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KAERI's Experience with the KJRR and Other Research Reactor Projects

- focused on KJRR and PALLAS -

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Outline

- ❖ Introduction
- ❖ On-going RR Construction Projects in Korea
  - ● Experience with KJRR project
  - ● Critical Assembly
- ❖ RR projects abroad
  - ● KAERI's international projects for RR technology
  - ● Experience from bidding of PALLAS project
- ❖ Closing Remarks

Introduction

- KAERI has accumulated extensive experiences on RR technologies through;
  - Operation and utilization of TRIGA MK II (250 kW) and TRIGA MK III (2 MW)
  - Design, construction and operation of HANARO (30 MW) and JRTR (5 MW)
  - At present, two construction projects are on going: KJRR (15MW) and critical assembly facility(10W) projects
- With these experiences, KAERI has attempted to export RR technologies from the early 2000s and carried out some RR projects abroad.
  - Projects for refurbishments of I&C system and installation of CNS for TTR-1, BTRR, and HOR reactors.
  - Participation in bidding for several RR projects such as DIPR, PALLAS, JRTR, and NextGen MURR projects.
- KAERI's experiences on RR projects are presented focused on KJRR and PALLAS projects

On-going RR project in Korea ; KJRR (1/6)

❑ KJRR (KiJang Research Reactor) project

❖ 15MW RR dedicated to mainly RI production and NTD service

- Under construction at Ki-Jang site and Scheduled for completion in 2027
- Expected to start normal operation in late of 2028

❖ Role Division between KJRR and HANARO

HANARO	① R&D by utilization of neutron beams ② R&D for key nuclear technologies ③ Backup for RI production and NTD services
KJRR	① R&D and supply of medical and industrial radioisotopes ② Neutron Transmutation Doping (NTD) services

1) Background of Launching of the KJRR project

❖ Pre-feasibility studies for a RI production RR

- 1999 : A study on the domestic production of RIs, by MOST (Ministry of Science and Technology)
- 2003~4: A pre-feasibility study on the development of the medical RI production reactor, by MOST

⇨ **Results : Lack of economic feasibility**

On-going RR project in Korea ; KJRR (2/6)

❖ Changes in circumstances

- ’08~‘09 : Shortage of Mo-99 over world → Importance of Public health
- ’07~’10 : Participation in bid of RR projects → Necessity of securing key RR technologies to strengthen the compositeness in RR market

⇨ **Reconsideration of a new RR project**

❖ Pre-feasibility study by MEST in 2009

❖ Site selection by a committee of MEST in 2010

❖ Feasibility study by MOSF in 2011

❖ Budget approval by the National Assembly in Nov., 2011

⇨ **Official Launching of KJRR Project on April 1, 2012**

① To secure the supply of key medical & industrial RIs domestic and abroad,

② To enlarge Si NTD services for power device market growth,

③ To develop key RR technologies and to be competitive in world RR market.

On-going RR project in Korea ; KJRR (3/6)

❖ Major scope of Pre-feasibility study

- Review and prospect for RR roles, markets of RIs and NTD service
- Expected benefits from a new RR
- Key technologies to be developed for a new RR
- Preliminary reactor specification
- Pre-strategic planning (Utilization plan of a new RR)
- Technical requirements for a site selection

❖ Major scope of Feasibility study

- Review of results of the pre-feasibility study
- Technical risks in the proposed project
- Cost and Benefit analysis for the lifetime of facility
- Impacts on social and political aspects

⇨ Pre-feasibility and feasibility studies should be practical and viable.

On-going RR project in Korea ; KJRR (4/6)

2) Progress and Status of the KJRR project

❖ Milestone

- April, 2012 : Official Launching of the KJRR project
- Nov., 2014 : Apply for Construction Permit (CP)
- Oct., 2015 : KINS began review and assessment of CP documents
- Sep. 2016 : Earthquake in Gyeongju
- Nov. 2017 : Earthquake in Pohang
- May., 2019 : Obtained CP
- April, 2023 : First concrete pouring
- Oct., 2023 : Apply for Operating License (OL) to NSSC (Nuclear Safety and Security Commission)
- April, 2027: Initial criticality
- Late of 2028 : Normal operation (Expectation)

On-going RR project in Korea ; KJRR (5/6)

❖ Delay of Project Schedule

- Earthquake scale
  - Gyeongju: 5.8, Pohang : 5.4, Kijang site criteria : 5.0
  - More than 3 years to clarify higher potential earthquake impact on the site
- Various design changes in the process of licensing review
  - No specific regulatory guidelines → Application of NPP's standards → Little application of graded approach to RR design → Excessive design
- Project management with little experience on complex project → trials and errors

→ These results in project delay and cost increase → Review of cost suitability by the government 2 times (around 2 years)

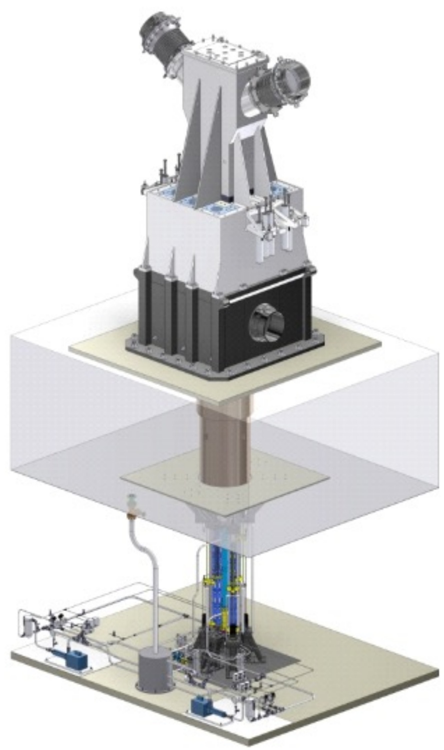
❖ Design features and key technologies to be developed in KJRR project

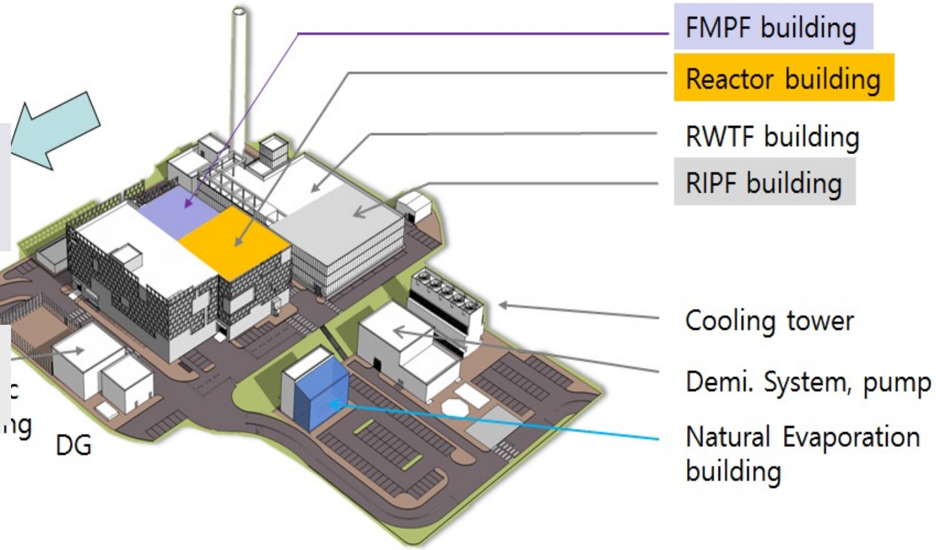
- Fuel: Plate type of U-7Mo with 8.0g-U/cc ← 1) 1st commercial use in the world
- Reactor bottom-mounted CRDM (Control Rod Drive Mechanism) while HANARO and JRTR utilize top-mounted CRDM.
- Mo-99 production process is also under development.
- Reactor specification

On-going RR project in Korea ; KJRR (6/6)

Specification of KJRR

Reactor Type	Open-Tank-in-Pool
Reactor Power	15 MW
Max. Thermal Neutron Flux	> 3.0×10^{14} n/cm^2·sec in core
Fuel Type & Material, F-Mo target	Plate type; 19.75% enriched, U-7Mo of 8 g U/cc in Al matrix, UAlx, 2.6 gU/cc
Fuel Loading	18 FAs, 7.0 kg of U^{235}
Coolant & Cooling Method	H_2O Downward forced convection flow
Decay heat removal	Passive cooling system
Moderator	H_2O
Reflector	Be, Graphite
Absorber Material	Hafnium





On-going RR project in Korea ; Critical Assembly (1/2)

❑ Critical Assembly project

- ❖ Critical Assembly (10W) will be constructed at Gampo branch.
- ❖ **Purpose**
  - For fostering human resources through education and training
  - For validation of a new reactor system design
- ❖ **Status**
  - Launching of the project in April, 2024
  - Under basic design and PSAR will be submitted in 2026
  - Scheduled for completion by the end of 2028, and will start operation in 2029

There was some concerns and debates about the necessity of a critical assembly because its role has been much decreased, and a small reactor(AGN-201K, 10W) is operating at Kyunghee university.

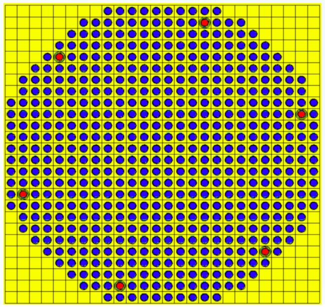
- AGN-201K continue to serve a role for basic education and training.
- A CA under design will focused on higher-level education and research.

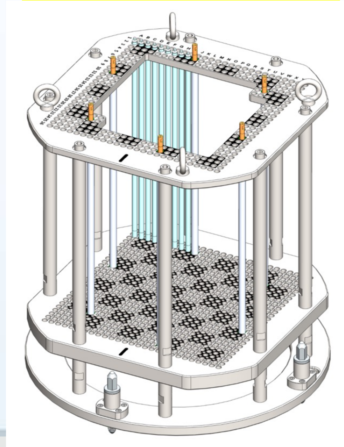
Concerns : lack of manpower, budget, no practical regulation guidelines

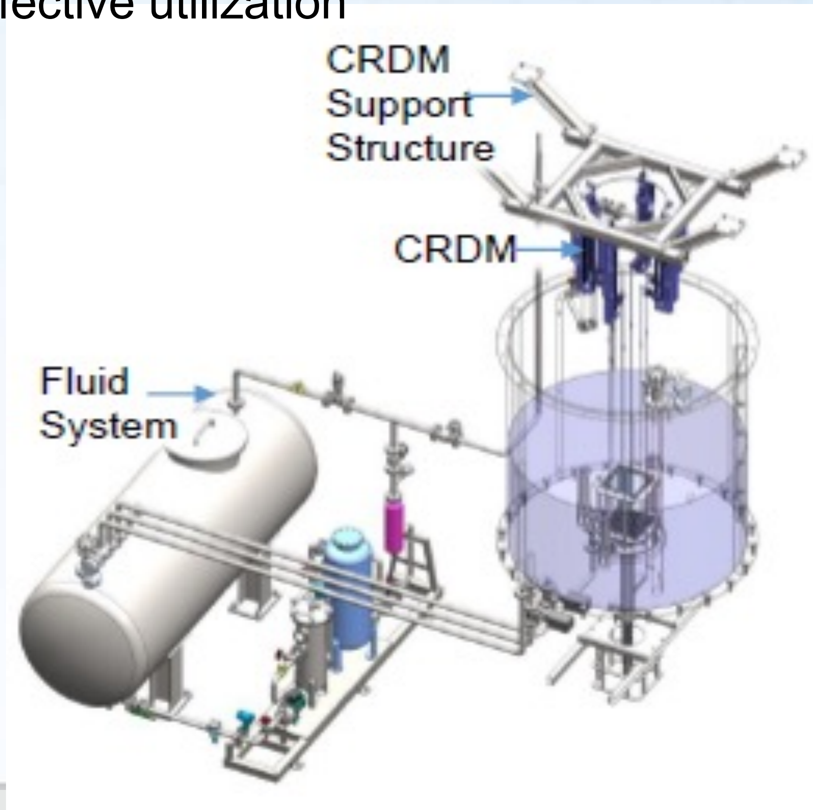
On-going RR project in Korea ; Critical Assembly (2/2)

❖ **Design Characteristics**

- Reactor power: ~ 10W
- Fuel: Rod type of UO_2 with 4.1 wt% enrichment (same as that of NPP)
- Core: ~ 550 UO_2 fuel rods, 40 cm in dia. x 38 cm in height, 6 B_4C control rods,
  Avg. neutron flux of ~ 3×10^8 n/cm²/s
- Reactor system: Small and simple
- Design prioritizes a very high level of safety (No prompt jump), and easy to start up and shutdown the reactor for effective utilization







RR projects abroad (1/4)

❑ KAERI's International Projects for RR technology

Project Name	Country (Organization)	Period	Objective	Remarks
PCS Upgrade	Greece (DEMOCRITOS)	'09.5. ~ '13.5.	• Engineering & safety analysis for replacing PCS of 5MW RR	Completed Engineering
I&C Upgrade (TRR-1)	Thailand (TINT)	'09.11 ~'13.11	• Modernization with digital I&C system (TRIGA, 2MW)	Completed Consulting
I&C Upgrade (ReDICS)	Malaysia (MNA)	'12.6. ~ '14.3.	• Modernization with digital I&C system (TRIGA, 2MW)	Completed EPC turnkey
I&C Upgrade (BTRR)	Bangladeshi (BAEC)	'21.7. ~ '24.6.	• Modernization with digital I&C system (TRIGA, 3MW)	Completed EPC turnkey
OYSTER	Netherlands (TU Delft)	'14.8. ~ '25.8.	• Establishment of CNS facility	Completed EPC turnkey
JRTR	Jordan (JAEC)	'10.3. ~ '16.8.	• Construction of 5MW RR, and Training & education	Completed EPC turnkey
NextGen MURR	USA (Missori Univ.)	'25.6. ~ present	• Design study for a RR to replace MURR (10 MW)	On-going
PALLAS	Netherlands (NRG)	'07.9. ~ '09.10. '15.10. ~ '17.9.	• Construction of a RR to replace the HFR (45MW)	Bid failed

RR projects abroad (2/4) - PALLAS Project (1/3)

❑ Experience from PALLAS project

❖ A project to construct a new RR to replace HFR (45MW) by NRG of Netherlands

❖ **Bidding Progress**

1st Bidding ('07.9. ~ '09.10.)

- 2007. 9 : Start of international bid for the PALLAS project
- '07.12 ~ '08. 5 : Dialogue phase → in-depth discussions with owner regarding to Conceptual design, Construction cost, and Project management
- 2008. 6 : Selection of KAERI (Korea), AREVA(France), INVAP(Argentina) for final competition
- 2009.6 : INVAP was selected as a preferred bidder
- 2010.1 : NRG declared the suspension of the project (due to failure to secure cost)

2nd Bidding ('15.10 ~ '17.9)

- 2015. 4 : Re-start of the PALLAS project
- 2015. 10 : Competition of 3 consortiums same as 1st round
- '16.4 ~ '17.4 : Dialogue phase
- 2017. 8 : KAERI consortium abandoned participating in bid (due to unreasonable financing request by owner)
- 2018. 1 : INVAP contract with NRG

RR projects abroad (3/4) - PALLAS Project (2/3)

❖ Changes of Project Management in Netherlands side

- 1st round : mainly NRG researchers and engineers
  - ✓ Focused on the reactor performance → PALLAS of 80 MW
- 2nd round : persons who have many experiences on project management
  - ✓ Optimization of utilization purpose and the expected cost → by adjusting the raking of utilization areas → Scale down PALLAS to 25 MW within the expected cost

→ Importance of project management group

❖ Dialogue phase in bidding process

- EU practice? Not like in typical bid process
- Many interactive, in-depth discussions with owner regarding to Conceptual design, Construction cost, and Project management, etc.

  (including several face-to-face meetings for a few days)

  ---> Reflected to final bid documents

RR projects abroad (4/4) - PALLAS Project (3/3)

❖ Lessons learned from the PALLAS Project

- Lack of key technology and design data
  - ✓ Little experiences on a MTR type RR → Needs for securing key technologies and design data for RRs → improve the completeness of bidding preparation
- Lack of experience on the project cost estimation
  - ✓ No experience on RR construction after HANARO → lots of difficulties in cost estimation → increase of cost and risks in bidding
- Inadequate project organization system
  - ✓ Unified and simplified project system with consortium members → optimal decision making and sharing responsibilities → reduce excessive project cost and risk
- Insufficient understanding of EU bidding practice and procedures
  - ✓ Frequent changes in design requirement through dialogue phase, Excessive guarantee request by owner → High risk to management of consortium members
- Lack of information on RR licensing practices
  - ✓ No detailed descriptive regulations → Discussion and consultation with licensing authority to determine important matters → Increase project risk and construction cost

Closing Remarks

- An RR project should be in line with national situations such as size, economy, science and technology level.
- An RR project is not attractive in terms of economics. Hence, the justification of the project is very important and should be clearly clarified.
- A strong commitment and budget support from the government is essential to launch the RR project. The participation of local government is also preferred.
- An RR project is politically and socially sensitive and the public acceptance (PA) is of importance because government support often depends on resident's and stakeholder's opinions.
- It is necessary to accurately estimate the cost as much as possible in carrying out the project and an interim check is required at each important point.
- Uncertainties in licensing process should not be underestimated, which can lead to increase of costs and delays of schedules. All benefit and risks should be discussed at early stage of the project as well.
- Establishment of project system with a well-assigned mission and roles between participant organizations is necessary, particularly, a project management group with capabilities for comprehensive planning and project management are needed.

Thank You for your attention !!!

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