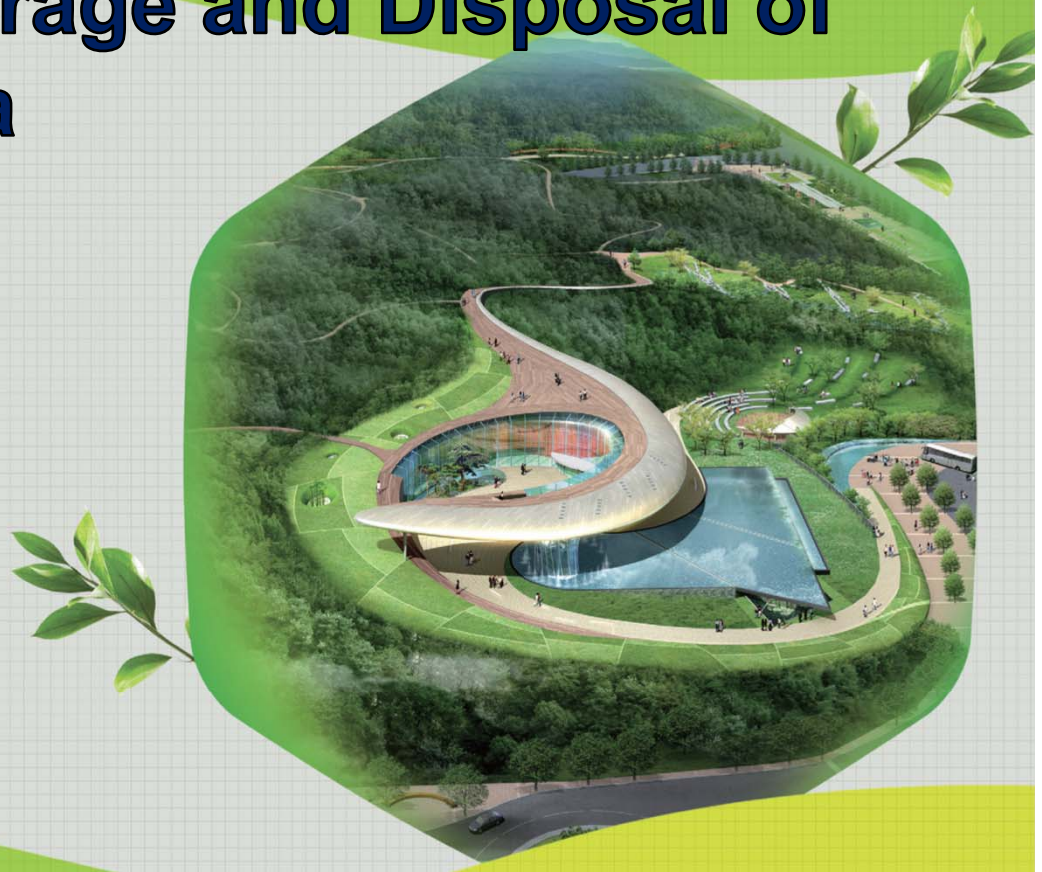
R&D Status and Plan for Transportation, Storage and Disposal of Spent Fuel in Korea



Jun 8, 2017

Cho, Chun-hyung

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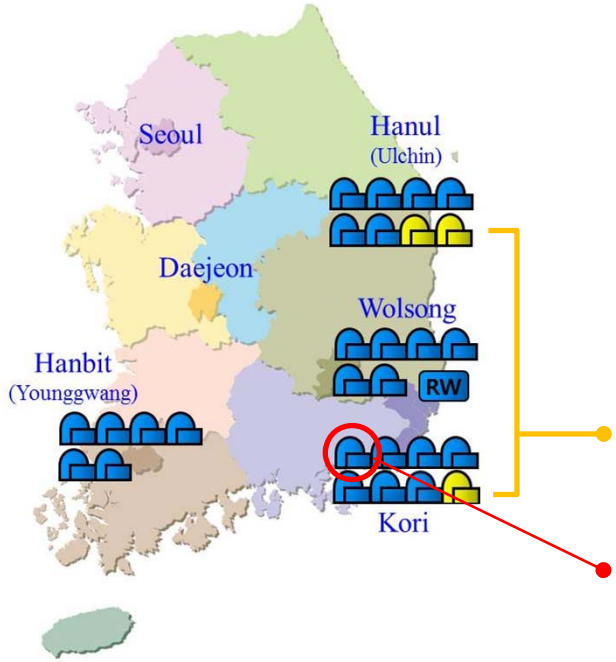
I SNF Management in KOREA

I. SNF Management in KOREA

Overview of Nuclear Power Plants



NPP
In operation
Under construction

25 units in operation, as of Dec. 2016
(21 PWRs and 4 PHWRs)

3 Units (Shin-Kori Unit 4, Shin-Hanul Units 1&2) are under construction

Kori Unit 1 will be permanently shut-down in June 2017

※ Inventory of Spent Nuclear Fuel (as of Dec. 2016, Unit : assembly)

PWR SNF					PHWR SNF (@Wolsung)		
Kori	Hanbit	Hanul	Shin-Wolsung	**Total**	Pool	Dry Storage	**Total**
5,834	5,965	5,123	253	**17,175**	131,308	291,600	**422,908**

I. SNF Management in KOREA

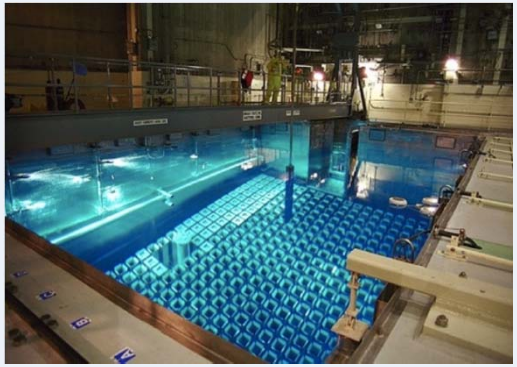
Status of SNF Management

PWR SNF

Stored in on-site SNF pool (Wet storage)

- Re-racking, trans-shipment btw wet storages within a NPP site

[PWR fuel]



[Wet storage(SNF pool)]

PHWR SNF

Stored in on-site SNF pool and dry storage facilities

[PHWR fuel]

[PHWR SNF pool]

Concrete Silo

MACSTOR/KN400

[Wolsung On-site Dry Storage Facilities]

I. SNF Management in KOREA

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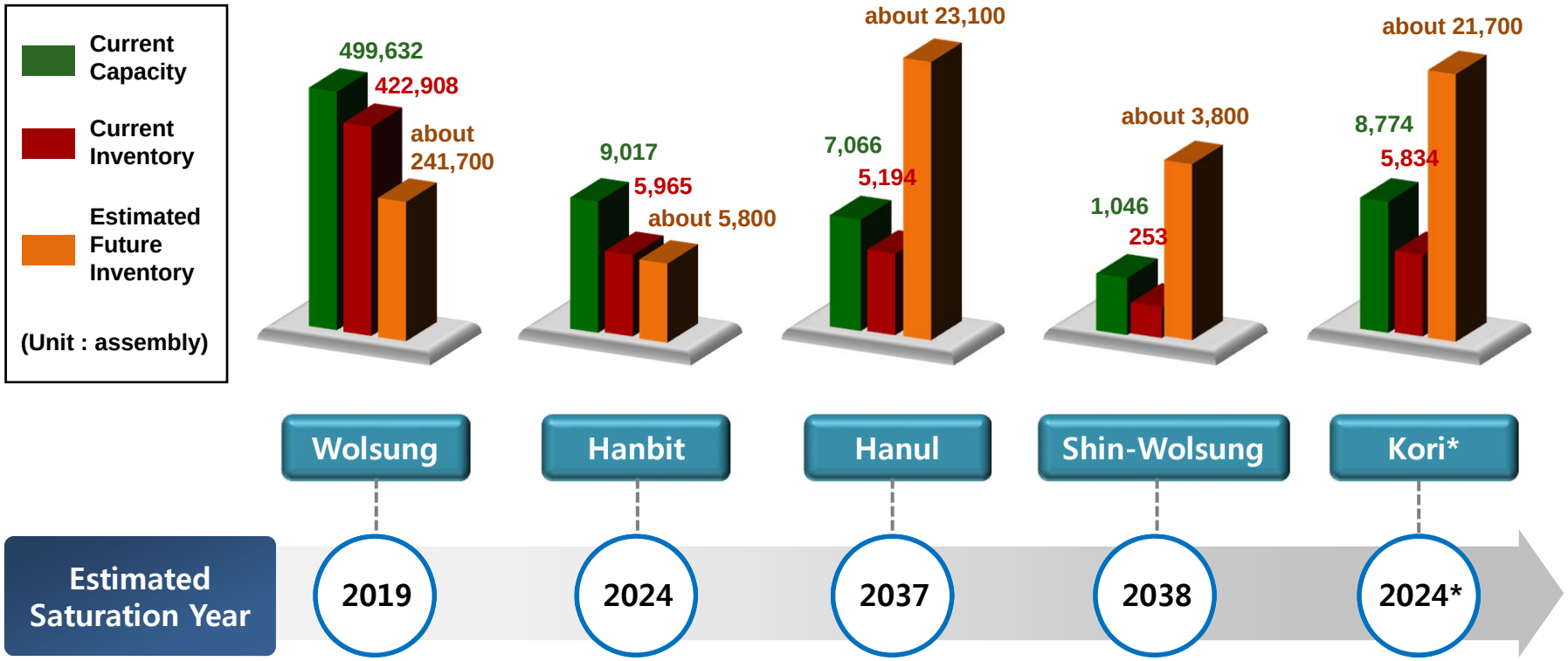
Saturation Year of Current On-site Storage Capacity



* In case of limiting the transfer btw units, Kori NPPs located in Kijang and Ulju will be saturated in 2024 and 2058, respectively

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II

SNF R&D Status in KOREA

II. SNF R&D Status in Korea

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On-site Transportation Technology

- **Full experience of on-site transportation (1990~)**
  - (PHWR) SNF Pool → Dry storage, (PWR) SNF Pool → SNF Pool
- **Fabrication & operation experience of KSC-1, KSC-4, KN-12, KN-18 transportation casks**
- **Development of a dual-purpose metal cask (KORAD-21, applied for licensing in 2016)**

KSC-1
· 1 assembly
· NPP → Research site (KAERI)

KSC-4
· 4 assemblies
· Kori NPP

KN-12
· 12 assemblies
· Kori, Hanul, Hanbit NPPs

KN-18
· 18 assemblies
· Hanul, Hanbit NPPs

KORAD-21
· 21 assemblies
· Licensing in progress

1987 — 1990 — 2002 — 2010 — 2016



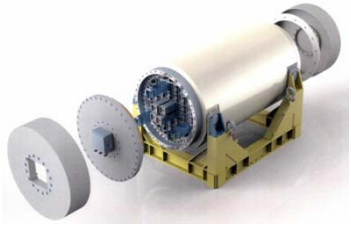


II. SNF R&D Status in Korea

Off-site Transportation Technology

❖ **ENSA/SNL/Korea multi-modal transportation test (in progress)**

- **Objective** : Assessing the vibration and impact on spent nuclear fuel through actual shipping and transportation processes
- KORAD/KAERI/KNF participated in Oct. 2016 in accordance with US proposal
- Surrogate PWR fuel assembly is included in the test



TEST PLAN

Santander (Spain) → Offshore transport ('17.07) → Zeebrugge (Belgium) → Ocean transport ('17.08) → Baltimore (US) → Rail transport ('17.09) → Colorado (US)

· Instrument gauge set-up ('17.03)
· Handling test ('17.06)
· Heavy-haul truck test

II. SNF R&D Status in Korea

Storage Technology

- **(PHWR SF) Design, licensing, construction and operation experience of Silo & MACSTOR-400**
- **(PWR SF) Close to commercialization of storage casks**
  - Development of a dual-purpose metal cask and a concrete storage cask in 2016

Concrete Silo
· 540 assemblies
· 300 units
· PHWR SF

MACSTOR
· 24,000 assemblies
· 7 units (+7 units planned in 2019)
· PHWR SF

KORAD-21/21C
· 21 assemblies
· PWR SF
· Licensing in progress

1992 — 2010 — 2016

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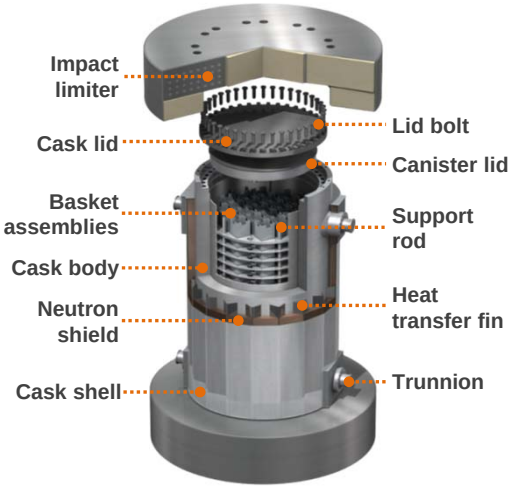
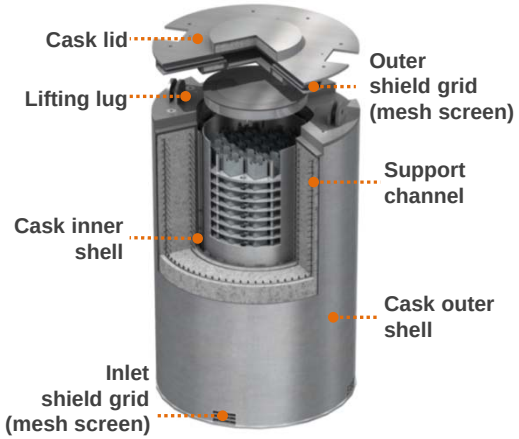
Dual Purpose Metal Cask/Concrete Storage Cask

- ❖ **R&D Period : 2009 ~ 2016 (87 months)**
- ❖ **Cask Description**

Items	Dual purpose metal cask	Concrete storage cask
Capacity	21 PWR F/A (WH & CE)	
Design basis SNF	▪ Max. BU : 45,000 MWD/MTU ▪ Max. initial enrichment : 4.5 wt. % U235 ▪ Min. cooling time : 10 yrs ▪ Max. decay heat : 16.8 kW/canister	
Canister	▪ Dimension : (O.D) 1.7 m X (L) 4.9 m ▪ Weight : 33 ton (with loaded SNF) ▪ Material : Stainless steel, Boral(B_4C+Al) or METAMIC	
Dimension	(O.D) 2.2 m X (L) 5.3 m	(O.D) 3.3 m X (L) 6.0 m
Weight	104 ton (canister included)	148 ton (canister included)
Material	Forged-carbon steel	Concrete, carbon steel outer shell



[Dual Purpose Metal Cask]



[Concrete Storage Cask]

II. SNF R&D Status in Korea

Disposal Technology

- **Preliminary R&D programs were started in 1997 by KAERI**
  - ('97~'06) KRS (Korea Reference disposal System) for direct disposal of SNF from PWR & PHWR
  - ('06) Operating KURT (KAERI Underground Research Tunnel)
  - ('07~'12) A-KRS (Advanced Korea Reference disposal System) for disposal of HLW generated from pyro-processing
- **KOINS (KOrad Integrated Natural barrier DB System) by KORAD ('10~'15)**

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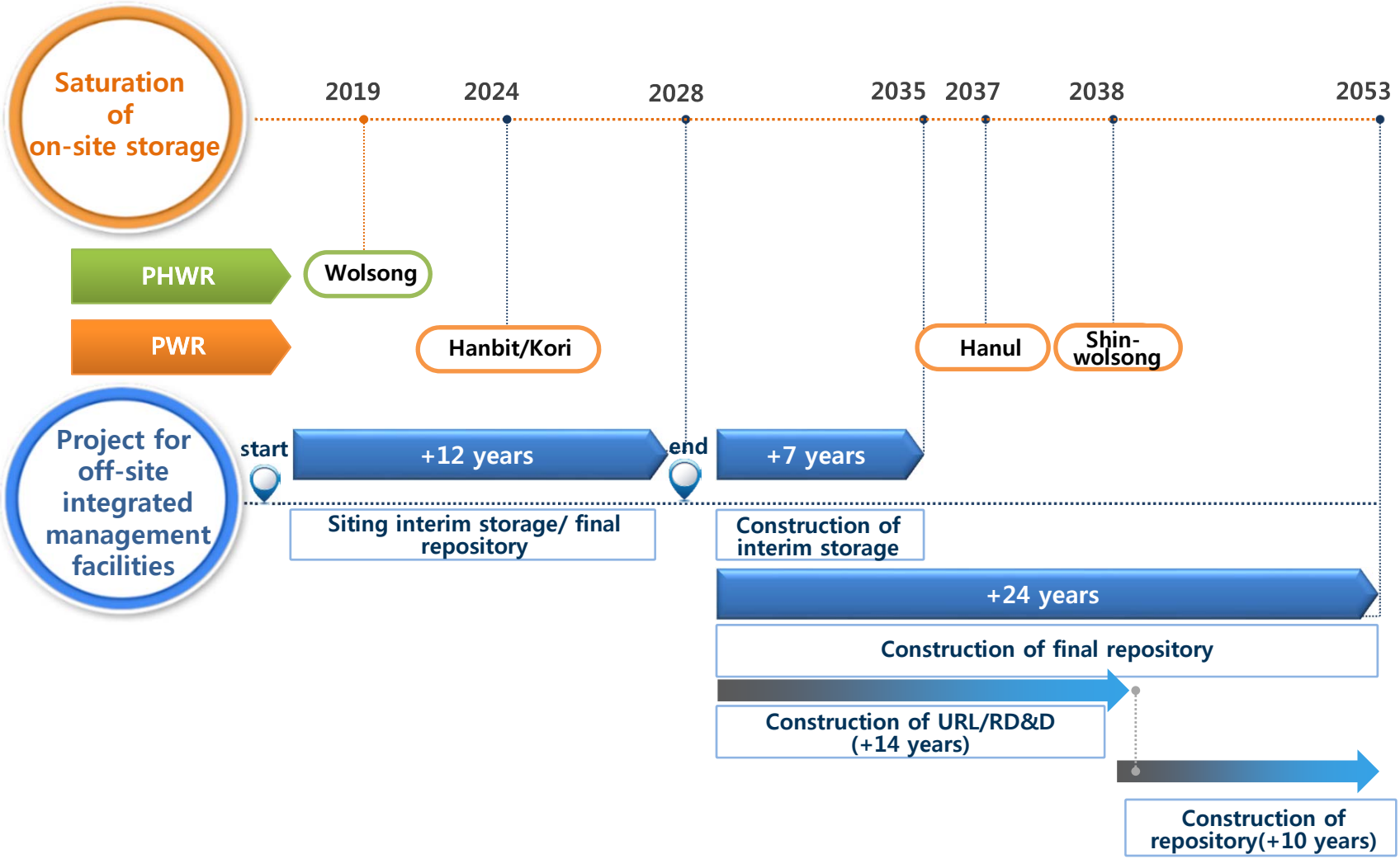
III SNF Technology Development Plan

III. SNF Technology Development Plan

Milestone for SNF Management



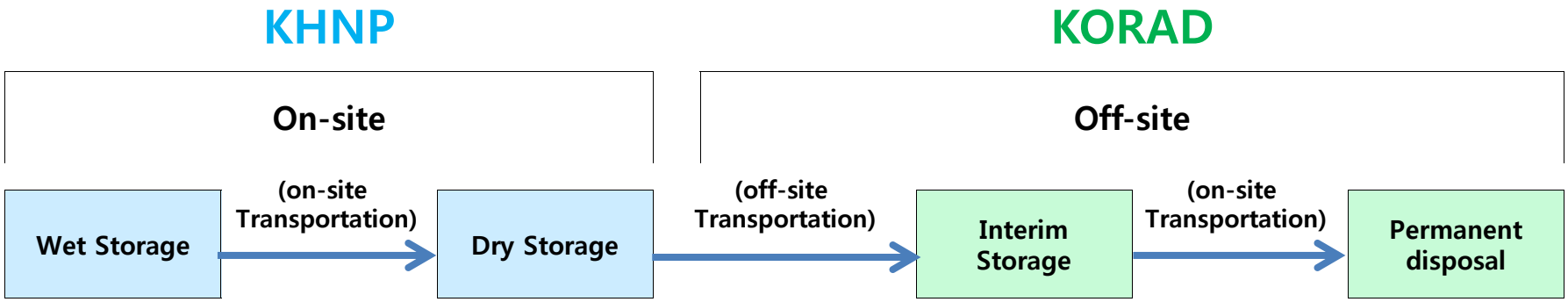
III. SNF Technology Development Plan

Standardization of SNF Management System

❖ Background

- Due to the separation of SF management responsibility in on-site from off-site, connectivity* and standardization of SF management system is very important

* On-site storage system affects on transportation to off-site storage facilities, interim storage and disposal system



[Responsibility SF Management]

III. SNF Technology Development Plan

Standardization of SNF Management System

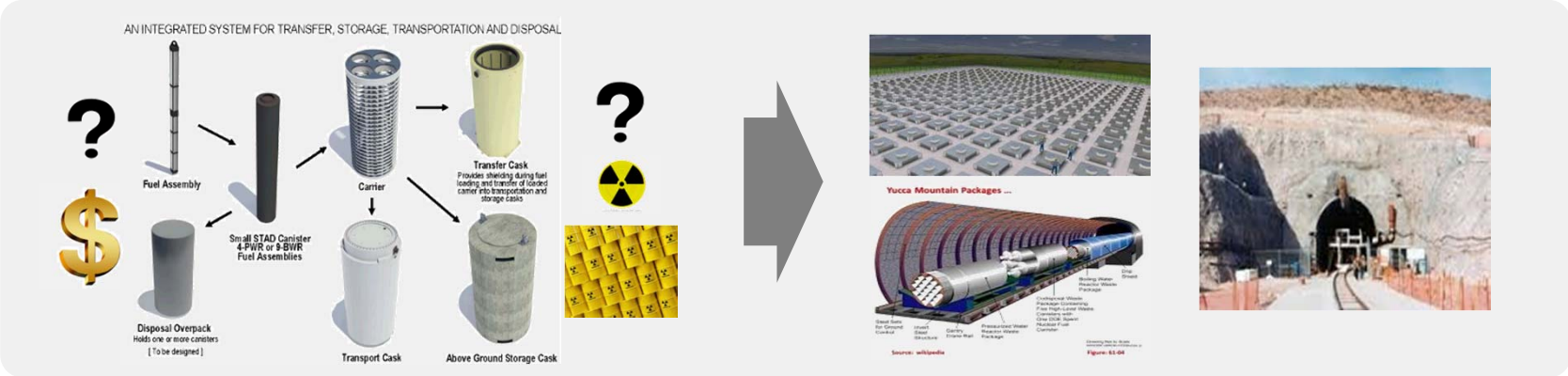
- **(Objective) Development standardized system for SNF management process**
- **(Works)**
  - Standardized canister/facility development for SNF management
  - Integrated SNF database system establishment
  - Regulation technology development / verification system establishment
- **(Progress/Plan)**

Proposal of R&D Plan ('16. 3)

Evaluation and selection process ('16. 3~'17. 3)

Pre-feasibility Investigation (~'18)

R&D beginning ('19~)



III. SNF Technology Development Plan

Transportation Technology Development

❖ **To prepare for interim storage operation, transportation technology for massive SNF shipment will be developed**

TRANSPORTATION TECHNOLOGY

Large capacity transportation cask for CANDU SF	Transportation scenario, Safety analysis technology
Road/sea transportation system (vehicle, ship, etc.)	High performance transportation cask for PWR SF

III. SNF Technology Development Plan

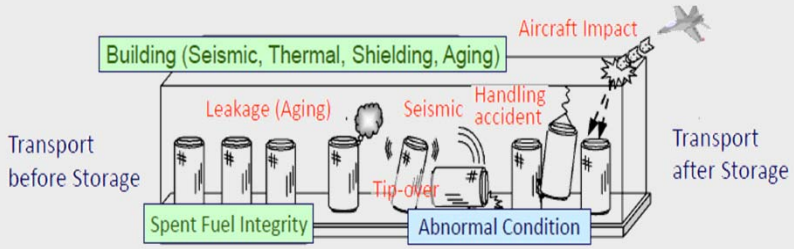
Storage Technology Development

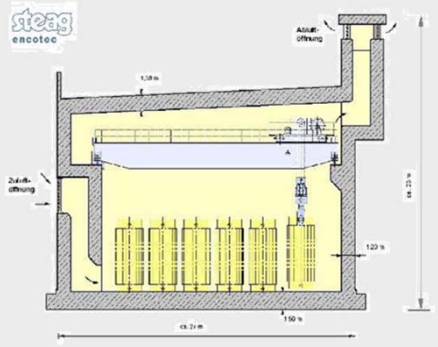
- **Design, construction & operating technologies for interim storage facility will be developed**

STORAGE TECHNOLOGY

Safety assessment technology including beyond design basis accident

Interim storage operating technology

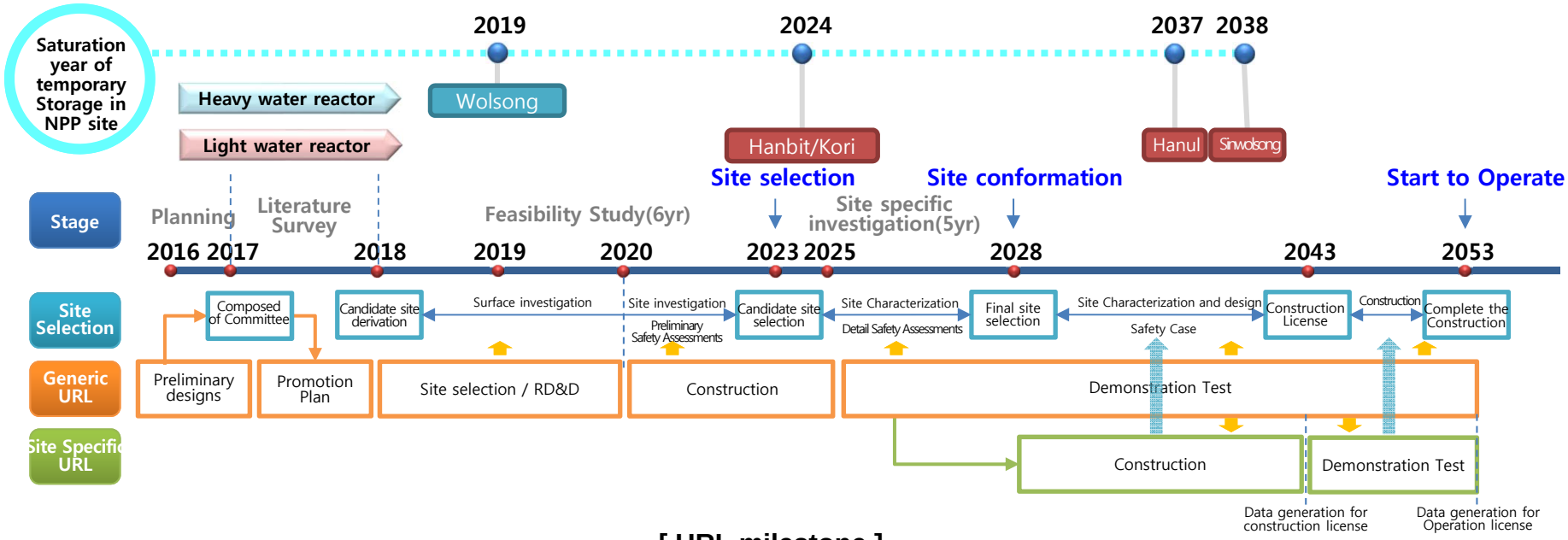




Disposal Technology Development

❖ Development comprehensive URL demonstration program

- Planning RD&D program to acquire licensing data for construction and operation of disposal facility

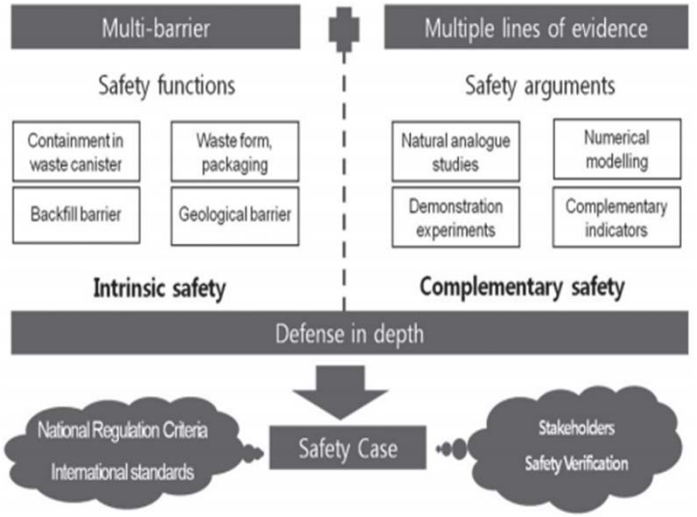


[URL milestone]

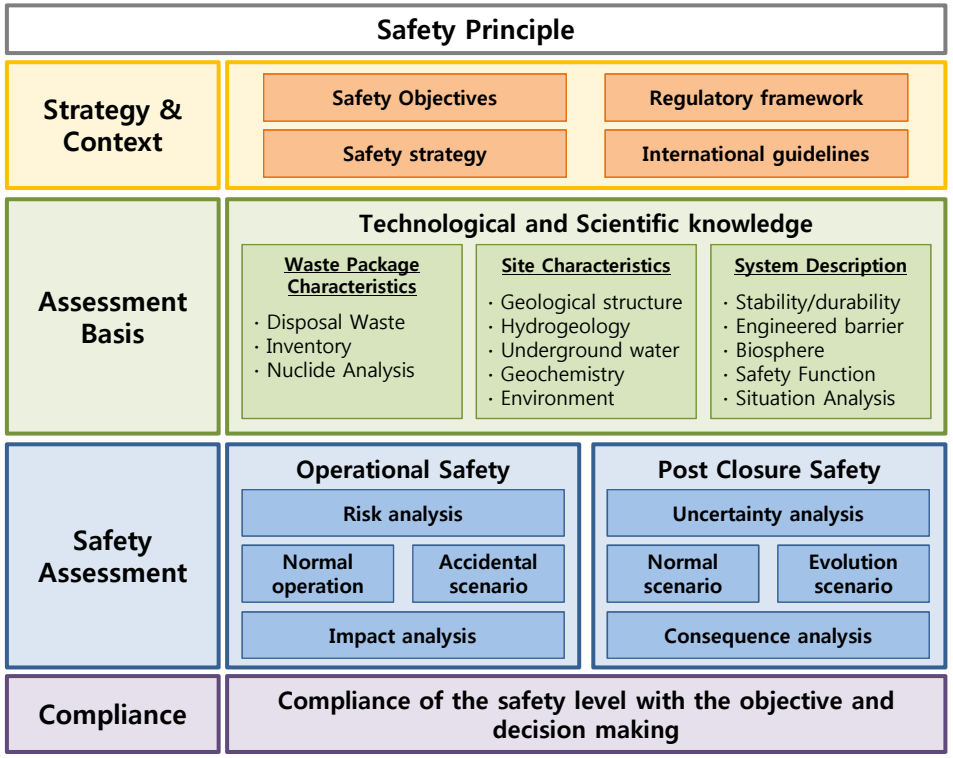
Disposal Technology Development

❖ Development of the safety case for SNF disposal facility

- Establishment of the comprehensive safety management system



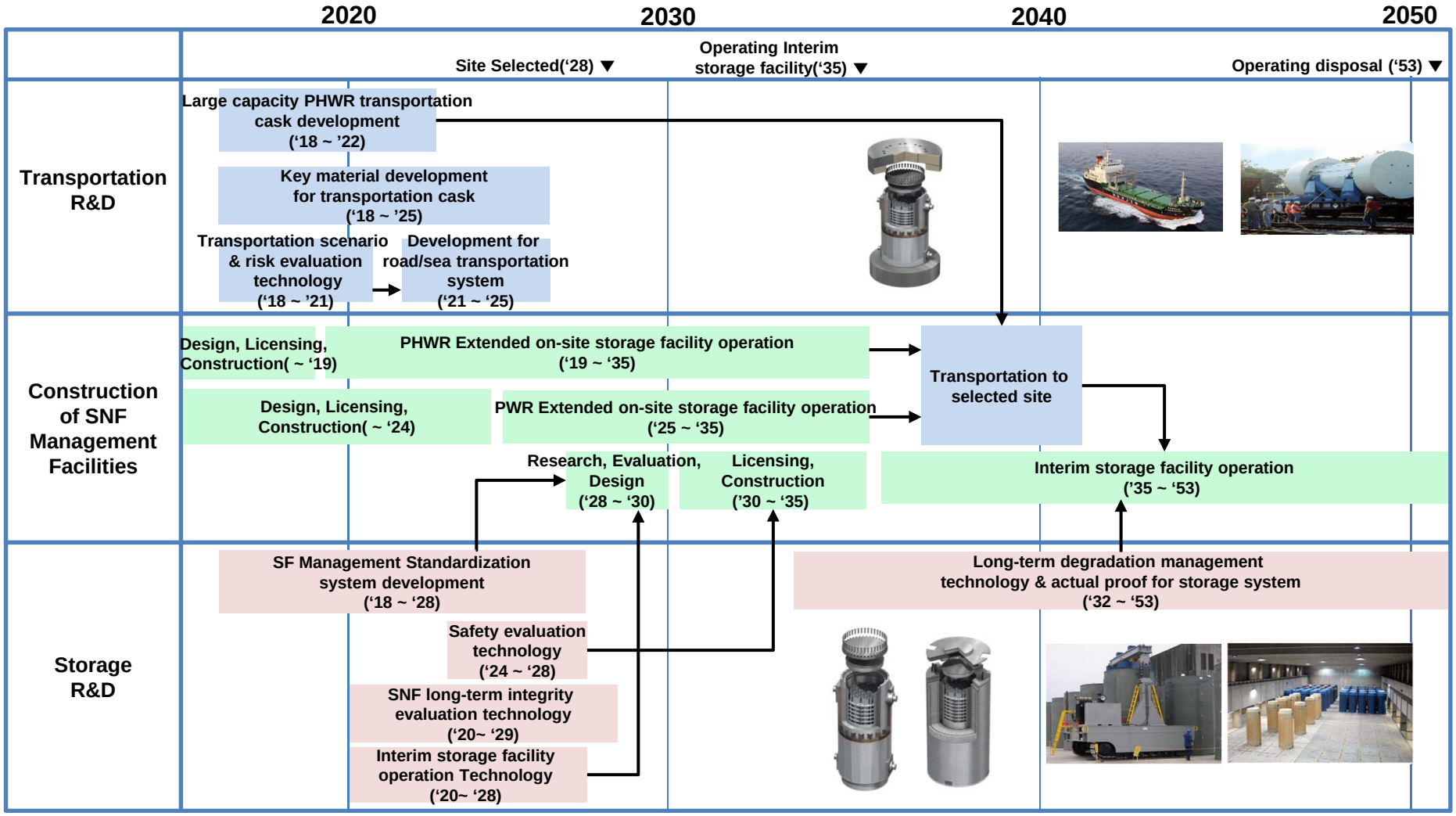
[Review on foreign safety case program]



[Safety approach of radioactive waste disposal site]

III. SNF Technology Development Plan

R&D Roadmap (draft)



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IV Conclusions

V. Conclusions

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◆ Safety of SNF Transportation/Storage is proven

- ❖ Globally, safety of dry storage technology has been verified through commercial operation about 40 years
- ❖ Experience of on-site transportation and operation of dry storage facility for PHWR will be helpful to advance technologies for PWR dry storage

◆ Vitalization of International R&D Cooperation

- ❖ To efficiently develop of SNF technology by international cooperation
  - Strengthening international cooperation through KOREA -US joint research program focusing on transportation, storage, and disposal
  - Promoting technical exchange and joint research with leading countries of disposal

  → Strengthening cooperation with Sweden, Finland, France, etc.

Efforts for developing technologies for safe SNF management are necessary for adjusting to the public requests.

Thank you for your attention!

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