Nuclear Energy in Korea

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Abstract

The total electricity generated in 1998 was 215,300 GWh with 43,261 MWe of total installed capacity of electric power, while in 1978 when the first Nuclear Power Plant began operation it was 31,510 GWh with 6,916 MWe installed capacity. The share of nuclear power generation in 1998 increased up to 41.7%. Currently, 16 units of nuclear power are operating with an additional four units under construction.

Nuclear power has contributed to enhancing energy security and supplying stable energy for Korea. The government's strong commitment to the nuclear power program together with a long-term national policy resulted in favorable conditions for KEPCO to manage the program and promote increasing levels of national participation in successive nuclear power projects.

The role of nuclear power as a sustainable energy resource can not be emphasized enough with respect to global environmental issues. Increasing the share of nuclear power in the total installed capacity for electricity generation will undoubtedly play a very important role.

General Information on Korea

The Republic of Korea lies on the southern part of the Korean peninsula in the Far East. Total area of the peninsular is about 220,000 km^2 and about 70% of the area are mountainous, while 98,445 km^2 belong to South Korea. As of the end of 1998, the country had a population of 46 million inhabitants with a growth rate of 0.95%. The Gross National Product (GNP) in 1998 was 317 billion US dollars, which had decreased by 5.8 % due to suffering from a lack of foreign exchange reserves since late 1997. The domestic economy began to be recovered since mid 1999.

Energy Situation in Korea

Korea is an energy-resource-poor country. There are no oil or gas resources and only limited anthracite coal deposits in the country. Uranium deposits identified are low grade and no development of these has taken place. Consequently, stable energy supplies have been a

principal consideration in formulating an energy policy. The primary energy consumption has rapidly increased as shown in Table 1 below, while that in 1998 had decreased by 8 % due to the recession.

Table 1. Primary Energy Consumption

(Unit : 1000 TOE)

Year	Total	Nuclear	Coal	Petroleum	LNG	Hydro	Others
1968	15,820	-	5,407	5,507	-	232	4,674
1978	38,087	581	9,893	24,123	-	452	3,038
1980	43,911	869	13,199	26,830	-	496	2,517
1985	56,296	4,186	22,022	27,142	-	915	2,031
1990	93,192	13,222	24,385	50,175	3,023	1,590	797
1995	150,437	16,757	28,092	93,955	9,213	1,369	1,051
1997	180,638	19,272	34,799	109,080	14,792	1,351	1,344
1998	165,932	22,422	36,039	90,582	13,838	1,525	1,526

The demand for electricity has been growing rapidly with the rapid economic growth. Total electricity generated in 1998 was 215,300 GWh with 43,406 MWe of total installed capacity of electric power, while in 1978 when the first Nuclear Power Plant began operation, it was 31,510 GWh with 6,916 MWe installed capacity. It is anticipated to increase up to 426,769 GWh with 79,061 MWe installed capacity by the year 2015. The generated electricity per capita in 1998 was 4,637 kWh, 30 times as much compared with that in 1968 when the decision to construct the first nuclear power plant had been made by the government.

Nuclear Power Program in Korea

The Korean government worried about its heavy dependency on oil and coal for power generation during the 1960's and 1970's when the share of fossil-fired generation was above 80%. In the late 1960's, the government carefully studied the feasibility of introducing a nuclear power plant to diversify the resource of fuel and to lessen the risk of imported energy sources. As a result, the government decided to construct Korea's first nuclear power plant, Kori-1 with a 587 MWe capacity, which began commercial operation in April, 1978.

As nuclear power was considered a semi-independent energy source because only the uranium is imported while the other components of nuclear energy are domestically available with self-reliance achieved in design, manufacturing and construction, the Korean government chose nuclear power as one of the main sources of electricity. In the mid 1980s, the government put in place an ambitious self-reliance program employing technology transfer and standardization of nuclear power plants. The share of nuclear power generation in 1998 increased up to 41.7% from 9.3% in 1980. It is anticipated to increase up to 44.5% by 2015.

At the end of 1999, the Korean government had established and announced the fifth Long-term Power Expansion Plan. According to the plan, Korea will continue to construct the 1000 MWe class Korean Standard Nuclear Power Plant (KSNPs) with gradual design improvements in the short-term and will develop the 1400 MWe class Korean Next Generation Reactors (KNGRs). While the Pressurized Water Reactor (PWR) is the reactor type of those KSNPs and KNGRs and has been main reactor type in Korea, the Pressurized Heavy Water Reactor (PHWR) will be considered as a complementary reactor type for enhancing the economic feasibility of nuclear power generation.

Currently, 16 units of nuclear power, 12 Pressurized Water Reactors (PWRs) and 4 Pressurized Heavy Water Reactors (PHWRs), are operating with four more units under construction. An additional eight units are planned to be constructed by 2015.

Table 2. Share of Nuclear Power Generation

Year	Installed Capacity	Nuclear		Gross Generation	Nuclear		Generation per Capita
	MWe	MWe	%	GWh	GWh	%	kWh
1968	1,274	-	-	6,026	-	-	157
1978	6,916	587	8.5	31,510	2,324	7.4	739
1980	9,391	587	6.3	37,239	3,477	9.3	859
1985	16,137	2,866	17.8	58,007	16,745	28.9	1,243
1990	21,021	7,618	36.2	107,670	52,887	49.1	2,202
1995	32,184	8,616	26.8	184,661	67,029	34.7	3,640
1997	41,042	10,316	25.1	224,445	77,086	34.3	4,366
1998	43,406	12,016	27.7	215,300	89,689	41.7	4,637
2000	49,056	13,716	28.0	250,627	101,238	40.4	Planned Value
2005	61,620	17,716	28.8	329,412	126,364	38.4	
2010	74,617	22,529	30.2	384,173	153,156	39.9	
2015	79,061	26,050	33.0	426,769	190,125	44.5	

Historical Review on Development of Nuclear Power in Korea

Nuclear power in Korea can be categorized in three generations from the point of view of technological self-reliance – total dependence and imitation, self-reliance preparation, and self-reliance promotion.

During the first generation, from the late 1960s to the early 1970s, three units, Kori-1&2 and Wolsong-1, were constructed through a turnkey contract, with the foreign vendor as the prime contractor. This can be characterized as a period of total dependence and imitation of technologies. Due to a lack of domestic experience in nuclear industries, the Korea Electric Power Corporation (KEPCO) totally relied on foreign suppliers, granting them overall responsibility for project management from design and construction to start-up. Domestic

industries were limited to civil and architectural work in the service facilities, as subcontractors. The major goals for self-reliance in this period were to find items available to be localized and to imitate the technology (exactly as instructed) of the foreign suppliers.

The first nuclear power plant, Kori-1 a 587 MWe PWR, was ordered to Westinghouse and was commissioned in 1978 after seven years of construction. To finance this project, KEPCO considered the conventional approach of requiring potential suppliers to offer financing with their bids. Over 50% of the total investment was from foreign sources.

During the second generation, from the late 1970s to the early 1980s six units, Kori-3&4, YGN(Yonggwang)-1&2 and UCN(Ulchin)-1&2, were constructed through a component base contract with foreign prime contractors. In that time, KEPCO managed project construction assisted by a foreign Architect/Engineering (A/E) company. KEPCO procured the balance of plant equipment and Korean contractors managed site construction, while domestic industries expanded their engineering and equipment supply roles. During this period, domestic participation increased and various vehicles of technology self-reliance were opened as well.

During this period, public financing arrangements were the main sources of funding for nuclear power projects with supplemental commercial loans. For the project implementation of Korea's fifth and sixth nuclear power units, Kori-3&4, about two-thirds of the foreign investments were financed through a public loan from the US EXIM in 1978. For a commercial loan arrangement, KEPCO initiated direct consultations from the Hong Kong based bank Chase Manhattan Asia Limited (CMAL). This bank had worked as the agent of a syndicate, comprising 40 commercial banks, since June, 1978. About 60% of the total investment was from foreign sources.

In the third generation, from the late 1980's to the late 1990s, KEPCO led component base projects as before, but the construction project management was internal. KEPCO assumed overall responsibility by awarding the prime contracts to Korean entities, while foreign suppliers served as subcontractors. In this period, YGN-3&4, the first project of its kind, was started along with a technology transfer contract to increase self-reliance in parallel with plant construction. For the UCN-3&4 project, Korean entities took responsibility for the entire project while foreign suppliers were mainly consultants.

The financing of YGN-3&4 project was in a quite different financing climate and had different aspects. In the early stages of project formulation in 1986, KEPCO considered a conventional financing approach, such as supplier's credits and commercial loans. However, the financing conditions were not attractive to KEPCO in view of market conditions, which favored borrowers at that time. On the basis of its own creditworthiness, KEPCO decided to take advantage of the availability and relatively low cost of dollar denominated borrowings through a commercial syndicated loan from Banker's Trust Company with a four-year currency option. The interest rate was a sub-LIBOR margin of –1.25%, while it was 0.25%

over LIBOR for a conventional loan.

Self-reliance in Nuclear Power Technology

Korea has attained self-reliance in nuclear power technology through a national policy for long-term self-reliance in fuel and plant design, manufacturing, construction and operation. To execute the policy, technology transfer and power plant standardization were chosen as major vehicles for self-reliance. The scope and responsibilities were defined and divided among the participating Korean entities as shown in Table 3, and in conjunction with that, plant standardization was conducted. For effective technology transfer, joint design with foreign partners was chosen as the mechanism for implementation.

Table 3. Division of Responsibilities (up to the end of December, 1996.)

Entity	Responsibilities
KINS	licensing support for the government
KEPCO	project management and operation
KOPEC	plant design (A/E) and development of A/E design technology
KAERI*	NSSS design, fuel design, and related R&D
HANJUNG	component design & manufacturing and development of manufacturing technology
KNFC	fuel manufacturing and development of fuel manufacturing technology
Universities	R&D of key technology

* Currently, KOPEC is responsible for NSSS design and KNFC for fuel design.

The strategy to acquire self-reliance in nuclear power technology was supported by four major means; actual project execution, technology transfer, power plant standardization and gradual improvement through research and development(R&D).

The YGN-3&4 project was selected as the base for self-reliance. Since the nuclear market was a buyer's market when the YGN-3&4 project was planned, the government included technology transfer as a condition of the contract. As a result, KEPCO engaged domestic main contractors while foreign subcontractors warranted the project. Well-planned training and joint design were adopted as a mechanism of implementation. The scope of technology transfer included the transfer of technical information, patents license, classroom training (CRT) and on-the-job training (OJT), and R&D participation and consultation.

Standardization of Nuclear Power Plant

Standardization means constructing plants to the same specifications in series for economic gains from repetitive works. However, new technology must be adapted to enhance

safety and performance. The standardization of nuclear power plants in Korea was implemented in four phases beginning in April, 1983.

The preliminary concept was formulated during the first phase from April, 1983 to July, 1985. During phase II, from September, 1985 to August, 1987, standardization was developed by the review of construction and operating experience, technology development, and the identification of items for design improvement. Since the YGN-3&4 project was executed with technology transfer, it was used as the reference plant of the Korean Standard Nuclear Power Plant (KSNP). In the third phase, from February, 1989 to April, 1991, KSNP was developed referencing YGN-3&4 and incorporating selected advanced design features. Phase IV has been the period of constructing Korean Standard Nuclear Power Plants with UCN-3&4 as the leading plant. More units, including YGN-5&6 and UCN-5&6, are under construction and will be completed by 2005.

Though the KSNP will be constructed repeatedly, the design will be gradually improved through R&D. Currently, Korea is developing the next generation reactor with a higher capacity, based on technology attained through self-reliance in 1000 MWe standard plant implementation.

Nuclear Power Related Organizations in Korea

For the nuclear power industry, the Ministry of Commerce, Industry and Energy (MOCIE) is responsible for such activities as follows:

- To formulate and implement basic plans and policies for the long-term security of energy and resources,
- To coordinate tasks on nuclear power generation and to formulate and implement its basic policies,
- To support the locating, construction and operation of nuclear power-related facilities and their safety management,
- To establish and implement a radioactive waste management plan, and
- To formulate and implement supporting activities for the surrounding areas of power plants and to apply related laws and regulations.

The nuclear regulatory organizations are composed of three parties; a national level decision-making body represented by the Korean Nuclear Regulatory Commission (KNRC) that is chaired by the Minister of the Ministry of Science and Technology (MOST), a regulatory authority represented by MOST and a technical expert group to support MOST represented by the Korea Institute of Nuclear Safety (KINS). The Korea Atomic Energy Research Institute (KAERI) is the national research institution for promoting the peaceful applications of nuclear energy by carrying out integrated R&D activities in the nuclear field.

The Korea Electric Power Corporation (KEPCO) has an integrated operating

monopoly over power generation, transmission and distribution of electricity. KEPCO owns 94% of the total electricity generating capacity. To construct nuclear power plants in Korea, KEPCO, the owner, designated the Korea Power Engineering Company, Inc. (KOPEC) as the prime contractor for Architect/Engineering, the Korea Heavy Industries & Construction Co., Ltd. (HANJUNG) for the supply of a nuclear steam supply system and turbine/generator, and the Korea Nuclear Fuel Co., Ltd. (KNFC) for nuclear fuel manufacturing. Procuring the balance of the plant was the responsibility of KEPCO as the owner. KOPEC was also designated as a subcontractor to HANJUNG for the design of NSSS. To perform the maintenance of power plants the Korea Plant Services & Engineering Co., Ltd. (KPS) was designated by KEPCO. These designated companies are subsidiaries of KEPCO. The structure of nuclear power related organizations are shown in Figure 1.

KEPCO will be split up into six new power subsidiaries in accordance with the Electricity Industry's Restructuring Program aimed at stimulating competition in the power generating business. According to the plan, KEPCO will allot power generation facilities, either currently in operation or under construction, to five thermal power subsidiaries and place all nuclear and hydro power plants under a single subsidiary.

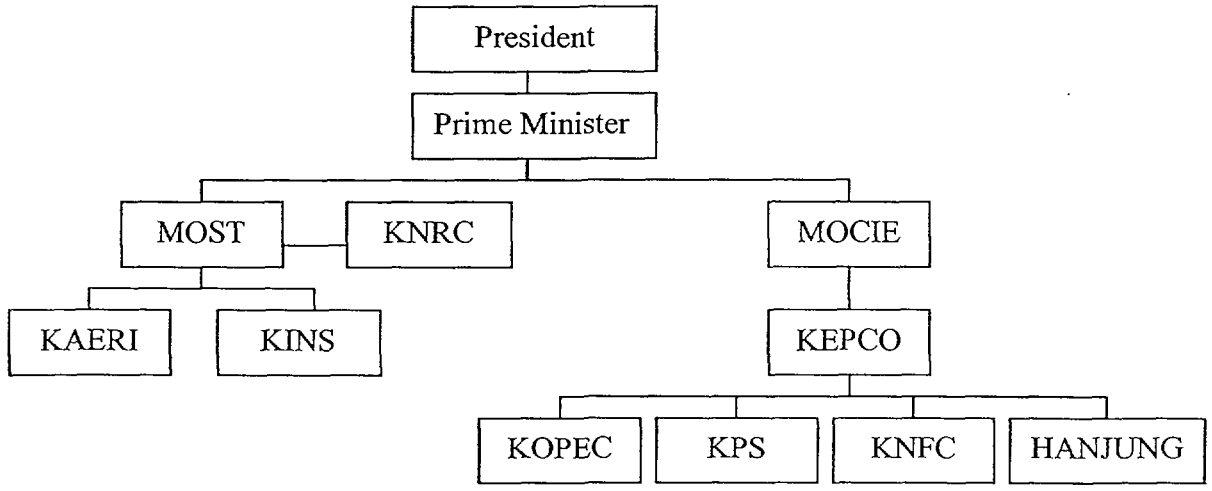

Figure 1. Nuclear Power Related Organizations in Korea

The Role of Nuclear Power for Environment

The problem of global warming, which became obvious from the 1980s, has given cause to vigorous activities for environmental preservation. Because the main causes of environmental contamination are air pollution, acid rain and greenhouse gas due to the use of fossil fuels, the use of fossil fuels should be cut to reduce the emission of SOx, NOx, and CO_2.

CO_2 emissions in Korea will be 2.2 times higher in 2000, and 3.3 times higher in 2010 compared to that in 1990. To reduce CO_2 gas emission, several options can be

considered: enhancement of energy efficiency, energy conservation, an increase in the use of new and renewable energy and a switch toward less greenhouse gas intensive power options. Switching fuel towards a less greenhouse gas intensive power option is the best choice for Korea.

Conclusion

The Republic of Korea, an energy-resource-poor country, set the issue of secured and stable energy supply as one of its top priorities. Nuclear power has been playing an important role in this issue.

Considering the development of Korea's nuclear power program, government's strong commitment to the program together with well-developed policies and proper implementation of long-term national plan to achieve self-reliance in nuclear power technology have been key factors for the successful nuclear power program. Nuclear power plant standardization facilitated self-reliance in the technology and promoted increasing levels of national participation in successive nuclear power projects.

Increasing the share of nuclear power in the total installed capacity for electricity generation will undoubtedly play a very important role for environmental preservation. In conclusion, the role of nuclear power as a sustainable energy resource can not be emphasized enough with respect to global environmental issues.

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