalized so that expansion of BEMS (Building and Energy Management System)/HEMS (Home Energy Management System)/FEMS (Factory Energy Management System) and smart appliances is expected. Lastly, a desire for cooperation between power industry and other industries such as telecommunications, constructions and power companies are increased. It means demand for green energy and CO2 is increasing. That would be why a bidirectional, smart and distributed robust power system is required.

2.4. The basic direction of the Korea Smart Grid Promotion Act

The basic direction of the Korea Smart Grid Promotion Act consists of the following four parts: First, the problem of the complexity will be solved by the Distribution Management System. D-EMS is for the intelligent integration of the local unit of smart grid operation. It is not only stable for the next generation power distribution system but also for the effectively integrates information and communication system. Secondly, S/W technical ability should be strengthened in comparison of H/W. Thirdly, It is suggests a roadmap for the power grid intelligence. The goal of the Smart Grid Promotion Act is promoting a stable operation. Fourthly, it is required to create collaboration structure among industries.

3. Korea Smart Grid Demonstration Overview

3.1. An overview of Korea’s Smart Grid Progress

The Korean government launched Power IT Project in 2005. It benchmarked intelligent grid model of the United States and had features to enhance power infrastructure and to create additional services. It also contained technology driven policy.

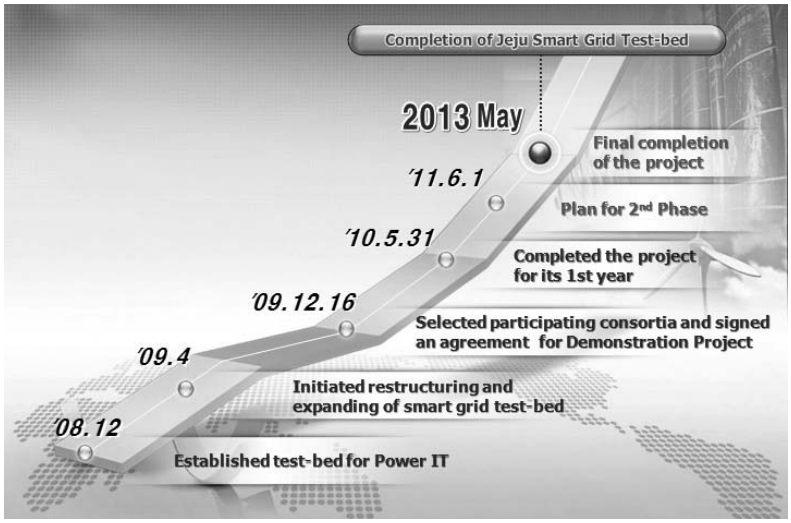
In 2007, there was energy technology and power IT development until new growth engine was established in 2008. At the same year, there was an attempt to shift focus on the export oriented integrated model influenced by a smart grid policy of the United States.

In 2009, Korea adapted a smart grid program. It contained basic business models for converging businesses with business model driven policy. In addition, Korea was designated as a smart grid leading country at the Major Economies Forum. The presidential committee on green growth was established to lead Korea's green development and to propose a global model and an open grid structure.

3.2. Smart Grid Demonstration Progress Timeline

In 2010, Korea initiated the Jeju Smart Grid demonstration project and launched the Total Operation Center (TOC). 168 companies and 12 consortia have been participating in the Jeju Smart Grid demonstration project. The three strategic directions stated in the vision and goals of the Jeju Smart Grid Test bed initiative clearly show the nature of a green growth strategy embedded in this project. The key concepts of basic stage are building a basic infrastructure of power grid place, transportation parts and enabling consumer, grid connection, which will be developed until 2011. After this, expansion stage, in which building an integration of renewable, electricity service, and accommodating DER (Distributed Energy Resources) will take place until 2013.

Figure 4-4| Jeju Smart Grid Demonstration Progress Timeline

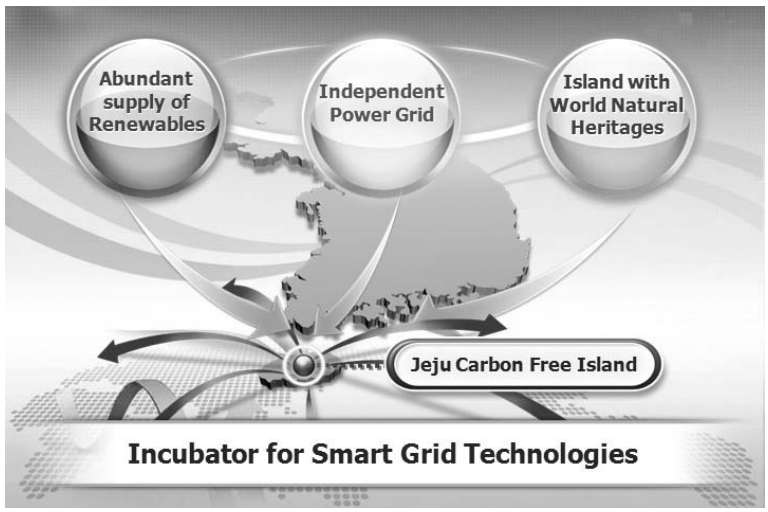


Source : Korea Smart Grid Institute.

3.3. Smart Grid Construction of Jeju

The most noticeable plan in Korea's Smart Grid project is the construction of a Smart Grid Test bed in Jeju Island. The Korean government selected Jeju, in June 2009, as the Smart Grid Test bed, and broke ground in August 2009. Test-bed is the very proof of a Smart Grid, the basis for a low carbon, green growth strategy.

Figure 4-5| Smart Grid Construction of Jeju



Source : Korea Smart Grid Institute.

Why is Jeju being used as the center of the smart energy technology? The following three observations can be summarized. First, Jeju has abundant renewable energy resources such as solar, wind and tidal power. Secondly, the power grid environment in Jeju is independent because Jeju is far from the mainland. Finally, Jeju was recognized by UNESCO as a world natural heritage. Such factors can be the starting point of smart grid technology.

3.4. Consortia for the Jeju Smart Grid Demonstration

In the Jeju Smart Grid Demonstration, about 10 consortiums will participate in testing technologies and developing business models in five areas. The three strategic directions stated in the vision and goals of the Jeju Smart Grid Test bed initiative clearly show the nature of a green-growth strategy embedded in this project. This project is conducted with the participation of the Korean government, Korea Smart Grid Institute (KSGI), Korea Electric Power Corporation, the Jeju Special Autonomous Province, companies joining the complex, Korea Smart Grid Association, research institutes, and academia. A total of 64.5 billion won will be injected between 2009 and 2013. Please see the table for the detailed information of the participating companies.

Figure 4-6 | Consortia for the Jeju Smart Grid Demonstration

	Leads	Participating	Investment(Dollar)
Smart Place	SK telecom	Samsung electronics, Korea Cable TV, Jeju broadcast etc (29 companies)	Govt : $ 5 million Private: $ 25 million
	olleh kt	Samsung SDS, Samsung Trade, Rootech etc (14 companies)	Govt : $ 4.7 million Private: $ 30 million
	LG Electronics	LG U+, GS pure cell, GS construction etc (15 companies)	Govt : $ 4.7 million Private: $ 17.5 million
	kepco	Samsung electronics, Taihan Electric, Nuri Telecom etc (38 companies)	Govt : - Private $ 10 million
Smart Transport	kepco	Samsung SDI, Lotte data communication, P&E Solution etc (22 companies)	Govt : $ 4.5 million Private:14 million
	SK energy	SK Network, Iljin Electrics, Ientech etc (13 companies)	Govt : $ 4.5 million Private: 13 million
	GS Caltex	LG CNS, ABB Korea, NexCon Take etc (7 companies)	Govt : $ 4 million Private: $ 8 million
Smart Renewable	kepco	KOSPO, Hyosung, LSIS etc (16 companies)	Govt : $ 4.7 million Private: 15.3 million
	HYUNDAI	Maxcom, Icellkorea etc (6 companies)	Govt : $ 4.7 million Private 7 million
	posco ICT	LG Chem, Woojin Industrial System, Daekyung Engineering etc (6 companies)	Govt : - Private: $ 9 million

Source: Korea Smart Grid Institute.

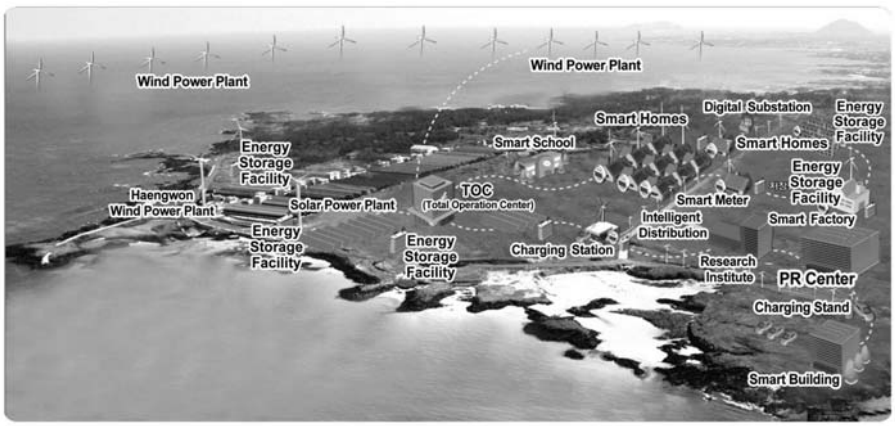
3.5. Characteristics of the Jeju Demonstration Project

Business in the Jeju Smart Grid Demonstration is quite competitive because 168 companies are participating in various fields. Increased participation by investment firms was found to be an environmentally friendly business model. Therefore, this project demonstrates Korea's aspiration for green growth. The Jeju Smart Grid Test bed will become the world's largest Smart Grid community that allows the testing of the most advanced Smart Grid technologies and R&D results, as well as the development of business models. This Test bed will also serve as the foundation for the commercialization and industrial export of Smart Grid technologiesExpectedly, it will greatly contribute to strengthening Korea's position as a leader in the global Smart Grid industry.

3.6. Jeju Smart Grid Test bed

The most noticeable plan in Korea's Smart Grid project is the construction of a Smart Grid Test bed in Jeju. The Korean government selected Jeju on June 2009 as the location for Smart Grid Test bed. The figure 4-7 shows the entire architecture of the Jeju Smart Grid Test bed. The Jeju Smart Grid is a type of integrated Test bed that allows the testing of the most advanced Smart Grid technologies and R&D results, as well as the development of business models. It will encourage the collaboration between public and private sectors to verify the different power market models. This project is conducted with the participation of the KEPCO, automakers, telecommunications companies and home appliance manufacturers. Especially, the major companies such as LG, SKT, KT and POSCO are collaborating to build this Test-bed. 12 consortiums, 168 companies in five areas are participating in testing technologies and developing business models. Also, the Jeju Smart Grid test bed is open to foreign companies to participate.

Figure 4-7 | Jeju Smart Grid Test-bed



Source: Korea Smart Grid Institute.

The Jeju Smart Grid project consists of 5 categories: Smart Place, Smart Transportation, Smart Renewable, Smart Power Grid, and Smart Electricity Service.

First, Smart Place aims to reduce energy consumption by installing advanced metering infrastructures (AMIs) in homes and buildings, and to allow consumers to re-sell stored energy. This allows an easy access to consumed electricity information via different media, such as Internet, TVs, mobiles etc., and provides incentives for consumers. Also, it provides integrated service between electricity and telecommunication. Smart Place will connect all smart appliances to AMI and operate micro grid. Second, Smart Transport aims to develop a service model for EV charging infrastructure and ensure system to minimize the effects that charging may have to the grid. Smart Transport will develop business models for auto repair service, parking management, navigation, etc. Especially, Smart Transport includes developing a charging infrastructure using distributed energy and EV charging system. Third, Smart Renewable focuses on development & field test of power stabilization technology and business models in the Jeju Smart Grid Test bed Smart Renewable targets the stabilization of unstable power from renewable energy sources. Also, it will test different modes to improve the quality of stored renewable energy and operate micro grid. Fourth, Smart Power Grid focuses on delivering next generation network using the smart grid as its basis. Smart grid will allow a two-way communication between the supplier and consumer, and perform a self automated recovery system. Finally, Smart Electricity Market aims to operate and establish a system that provides real time pricing for consumers and ensure high quality of electricity.

3.6.1. First Phase Progress Report

Korea recently released its official assessment of the first year results of the Jeju Smart Grid Project (December 2009 to August 2010) and demonstrated public exhibitions. Public consensus is necessary to implement a nationwide smart grid project. Companies not only present and introduce smart grid prototypes but also educate the public. The exhibition will be sustained during and after the demonstration project so that participants can witness first hand on technologies and viable business models. Main Exhibition center shows the Korea's smart grid concepts and the Jeju Test bed. Four smart grid themed exhibitions featured SKT's Smart Convergence, KT's Smart Mobile Energy, POSCO's Smart Renewable, and LG's Smart Appliances.

Figure 4-8 | Four Smart Grid themed exhibitions

Source : Korea Smart Grid Institute.

Notwithstanding the big accomplishments, some problems still remain. First, inflation of business model is induced by a mixed technology and business oriented policy. Second, it seems unable to solve a dilemma among converged businesses with the incompetent convergence collaboration of information. Third, government policy and KEPCO's confused judgment on its business management result in weak leadership. Ever since, KEPCO has voluntarily abandoned its leadership. Forth, innovative procedures are not suitable for the performance and its progress speed. For example, the U.S. is accelerating into market penetration after establishing its infrastructure and standards, but Korea preceeded to develop R&D first, then established infrastructure. And the last, technology track is not oriented. Power IT version, converged BMs version, demonstration version, various simultaneous versions are mixed. Therefore, dynamic application of limited supplies is only possible.

3.6.2. Next Steps

The next steps in the Jeju Smart Grid Test bed are verifying the 5 domains of demonstration projects, inducing competition, and acting smart grid promotion. Test-bed will create platform for energy management and test demand response solutions. Also, it will provide a smart metering service and construct facilities for the operation of micro grid. Each consortium will perform in a competitive environment, and the government will provide persistent support to allow creation of new business models. Business outcomes will be incorporated with national standard and deployment of smart grid. The law is expected to be enacted to stimulate the smart grid and to help facilitate the execution of the national smart grid roadmap.

In Korea, the smart grid is to create value through the convergence of different industry

sectors. However, there is still too much uncertainties in regulation and electricity markets. These uncertainties could hinder companies interested in the smart grid from actively investing in smart grid. To alleviate the uncertainties and risks, new legislation of smart grid is proposed.

4. Smart Grid Promotion Act

4.1. Background

The Smart Grid Promotion Act allows technological and institutional continuity for smart demonstrations and smart pilot city projects. The project outcome from the Jeju Smart Grid demonstration will help coordinate different aspects of smart grid businesses, such as smart grid deployment, R&D, workforce Development, etc. Enactment of the Smart Grid Promotion Act will provide a solid foundation for the smart grid related businesses and induce greater investments.

Currently, smart grid R&D is much dependent on voluntary participations from companies. It needs legislative support to sustain project and maintain companies' participation in the future. Major economies such as the United States and EU are designing to enact legislations to support R&D, standards, and smart grid deployment. There is an urgent need to provide legislative support for the smart grid to address climate change issues and to compete in the global green market. In addition, the Electricity Enterprise Acts applied to generation, transmission/distribution and power exchange restrict convergence of business. It is needed to transcend current legislative constraints by regulating a law that advocates converged infrastructure. Smart grid is a key technology that allows energy reduction, EV deployment and use of renewable energy. Formulated solid frameworks such as the National Smart Grid Roadmap and the Jeju Smart Demonstration project are required to facilitate enactment of smart grid regulations.

4.2. Framework for Smart Grid Policy

The purpose of framework for the smart grid policy is to develop and execute primary plan for a smart grid (i.e., to develop and execute comprehensive plan for the deployment of smart grid and fostering of correlated businesses). Primary plan (5 years) is aimed at technology development, deployment, commercialization and standards, etc. Enforcement plan manages outcomes and coordinates plans annually. Another purpose of framework is to develop a periodic transitioning plan for technology deployment and replacement to ensure participation from electricity suppliers and users. The 19th article under the primary plan for smart grid designates one relevant institution as the Korea's Smart Grid Promoting Agency and requires the institute to execute governmental policies, oversee R&D, smart demonstration, deployment and ensure information security.

4.3. Legislative Support and Application

Individuals wishing to initiate a business for managing and supporting of the smart grid industry may register via the Minister of Knowledge and Economy (MKE). The scope of work for smart grid business ranges from manufacturing of equipments to providing correlated services. Business license registration standard will be based on the presidential decree.

This bill provides a basis for companies to receive subsidy in the case that they are making business investment for the benefit of the public and plans to finance through utilizing the Electric Power Industry Basis Fund, the Treasury of Energy Resource and the National IT Industry Promotion Agency Fund. If necessary, a smart pilot city will be selected for the wide deployment and dissemination of smart grid; government will manage portion of the required expense. The selection standard and process will be in accordance with the presidential decree. It provides administrative and financial support regarding technology development, demonstration, policies and workforce development.

It also provides technological and resourcing support regarding international standard, R&D collaboration to help domestic companies to penetrate into international market. Furthermore, it enforces technology verification and technology standardization to secure safety of smart grid and its compatibility with related equipments and products.

4.4. Compiling, Applying and Securing Information

Compiling private information for smart grid cannot occur without the consent from the information provider. Information provider can request access and deletion of his/her personal information; the information holder is required to take an appropriate action.

To provide efficient service for grid users/consumers, a service provider can request to share/access collected information from another service provider. However, request to share information should be carried out, if not, an appropriate action will be taken by the Minister.

The Minister of Knowledge Economy may advise business operators on technology standard, information access and service interconnection to ensure compatibility of the smart grid. It will take measures to protect the smart grid from outside source intrusion. No individual has the right to access, manipulate, demolish, expose smart grid or take other violating actions without permission or justified reason.

4.5. Smart Grid Demonstration Action Plans

There are Smart Grid Demonstration action plans with five areas.

○ Step 1 (2010~2012) : Testing of new technologies with construction and operation for Test bed is completed.

○ Step 2 (2013~2020) : Expansion of region and advancement for consumer side are completed.

○ Step 3 (2021~2030): National unit with advancement of the entire grid is completed.

Table 4-1 | Smart Grid Demonstration action plans

Goal	Step 1 ('10-'12) Construction / Operation for Test-bed (Technology Testing)	Step 2 ('13-'20) Expansion of Region (Advancement for consumer side)	Step 3 ('21-'30) Completion of National unit (Advancement of entire grid)
Smart Grid	• demonstration of digital transmission technology • demonstration of automotive distribution • demonstration of technology for power delivery facilities which monitor and diagnosis	• controls of real time monitoring for wide-system • connection with power distribution system to distributed power generation / storage device	• operation of smart grid with integrated energy
Smart Consumer	• management of power for smart home • variety of rates and consumers' choices	• power management of smart building/plants • activation for consumers'power generation	• non zero energy home/ building
Smart Transportation	• construction of EV charging facility, pilot operation • EV pilot testing	• expansion of EV deployment • development of businesses for charging infrastructure and service	• common charging infra • variation of EV/charging service • V2G services
Smart Renewables	• connection to renewables • pilot testing of microgrid • operation of power energy storage with small scale	• construction of systems for renewable deployment • pilot testing of microgrid • operation of power storage device with medium and large scale	• development of renewables with wide scale • common use from microgrid
Smart Elect. Service	• development of real time rate • pilot testing of wholesale power market with real time • pilot testing of demand resources with real time	• trading derived products of wholesale power market • application of real time rate nationwide • voluntarily market participation	• activation for various types of power trading • activation of convergence market for power industries • leading of market for Northeastern Asia

Source: Korea Smart Grid Institute.

5. DAS (Distribution Automation System) in Korea

DAS (Distribution Automation System) is a system that makes the distribution system operating in high efficiency. DAS is the remote monitoring and control system of breakers and switches on distribution network in real time covering the distribution substations and supporting the optimal network operation such as fault processing, loss minimization and load balancing. It is composed of the control center, automated switches, remote terminal units (RTUs), communication network and the modem. In the intelligent DAS, additional functions such as Monitoring & Diagnosis of the equipment, Power Quality monitoring and interconnection of DG to the power grid are added. The control center consists of the main server, backup server, historical server, MMIs and FEPs. In the distribution network, several kinds of automated switches and breakers are networked through the RTUs. Finally the communication network interconnects the RTUs in the field and the FEPs in the control center. The main server is the integrated system with SCADA and DAS, includes several kinds of applications, monitors and controls the substation and the distribution feeder together.

In the late 1990s, the development of DAS was completed by KEPCO. It is being operated in 189 nationwide branch offices and 41 distribution centers successfully. It is expected to reduce the average time for each outage by about 33% and to improve the reliability, efficiency of operation, and execution for DAS from automatic load transfer.

Table 4-2| Processes of DAS

Period.	KEPCO's Progression
'65	2 Looped feeders were constructed (Between substations in Seoul) 220/380V LV line recommended
'83	"Distribution Automation Research Plan" confirmed
'84	Test feeders decided (4 Lines in Kyunggi Area)
'88	Test Facilities were installed and tested
'90	KODAS (Korea Distribution Automation System) development initiated
'98	Small DAS installed and operated - Simple functions (PC level)
'03	Small DAS installed and operated - Simple functions (PC level)
'06	System Automation Rate: 52.8%
'09-	Fault-Preventive DAS will be developed (2011-2020) Expected Rate of System Automation: 100% (2015) Connection with SCADA (Intelligent DAS) - SCADA + DAS + AMR Communication Method Change - PLC, TRS 6-Divided 3-Connected system

Source : Korea Smart Grid Institute.

6. Conclusions

In order to achieve successful implementation and deployment of a smart grid in Korea, Korea is trying political attempt to converge various businesses for construction of zero-carbon city, development of renewable energy, smart appliance, U-city, power grid with intelligent distribution and smart transportation. However, there are some problems and pending issues to solve: to apply the technology development and demand oriented power system/supply chain for heavy electricity industries is urgently needed.

Korea has the best power and telecommunication infrastructure, but lacks other capabilities. Korea needs to utilize strengths which is simultaneous cooperation based on solid platform. It shows the most optimal application services/smart phone services markets with the strategy.

Some supports are required to perform the roadmap: 1) technology development and business support, 2) expansion of optimal model on the implementation for smart grid, 3) infrastructure construction, 4) improvement of legislative and political systems.

First, power market may improve core technologies of smart grid and advance the international market. The entire cycle, 'technology development standardization common uses,' makes a local market grow. It advances the international market development by the engine of innovative industries. It promotes to deploy EVs, energy charging devices for EVs, AMR/IHD, and energy storage devices, which can widen the market in 2011. Government can provide financial supports with the mid and long term technology development on preferential. It is required private matching funds to support for the technology development with a short term demonstration.

Second, it might activate to invest and encourage the public' participation when it succeeds in building up the model from the Jeju Test-bed and expanding projects step by step.

Third, it is necessary to establish early the smart grid infrastructure and incentives. Also, the strategy of penetration on the international market needs standardization/certification systems and training systems for experts. It should ensure the security system for a reliable smart grid construction and operation.

Lastly, it needs the establishment of institution and regulation at an early step. The improvement forces convergence of relevant business to develop innovative industries. It includes adopting the rate of real time and countering plans for reliable power supply. Enforcement of the Smart Grid Promotion Acts is to implement long-term projects. It shows an importance of financial supports and tax incentives in order to develop smart grid and operate it effectively.

Therefore, those supports play a crucial role in performing the smart grid roadmap.

6.1. Suggestions for Saudi Arabia

Saudi Arabia established a long term development plan (2005-2024) that includes development of its social infrastructure, such as creating jobs and setting up a good education system, medical system and welfare services. The country is also making huge investments in basic infrastructure for the education, health, water, transportation, communications and housing sectors. Currently large cities, such as the King Abdullah Economic City, are under development in the country. To prevent investment redundancies from occurring during the infrastructure investments and to ensure that all the various services are effectively interconnected, the cities need to be operated in an organic manner. This is all possible with the ICT based U-City. It is hoped that Korea, a globally recognized ICT leader and the first country in the world to set up a U-City, can provide substantial benefits to Saudi Arabia by sharing its vast knowledge and experience in this field. First, an overview of Korea's expertise and knowhow in this area is provided, which may be beneficial to Saudi Arabia in its ICT and city infrastructure development. Then, recommendation of the U-City model is made which is considered to be most suited to Saudi Arabia's needs.

Korea’s Power Grid Expertise

Korean power systems have been expanded and improved rapidly in terms of quantity and quality, complying with the requests of customers to follow the improvements in the level of life styles and for the stimulation of industrial development. That is, since the development of a network of 154kV power systems around the middle of the 1970's and the first operation of the 345kV transmission line for domestic use in 1976, the construction of 345kV transmission lines contributed to a revolutionary improvement in supply reliability and a reduction of power loss in spreading to a nationwide grid as well as to metropolitan areas. Also, to solve the difficulty of obtaining financing for transmission lines, a plan to increase the 765kV transmission line voltage was adopted in 1998. In 1997, to solve the deficit of the management by reducing generation costs in the Jeju area, the business of the HVDC power system interconnection between Jeju island and the main peninsula was completed.

Table 4-3| Major Achievement in Transmission and Distribution Systems

Year	Major Achievements in Transmission and Distribution Systems
1975	Construction of the first 345kV transmission line running 93km between Yoe Soo power plant and Sin Nam Won substation
1979	Installation of Dual On Line Real Time Computers in the head offices of A.F.C (Automatic Frequency Control) and E.L.D (Economic Load Dispatch)
1981	Start up of the first SCADA system in the Seoul Power Transmission Department
1988	Department establishment of EMS (Energy Management System)
1992	Construction of the highest pylon (195m) in Asia crossing the Han River
1993	Construction of the first 345kV underground transmission line running between Mi Geum and Seong Dong in the eastern area of Seoul
1997	Plant for 300MW HVDC link between Jeju Island and the mainland
2002	The first 765kV transmission line energized
2003	NDIS system operated in Seoul

Source : Korea Smart Grid Institute.

Korea has boasted its advanced technologies and experience in transmission and distribution system operation and automation. The T&D loss rate was world top level of 4.01% in 2008. The Korean power system has a 3 level hierarchical structure comprised of a Central Load Dispatching Office (CLDO or EMS), a Regional Control Center (RCC or SCADA) and a Local Control Center (LCC (or M SCADA). SCADA's major functions are presented in Table 2-6. First, the responsibility of the CLDO is to give out dispatches and the operation of the 345kV power network, frequency control, economic dispatch, and control of the operation plant units except small hydro power plants. Second, the responsibility of the RCC is to manage all the 154kV power network facilities and small power plants, which are not controlled by the CLDO. KEPCO (Korea Electric Power Corporation) introduced the SCADA system in the RCC in 1981 and had it installed in 12 PTDO's (Power Transmission District Offices). Third, local control centers are installed in power transmission centers. They monitor and operate remote unmanned substations. The M 7500s were KEPCO's-first SCADA generation system and are now being replaced with the new system, XA-21. The M 9200 is the second-generation system and is still in operation. The TADCOM-5000 and TADCOM-Xs are systems made in Korea which located in a few RCCs and 29 SCCs (Sub Control Centers).

Distribution automation has been adapted from the early 1990's in Korea. And, numerous R&D has been also conducted, adopted and even exported in this field. DAS is the system that remotely monitors and controls switches over feeders. The early version of DAS mainly focused on remote monitoring and control, but now more advanced functions have been adapted such as automatic fault processing, network reconfiguration to minimize losses in distribution domain, load balancing in feeder line and so on. R&D in this area has been started since 1991. The first

generation of the DAS aimed at remote monitoring and control of switches in the field with IT technologies. And the second generation expanded the functions to the automatic fault detection and processing in the feeder line and optimal operation with the minimizing losses and load balancing in the distribution network. And the third pursues real time monitoring of aging status for distribution devices and of power quality. Related project for this has been conducted until 2010. And the fourth generation could be the fault prediction system with a considerable amount of Distributed Energy Resources (DERs) in the future distribution network. The first and the second model have been deployed and operated over 80 and 110 branch offices respectively. And the first system has been replaced to the second system recently. The distribution network in Korea has an operation voltage of 22.9kV, and designed with multipoint feeder direct grounding. There are 7,700 distribution feeders and 45,417 automated switches were installed in feeders. Each feeder has six or seven automated switches for efficient MV network operation. System designers can select the optimal communication media among optical fiber, telephone wire, wireless data communication, CDMA, and trunked radio service depending on the field conditions. TDAS was set up in 190 business offices located in all major cities of South Korea.

Table 4-4| SCADA Major Functions

Major Functions	Items
- Remote supervisory for power system's operation	- Circuit breakers and disconnection switches - Protection relay's operation - Alarm occurrence
- Remote control of unmanned substations' equipment	- Circuit breakers and disconnection switches - Transformer tap changers - Static condenser - Control panel switches
- Tele-metering	-Line Voltage, Current and Bus Voltage - Watt, Var -Oil temperature and wire temperature of transformers
- Event logging	-Circuit breaker's and disconnection switches'operation - Alarm due to network faults - Alarm due to system faults - Alarm due to equipment's erroneous action
- Report generation	- Daily monthly, and/or yearly reporting
- Dispatcher training function	- DTS(Dispatcher Training Simulator)
-Data Link	- EMS-SCADA: network status, network load current - SCADA-SUB SCADA: 154kV substation status, load current

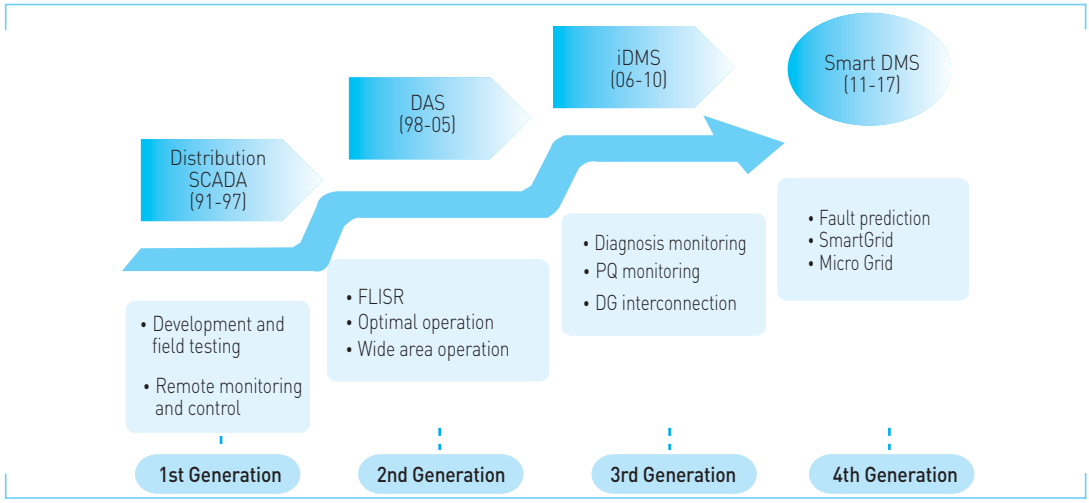
Source : Korea Smart Grid Institute.

Table 4-5| Number of DAS

Item	1998	2000	2002	2004	2006	2007
Automated Switch Numbers	896	8237	16915	25443	33785	45417
Ratio(%) of automated MV Feeders	5	42	50	75	90	96
TDAS installation Numbers	1	2	12	34	67	190

Source : Korea Smart Grid Institute.

Figure 4-9 | Development of Distribution Management in Korea



Source : Korea Smart Grid Institute.

In Korea, a Government program has been launched in 2006 to upgrade Korean power system infrastructure by merging state of the art IT technologies. In transmission and distribution area, 9 projects has started, iDMS is one of the projects for the followings.

- Remote operation of facilities from S/S to customer
- SCADA+DAS+GIS+AMR integrated solutions
- High speed data highway and intelligent RTU
- Intelligent equipment / sensor and real time diagnosis
- Interconnecting DG
- Enabling optimal network operation

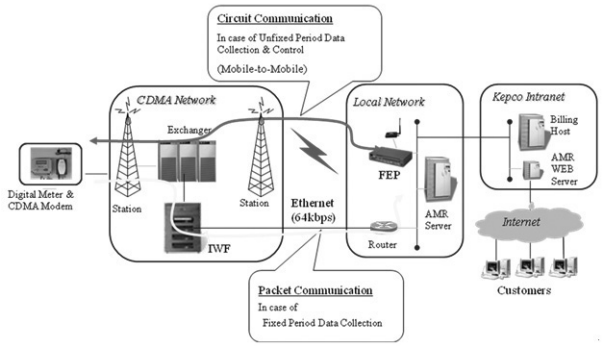
For this, iDMS project has 4 main research topics.

(1) Development of the Central Control System and integration
(2) Development of the Intelligent RTU and data processor

(3) Development of the Intelligent distribution equipment / sensors
(4) Development of the DG integration and field test

AMR (Automatic Meter Reading) is a next generation technology used to increase efficiency of electricity management by replacing traditional manual meter reading process performed by human resource with computer and communication technology. Central computer performs reading of usage meter of individual consumer and as results, calculation errors have minimized remarkably thus satisfy services level for customers as well as effective management of energy. KEPCO has introduced AMR system by using CDMA network for their industrial and commercial customers at year 2000 and as a result, they opened new era of commercialized AMR system. Recently, the number of customers with AMR has increased to 150 thousands. Also, pilot project for general house holders (low voltage) who use 40 % of total electricity of Korea is in progress for 1500 houses in Jeju since end of 2001. Mechanical remote meter readers easily seen by residential and commercial building in the past will disappear in near future.

Figure 4-10 | AMR Architecture



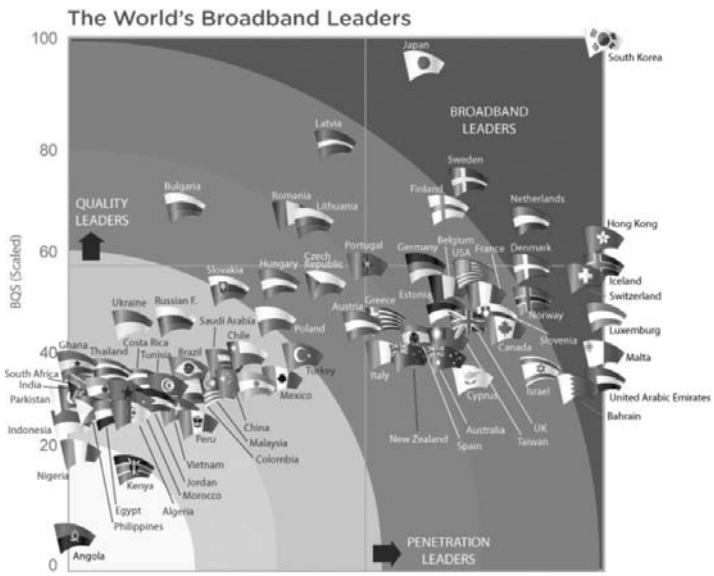
Source : Korea Smart Grid Institute.

Korea's ICT and U City Expertise

Being a world-recognized ICT leader, Korea is quite competent in the building and operation of top-notch fixed and wireless networks. Telecommunications services are accessible from anywhere in the country (nationwide coverage), and the country currently has 19.5 million landline phone users, 50 million mobile phone users (penetration rate: 102%), and 16 million households as fixed line Internet users (penetration rate: 93%). The fixed line broadband Internet service, in particular, is on the rise worldwide. As much as 49% of Korea's broadband Internet subscribers are FTTH users, which is a significantly higher figure than the world average which is at the 11% level. Figure 4-11 shows the ranking of countries based on their

broadband Internet service quality. Korea ranked first in the market penetration rate and readiness for future services such as IP based TVs and video communications. In addition, Korea was the first in the world to launch a commercial WiBro service and it has also been actively leading the provision of wireless broadband Internet services by setting up more than 20 thousand Wi-Fi hotspots across the country. Such fixed and wireless communications infrastructure has set the stage for various new services, such as e-commerce (market worth KRW671 trillion), contents (market worth KRW5.7 trillion won), online advertisements (market worth KRW1.5 trillion) and the IPTV. Each of these services has grown to the extent that it is now considered an industry in its own right.

Figure 4-11 | Country Ranking Based on Broadband Internet Quality

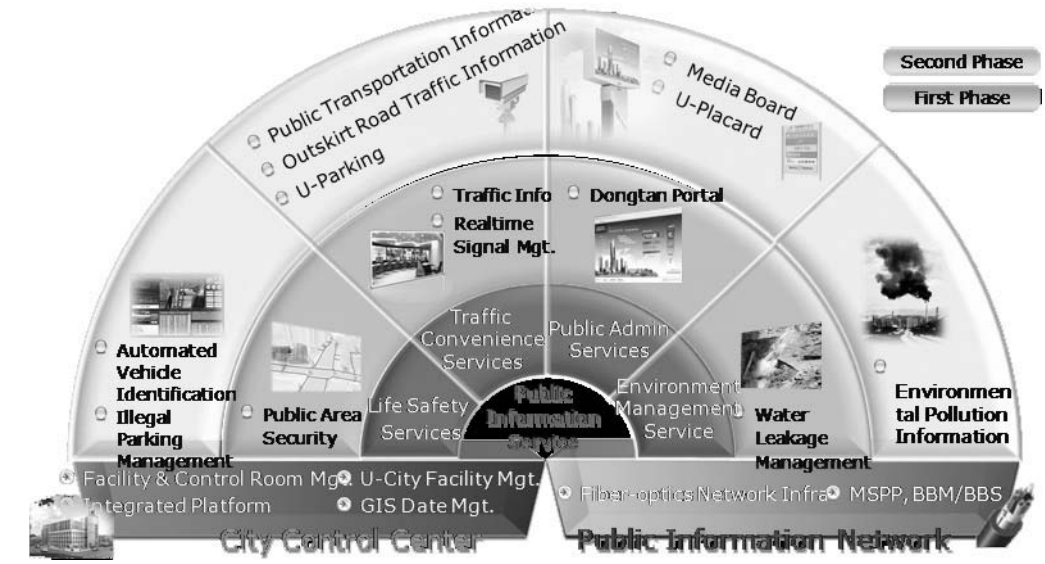


Source : University of Oxford.

Buoyed by its strong ICT infrastructure and skill sets, Korea is actively engaged in the U - City business. The U-City, which was formed based on cutting-edge IT technology, is a city designed to ensure that information needed for efficient management of the city is accessible from anywhere at anytime. Korea built the world's first U-City in the Dongtan area of Hwasung city. It is the only country in the world to have the knowledge and expertise required for all the stages, starting from design to operation of the U-City. The construction of the U-City was initiated in 2006 in Dongtan, a 903.7 ha sized area that holds 40 thousand households and 120 thousand residents. The project was completed after three years, with the city in full operation now. In the U-City, various public safety, crime control, traffic convenience, and environment

management services are provided, such as the real time traffic information service, traffic lights control, illegal parking management, license plate identification, CCTV based remote security service, water leakage management, e-bulletin board (U-Placard), and the information service for the environmental pollution (See Figure 4-12). Furthermore, air and water quality related environmental data, vehicle and public safety information are all collectively managed in real time at a central control center. In this 860m^2 sized control center, there are 28 monitoring agents who work in four shifts and 602 CCTV cameras and real time information are provided to assist the agents in their control work .

Figure 4-12 | Dongtan U City Services



Source : Dongtan U City.

Operation of the Dongtan U-City has brought about numerous economic and social benefits to Korea. This integrated form of management is expected to directly lead to a cost savings of around 2.9 billion won (Table 4-6).

Table 4-6| Cost Savings Resulting from Dongtan U-City Operation

Classification	Items	Cost Saving (USD)
Implementation Cost	Integrated Center for several services	2.5 million
	Space saving	20 thousand / yr
Operation Cost	Labor cost for city management	60 thousand / yr
	Maintenance cost	60 thousand / yr
	Other benefits from integrated operation	200 thousand /yr
Total		2.9 million

Source: Ministry of Land, Transport and Maritime Affairs Analysis Data.

Aside from the cost savings achieved through the integrated management, there are also benefits arising in the areas of public safety and overall cost efficiency. Thanks to the license plate recognition method using the CCTV, identifying cars has become much easier, leading to a major drop in the crime rate by as much as 50%. As for the overall cost efficiency, the benefit cost(B/C) ratio derived for the past 11 years of operation is 1.57.

Table 4-7| Dongtan U-City Cost Benefit Analysis

Classification	Item	Scale	Remarks
Total Cost	Implementation Cost	KRW 46 bil.	
	Operation Cost (11 yrs)	KRW 20.3 bil.	
Total Benefits	Direct Benefits for Local Government	KRW 7.9 bil.	Tax income increased through personnel cost reduction and illegal parking management
	Social Benefits	KRW 96.3 bil.	Transportation time saved, water loss caused by water leakages prevented, property loss and casualties reduced through crime prevention measures, traffic congestion prevented through management of illegal parking
B/C (Benefit/Cost)		**1.57**	

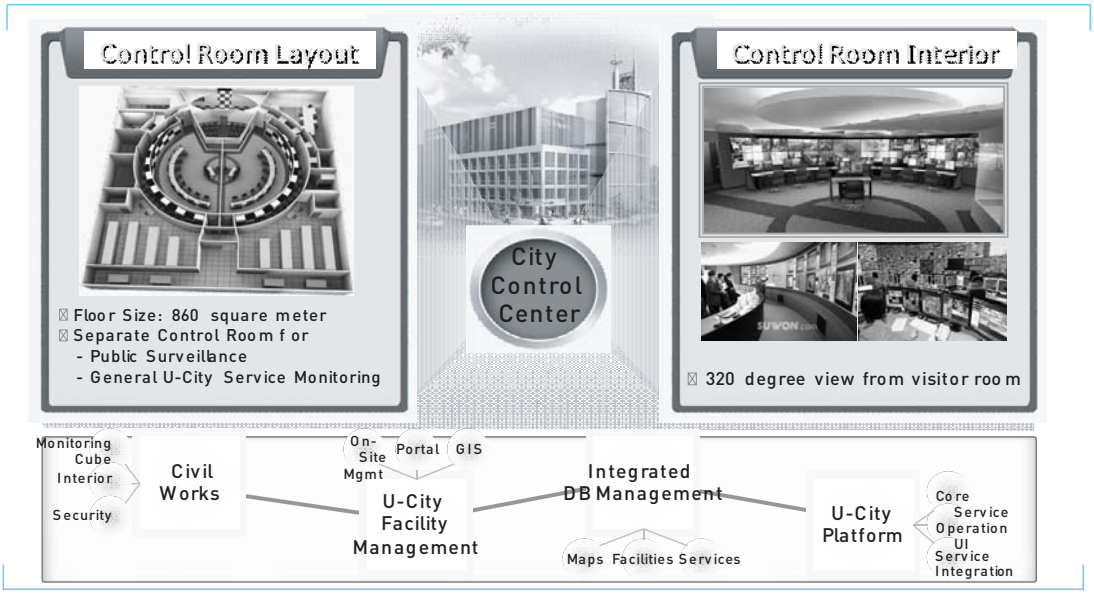
Source: Ministry of Land, Transport and Maritime Affairs Analysis Data.

Despite these validated economic and social benefits, instead of simply concluding that the U-City is a perfect model, Korea is using its experience to identify obstacles that may hinder a successful development, and seeking ways to effectively solve such obstacles. The biggest obstacle is that currently the U-City is centered around the construction companies, telecom

operators, and the major players in the U-City. This Problem which makes it difficult to apply an integrated control system to the city. To resolve this problem, Korea is seeking close collaboration with other industries as well, such as the energy, medical and educational sectors. Another obstacle is that due to the fact that the U-City is interlinked with various industries, the business scope is overly wide and conflicts of interest are occurring due to the large number of business regulations at play. As a result, achieving convergence between industries can be somewhat difficult. Therefore, the government's active intervention is needed to facilitate an effective convergence with the energy industry and to promote collaboration between industries. Another problem that needs to be addressed is the expectations held by the U-City citizens. A lot of the citizens have misconceptions, thinking that the U-City is like the futuristic cities featured in science fiction movies and as a result, they end up being disappointed when they see that the newly built U-City is not what they had expected. Thus, starting from the planning stage, the government and relevant parties need to make sure that the objective and expected benefits of the U-City are clearly communicated to the citizens.

To achieve maximum economic and social benefits, Korea is currently working to convert the U-City which was previously structured around the ICT and construction businesses, into one which is centered around an integrated control system. As such, efforts are being made to effectively combine the infrastructure from various sectors, such as the energy, medical and educational sectors, and to establish it into a “Green Smart City,” so that the climate change issue, a subject of much concern these days, can be properly addressed.

Figure 4-13 | Dongtan U-City Central Control Center Setup

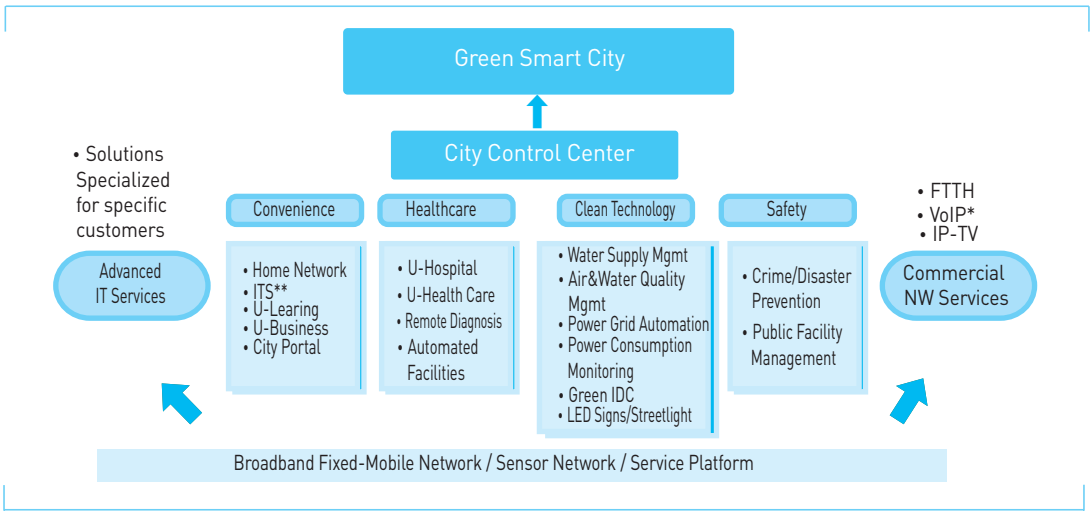


Source : Dongtan U City.

6.2. Green Smart City in Saudi Arabia

"Green Smart City" refers to a U-City that uses its fixed and wireless communications infrastructure and City Control Center to provide useful solutions, such as educational, health, security, Green IT and energy conservation solutions. The various services that were provided and validated in the Dongtan U-City, such as security, transportation convenience and environmental services, will naturally be provided, and these will be accompanied by energy infrastructure management services, such as water supply management, power grid automation management and power consumption monitoring. In addition, to support Saudi Arabia's long term master plan initiative, which is to expand the country's educational and medical infrastructure, services such as U-Learning, clinical data repository, chronic illness management and telemedicine, will be provided as well (See Figure 4-14).

Figure 4-14 | Saudi Arabia Green Smart City



Source : Korea Smart Grid Institute.

More specific examples of the medical services available include U Hospital, which is currently in use at the major hospitals in Korea, such as Severance Hospital, Seoul National University Hospital and Asan Medical Center. Severance Hospital in particular started using medical information systems since 2005, such as the prescription order communication system(OCS), picture archiving & communication system, electronic medical record(EMR) and management information system, and also adopted the RFID patient card and smart card for the convenience of their medical staff and patients. By adopting the U Hospital system, the patient diagnosis and treatment process could be simplified, leading to shorter waiting time for patients. Hospitals can now provide one stop services, mobile services and swift medical services to its patients. As for the medical staff, they are provided with an enhanced information sharing

system and increased business efficiency. Moreover, from the business management perspective, as the strategic, financial and operational cost data are provided, an activity based cost management system can be effectively set up (See Figure 4-15).

Figure 4-15 | Severance Hospital's U Hospital System

Source : Severance Hospital.

U-Health Care makes life more convenient for patients suffering from chronic medical conditions such as diabetes or hypertension, as they no longer need to come to the hospital, but can instead receive telemedicine services ranging from remote diagnosis to health management. For example, Severance Hospital started providing a pilot service in March, 2011 to fifty of its diabetes patients. The patient's blood glucose level is measured and then sent to the doctor on an as needed basis via a video phone, to be used by the doctor during the diagnosis and treatment of the patient. In addition, the patient can also use the video phone to directly consult with the doctor and talk with a call agent to make appointments with a doctor (See Figure 4-16).

Figure 4-16 | Severance KT U-Health Care Solution

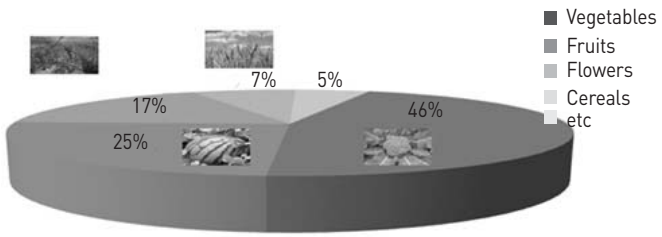
Source : Severance Hospital.

Korea's U-Hospital and U-Health Care, both validated solutions, will likely bring great benefits to Saudi Arabia, which does not yet have sufficient medical staff and facilities and where 9% of the total population suffers from chronic medical conditions such as diabetes and obesity. It is expected that Korea's experience and expertise in ICT and the U-City, including the Green Smart City medical services, will contribute enormously to Saudi Arabia's social and economic advancement.

6.3. Implementation in Saudi Arabia for Agriculture

The most important factors to produce crops are temperature, humidity, and the amount of sunlight. Especially, in the Middle East, where is extremely dry with strong sunlight, maintaining stable level of temperature and humidity is a very crucial technique.

Figure 4-17 | Severance KT U Health Care Solution



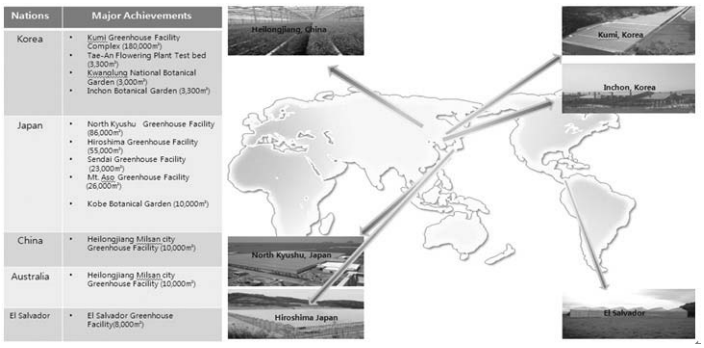
Source : Ministry for Food, Agriculture, Forestry and Fisheries.

In Korea, which has small agricultural land and seasonal climatic fluctuations, automated greenhouses supported by high technology and science are commonly practiced to bring an efficient and stable crop production. An automated greenhouse provides an optimizing environment for growing crops, using a computer network system to control various units, such

as air conditioning, heating cooling system and artificial lights.

An automated greenhouse can be divided into two categories of an automated plastic greenhouse and an automated glasshouse. In Korea, among crops grown in greenhouses, vegetables (46%) and fruits (25%) are the most popular, followed by cultivating flowers (17%) and cereals (7%) respectively.

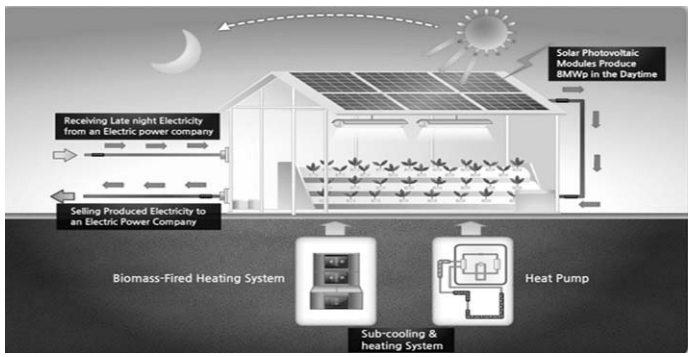
Figure 4-18 | Overseas Expansion by Korean Technology



Source : Ministry for Food, Agriculture, Forestry and Fisheries.

Based on the domestic greenhouse management experiences, many countries have been achieving a lot of greenhouse constructions and related technology transfers. In the case of Japan, Korean companies' biggest greenhouses importer, over a million square meters of greenhouse facilities have been made in various regions, such as Hiroshima (55,000 m^2) and North Kyushu (86,000 m^2). Besides, Korean companies keep their greenhouse construction records on track in many countries in the world, such as China (10,000 m^2), Australia (20,000 m^2), and El Salvador (8,300 m^2).

Figure 4-19 | Overview of greenhouse for smart grid



Source : Ministry for Food, Agriculture, Forestry and Fisheries.

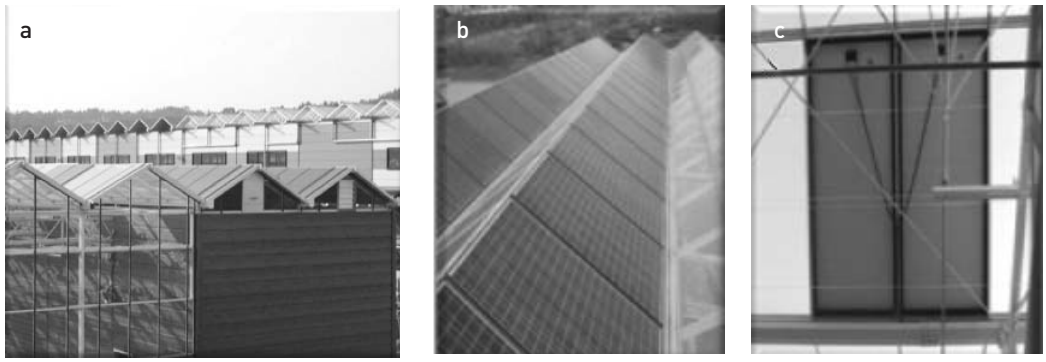
With the experience, Korea would like to suggest "An Automated Glasshouse, Using Sunlight and Artificial Lighting with Solar Photovoltaic Modules." This facility is composed of an ordinary automated glasshouse, installed solar photovoltaic modules on the rooftop to use the abundant amount of sunlight in the Middle East.

If solar photovoltaic modules are installed on the rooftops of 300,000 square metered glasshouse facilities, it can generate up to 8 MWp (Mega Watt Power).

The electricity, produced by its photovoltaic system in the daytime, can be sold to a local electric power company. On the other hand, the local power station can provide "late night electricity" such as artificial lights to the local facilities to operate various necessary production units at night.

Additionally, a geothermal heat pump and a biomass fired heating system can be used as auxiliary heating cooling system to overcome a huge daily temperature difference in the Middle East area.

Figure 4-20 | Structure of greenhouse system for smart grid



Source : Korea Smart Grid Institute.

(a) The rear view of the whole facility
(b) The view of Solar Photovoltaic Modules on the rooftop
(c) The looking up view from the inside of the glasshouse

The capacity of the photovoltaic system can be decided by the various data, such as the amount of sunlight and the kind of crops.

Korea hopes this revolutionary and eco-friendly crop production system would be commonly used in the Middle East area.

References

Master Plan Research of Jeju Smart Grid Demonstration, Korea Smart Grid Institute, 2010.

http://gifkorea.org/file/roadmap.pdf2010.1.25. Korea Smart Grid Roadmap, Ministry of Knowledge and Economy.

Ministry of Strategy and Finance, Republic of Korea
Government Complex 2, Gwacheon, 427-725, Korea Tel. 82-2-2150-7732 www.mosf.go.kr

Korea Development Institute
130-740, P.O.Box 113 Hoegiro 49 Dongdaemun-gu Seoul Tel. 82-2-958-4114 www.kdi.re.kr

93320
9 788980 635375
ISBN 978-89-8063-537-5

Knowledge Sharing Program
Center for International Development, KDI
- P.O. Box 113 Hoegiro 49 Dongdaemun-gu Seoul, 130-740
- Tel. 02-958-4224
- www.ksp.go.kr