Role of Government &
International Cooperation on Nuclear Safety and
Power
-Korean Experiences-

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Historical Overview

Contribution of International Cooperation in early stage

National Nuclear System & HRD

Role of Government for National Nuclear Development

Conclusion
An Overview of Korean Nuclear Programs & HRD

1960s
- Preparation for Nuclear Energy
  - Joining IAEA Research Reactor

1970s
- Introduction of Nuclear Power
  - Construction of Kori #1

1980s
- Promoting Localization
  - Establish Localization Plan

1990s
- Technology Self-reliance
  - OPR1000, Hanaro Development

2000s
- Advanced Tech. Development
  - APR1400 Development

Oversea Training
- Universities
  - NTC/KAERI

Basic Training
- Utilities
  - Regulator

IAEA Regional Training

Domestic NHRD
- INTEC

Global NHRD
- INSS/KINS
**Preparation for Nuclear Energy (1950s-1969s)**

- **Government Organization – 1956**: Scholarship for NE at Oversea
- **Joining IAEA – 1957**: Establish Nucl. Eng. Dept. at HY Univ.
- **Construction of TRIGA Mark-II – 1959**: Establish KAERI
- **1960**: Establish Nucl. Eng. Dept. at Seoul Univ.
- **1961**: Training by the IAEA RI Mobile Lab.
- **Organizing NPP Steering Com. – 1962**: Laws for a RI Handling License
- **1963**: Training for Radiation Workers
- **Final plan for the 1st NPP – 1967**: Establish NTC/KAERI
- **1968**: Basic Training for NPP at NTC
- **1969**: Establish the Korea Nuclear Society
Historical Overview

Introduction of Nuclear Power (1970s)

- Signing of NPP Contract – 1970
  - Establish RO License Laws
- Grand Breaking of 1st NPP – 1971
  - Basic Training at NTC/KAERI
  - Training in a Supplier’s Country
- 1973
  - Provide Research Reactor Training Course for University students at NTC/KAERI
- 1976
  - Establish a National Technical Qualification System
- 1977
  - Provide NDT Training at NTC/KAERI
- 1978
  - Provide Utility Training Center at a NPP Site
- 1979
  - Establish Nucl. Eng. Dept. at KH Univ.
Historical Overview

◆ Promotion for a Localization of the Technology (1980s)

- Establish Localization Plan – (YW Unit 1, 2)
  - Establish Nuclear Safety Center –
  - Establish KOPEC (A/E) –

- Start Localization Plan – (NSSS and Nuclear Fuel Design from YW Unit 3, 4)

- Construction of HANARO – Research Reactor

1980
1981
1982
1984
1985
1986
1988
1989

- Establish Nuclear Engineering Dep’t at KAIST
- Establish Energy Eng. Dep’t at Jeju Univ.
- Establish Nuclear Eng. Dep’t at Chosun Univ.
- Start IAEA/KOICA Regional Training Course
Historical Overview

◆ Technology Self-reliance (1990s)


Complete NSSS and Fuel Design and Manufacturing – 1992

Construction of OPR1000 – 1993

Development of APR1400 – 1995

- HANARO Research Reactor


- MOU with IAEA for Fellowship Training at KAERI

- MOU with IAEA for Regional TC

Development of an Advanced Reactor – 1998

Operation of OPR1000 – 1999
Historical Overview

- Nuclear Energy Policy for Green Growth

- Establish 2\textsuperscript{nd} Nuclear Promotion Plan –
  - Open RCA Regional Office at KAERI
  - CP Application of APR 1400 –

- Open Advanced Radiation Technology R&D Center –
  - Development of the ANENT Web-portal
  - WNU Summer Institute in Korea

- Establish INSS/KINS –
  - KINS-KAIST Safety Master Course

2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Human Resource Development

The First President Rhee recognized the importance of nuclear energy after the meeting with Mr. Cisler (Former president of the Detroit Power Company)

- Mr. Cisler recommended the training of young scientists and engineers in overseas

- More than 300 students sent out to overseas under full government support
  - U.S., U.K., France and West Germany

- They became the main human capital for nuclear development and safety
Nuclear Power Plant Construction

- As part of the first Long-term Plan for Electricity Supply, the generating capacity of the first nuclear power plant, Kori Unit-1, had been determined in 1967;
  - Total installed Capacity in Korea < 2,000MWe
  - Initial plan was 150,000 kW
    - Considering Korea’s total electricity production at the time, the reasonable capacity of the nuclear power plant was 150,000 kW.
  - Consultation with IAEA Expert, Mr. Krynn
    - “Determine the generation capacity based on the electricity demand forecast of 10 year future, not present”
  - Finally, determined to be 587,000 kW
## Contribution of International Cooperation in Early Stage

### Activities (1957-1969) | Total
---|---
*International conference and symposium (both attending and hosting)* | 47 times

*Inviting foreign technical experts* | 61 times (81 persons: 1 day ~18 mos.)

*Sending internal human resources* | 310 persons under poor financial condition

*Participation in international scientific projects* | 16 times (with IAEA)

*Safety and proliferation resistance system* | Bi-lateral, IAEA-INFCl and NPT
National Nuclear System & HRD

President
Prime Minister

Atomic Energy Commission
Nuclear Safety Commission

MEST (Ministry of Education & Science Technology)

KAERI
KAERI

National R&D program

KINS
KINS

Safety & Regulation

Scientific Technology Commission

- Ministry of Knowledge Economy
- Ministry of Foreign Affairs & Trade
- Ministry of Planning & Budget

Nuclear Industries

- Utility: KHNP
- Nuclear Vendors: KOPEC, KNFC, DOOSAN

Academia

- Universities
- Other Research Institutes

Public

- News Media, NGOs, Local Society

KOPEC: Korea Power Engineering Company

KOPEC: Korea Hydro & Nuclear Power Company

KNFC: Korea Nuclear Fuel Company

DOOSAN: DOOSAN Heavy Industries & Construction Company

KNS: Korean Nuclear Society

KAIF: Korea Atomic Industrial Forum

KNEF: Korea Nuclear Energy Foundation
National Nuclear System & HRD

Cooperation Framework for NHRD

**Government**
- Nuclear Policy and Promotion
- Planning of Nuclear Power
- Nuclear Regulation and Control

**Regulatory Authority**
- Licensing
- Inspection
- Evaluation and Analysis of Nuclear Safety

**Nuclear R&D Institutes**
- Development, Acquisition, Dissemination of Nuclear Technology
- Nuclear Manpower Training

**Universities**
- Education in Nuclear Eng.
- Education in Science & Eng.
- BS, MS, PhD Degree

**Industries**
- Construction, Design & A/E
- Manufacturing of Component and Equipment
- Manufacturing of Nuclear Fuel

**Utilities**
- Operation and Maintenance of NPP
- In-house Training for NPP Personnel
- Distribution/Transmission

**Society & Associations**
- Korea Nuclear Society
- Korea Radioisotope Association
- NDT Promotion Association
First Phase : Role of Government

Korea in 1950s

- Korean War : 1950~1953
  - Left the country totally impoverished
  - Industrial and social infrastructure was completely destroyed.

- Electricity Supply : from one big hydro plant in North Korea
  - After the cease-fire in 1953, North Korea blocked it
  - Electricity generation capacity of the South Korea
    - only 127,000kW about 1/500th of today’s capacity

- Per Capita Gross National Product (GNP) : $70 (In 1954)

- At the end of 1950s, Korean economic and industrial situation;
  - Excessive population density in the small country,
  - Lack of energy resources,
  - Industrial infrastructure destroyed by the Korean War,
  - Large expenditures on defense under the cease-fire state,
  - Political instability, little experience in administration and the lack of government driving force, and
  - Insufficient domestic private capital
First Phase: Role of Government - NEPIO

- Pre-NEPIO in Korea (AES in 1956)
  - Organizing an informal study group
    - Voluntary group of young scientists and engineers without any funding for the services
    - Self-studies on the nuclear technology and the Atomic Energy Act of other countries
  - Establishment of Atomic Energy Section (AES) under ministry of education
    - Played a central role in the initial nuclear power programme for 2 years
      - Establishing the Atomic Energy Department (AED)
      - Establishing AERI
      - Selection of the research reactor to be introduced
      - Securing funds for building national infrastructures with the Ministry of Finance
      - Sending nuclear technology trainees abroad for human resources development
    - Developed the Atomic Energy Act (Approved by the National Assembly in 1958)
NEPIO in Korea (AED)

- Establishment of AED (in 1959)
  - Responsible for the nuclear energy programme including administration, regulation and research
  - Members: attracted from various areas including government, politics, universities, research institutes
- Special features and privileges:
  - Directly under the President
  - Dealt with use, development, production and management of nuclear energy and other related technology
  - BO: administration
  - Research institute: responsible for scientific and technical research
First Phase: Role of Government - NEPIO

- Establishment of KEPCO
  - The military power group took over the government on May 16, 1961
    - Established the owner/operator organization as the state-owned electric power company, the Korea Electric Power Company (KEPCO)

- Transferring Responsibility (AED \(\rightarrow\) KEPCO)
  - Initially KEPCO did not have the responsibility for preparing the NPP introduction as the owner/operator.
    - It was still AED’s responsibility and
    - KEPCO was assisting the AED
  - In 1968, the responsibilities for preparing the NPP introduction: AED \(\rightarrow\) KEPCO

- Change of AED Function
  - AED concentrated on policy making, safety regulation and licensing

- In 1967, the AED \(\rightarrow\) Office of Atomic Energy (OAE) under the Ministry of Science and Technology (MOST), instead of being directly responsible to the President.
  - With this change, the role of owner/operator was transferred to KEPCO
  - The functions of the AED (OAE) were steadily moved to R&D and safety regulation parts of the overall programme infrastructure.
Disappearing of NEPIO

- After KEPCO became the owner/operator,
  - the NEPIO handed over many of their functions to KEPCO.
- OAE became a smaller section in MOST in 1973
  - with separation of the research institutes
  - They shifted their functions to permanent organizations for the national nuclear power programme.
- The NEPIO was steadily transferring authorities
  - to various specialized institutes and
  - disappearing.
First Phase: Role of Government - Legislation

- **Introduction**
  - The enactment of the AEA should precede the development effort for a nuclear power programme.
  - The AEA must encompass a wide range of issues from management responsibilities to regulatory frameworks.

- **Initial drafting of AEA in Korea**
  - With the birth of the AES,
    - *On July 2, 1956, the draft of Atomic Energy Art was submitted to the National Assembly.*
  - The Act officially became effective on March 11, **1958**.
    - *The provisions for the regulation of the NPP were enacted in 1969.*
      - No legislation on NP regulation until 1969
First Phase: Role of Government – Regulatory Framework

- Introduction
  - For the success of a long-term NP programme, an independent and competent regulatory body is essential.

- Shortage of Human Resources
  - Not feasible to launch a separate regulatory body
  - Until 1968, development section, in the AED, carried out regulations only for radiation protection and research activities.

- Preparation of Legislation for Regulatory Framework
  - As the first NPP construction effort became tangible,
    - the government was compelled to establish the regulatory organization responsible for the licensing of the construction permit for the first NPP.
  - On 24 January 1969, provisions for safety regulation were enacted.
First Phase: Role of Government – Human Resource Development

- Introduction
  - With the limited human resources, it was difficult to launch domestic education systems on nuclear engineering.
    - *up-to-date education and training could not be provided within Korea and*
    - *began supporting overseas training of young researchers.*
  - In the early phase, with two major efforts
    - *sending trainees abroad and inviting experts for lectures, reviews and research.*

- Overseas Training
  - The young talented group had been trained in the USA and Europe.
    - *From 1956 to 1958, most human resources development was made through overseas training, funded by the government despite the extreme lack of foreign currency.*
  - From 1955 to 1964, Korea sent 237 persons abroad, but only 150 persons returned to Korea.
    - *To solve the problem, in 1961, the government imposed return obligations on all government scholarship students.*
First Phase: Role of Government – Human Resource Development

- Establishment of Domestic Education System
  - Launching undergraduate education (Nuclear Engineering Departments)
    - in Hanyang University (1958) and Seoul National University (in 1959)
  - Return of 1st wave of trainees
    - Universities could strengthen the nuclear engineering education

- Securing high-quality manpower
  - Special privileges for securing high-quality human resources
  - Other Human Resources working in Foreign Organizations invited by the Government for relocation to Korea.
Second Phase: Role of Government – Industry Involvement

- **Turnkey Contract Approach**
  - where main contractors were responsible for design, construction and commissioning of the whole project and in charge of the project management.

- **Contract**
  - KEPCO contracted WEICO (PWR) for the first NPP, Kori 1, in 1970.
    - **WEICO**: Westinghouse Electric International Company
    - *Like the first NPP, the second NPP in Korea, Kori 2, was also ordered from WEICO in 1974.*
  - First CANDU plant, Wolsong 1, was ordered from the AECL, Canada in 1975.

- **Domestic Industries Involvement**
  - Domestic industries and technicians participated in civil engineering, construction and nondestructive testing.
  - Local industries tried to establish quality control database and experience by participating in the construction of the second and third NPP.
Second Phase : Role of Government - Localization

- **Localization Policy** *(Non-Turnkey contracts approach)*
  - Domestic companies: sub-contractors, Foreign companies: main-contractors
  - Contracts were separately awarded for major components
    - *Thus enabling more domestic industries to participate as subcontractors*
    - *Classified components by localization feasibility, importance, and target schedule.*

- **Supply of Components**
  - KEPCO was obligated to utilize the developed components
    - *through agreement with the suppliers of the NPP*
  - Kori 3&4: contracted to a foreign supplier with terms for domestic component supply

- **Localization Results**
  - Increasing components supply from local suppliers
  - Quality management for local suppliers was put into place
    - *to improve the quality of both nuclear and non-nuclear products.*
Second Phase: Role of Government - HRD

- **University Programmes**
  - Expanded beyond theoretical education into engineering courses
    - *Design process of an NPP, nuclear fuel cycle, nuclear power economy, reactor safety analysis and heat transport*

- **Overseas Training**
  - Government continued funding scholarships, but at a reduced budget.

- **KAERI NTC**
  - Nuclear Training Center was established in KAERI.

- **KEPCO Training Center**
  - KEPCO contracted with WEICO for training
  - Additional staff was trained at existing thermal plants and research organizations.
  - KEPCO opened training center at the Kori 1 site.
![Second Phase : Role of Government - Regulation](image)

- Establishment of NSC (in 1981 : predecessor of today's KINS)
  - as part of KAERI
  - Many experienced researchers of the KAERI joined the NSC

- Regulatory Activities
  - 6 NPPs were constructed by employing localization policy.
    - *Kori unit 3&4, Yonggwang units 1&2, Ulchin units 1&2*
  - Two step licensing system (CP and OL) was incorporated into the law
  - Licensing difficulties encountered *from different Origin of Countries*
    - USA, Canada, France
As part of technological self-reliance program,
- major efforts have been concentrated on maximizing technological development and improvement of domestic industries

Component contract approach
- Plant owner took the major responsibility and risk associated with the project implementation
- The top priority for selecting suppliers was the condition of transferring higher nuclear technology

Starting from Yonggwang units 3&4 contracts in 1987,
- KEPCO assumed the overall management and responsibility for construction projects.
- Prime contractors: domestic companies
- Foreign companies: subcontractors
Third Phase: Role of Government - Regulation

- Establishment of KINS
  - KINS was founded in 1990 to ensure the independence of Regulation

- Regulatory Activities
  - Licensing for Yonggwang 3&4 (CE design)
  - Licensing for Wolsong 2, 3 & 4
    - Heavy water reactor designed by AECL
  - Licensing for Ulchin 3&4 (first standardized units of OPW-1000), Yonggwang 5&6 (OPR-1000)
  - Safety review for LWR project of the Korean Peninsula Energy Development Organization (KEDO)
    - Construction of two LWRs in North Korea – Suspended from Dec. 1, 2003

- Localization of Industry Code – Industry Initiative
  - Korea Electric Power Industry Code (KEPIC) was developed based on major international codes such as ASME, IEEE, etc.

- The Project has been carried out as part of national energy development program:
  - To take economic advantage of larger output per unit,
  - To consider the difficulties in obtaining new NPP sites

- Improved design features
  - Direct reactor vessel injection of emergency core cooling water,
  - Digitalized instrumentation and control system,
  - Workstation based control room and
  - In-containment refueling water storage tank, etc.

- APR–1400 has much improved economy and operational performance, and much enhanced safety features compared to KSNP:
  - Design Life : 60 y’s compared to 40 y’s for KSNP
  - CDF/(yr) : $10^{-6}$ compared to $10^{-4}$
  - Seismic Design (g) : 0.3 compared to 0.2
  - Rad. Exposure (mSv/person/yr) : 20 compared to 50
In 2000s : Role of Government - Advanced Technology Development

- Continued Safety Enhancement for OPR-1000
  - Design improvement and enhancement in safety features and operating performance has continued since YGN 3&4 and UCN 3&4:
    - To reflect changes in industrial codes and standards i.e., ASME, IEEE
    - To incorporate the feedback of operating experience and technical development in the industry
  - Major enhancements for succeeding OPR-1000:
    - Mid-loop operation capability,
    - Safety depressurization system,
    - \( H_2 \) igniters as part of severe accident prevention and mitigation,
    - Digital control system, and computer-based plant protection system for UCN 5&6 and later units,
    - Human factors in control room design,
    - Application of domestic industrial codes and standards (KEPIC) starting with UCN 5&6,........
Licensing and Regulation for APR-1400

- Standard Design Approval (SDA) System was introduced
  - Issued for APR-1400 in 2002.
- Construction Permit was issued for APR-1400 (Shin-Kori units 3&4) in 2003

International Cooperation for New Entrants

- Establishment of International Nuclear Safety School in 2008
  - A number of co-host training programs with IAEA
  - Nuclear Safety Master Degree Program from 2009
  - Nuclear Infrastructure Support Group
Conclusion

- **Korean NP Programme**
  - Competent NEPIO(AED) played key roles for planning and implementations of successful NP programme
  - Consistent Nuclear Policy has been in place whatever the government changed
  - Human Resources development & international collaborations have been key for establishment of comprehensive nuclear infrastructure

- **Sharing & Cooperation**
  - For taking a shortcut to develop nuclear energy & regulatory system,
    - *Cooperation between experienced countries and newcomers is particularly meaningful.*
  - Korea is willing to share nuclear technologies and regulatory experiences learned and accumulated during the past five decades with newcomers.
Safety Challenges in a Flat, Mixed and Open World

- International cooperation between new entrants and NPP countries in the Flattening world

- Harmonized safety approaches for the Mixed Reactors Generation

- Safety challenges in New Environments More Open to the Information
We invite all of you !!!

International Forum on Nuclear Safety Challenges in the Flat, Mixed and Open World
19-20 April 2010  Seoul, Korea

Email : kins2010@intercom.co.kr, Website : http://2010forum.kins.re.kr
That’s the way it is!!!

When you want it the most,
   There’s no easy way out.
When you are ready to go,
   Your heart left in doubt.
Don’t give up on your faith.
Love comes to those who believe it.
That’s the way it is.
Thank you very much

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