The status and prospects of Nuclear Energy in Korea

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1. Introduction

Through its wide variety of utilization in electricity generation, medicine, agriculture and many other industries, nuclear energy is contributing greatly to the development of human civilization and to the increase of general welfare. Moreover, nuclear power recently is taking a position as a clean and reliable power source.

Nuclear power has played a key role in the economic development of Korea since 1980s by securing a long-term stability of both power supply and low electricity cost.

Korea now takes pride in the successful achievements of its nuclear power projects. Two examples of our achievements are that Yonggwang 3&4 project gained the "Project of the Year Award" in 1995 and that Wolsong Unit 1 ranked first in the world three times for its excellent operating performance.

This presentation is aimed at introducing the status of nuclear power in Korea as well as the future prospects for nuclear energy.

2. Current Status of Nuclear Power in Korea

Nuclear Power Status

Since the commercial operation of Kori unit 1 in April 1978, the first Korean nuclear power plant, the development of nuclear power generation in Korea has been rapidly growing, and as of the end of 1996, the nuclear power generation reached 36.0% of the total power generation in Korea.

As of May 1997, eleven(11) nuclear units, which comprise ten(10) PWRs and one(1) CANDU, are in commercial operation as shown in Table 1.

[Table 1] Status of nuclear units in operation

Nuclear	units	Type	Capacity (MWe)	Manufacture		COD
				Reactor	T/G	
Kori	unit #1 unit #2 unit #3 unit #4	PWR	587 650 950 950	W " " "	GEC " " "	1978. 4 1983. 4 1985. 9 1986. 4
Wol-song	unit #1	PHWR	679	AECL	NEI-Parsons	1983. 4
Yong-gwang	unit #1 unit #2 unit #3 unit #4	PWR	950 950 1000 1000	W " Hanjung/CE "	W " Hanjung/GE "	1986. 8 1987. 6 1995. 3 1996. 1
Ulchin	unit #1 unit #2	PWR	950 950	Framatome	Alsthom	1988. 9 1989. 9

The Yonggwang unit 4 began commercial operation in January 1996, three months ahead of the original construction schedule.

Particularly, in 1995, Yonggwang units 3&4 gained the "Project of the Year Award" from "Power Engineering International" magazine for their excellence in design, construction and operation.

Through Yonggwang units 3&4, Korea has made a remarkable achievement in technology self-reliance and the standardization of nuclear power plant.
Presently, nine(9) additional nuclear units consisting of six(6) PWRs and three(3) CANDUs are under construction with two more nuclear units at the planning stage as well. Once these nine units are successfully completed as scheduled by 2005, the total installed nuclear power will be 18,720 MWe. The ratio of nuclear power generation will then be 27.5% of the total power generation in Korea.

Nuclear Power Operation

As a result of great efforts for the improvement of the safety of nuclear power plant, the performance of Korean nuclear power plants has shown remarkable improvement in comparison to the world average.

A comprehensive program with both short-term and long-term goals has been utilized to improve plant capacity factor. The short-term plan involves reducing the number of plant trips caused by human error and equipment failure, shortening the refueling outage period and improving the quality of facilities.

KEPCO has set a company-wide goal of "One Cycle Trouble Free" program which is called "OCTF". As a consequence of several remarkable improvements, the number of unexpected plant trips has been reduced steadily from 7.5 in 1985 to 0.9 occurrences per reactor in 1996.

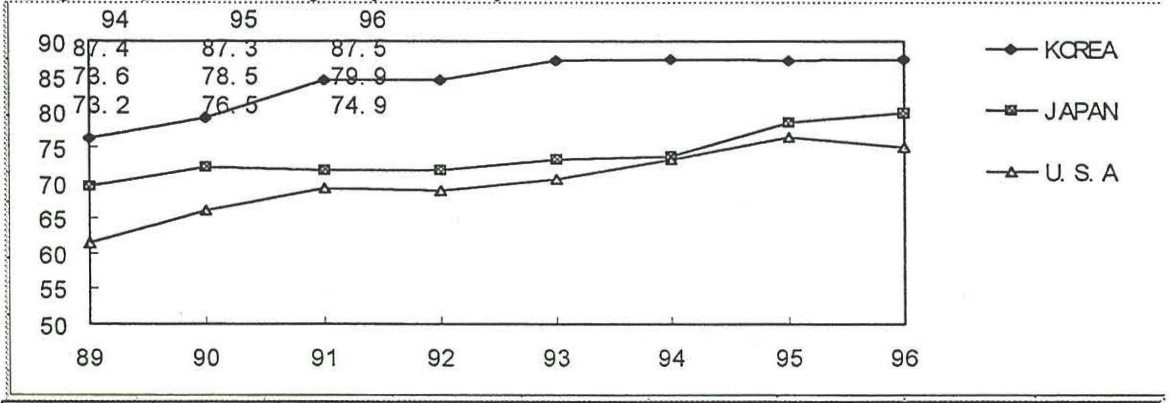
Kori unit 4 recorded a 423 day OCTF operation from 1995 to 1996, the longest operation duration without a reactor trip in Korea, and Kori unit 3 has also demonstrated OCTF operation.

It is also noteworthy that the Kori unit 1 which has operated for the longest duration [nineteen(19) years] in Korea, recorded a 365 day OCTF operation from 31 March 1996 to 30 March 1997.

Long-term efforts include improving the operability of equipment & systems, and operational management as well as ensuring operational feedback in the design of plants under construction.

In 1996, the average capacity factor of Korean nuclear plants was 87.5%, the highest record since the commercial operation of Kori unit 1 in 1978.

[Figure 1] Trend of capacity factor by nation



	89	90	91	92	93	94	95	96
KOREA	76.2	79.3	84.4	84.5	87.2	87.4	87.3	87.5
JAPAN	69.4	72.2	71.7	71.8	73.2	73.6	78.5	79.9
USA	61.5	66.1	69.3	68.9	70.6	73.2	76.5	74.9

* References : Nucleonics Week (U.S.A)
Korean Nuclear Power Plants

This achievement is due to a number of factors as follows;

- reduction of unexpected plant trips
  - improvement of maintenance & inspection technology
  - training of operation and maintenance staff
- improvement of maintenance quality and minimization of forced outages
  - increase of on-line maintenance work items
- adoption of an extended fuel cycle for PWR plants
  - a fifteen(15) month operating cycle for 600MWe class plants, and an eighteen(18) month fuel cycle for 950MWe class plants started in 1993
- the age of the nuclear power plants
  (7 of 11 Korean NPPs have been in-service 10 years or less)

Nuclear power Construction

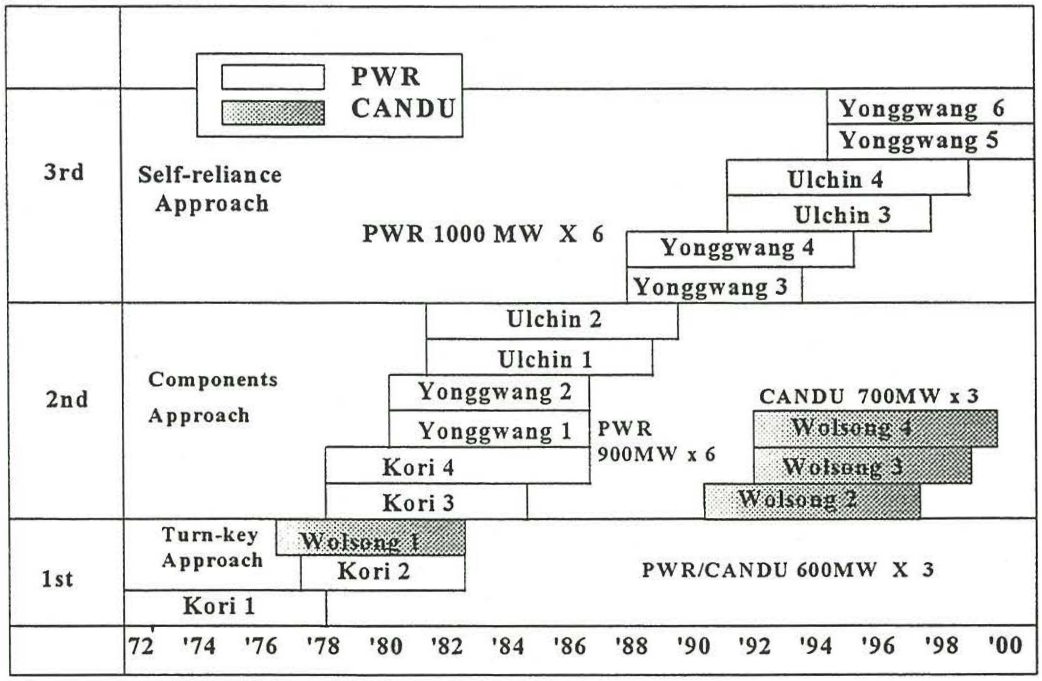
Nuclear power construction in Korea can be divided into 3 stages as follows :

In the *first stage*, nuclear power plants were constructed on a "turn-key" basis by foreign contractors. The local Korean contribution was limited to the area of raw material supply, participation in civil works, and so forth. Two PWRs and one CANDU were constructed under this "turn-key" approach.

In the *Second stage*, KEPCO started non turn-key base contracts with foreign prime contractors under KEPCO's project management based on experience from the first-stage.

KEPCO took overall responsibility for the project management with assistance from foreign contractors in supplying NSSS, T/G equipment and A/E services. Domestic companies partially participated as subcontractors in a scope of engineering services and equipment supply. Six(6) PWR units of 950 MWe were constructed under this non turn-key base approach, consequently strengthening Korea's own capability in supervising nuclear power projects construction.

[Figure 2] : Nuclear Power Construction by Stage

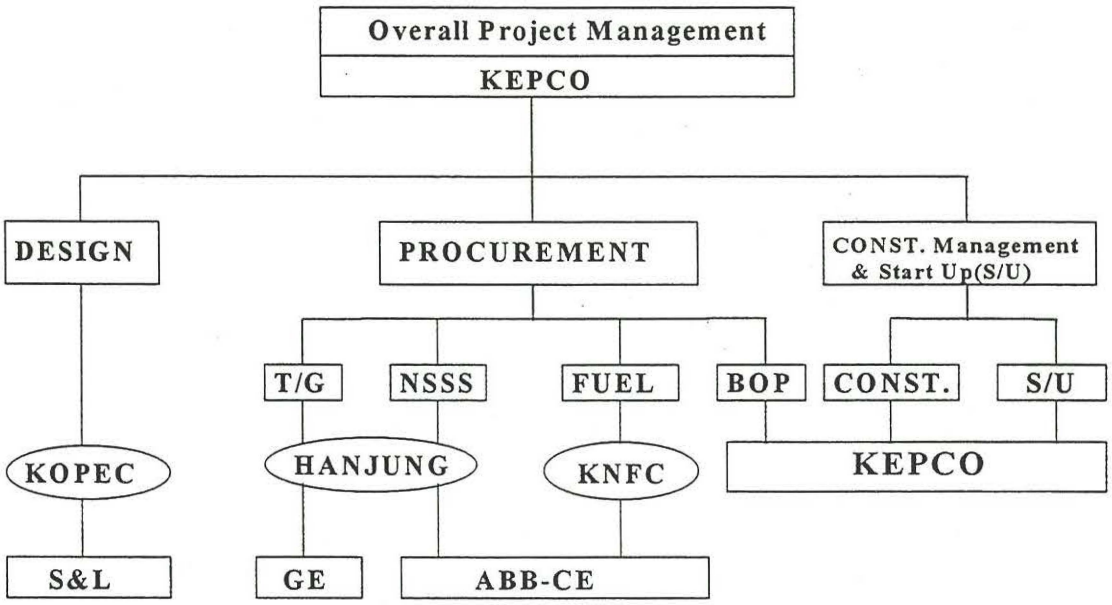


The *third stage* commenced with Yonggwang Units 3&4.
KEPCO contracted with Korean Electric Power Group (KEPG) as prime contractors and the foreign companies as their subcontractors in an effort to achieve technology self-reliance of nuclear power plant. KEPCO has directly managed the overall project including construction management, direct procurement of equipment & materials, and start-up activities.

KEPG participated energetically in plant design and equipment manufacturing with the assistance of foreign subcontractors who supplied technology transfer in designated areas.

All Korean contractors involved in the nuclear power program have improved their respective capabilities through technical on-the-job participation in their disciplines of nuclear power technology, which was transferred to Korea through separate contracts.

[Figure 3] : Project Structure



- KEPCO : Korea Electric Power Corporation
- KOPEC : Korea Power Engineering Co.
- HANJUNG : Korea Heavy Industries & Construction
- KNFC : Korea Nuclear Fuel Co.

The success of Yonggwang 3&4 project has proven Korea's technical capability to design and construct a nuclear power plant and laid the foundation to expand its business to the global market. Nowadays, KEPCO is vigorously promoting designing and constructing Ulchin 3&4, Yonggwang 5&6, and Ulchin 5&6 by utilizing Korean national resources in cooperation with KEPG.

On March 19, 1996, KEPCO was also designated as the prime contractor of the LWR project by Korean peninsular Energy Development Organization (KEDO), a consortium of the Republic of Korea, U.S.A and Japan.

CANDU Status in Korea

On-power refueling and flexible power management are some of the advantages in contributing towards the high capacity factor for CANDU compared with other reactor types.

Wolsong Unit 1 began commercial operation in April 1983 and has achieved an average life time capacity factor of 85%.

[Table 2] World record in Capacity factor of Wolsong 1

Duration	Capacity factor (%)	Reported by
Apr.1,'85 - Mar. 31,'86	98.4	NEI
Oct.1,'91 - Sep.30,'92	98.0	Statistics
Jan.1,'93 - Dec. 31,'93	100.8	

Wolsong Units 2,3&4 are 700 MWe class PHWRs which are identical to, and being constructed next to Wolsong Unit 1. KEPCO signed contracts with AECL for Wolsong 2 in December 1990 and for Wolsong 3&4 in September 1992. AECL is responsible to supply the A/E and NSSS contract under KEPCO's overall project management including direct construction management and start-up services.

Wolsong 2 is currently under the final stage of commissioning toward the commercial operation date, 30 June 1997, despite experiencing some severe equipment failures such as control valves, ion exchange column screens and boiler feed water pumps. However, AECL and KEPCO worked expeditiously and cooperatively to overcome these difficulties.

First Criticality was achieved on 27 January 1997, with First Synchronization on April 1. Full power was reached on April 28, highlighting a very successful Phase C program.

Compared with all other CANDU-6 plants, Wolsong 2 has the distinction of achieving the shortest time for "fuel load to criticality (83 days)" and "criticality to 100% full power (92 days)".

We anticipate the declaration of the commercial operation by 30 June 1997 as scheduled.

Wolsong 2 will be recorded as the nuclear power plant which will enable nuclear installed capacity in Korea to exceed 10,000 MWe on its Commercial Operation. Also this unit will achieve the shortest duration of "first concrete to in-service in fifty-eight months (58)" among CANDU-6 plants in the world to-date.

Wolsong unit 3 with the Commercial Operation on 30 June 1998, is now less than 12 months behind Wolsong 2, despite having started the "first concrete" about eighteen (18) months after that unit. The turnover of systems to Commissioning is satisfactorily underway, with Fuel Loading scheduled for this November.

Wolsong unit 4 is in the bulk installation phase, and is expected to meet the Commercial Operation date of 30 June 1999.

In addition, a Feasibility Study is being implemented to confirm the technical and economic viability of the CANDU 9 (900 MWe class). This study is to be completed before the establishment of the basic construction plan for two new nuclear units.

In November 1994, KEPCO and AECL signed a Memorandum of Agreement for CANDU export to third countries, establishing a framework for future cooperation. Both parties are cooperating jointly in exploring third country markets for CANDU export and in participating in CANDU projects in such countries. Based on the spirit of agreement and close cooperative construction experiences on Wolsong 2,3&4 projects between AECL and KEPCO, Korean entities are proceeding in joint participation with AECL for the Akkuyu Project in Turkey and Qinshan Project in China.

Also KEPCO is strengthening the interplant technical cooperation through an agreement with CANDU utilities such as Hydro-Quebec and New Brunswick Power Corporation.

3. Future Prospects of Nuclear Energy

Long-term Power Development Program

The Long-Term Power Development Plan established in December 1995, covers the national power development plan for 15 years from 1995 to 2010.

According to this plan, the annual growth rate of electric power demand is expected to be 5.8% on average between 1995 and 2010, and the total generating capacity including all resources will increase from 32,180 MW in 1995 to about 1.6 times by the year 2000, 2.1 times by 2005 and 2.5 times by 2010.

Power source diversification, site selection problems, financing and the environmental protection issues must all be taken into consideration in determining a proper composition of power resources.

By 2010, a total of twenty-eight (28) units of nuclear power plants will be in operation with the installed capacity of 26,330 MWe, representing 33.1% of the total installed electricity generating capacity.

The total power generation will also increase from 182,130 GWh in 1995 to approximately 1.4 times by the year 2000, 1.8 times by 2005, and 2.2 times by 2010. The total power generation in 2010 will be 408,190 GWh, of which the nuclear power plants will contribute 45.5%.

Improvement of KSNP Design

KEPCO is continuously developing the Korean Standard Nuclear Power Plant (KSNP) based on experience of construction and operation of Yonggwang 3&4 to improve the

construction economy of the nuclear power plants. KEPCO will incorporate the lessons learned through the construction of a series of KSNPs.

KEPCO is actively endeavoring to improve the general plant arrangement and implementing an environment friendly design.

Major activities of this program will be as follows :

- Comprehensive improvement in the general arrangement.
- Optimization of the design of building, system, and bulk installation.
- Expansion of the automatic operation of facilities.
- Improvement in construction methods.
- Improvement in the operability and maintainability

4. Conclusion

Even though existing natural energy resources are limited, energy consumption in Korea has continuously increased along with economic development and improved living standards.

As a diversified energy resources, nuclear power has contributed and will continue to contribute significantly to the development of Korean industry as a stable energy resource.

We hope to expand our nuclear power development program without delay, while making every effort to enhance nuclear safety based upon public acceptance.

One of the merits of nuclear power is a low lifetime cost. However, there is an increased competition from oil & coal-fired plants and it is becoming increasingly difficult to gain public acceptance for the future nuclear power plants. Also, the regulatory requirements for nuclear safety have been strengthened and intensified since the two nuclear incidents at TMI and Chernobyl.

In this regard, I propose that each organization within the nuclear industry should try to reduce the cost of nuclear energy generation by eliminating the inefficiencies involved in licensing, design, construction and operation areas in order to successfully accomplish our goals.