Introduction to APR1400 FOAK (First-Of-A-Kind) Project

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I. Status of APR1400 FOAK Project
Brief Development History

1970s
- Introduction of Nuclear Power Plant
  - Construction of Kori #1 (’71~’78)

1980s
- Promotion of Localization
  - Establishment of Localization Plan (’84)

1990s
- Technology Self-reliance
  - OPR1000(KSNP*) Development
    - Hanbit #3,4 (’95)

2000s
- Technology Advancement
  - APR1400 Development
    - Export to UAE (’09)
    - OPR+ Shin-Kori #1,2 (’10,’12)

2010s
- Korean Gen III+ Nuclear Reactor
  - APR1400 FOAK Unit
    - Shin-Kori #3 (’16.12)

* KSNP: Korea Standard Nuclear Power Plant
# APR1400 Projects Status

<table>
<thead>
<tr>
<th>Operation</th>
<th>Under Construction</th>
<th>Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korea</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>UAE</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

## KOREA

- **Shin-Kori**
  - Dec 2016: Shin-Kori APR 1400
  - Aug 2018: Shin-Kori APR 1400
  - Mar 2021: Shin-Kori APR 1400
  - Mar 2022: Shin-Kori APR 1400

- **Shin-Hanul**
  - Feb 2018: Shin-Hanul APR 1400
  - Feb 2019: Shin-Hanul APR 1400
  - Dec 2022: Shin-Hanul APR 1400
  - Dec 2023: Shin-Hanul APR 1400

## UAE

- **Barakah**
  - May 2017: Barakah APR 1400
  - May 2018: Barakah APR 1400
  - May 2019: Barakah APR 1400
  - May 2020: Barakah APR 1400
APR1400 FOAK Project

Shin-Kori #3,4 Project Profile

- Reactor Type: APR1400
- Capacity: 1,400 MWe \( \times 2 \)
- Construction Period: ’07.09~ ’18.09
- Reference plant for UAE BNPP 1~4
- Location: Ulju-gun in Ulsan city

Shin-Kori unit 3 has been in operation since ‘16.12
(10.4 billion kWh/year : 2% of the total generation in South Korea)
SKN Unit 3 Major Milestone

- '08.10: First Concrete
- '10.07: Reactor Installation
- '15.11: Fuel Loading
- '16.12: Commercial Operation

Nuclear Safety First, Last and Always
II. Challenges of APR1400 FOAK Project : Design
Design Challenges

<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>Fuel</td>
<td>HID-1L</td>
<td>PLUS 7</td>
</tr>
</tbody>
</table>

### Safety Requirements

<table>
<thead>
<tr>
<th></th>
<th>OPR1000</th>
<th>APR1400</th>
</tr>
</thead>
<tbody>
<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 Inj.</td>
<td>4-train, DVI, w/ FD</td>
</tr>
<tr>
<td>MMIS (Control System)</td>
<td>Analog</td>
<td>Digital</td>
</tr>
</tbody>
</table>

### Others

<table>
<thead>
<tr>
<th></th>
<th>OPR1000</th>
<th>APR1400</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV Head Area Structure</td>
<td>Independent Structure</td>
<td>Integrated Head Assemb.</td>
</tr>
<tr>
<td>Rx Vessel Wall Cooling</td>
<td>Air Cooling</td>
<td>Air Cooling / ERVC(SA)</td>
</tr>
<tr>
<td>RWST</td>
<td>Outside Containment</td>
<td>Inside Containment</td>
</tr>
</tbody>
</table>
Design Challenges (Cont’d)

Major Advanced Design Features (SIS)

- 4 trains with direct vessel injection (DVI)
- Low pressure safety injection pumps eliminated
- Installation of Fluidic Device (FD) in the Safety Injection Tanks to allow effective use of water inventory
- In-containment Refueling Water Storage Tank (IRWST)

OPR1000 Configuration  
APR1400 Configuration  
Fluidic Device (FD)
Design Challenges (Cont’d)

Severe Accident Mitigation Systems

- Hydrogen Mitigation System
- Safety Depressurization and Vent System
- Cavity Flooding System
- In-Vessel Retention & Ex-Reactor Vessel Cooling System, etc.
Safety Enhancement after Fukushima

33 items resulted from government’s safety review have taken measures

Prior to Shin-Kori Unit 3 Commercial Operation: 30 items Completed

- Earthquake: 4 items completed including “Increasing seismic capability of safety shutdown systems”
- Flood: 11 items completed including “Securing mobile generating units as well as battery racks”
- Severe accident: 5 items completed including “Reinforcing severe accident management training and drills”
- Emergency response: 10 items completed including “Securing radiological protection equipment for local residents”

After Shin-Kori Unit 3 Commercial Operation: 3 items

- Completed: 2 items completed including “Protection of outdoor tank”
- To be completed: 1 item ("Strengthening cooling water intake capability and plant protection against severe coastal flooding")
III. Challenges of APR1400 FOAK Project: Supply Chain
## Supply Chain Management

### New Equipment / Components : MMIS

<table>
<thead>
<tr>
<th>OPR1000</th>
<th>APR1400</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MCB (Alarm Window)</strong></td>
<td>MCR (Operation Consoles / Safety Console/LDP/Mini-LDP/Alarm CRT)</td>
</tr>
<tr>
<td><strong>Plant Control System</strong></td>
<td>ESF-CCS (NSSS ESFAS) / P-CCS (NPCS, DPS, PCS)</td>
</tr>
<tr>
<td><strong>Remote Shutdown Panel</strong></td>
<td>IPS (NAPS, CPS &amp; TG Interfaces) /QIAS-N</td>
</tr>
<tr>
<td><strong>Radwaste Control Panel</strong></td>
<td>Remote Shutdown Console / Shutdown Overview Display Panel</td>
</tr>
<tr>
<td></td>
<td>Radwaste Control Console/Rad-LDP</td>
</tr>
</tbody>
</table>
Supply Chain Management (Cont’d)

New Equipment / Components: MMIS (cont’d)

### Issues
- Late MMIS design finalization and integration
  - delay of NSSS design and BOP suppliers’ input data offering
- Delay of clarification with suppliers about finalized design
- Occurrence of extra design change after offering finalized design
  - some of system design amendment
  - design amendment reflecting of performance constraints of equipment platforms
- Poor equipment design because of the first manufacture
  - poor experience of BOP and integrated manufacture design

### Lessons Learned
- Timely integration and offering of finalized design data
  - preconditioning of information offering schedule before contract
- Inspection inconsistent data among documents
  - C&ID, CLD, Display DWG, PWDB, MMI DB, etc.
- Establishment and Execution of rapid Review & Comment procedure
  - Shortening of review period by periodic association and dispatched engineers
- Early recognition of extra system design amendment
  - Deciding amendment reflection point and ways
Supply Chain Management (Cont’d)

CFSI Issue – improvement measures

Institution
- Enforcement of Nuclear Industry Management Law (‘15.07.01)

Organization
- Guarantee of A/E’s independence against equipment suppliers
- Establishment of Nuclear Safety Engineering Center in A/E

Monitoring
- Test in the presence of NPP operator, A/E (Third party verification process)
- A/E’s review of CGI Dedication report

System
- Establishment of NPP safety equipment quality management system

EQ Process Improvement
IV. Conclusion: Insights gained from APR1400 FOAK Project
Impact of design change/finalization during construction

- Delayed acquisition of license due to reinforcement of regulatory review by adopting new system design & equipment
- Delayed purchase/supply due to vendor restriction in new design
  → Minimize the delay of pre-operation and power ascension test

Challenges related to a suitable supply chain

- Restriction in purchasing equipment with new proven technology by the decline of suppliers due to decrease in NPP construction
  Case1: Difficulty in safety grade equipment with the latest IT technology and performance/EQ validation
  Case2: Redesign and verification by the manufacturer due to lack of equip’t to meet the reinforced seismic design requirements
  → Require continuous encouragement to meet the schedule
Insights gained from APR1400 FOAK

Construction/commissioning management and related risks

- Difficulty in schedule due to design changes and equipment supply issue
- Delayed delivery of equipment due to EQ dissatisfaction
  → Systematic cooperation among designer, constructor and supplier
As a whole,

- The design completeness and the licensing issues should be resolved prior to start of construction, if possible.
- However, even if the schedule is somewhat affected, the efforts to enhance the safety of NPP have to be continuously made during construction.
- Stable supplier management, document/licensing issue control and independent verification system should be established in advance.
Good practices of APR1400 FOAK

Settlement of the code case issue

- Delayed revision of C&S reflecting the latest designs and materials
- Continuous discussion with code committee during construction period
  → Publication of code case on time to be used for qualified material and new design for some safety-class equipment

Schedule improvement by adopting modern const. tech.

- Adopt composite structure to some aux. bldgs
- Modular construction using large capacity construction crane to CLP, IRWST, SSLP
- Application of reinforcing steel 3D model to the containment dome etc.
APR1400 FOAK Project faced to a lot of challenges. Despite the many concerns, based on the consistent efforts of all construction entities including utility/government, and ongoing continuous experience in building new NPPs, they have been successfully built and operated.
THANK YOU !!!