KINS-NRC Information Exchange Meeting on the Spent Fuel

Spent Fuel Management in Korea

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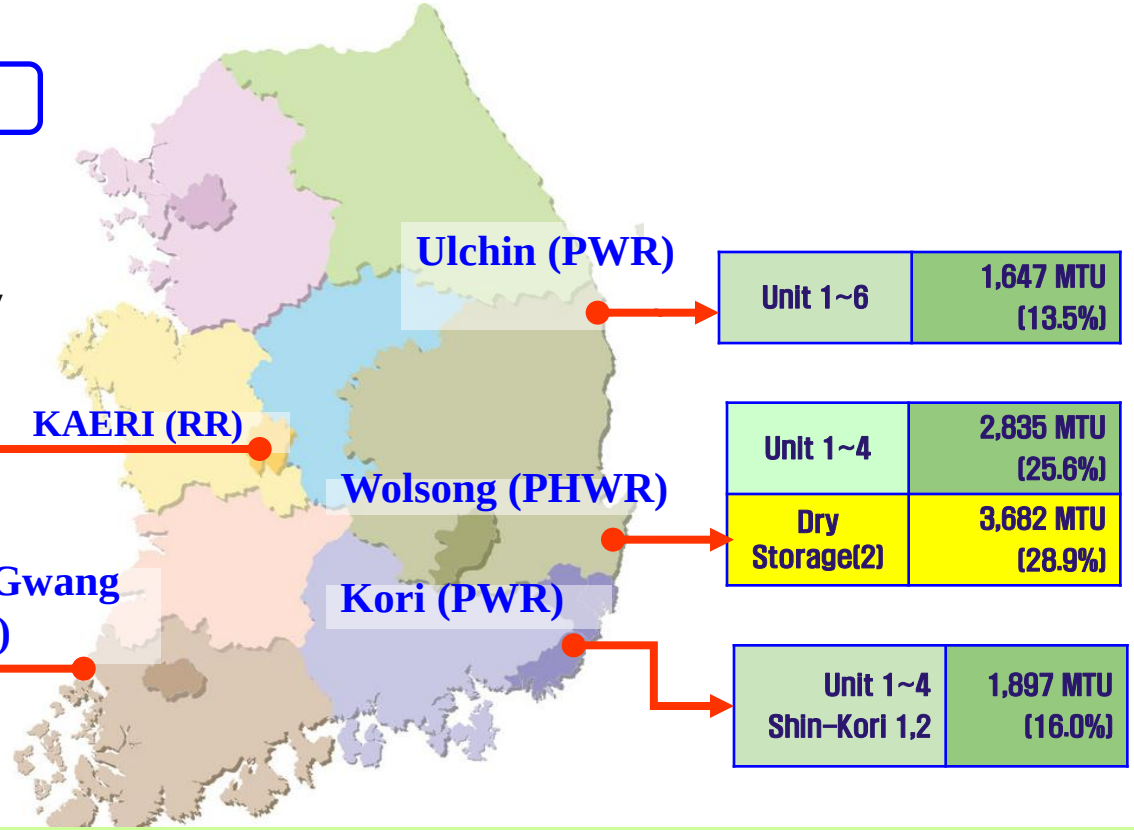
Introduction of Spent Fuel Management

❒ Spent fuel Inventory in Korea (2011. 12.31)

Total in Korea: 12,014 MTU

- 12,010 MTU (99.96%) at NPPs
- 4.0 MTU (0.04%) at KAERI
- Generated by PWR: 320 MTU/y
- Generated by PHWR: 380 MTU/y

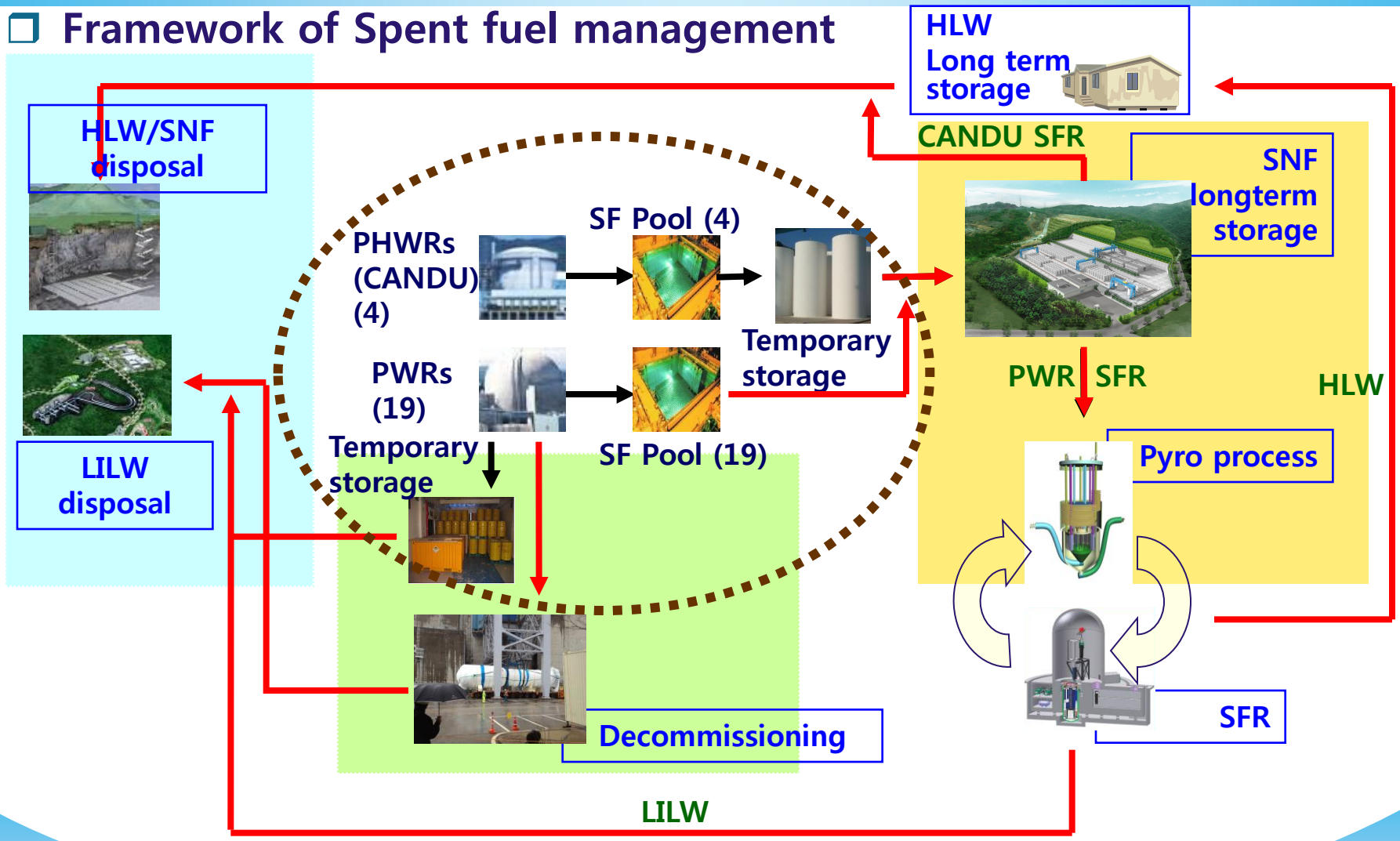


❑ To secure the on-site storage capacity

- PWR's storage facility has been expanded by re-racking and transshipment to other units.
- CANDU SFs have been transferred to the dry storage facility (Silo) since 1991, and the 7 modules of dry storage facility (MACSTOR) since 2010

Introduction of Spent Fuel Management

❒ Framework of Spent fuel management



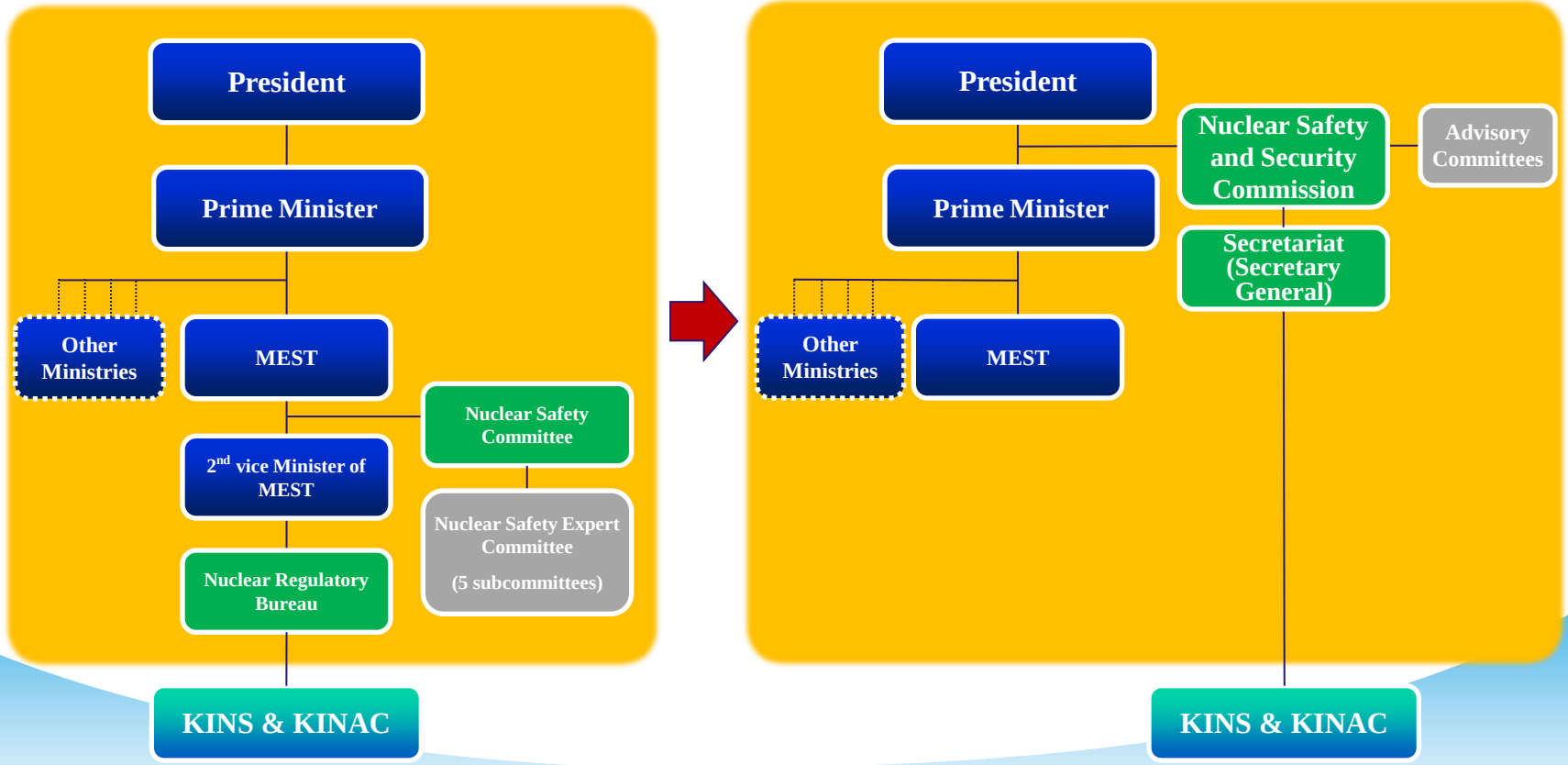
HLW/SNF disposal safety regulation

Spent fuel temporary storage and transportation

Independent Spent fuel Interim Storage and reprocessing

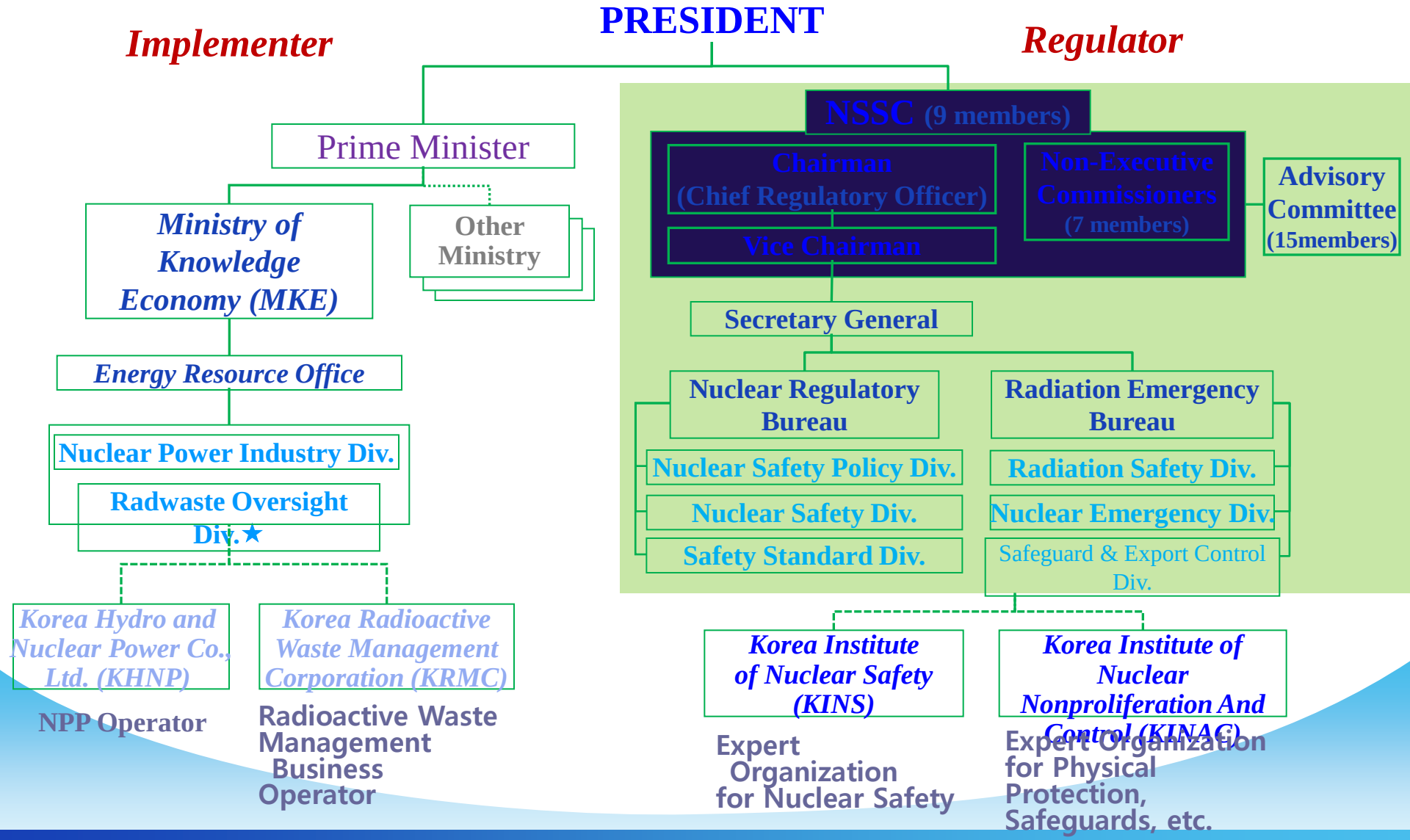
Legislative and Regulatory Framework

- The Nuclear Safety & Security Commission is an independent nuclear regulatory authority under the President and responsible for 3S (safety, security, and safeguards).
  - KINS & KINAC are regulatory expert organizations supporting NSSC



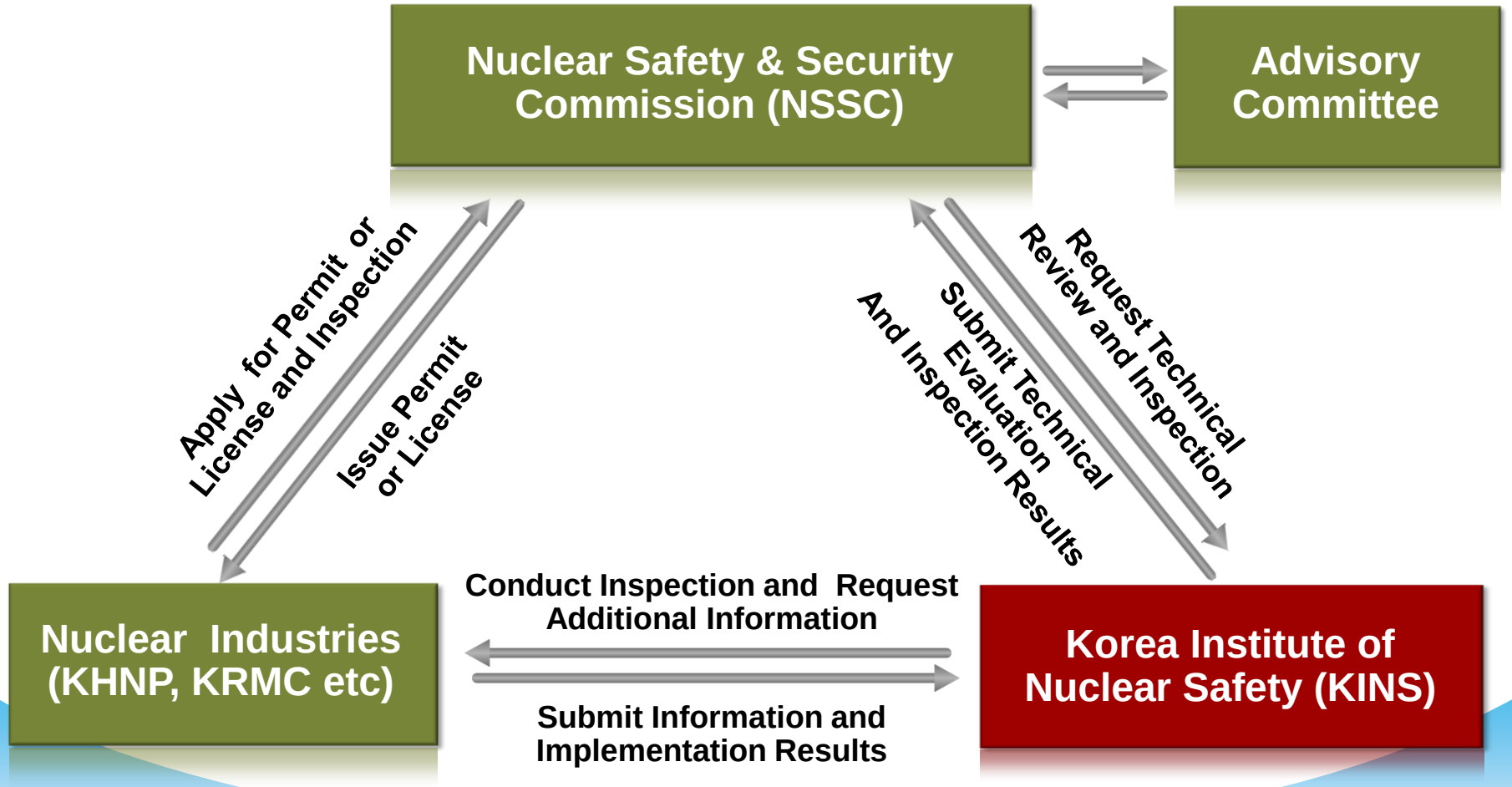
Legislative and Regulatory Framework

- **Related Major Ministry & Organizations (as of April 2012)**



Legislative and Regulatory Framework

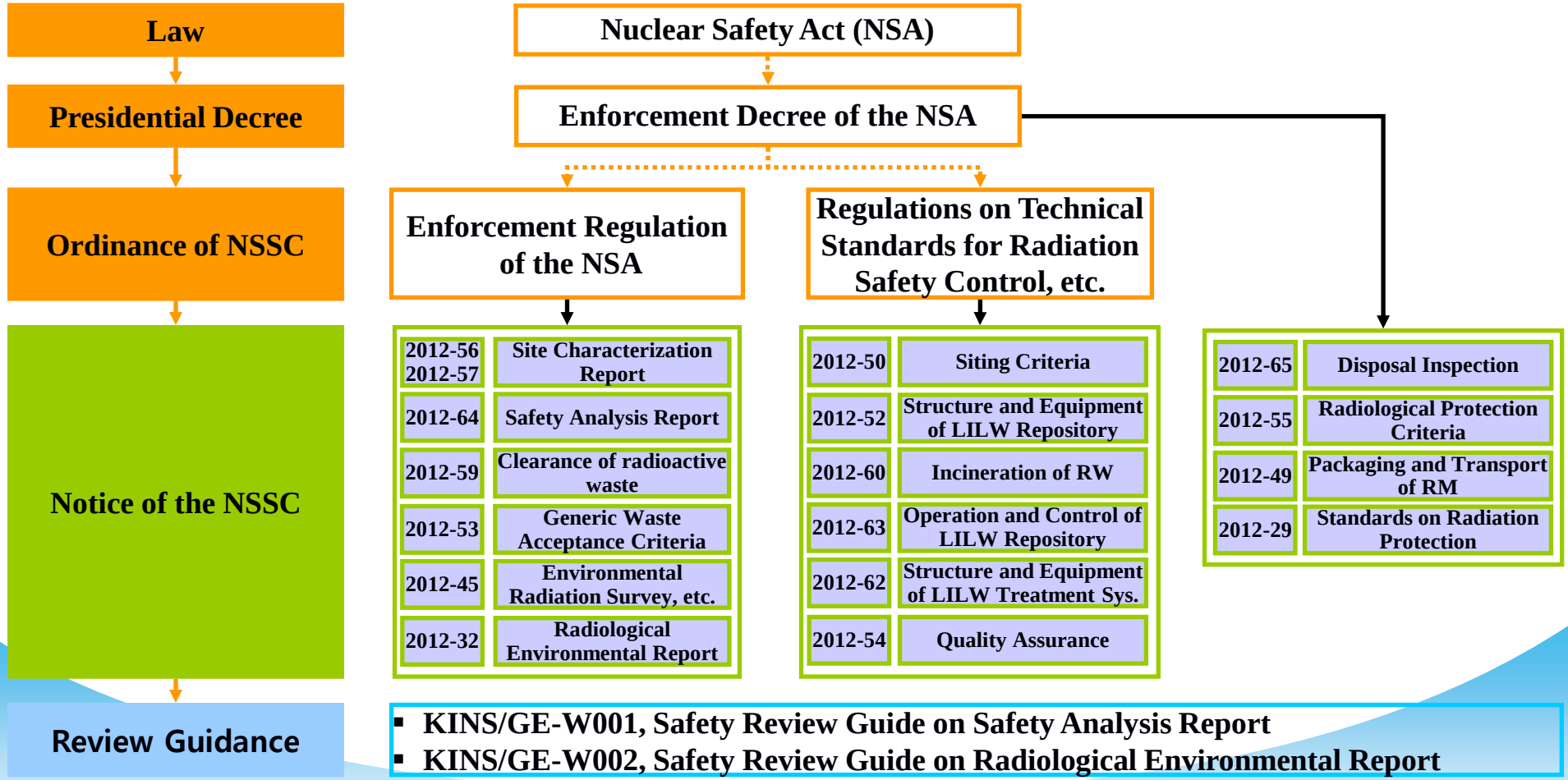
- **Interactive Mechanism for Nuclear Safety Regulation**



Legislative and Regulatory Framework

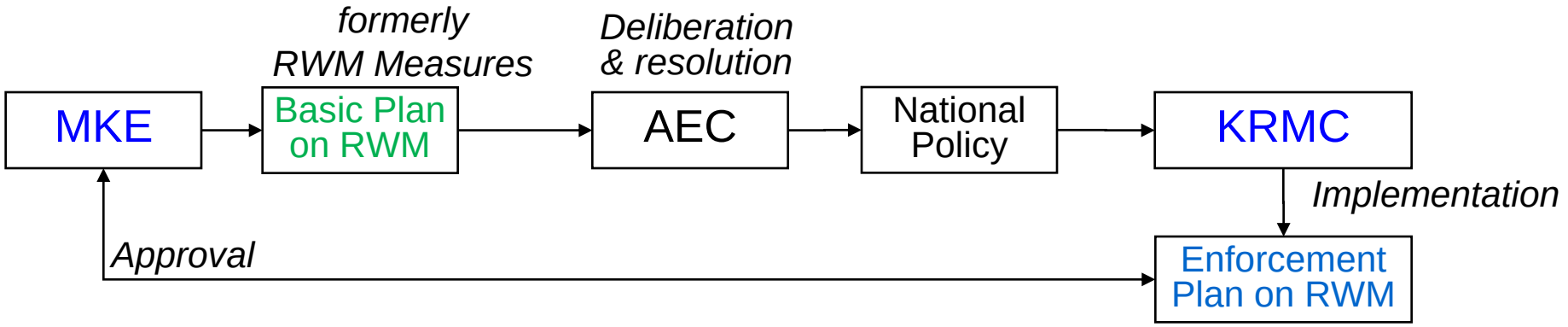
NSSC notices for Radioactive Waste Safety

- After enacting the Nuclear Safety Act and establishing the NSSC, the former MEST Notices was amended to the new NSSC Notices.

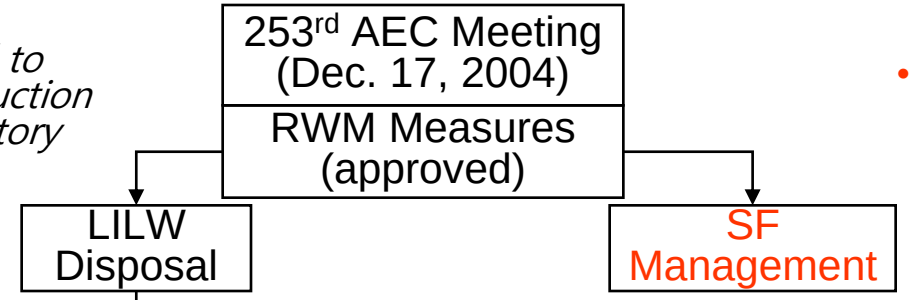


Legislative and Regulatory Framework

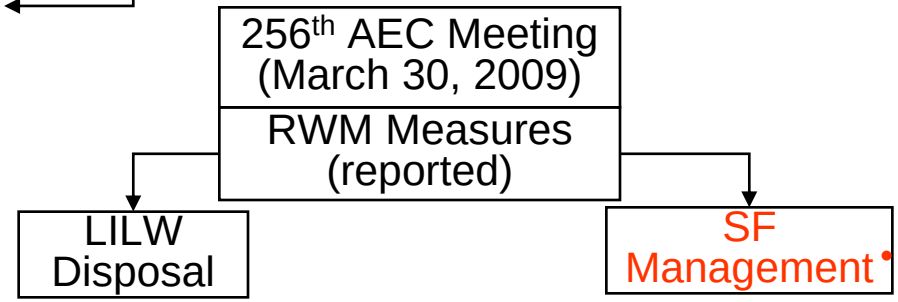
National Policy on RWM & SF



- *The AEC resolved to proceed with construction of the LILW repository firstly by 2008*



The disposal facility is now under construction



- *The MKE reported the status of construction of the WLDC.*

- *Measures for SFM including interim storage: to be determined in a timely manner through national consensus by public consultation among stakeholders, with consideration given to the development of domestic and international technology*

- *Reported the publicizing plan*

Legislative and Regulatory Framework

Milestones of Policy Making on SF Management

Dec. 17, 2004

253th AEC

- Planning for Policy-making on SFM options (including interim storage) through public consultation

April 2007 to April 2008

Conflict Management Sub-Committee of NEC

- Study on publicizing options
- Publication of a Recommendation Report

Aug. 2008

MKE

- Reporting to the NEC on the publicizing plan based upon the recommendation report

March 30, 2009

MKE

- Reporting the basic plan and tentative schedule for publicizing to the 256th AEC

June to Aug. 2009

MKE

- Composing the publicizing committee on the SF
- Suspending the committee

Dec. 2008 to May 2009

KRMC

- Designing detailed program for publicizing by contracting external organizations

Dec. 2009 to Dec. 2010

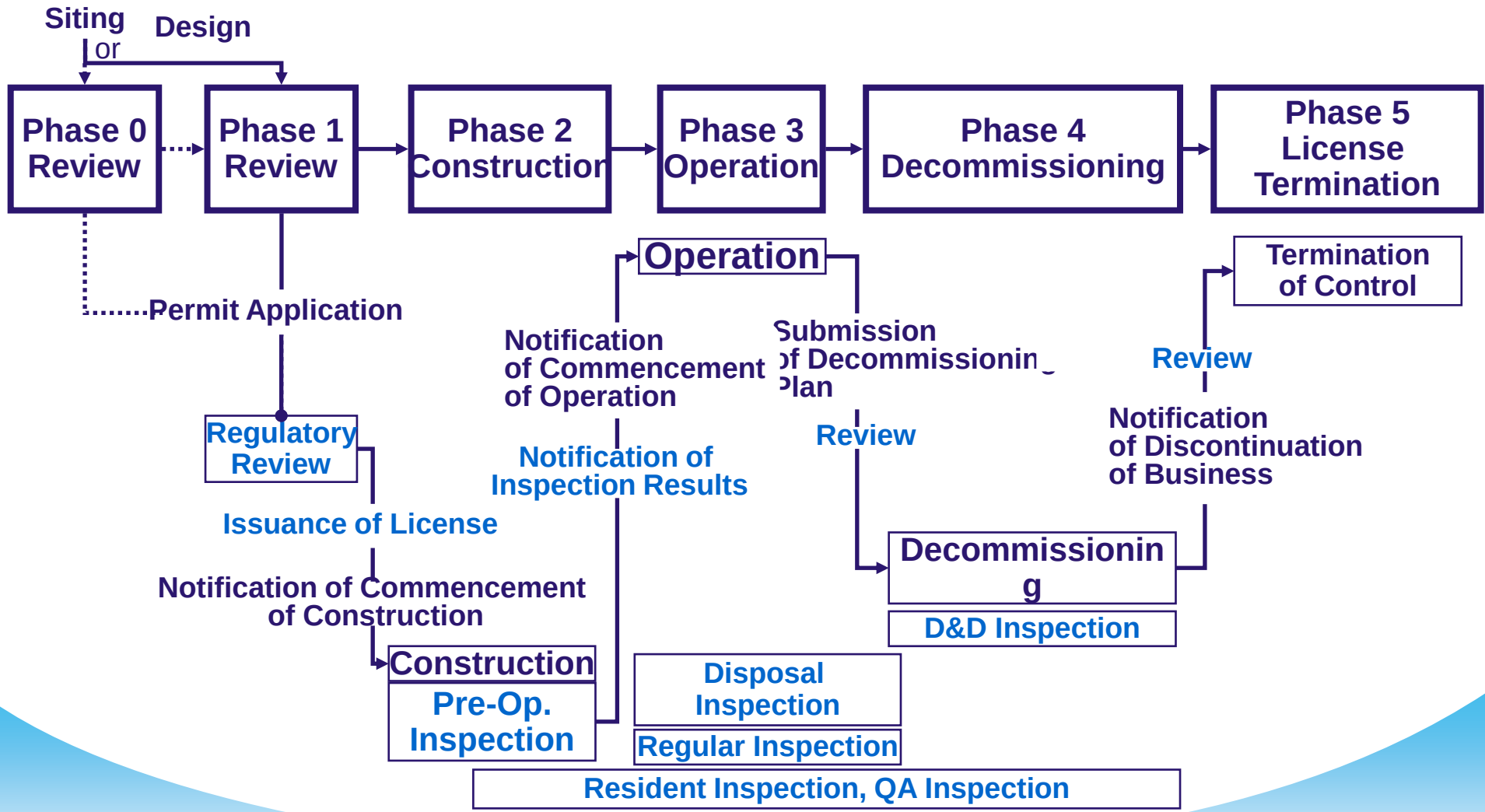
MKE

- Project on the SF Management Options and Roadmap by KNS, KRS etc.

- **NEC: National Energy Commission**

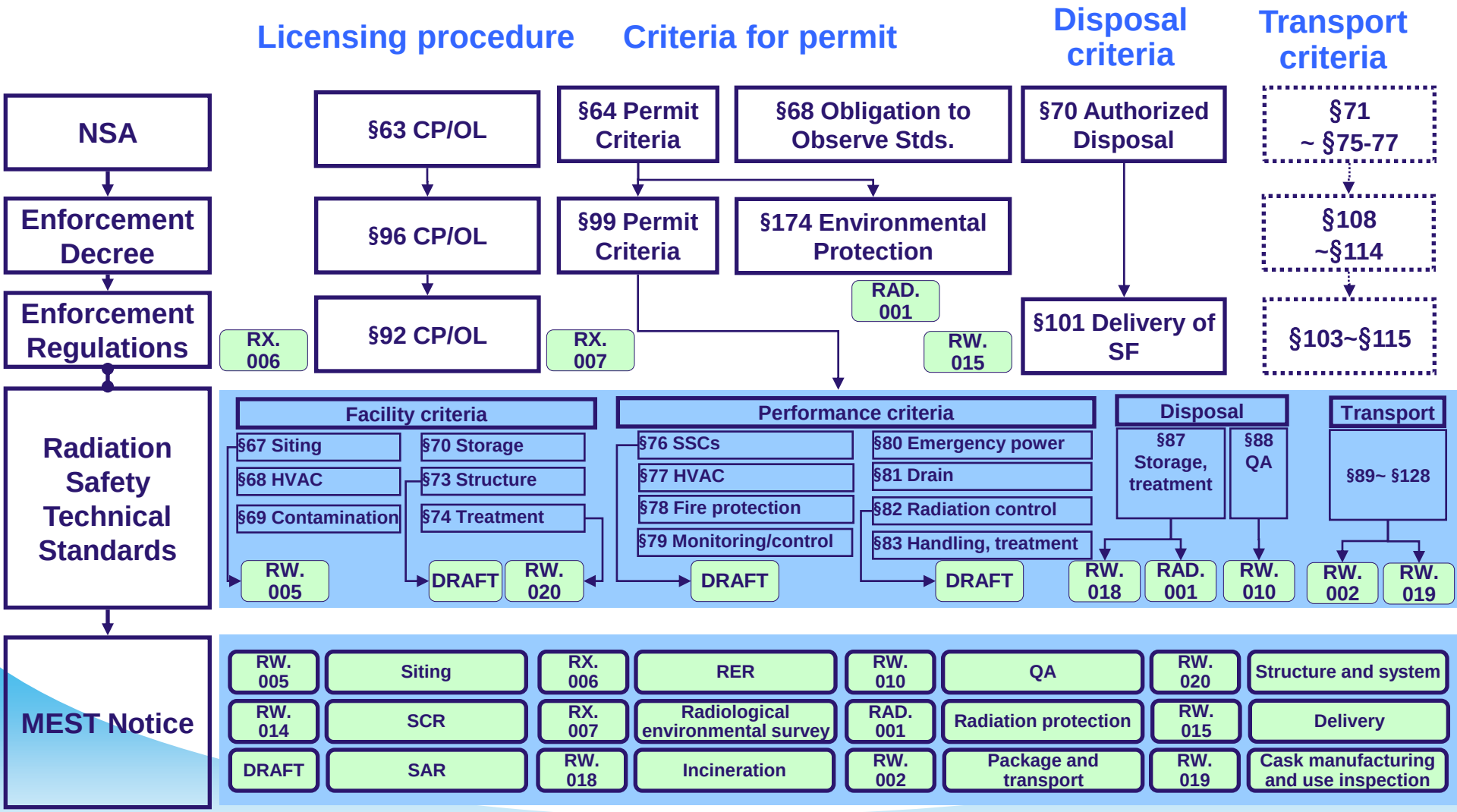
Legislative and Regulatory Framework

- **Stepwise regulatory system – interim storage**



Legislative and Regulatory Framework

- **Licensing procedures and regulatory requirement**



Legislative and Regulatory Framework

● Documents for permit application – interim storage

NSA §63 - related

① **Radiological Environmental Report**

② **Safety Analysis Report**

③ Safety Administration Rules

④ Design and Construction Methods

⑤ Quality Assurance Program

Enforcement regulations of the NSA §92 - related

① Construction and Operation Plan

② Storage, Processing and Disposal Methods

③ Types and Volume of SF

④ Technical Capabilities regarding Construction and Operation

⑤ Equipment and Manpower

Legislative and Regulatory Framework

- **Standards on interim storage of SF**
  - **Siting Criteria**
    - Meteorological conditions, Hydro-geological features, Earthquakes
    - Ecological characteristics
    - Availability of existing water resources, etc.
  - **Standards for Structure and Equipments**
    - Shielding
    - Prevention of criticality and sufficient cooling capacity
    - Prevention of radiological hazards due to natural phenomena
      - Tsunami, Tornado, Typhoon, Flooding, Heavy Snow/Rainfall, Earthquake, etc.
    - Retaining safety functions in fire and/or explosion accidents
    - Prevention of undue radiation exposure due to accidental release of RM

Legislative and Regulatory Framework

- **Standards on structures and facilities of interim storage of SF**

Articles in the draft Notice	U.S. (10 CFR Part 72)	IAEA (Safety Series No. 116)
§4 (Basic requirements) §23 (specs. and stds.)	**Subpart A, F**	**§ 201-206, § 207-212**
§4 (Basic requirements), §5 (Base foundation)	**§ 72.122(b)(2)(ii)**	**§ 217, § 322-332**
§13 (Materials)	**§ 72.120(d)**	**§ 230-237, § 342-245**
§11 (Removal of heat)	§ 72.128(a)(4)	§ 225-229, § 338-341
§8 (Criticality)	§ 72.124(a)~(c)	§ 213-216, § 320-321
§10 (Confinement)	§ 72.122(h)	§ 223-224
§9 (Shielding)	§ 72.126(a)(6)	§ 221
§14 (Radiation protection)	**§ 72.126(a)~(c)**	**§ 218-220; § 333-337**
§15 (Fire protection)	**§ 72.122(c)**	**§ 409-411**

Legislative and Regulatory Framework

- **Standards on structures and facilities of interim storage of SF**

Articles in the draft Notice	U.S. (10 CFR Part 72)	IAEA (Safety Series No. 116)
§12 (Handling equipments)	§ 72.128(a)	§ 238-232 § 346-347
§22 (Test, monitoring, inspection, and maintenance)	§ 72.122(a),(f)	§ 601-603
§6 (Natural disasters) § 7 (Man-made accidents)	§ 72.122(b)	(SS No. 118)
§16 (Alarming equipment) §17 (Lighting) § 19 (Maintenance of facilities)	§ 72.122(j),(k)	§ 401-418
§24 (Prevention of sharing systems)	§ 72.122(d),(k)(4)	
§20 (Emergency power)	§ 72.122(k)(3)	§ 402~403
§26 (Decommissioning)	§ 72.130	§ 701-703
§4 (Basic requirement)	§ 72.122(l), § 236(h),(m)	

National Policy for Long-term Management of SF

- **Efforts toward the National Policy-Making**
  - Studies on publicizing the opinion for SF management (since 2006)
  - Reporting the publicizing plan to the Atomic Energy Commission (March 2009)
  - Continuous R&D Activities on Long-term Management Options
    - R&D on Disposal SF
      - Continuous and Systematic R&D programs on disposal of SF mainly done by the KAERI since 1997
      - KURT(Korea Underground Research Tunnel)
    - R&D Planning for Advanced Nuclear Fuel Cycle
      - Proposal and approval of the R&D Plan for a proliferation-resistant fuel cycle consisting of the Pyro-process and the Sodium Fast-cooled Reactor
    - Development of HLW(SF) Geological Disposal Requirements (Draft)

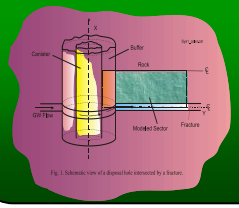
National Policy for Long-term Management of SF

- **To develop the Advanced Korean Reference disposal System(A-KRS) to integrate all HLW and LILW to be gegerated in the future**

System Development

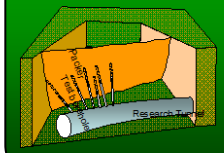
- Source-term Character.
- Disposal sys. design & assessment
- National policy

TSPA Study



-Safety assess. of disposal system
- QA system

Geoenvironment



- Groundwater
- Tectonics
- Geology
- In-situ hydraulic tests (KURT)

Reference System (A-KRS)

- feasible
- safe
- confident

Nuclide Migration

- AT/FP migration tests in reducing condition
- Database

Demonstration of EBS Performance

- Eng. Scaled THM behaviour experiments
- EDZ characterization
- Basic study for Demonstration and Validation of EBS perform.

National Policy for Long-term Management of SF

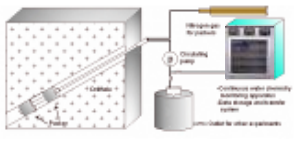
KAERI R&D Plan on Geological Repository for SF

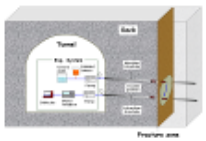
2005 | 2007 | 2012 | 2015 | 2020 | 2030 | 2040

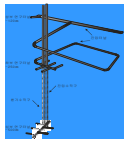
Generic Study

Validation & Demonstration

Implementation



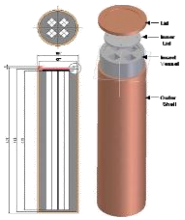


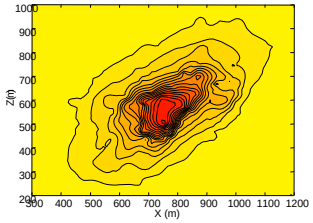


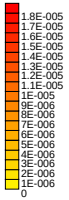
Site Investigation → Repository Design/Const → O/M → Disposal PHWR SF

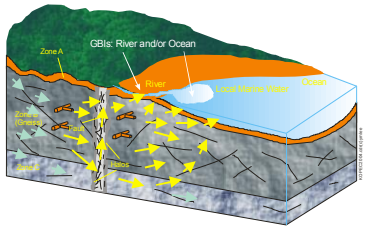
KURT in situ tests and Validation → Integrated Safety Case & Verification

A-KRS → Assessment









2015

- Conceptual design of Advanced Korean Ref. disposal System (A-KRS) and assessment
- Development of safety case
- Demonstration of EBS's Performance in KURT

2020

- Development of safety case
- Regulations for siting
- Completion of basic R&D and start of implementation (2020-2030)

Actions after Fukushima Accident

- **Identification of vulnerability and Safety Improvements**
  - Special Safety Inspection on NPPs (2011.3-4)
  - Determine Safety Improvement vs. Fukushima(2011.5-7)
- **Strengthened Regulatory System**
  - Establishment of NSSC (2011.10)
  - Refinement of Safety Inspection System (2012.4)
- **Public Outreach and International cooperation**
  - Strengthening Environmental Radiation Monitoring
  - Daily Briefing at Press Conference and Web-pages
  - Cooperation with Neighboring Countries
    - Korea-Japan-China Cooperation, including Top Regulators' Meeting(TRM)

Post –Fukushima Actions for SF

- **Special Safety Inspection for nuclear facilities (Phase I)**
  - The MEST, decide to conduct a comprehensive Special Safety Inspection on NPP & research reactors & nuclear fuel cycle facility
  - 6 teams, 73 experts for 27 inspection items
  - Identified a total of 50 long-and short term improvement for safety of NPP

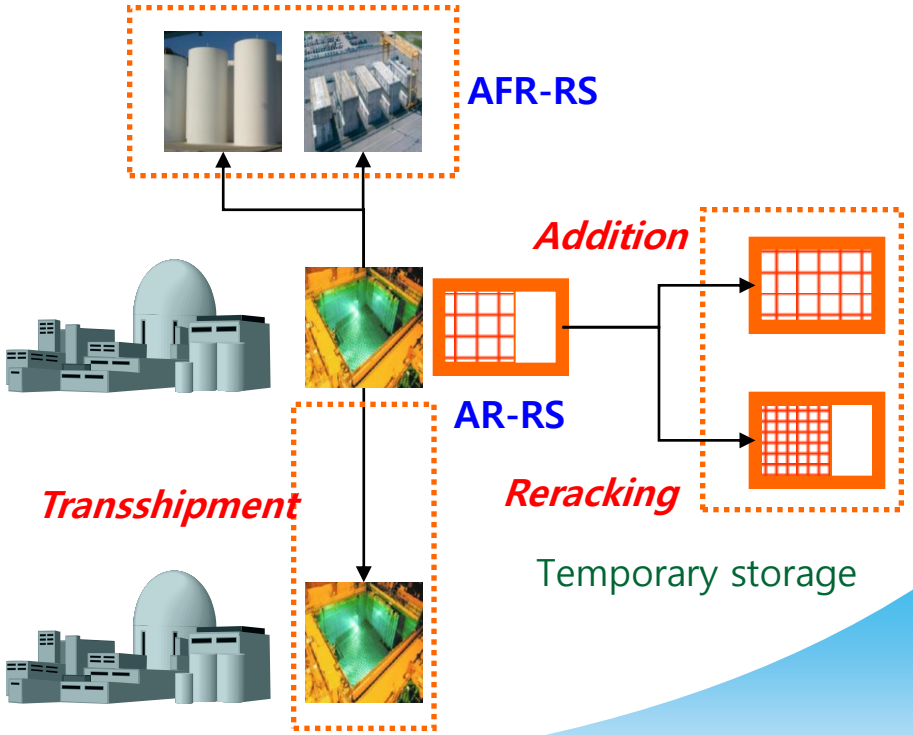
Post –Fukushima Actions for SF

- 'Ensuring countermeasures against loss of the spent fuel pool cooling function'
  - To fill water directly into the spent fuel pool using the hydrant located inside the Fuel Handling Building(FHB)
  - To fill water directly into the spent fuel pool using fire engine from outside the FHB
  - To install emergency water filling pipes on the spent fuel pool and, if necessary, connect the newly installed pipes of the water purification facility to fill water into the spent fuel pool
  - To connect the fire hose of the fire engine to the newly installed pipes to fill water into the spent fuel pool
- These identified improvements will be implemented in Phase 2, which is to enhance the safety regulation standards and guides for NPP

Actions to Secure Storage Capacity for SF

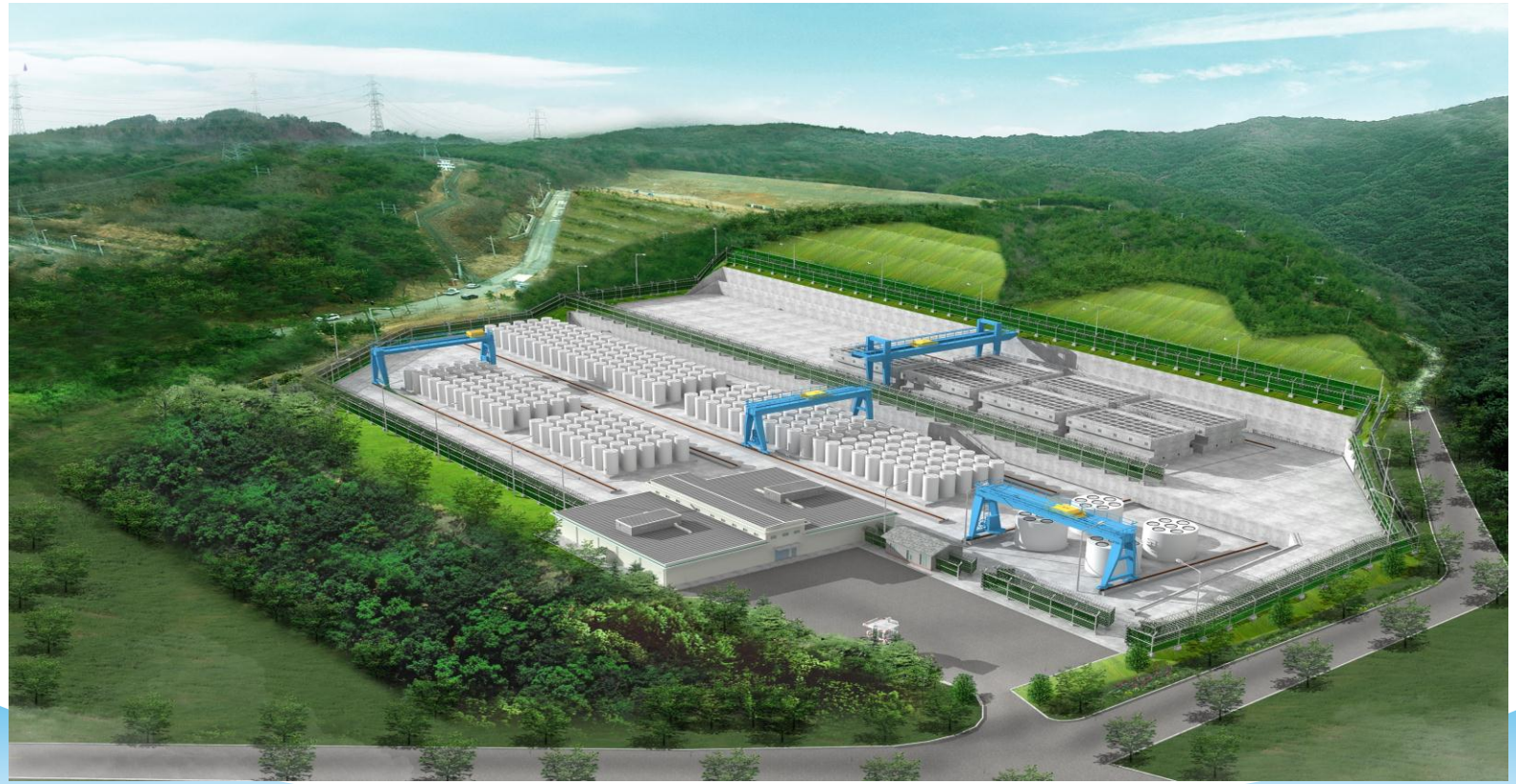
- PWR : expanded by re-racking and transshipment to other units
- PHWR : dry storage facility(300 Silo) since 1991 and the 7 modules of dry storage facility(MACSTOR/KN-400) since 2010 on site

NPP Site	Measures
Kori	Unit 1 and 2: Transshipment Unit 3 and 4: Addition and Reracking
Yonggwang	Unit 1: Addition and Reracking Unit 2: Addition Unit 3 and 4: Reracking Unit 5 and 6: Reracking is planned in 2012
Ulchin	Unit 1 and 2: Transshipment Unit 1 to 4: Reracking Unit 5 and 6: Reracking is planned in 2013
Wolsong (PHWR)	AFR-RS Dry Storage: Silos and Vaults



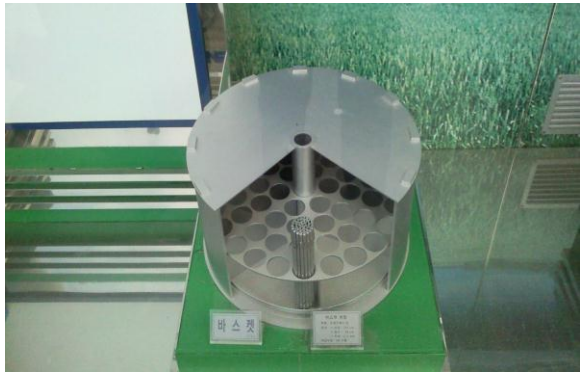
Actions to Secure Storage Capacity for PHWR SF

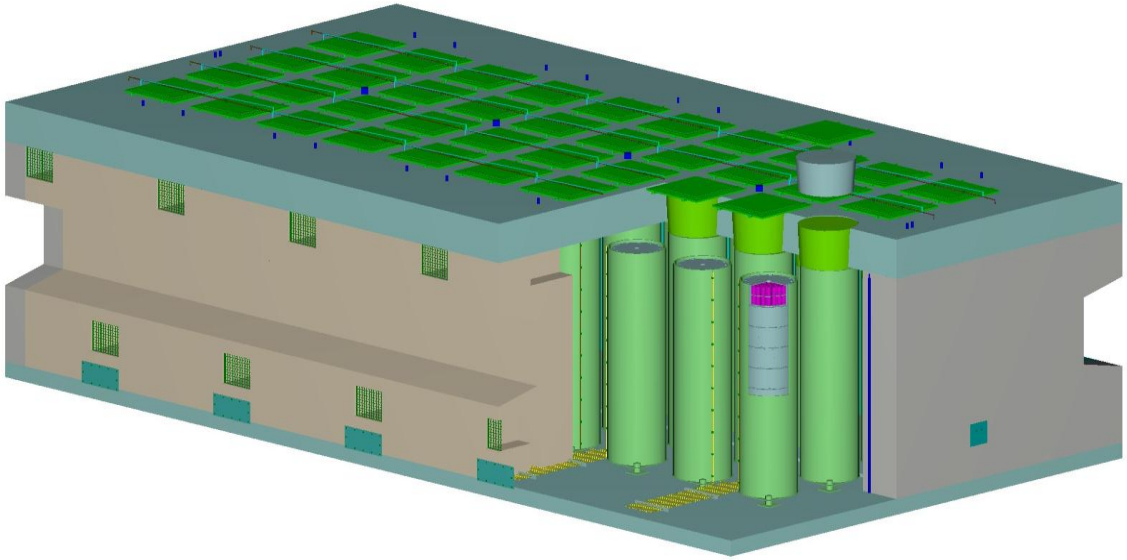
- **Dry Storage for PHWR Spent Fuel – Silo & vault**
  - Silo : 300 units
  - MACSTOR/KN400 : 7 modules



Actions to Secure Storage Capacity for PHWR SF

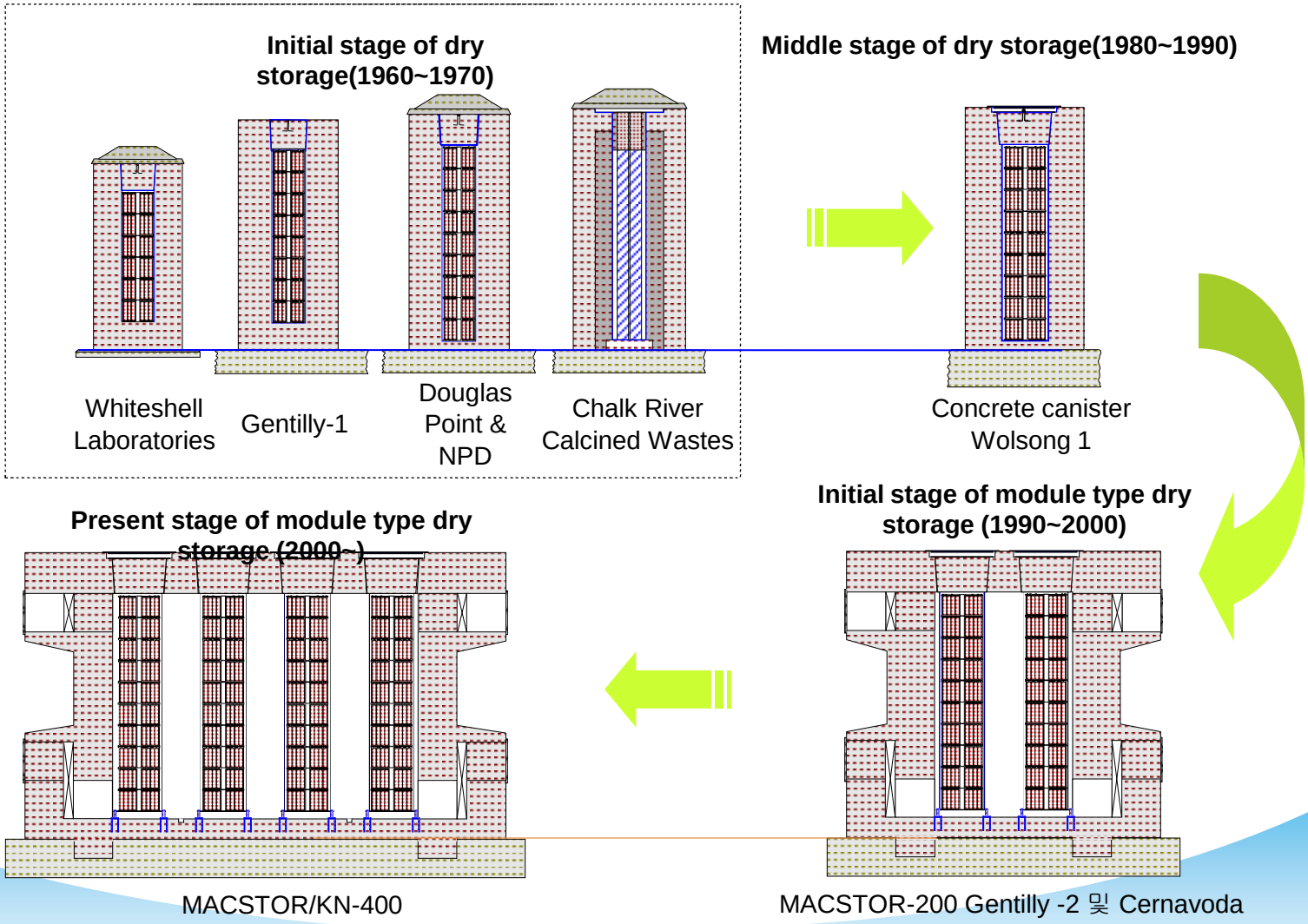
- **Inside of the spent fuel storage facility**





Actions to Secure Storage Capacity for PHWR SF

- **Development of the PHWR Spent fuel storage facility**



Actions to Secure Storage Capacity for PHWR SF

- **Comparison between Canister type and MACSTOR type**
  - Spent fuel : undamaged CANDU type spent fuel at least after cooling 6 years in the spent fuel pools

	Silo (canister)	MACSTOR
Basket	60 bundle	60 bundle
units	300	7 module
Capacity	9 basket/unit	400 basket/module
Total capacity (unit : bundle)	162,000	168,000
(Expected) saturation time	2010. 04	2018

Transport Regulation of Spent fuel

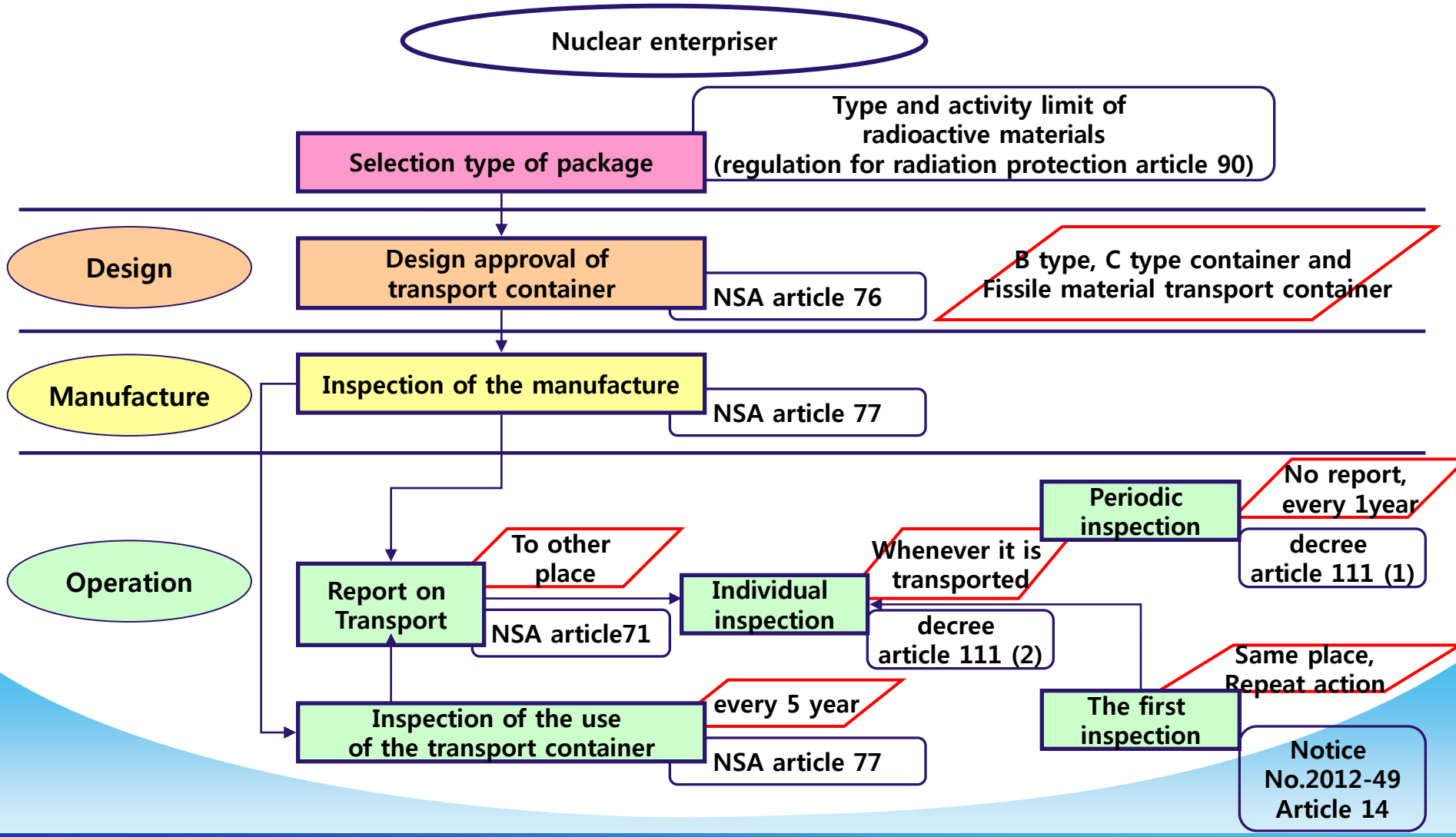
- **Spent fuel in view of the transport**
  - Types of package (which are subjected to the activity limits and material)
    - Type L package (Excepted package, IAEA)
    - Type IP package (be classified IP-1, IP-2, IP-3)
    - Type A package
    - Type B package (be classified type B(U) and type B(M))
    - Type C package
    - Fissile material package

Transport Regulation of Spent fuel

- **Regulations**
  - Review
    - Approval of package designs :
      - Nuclear Safety Act article 76, Enforcement decree article 112 and Enforcement regulation from article109 to article 111
      - Objective : type B container, type C container, fissile material container
  - Inspection
    - Inspection of the manufacture and the use (every 5 year)
      - NSA article 77, Enforcement decree article 113, and enforcement regulation from article 113 to article 114
      - Notice No. 2012-61 : Regulations for manufactures and periodical inspection of Transport containers for Radioactive Materials
    - Inspection of transport :NSA article75
      - Periodic inspection (every 1 year) : To confirm of the satisfaction of technical standard concerning Package or Transport (ASA enforcement decree article 111 (1))
      - Individual inspection : whenever spent fuel is transported (ASA enforcement decree article 111 (2))

Transport Regulation of Spent fuel

- **Safety regulations for transport of radioactive materials**



Transport Regulation of Spent fuel

- **Status of spent fuel transport cask in Korea**

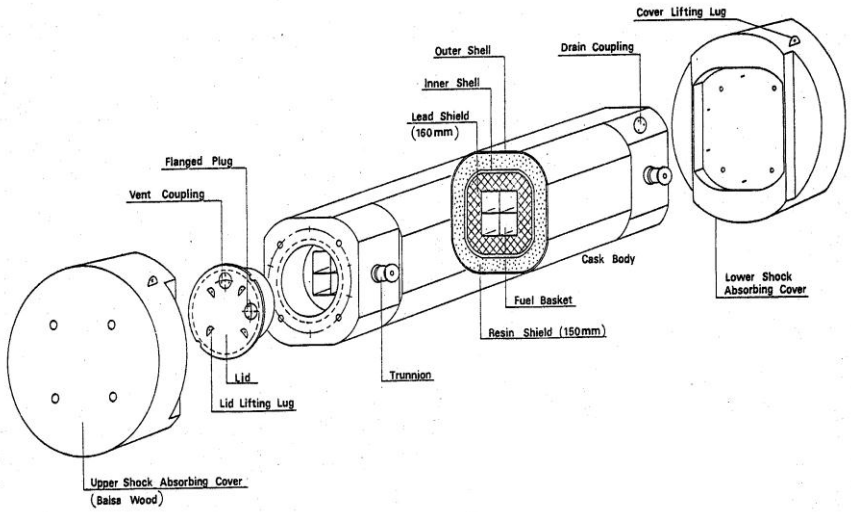
Institute	Model	capacity (FA)	Burnup (MWD/MTU)	enrich ment (wt%)	Cooling time (yr)	weight (ton)	quantity (ea)	Remark
KAERI	KSC-1	1	40,000	-	1	28	1	Transport between NPP-KAERI
KAERI	KSC-4	4	38,000	3.5	3	37	2	Transshipment Between Kori NPPs
KHNP	KN-12	12	50,000	5.0	7	75	5	Transshipment of WH type spent fuel where KORI, ULJIN, YOUNGGANG
KHNP	KN-18	18	55,000 60,000	5.0	7 9	104	manufac turing	Transshipment of CE type spent fuel where ULJIN and YOUNGGANG
KHNP	HI-STAR 63	PHWR 120	7,800	0.711	6	25	2	Transshipment Between WOLSONG 1&2 and MACSTOR

Transport Regulation of Spent fuel

- **KSC-1 transport cask**

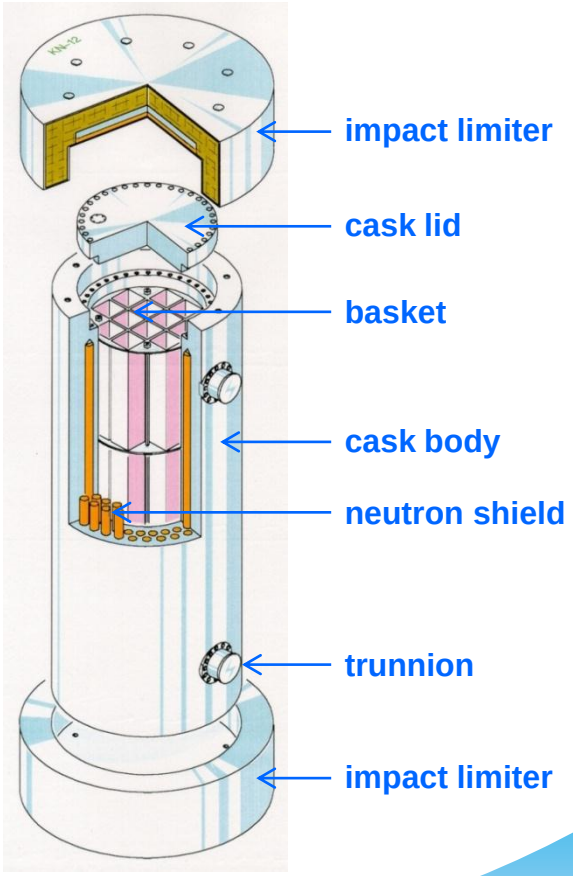
Transport Regulation of Spent fuel

- **KSC-4 transport cask**



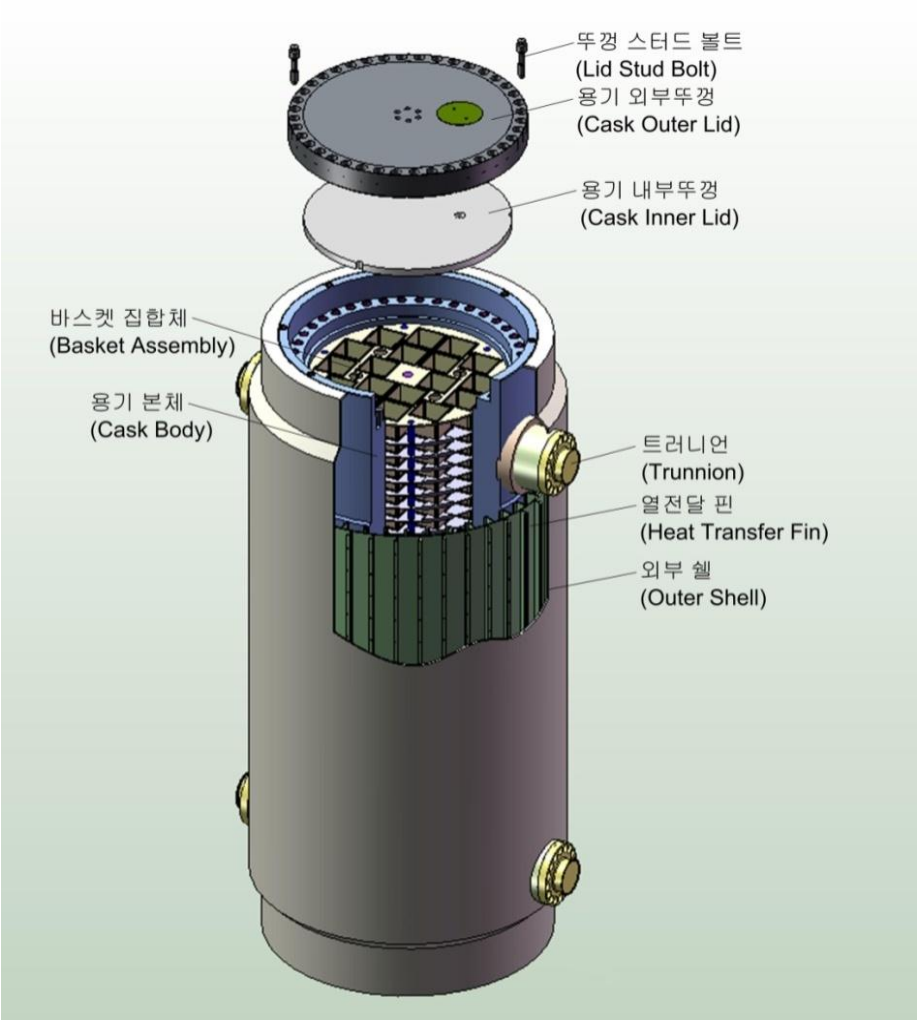
Transport Regulation of Spent fuel

- **KN-12 transport cask**



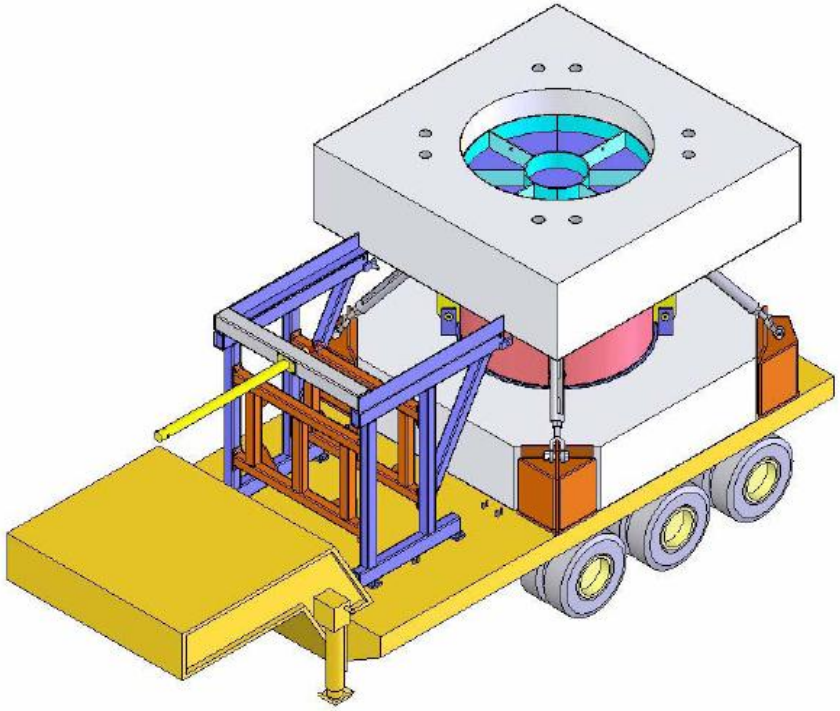
Transport Regulation of Spent fuel

- **KN-18 transport cask**



Transport Regulation of Spent fuel

- **HISTAR-63 transport cask**



Research Project for Long-term Storage of Spent fuel

- **Development of regulatory verification technology on the long-term storage of spent fuel**

Research area	year	contents
Establishment of the Licensing and reformation direction of Atomic Safety Act	1st year	.Review the applicability of the Nuclear Safety Act related to licensing regulatory system
	2nd year	.Establishment of the Reformation direction for the NSA Criteria and standards for long-term storage of spent fuel
Development of Technical standards and Review guide	3rd year	.Development of the draft of the NSSC notice for HLW (including SNF) transport vessel
	4th year	. Development of the technical standard & review guide (I) (Review guide for transport risk evaluation) (Review guide for evaluation of spent fuel storage siting applicability)
	5th year	.Development of the technical standard & review guide (II) (Review guide for evaluation of source term, criticality, heat removal, shielding) (Review guide for evaluation of structure and equipment of spent fuel storage facility)

Thanks for your attention