2015 ISOE Asian ALARA Symposium
Tokyo, Japan, 9-11 September, 2015

Considerations on Radiation Shielding Safety Review of High Density Storage Racks Additionally Installed in Spent Fuel Pools

9 Sept., 2015

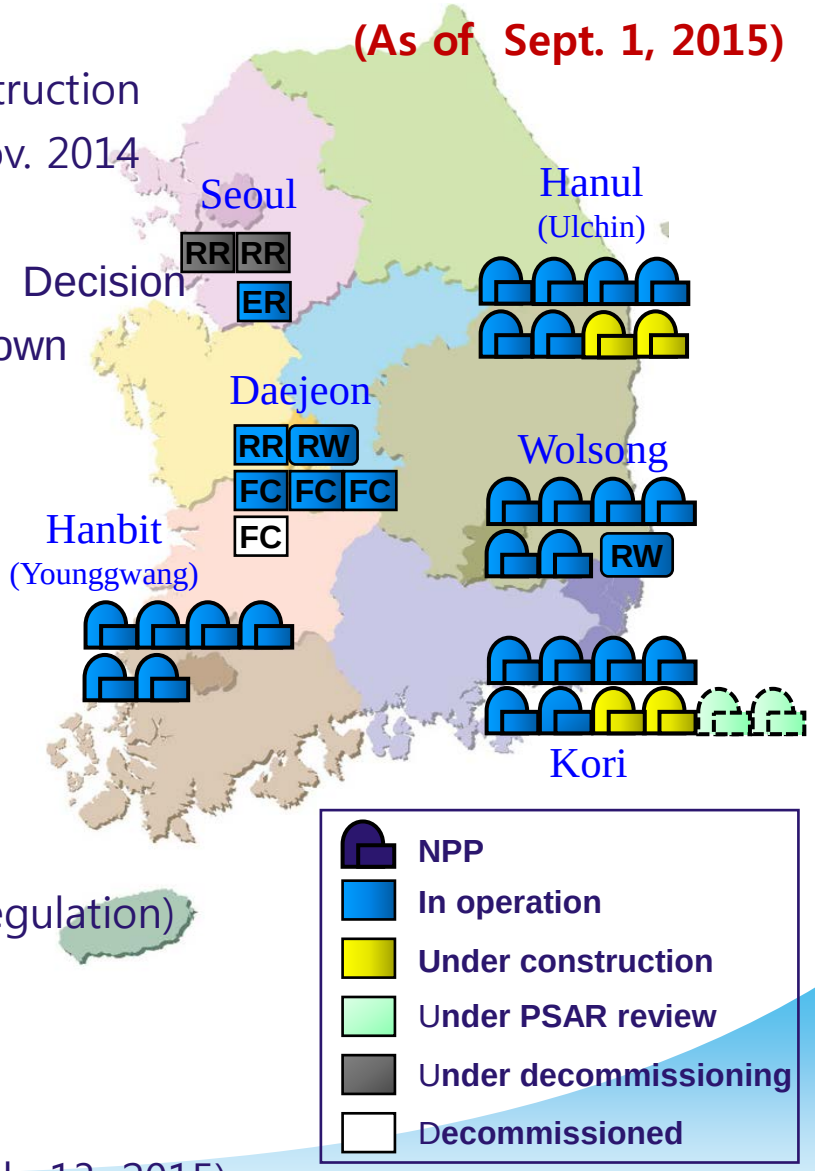
Byeongsoo KIM

한국원자력안전기술원
KOREA INSTITUTE OF NUCLEAR SAFETY

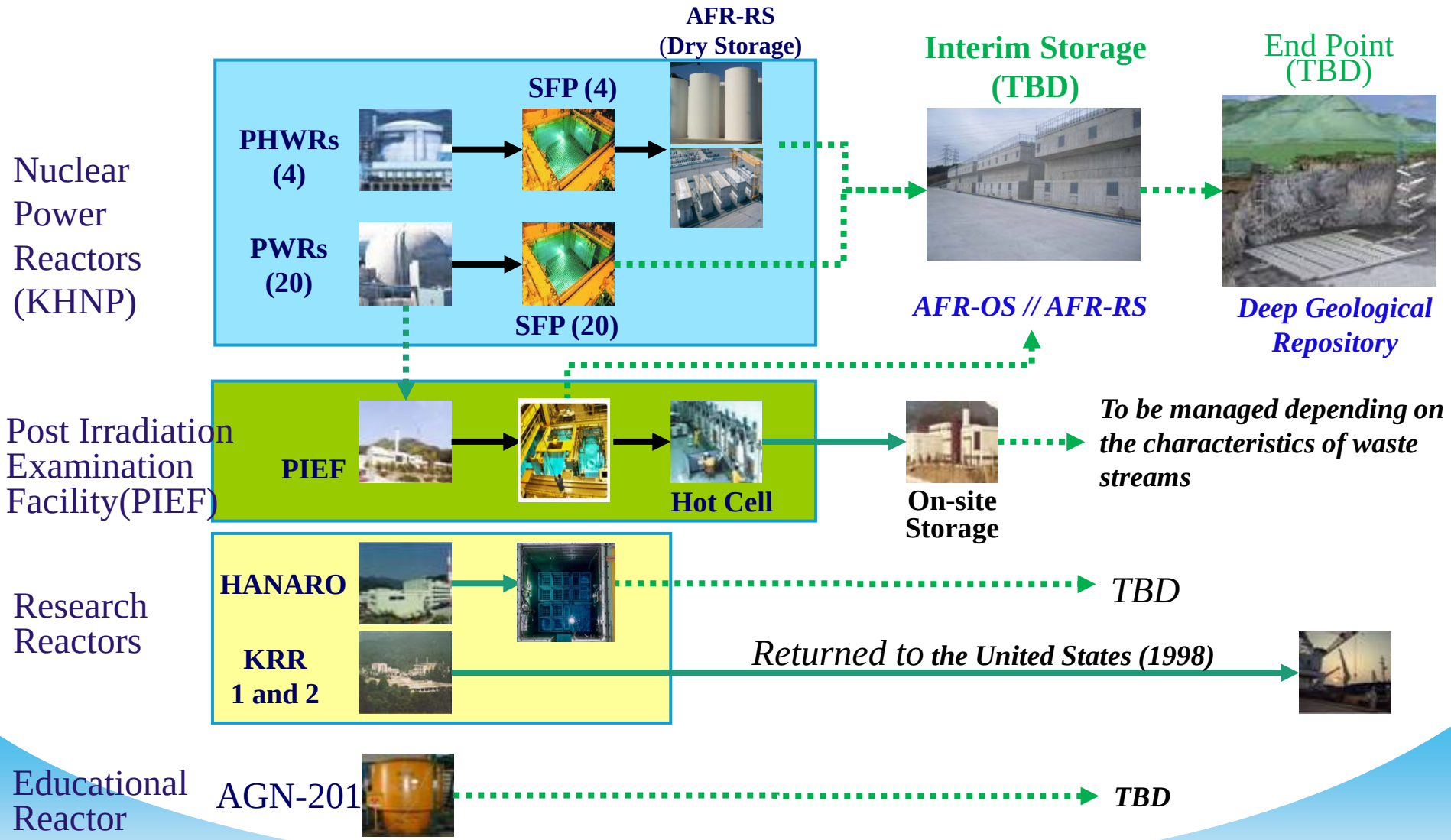
Contents

Major Nuclear Facilities

- **Nuclear Power Plant (NPP)**
  - 24 units in operation and 4 units under construction
    → OL for Shin-Wolsong Unit 2 granted in Nov. 2014
  - 2 units under PSAR review for CPs
  - Kori Unit 1 : (June 16, 2015) Decommissioning Decision
    (after June 19, 2017) Permanent Shutdown
- **Research Rector (RR) / Education Reactor (ER)**
  - HANARO (RR)
  - KRR 1 and 2 (RR, under decommissioning)
  - AGN (ER)
- **Nuclear Fuel Cycle Facility (FC)**
  - Fuel Fabrication Plant for NPP
  - Fuel Fabrication Facility for RR
  - Post-Irradiation Examination Facility (PIEF)
  - Uranium Conversion Facility (released from regulation)
- **Radioactive Waste Management Facilities (RW)**
  - RI Waste Management Facility
  - Wolsong LILW Disposal Center (WLDC)
    → in operation since 2015 (First disposal on July 13, 2015)



Framework of SF Management

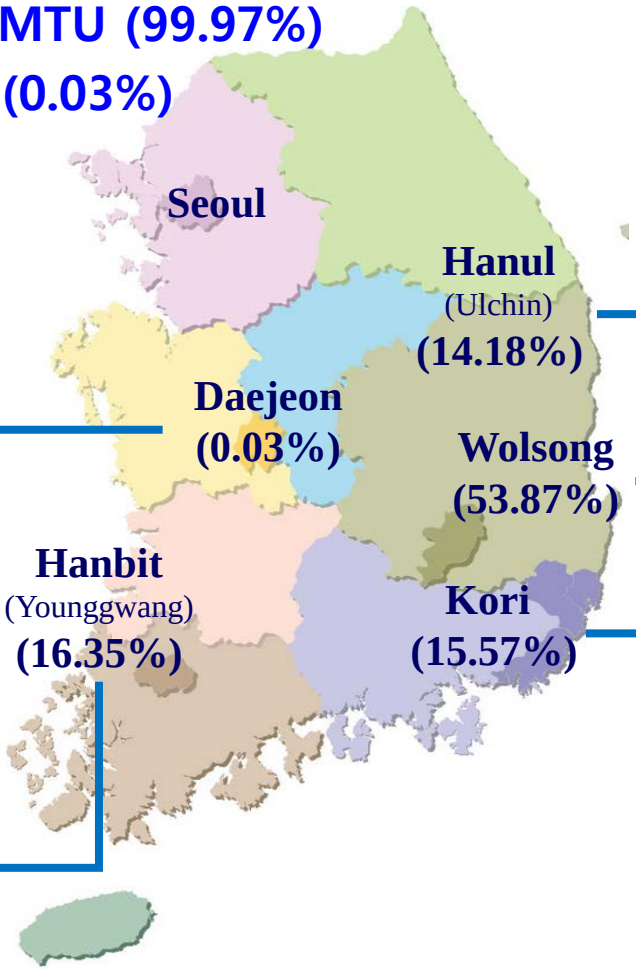


Inventory of Spent Fuels

Total 13,812.02 MTU

(As of Dec. 2014)

- KHNP: 13,807.84 MTU (99.97%)
- KAERI: 4.18 MTU (0.03%)



HANARO 	0.86
PIEF 	3.32
Sum	**4.18**

Unit 1~Unit 6 	**2,258.47**

Unit 1~Unit 6 	**1,958.43**

Unit 1~Unit 6 	2,532.77
Dry Storage 	4,907.93
Sum	**7,440.70**

Unit 1~Unit 6 	**2,150.24**

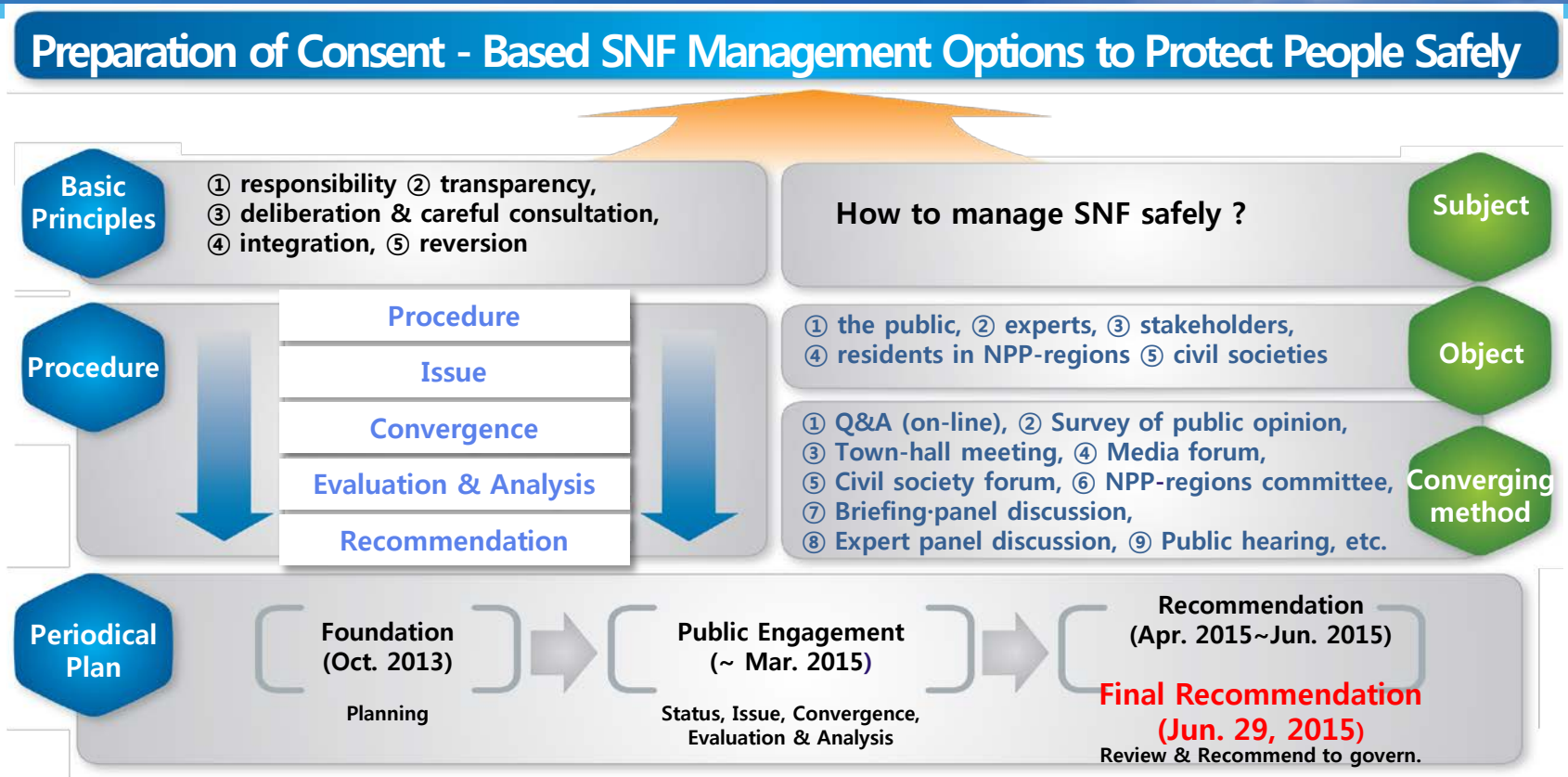
PECOS : Establishment and Operation

- Establishment of Public Engagement Commission on SFM (PECOS) for National Policy
  - The 2nd meeting of AEPC (Atomic Energy Promotion Committee) in Nov. 2012
    - Decision to revisit the national policy for SFM based on public consensus for mid- to long-term perspective
    - As part of efforts, decision to establish PECOS**, an independent advisory body**, established in October 2013 to perform public engagement activities
  - On June 29, 2015, PECOS recommended **public-consulted management options for SF**, as a candidate national policy to the Government, MOTIE (Ministry of Trade, Industry and Energy).
  - On June 30, 2015, PECOS officially stopped its operation and activities.
  - The Government will decide on possible changes to the policy for SFM based on the PECOS recommendations.

Public Engagement Commission on Spent Nuclear Fuel Management

https://www.pecos.go.kr

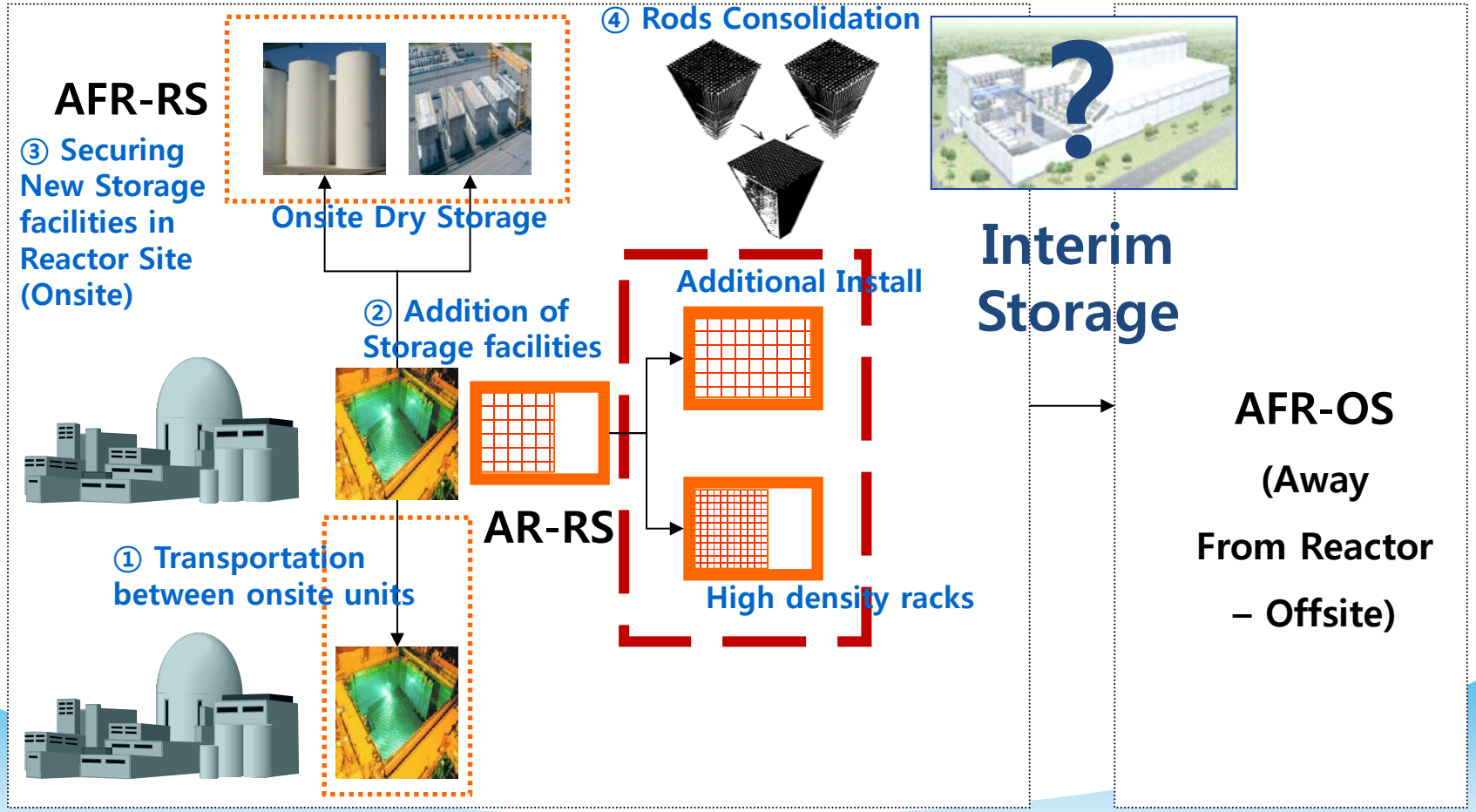
PECOS : Activities and Recommendation



- **Brief Summary of 10 Recommendations (June 29, 2015) by PECOS**
  - New interim SF storage facilities (PWR: by 2024, PHWR: by 2019)
  - New SF disposal facilities (by 2051), Site Selection of URL (by 2020), Start of research in URL (by 2030)
  - New Public Monitoring Center, Fund, Licensee, Standards, Law & Agency responsible for R&D, SFM

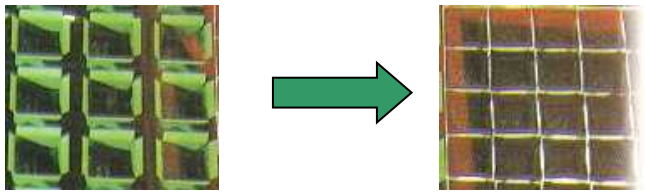
Expansion of Temporal Storage Capacity of SF

- **Various ways to expand temporal storage capacity of spent fuels**
  - This presentation is about **Additional Install of High density Racks** in Spent Fuel Pools.



Install of High Density Racks in SFPs of NPPs

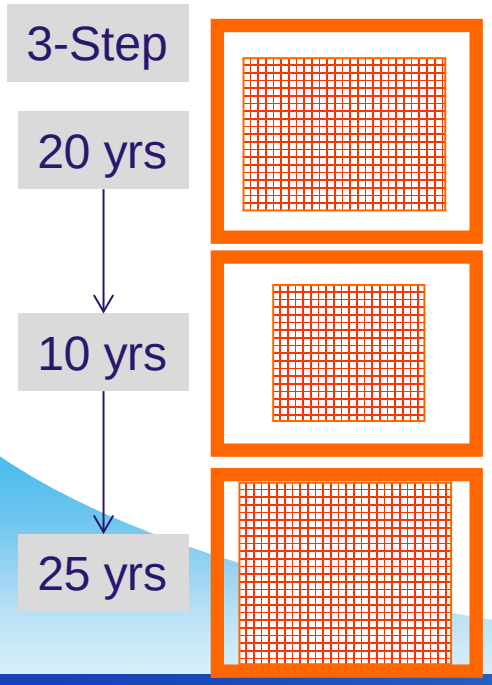
- **After 1995, existing NPPs began to install high density (HD) racks.**
- **10 units replaced existing normal racks with high density racks.**
  - Kori Unit 3 & 4 : Replacement with HD racks in 2002 & 2006.
  - Hanbit Unit 1, 2, 3 & 4 : Rep. HD racks in 2007, 1997, 2006 & 2006.
  - Hanul Unit 1, 2, 3 & 4 : Rep. HD racks in 1995, 2005, 2008 & 2008.



- **However, Kori Unit 1 & 2 and CANDU reactors (Wolsong Unit 1, 2, 3, 4) don't install high density racks.**
- **KSNP & New NPPs are designed to have high density racks in SFP.**
  - First, at **construction stage**, only 50 % of HD racks are installed.
  - Later, at **operation stage**, **additional install and re-racking** of HD racks.
    - Hanbit Unit 5, 6 : additional install of HD racks in 2012 & 2012.
    - Hanul Unit 5, 6 : additional install of HD racks in 2008 & 2013.
    - ShinKori Unit 1, 2: additional install of HD racks(planned in 2015~16)
    - ShinWolsong Unit 1, 2 : additional install of HD racks (planned)
    - ShinKori Unit 3, 4 : additional install of HD racks (planned after OL)
- **For reference, ShinKori Unit 5, 6 are designed to have two SPFs to accommodate all spent fuels for its design life of 60 years.**

Case Study : Additional Install of High Density Racks

- **During 2014~2015, safety reviews were made for additional install of high density racks in spent fuel pool of NPPs whose operation began in 2011 and 2012.**
  - All items related to nuclear safety, such as criticality safety, structural safety, seismic safety, thermal hydraulic safety, accident safety, and radiation shielding safety were reviewed.
- **For above NPPs, 3-Step Approach (20 years – 10 year – 25 years) was applied to fill SFP with High Density Racks.**
  - For reference, different approach could be applied to different NPPs.



In original design, high density racks are installed in SFP to accommodate spent fuel assemblies for 20 years. (1150 fuel assemblies)

At the stage of construction, SFP was filled with high density racks just for 10 years.

At the stage of operation, SFP is fully filled with high density racks for 25 years (original 20 years + additional 5 years : final total assemblies are 1450). Increased SFP capacity is about 26% compared with original design.

Considerations on Shielding Safety Review

- **Review items for radiation shielding safety review**
  - **Shielding capability of the cooling water of SFP**
    - Represented as the limitation of pool surface dose rates (25 μSv/hr)
      - Additional inquiries such as geometry modelling, materials, code input files and output files are required to identify the pool surface dose rates.
        ⇒ For MCNP, identification of proper use of Variance Reduction Technique and pass of all statistical tests and relative errors.
      - If necessary, confirmatory calculation is performed by using different approach to evaluate the surface dose rates or some reference values.
    - Shielding capability of SFP water : identified as much enough to limit the surface dose rates even in case of the increased fuel assemblies.
  - **Effect on radiation zoning** due to increased spent fuel assemblies
    - Radiation zone 2 (1~10 μSv/h) on accessible regions inside fuel building
    - Radiation zone 1 (< 1 μSv/h) on the outside surfaces of fuel building
    - No effect : identified by asking additional inquiries for dose rates
  - **Effect on shielding source terms** applied to design shielding capability of SFP cooling and cleanup system due to the increased
    - No effect : identified by asking additional inquiries for evaluation procedures of shielding source terms

Conclusion

- **Install of high density storage racks in SFP is to expand the temporal storage capacity of spent fuels in NPP.**

- **In Korea, since 1995, high density storage racks have been installed in SFP.**
  - Now almost existing NPPs have been equipped with high density racks in SFP **by replacement or additional install.**
  - There still **remain regulatory needs** for safety review for newly-constructed NPPs whose storage capacity have not been yet expanded.

- **Considerations are drawn on review items necessary to assess the radiation safety of high density storage racks.**
  - These considerations can be helpful to standardize radiation shielding safety review activities until fully-developed safety review guides are prepared for additional install of high density storage racks in spent fuel pools in NPPs.

Thank You.