Nuclear Reactor Development in Korea: Its History and Status

ICENES 2007 (June 5, 2007)

Dong-Su Kim
Senior Vice President
Korea Power Engineering Company
Contents

1 Nuclear Power Development in Korea

2 OPR1000 & APR1400

3 Path Forward

4 Lessons Learned and Recommendations
Nuclear Power Development in Korea
Nuclear Power Plant Program In Korea

- APR1400
- PWR 1400MW X 4

- IMPROVED OPR1000
- PWR 1000MW X 4

- OPR1000
- PWR 1000MW X 8
- PHWR 700MW X 3

- Non Turn-key
- Ulsan 1,2
- Yonggwang 1,2
- Kori 3,4

- Turn-key
- Wolsong 1
- Kori 1

- PWR/PHWR 600MW X 3

- Shin Ulchin 1,2
- Shin Kori 3,4
- Shin Wolsong 1,2
- Shin Kori 1,2
- Ulchin 5,6
- Yonggwang 5,6
- Wolsong 2,3,4
- Ulchin 3,4

- Contract COD
- PWR
- PHWR

Year:
- '72
- '75
- '78
- '81
- '84
- '87
- '90
- '93
- '96
- '99
- '02
- '05
- '08
- '11
- '14
- '17

Generated Power (GW):
- 26.9
- 17.3
- 7.2
- 1.8
Nuclear Power Plants in Korea

(As of May, 2007)

- Operation (20 units)
- Construction (6 units)
- Planned (2 Units)

Seoul
Yonggwang
Kori
Wolsong
Ulchin
Daejeon
History of Nuclear Power Development

1971 ~ 1978
Introduction of Nuclear Power Plant
- Turn-key Contract
- Foreign Contractor Led Project

1978 ~ 1987
Promotion of Localization
- Non-turnkey Contract
- Increased Local Participation
- Foundations for Technology Self-Reliance

1987 ~ 1995
Technology Self-Reliance
- Technology Transfer
- Self-Reliant Design
- OPR1000 Development

1995 ~
Advanced Reactor Development
- Replication of OPR1000
- Improved OPR1000 Development
- APR1400 Development
- Overseas Engineering Services (Akkuyu Project)
Evolution of Technology

- National Nuclear Energy Policy for Technology Self-Reliance (Government Support)
- Define Scope & Responsibilities Among Local Entities (Teamwork)
- OPR1000 Standardization Program (Technology Transfer)
- Reference Design
- OPR1000
- APR1400

- YGN 3&4
- Joint Design
- Technology Transfer Contract
- Led by Local Companies
- Support of Foreign Partner
- Replication of OPR1000
- Design/Economics Improvements
- Improved OPR1000
- Experiences from OPR100
- Power Increase
- Further Improvements of the Design/Economics
OPR1000 & APR1400
Design Characteristics
- Type and Capacity: PWR, 2825 MWt
- Plant Lifetime: 40 years
- Seismic Design: SSE 0.2g
- Safety Goals: CDF ≤ 10^{-4} /RY
- Plant Availability: > 87%
- Unplanned Trips: ≤ 0.8/year
- Refueling Interval: 18 months

Design Concept
- Design optimization utilizing proven technology
- Feedback of operating experiences
- Improved plant economics and safety
- Standardized design
Design Characteristics
- Type and Capacity: PWR, 4000 MWt
- Plant Lifetime: 60 years
- Seismic Design: SSE 0.3g
- Safety Goals: CDF \( \leq 10^{-5} \)/RY
- Plant Availability: > 90%
- Unplanned Trips: \( \leq 0.8 \)/year
- Refueling Interval: 18~24 months

Design Improvements
- Design improvements to meet ALWR URD
- High reliability and better performance
  - 4 train safety injection, DVI, IRWST
  - POSRV for stable operation
- Severe accident mitigation: ERVC
- Digital protection and control systems
## Comparison of OPR1000 and APR1400

<table>
<thead>
<tr>
<th>Parameters</th>
<th>OPR1000</th>
<th>APR1400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal/Elec. Power</td>
<td>2825MWt / 1000MWe</td>
<td>4000MWt / 1450MWe</td>
</tr>
<tr>
<td>Design Life</td>
<td>40Yrs</td>
<td>60Yrs</td>
</tr>
<tr>
<td>Seismic Acceleration</td>
<td>0.2g</td>
<td>0.3g</td>
</tr>
<tr>
<td>Safety Requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- CDF</td>
<td>&lt; 10^{-4}/RY</td>
<td>&lt; 10^{-5}/RY</td>
</tr>
<tr>
<td>- Thermal Margin</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>- Operator Action Time</td>
<td>Min. 10 minutes</td>
<td>Min. 30 minutes</td>
</tr>
<tr>
<td>- Emergency Core Cooling</td>
<td>2-train, Cold leg Injection</td>
<td>4-train, DVI, Fluidic Device in SIT</td>
</tr>
<tr>
<td>Performance Requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Plant Availability</td>
<td>87%</td>
<td>90%</td>
</tr>
<tr>
<td>- Unplanned Trip</td>
<td>&lt;1/yr</td>
<td>&lt;0.8/yr</td>
</tr>
<tr>
<td>- Refueling Cycle</td>
<td>15-18 months</td>
<td>18-24 months</td>
</tr>
<tr>
<td>MMIS</td>
<td>Digital</td>
<td>Digital</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Reactor Vessel Wall Cooling</td>
<td>Air Cooling</td>
<td>ERVC</td>
</tr>
<tr>
<td>- RWST</td>
<td>Outside Containment</td>
<td>Inside Containment</td>
</tr>
</tbody>
</table>
**Current Status and Path Forward**

**Korea**
- Active construction until next decade
- Decrease in new power plant demand after 2020

**World**
- **Nuclear Renaissance**

- NuTech-2015 Program
- Development of APR+ for both domestic and oversea demands
- Economic and safety enhancement:
  - power Increase, passive safety features
Lessons Learned and Recommendations
Building Nuclear Power Plants

- Basic Design
  - Plant Plot Plan
  - RCS Loop Arrangement
  - System Design
  - Safety Analysis
  - PSAR

- Building Design
  - Fluid Design
  - Mechanical Design
  - I&C Design
  - Piping Design

- Review & Approval of CD/Vendor Documents
  - Design/Technical Specification

- Witness of Test & Inspection
  - Guidelines for Inspection, Test & Operation

- Technical Assistance of Installation & Startup
  - FSAR

- Operating & Maintenance Support

- Commercial Operation

- Technical Assistance

- Installation & Startup

- Equipment Manufacturing
  - Setup Reactor Vessel
  - Design Report

- Field Installation
  - Test & Inspection
  - Startup Test

- Commercial Operation

Building Nuclear Power Plants

- Contract
  - Excavation
  - First Concrete
  - Setup Reactor Vessel
  - Fuel Loading

- 21M
- 6M
- 0M
- 24M
- 47M
- 56M

- Startup
Roles of Nuclear Industries in Korea

KOPEC
Korea Power Engineering Co.
NSSS + A/E DESIGN

KPS
Korea Plant Service Co.
PLANT MAINTENANCE

KHNP
Korea Hydro & Nuclear Power Co.
PROJECT MANAGEMENT & OPERATION

KNFC
Korea Nuclear Fuel Co.
NUCLEAR FUEL SUPPLY

KAERI
Korea Atomic Energy Research Inst.
RESEARCH & DEVELOPMENT

DOOSAN
DOOSAN Heavy Industries & Construction Co.
EQUIPMENT SUPPLY

Construction Companies
CONSTRUCTION
### Factors to Be Considered

<table>
<thead>
<tr>
<th>National Nuclear Energy Policy</th>
<th></th>
</tr>
</thead>
</table>
|                               | Government lead and support  
|                               | Long term policy  |
| Scope                         |  |
|                               | Long-term demand for new plants  
|                               | Spin-Off Effects  |
| Distribution of Divisions of Responsibilities |  |
|                               | Minimization of interfaces  
|                               | Effectiveness of design change and/or developments  |
| Design Capability             |  |
|                               | Continuous long term construction plan  
|                               | Sufficient demands for new plants and O&M services  |
Summary

- **Nuclear Power Plant Technology in Korea**
  - A success model of introducing nuclear power
    - Combined dedication of utility and industries for a common goal
    - Strong government support
  - Development of OPR1000 and APR1400
  - Further development of more competitive light water reactor model planned

- **Lessons Learned and Recommendations**
  - National Nuclear Energy Policy
  - Scope of Technical Self-Reliance and Localization
  - Distribution of Divisions of Responsibilities
  - Design Capability
Thank You.