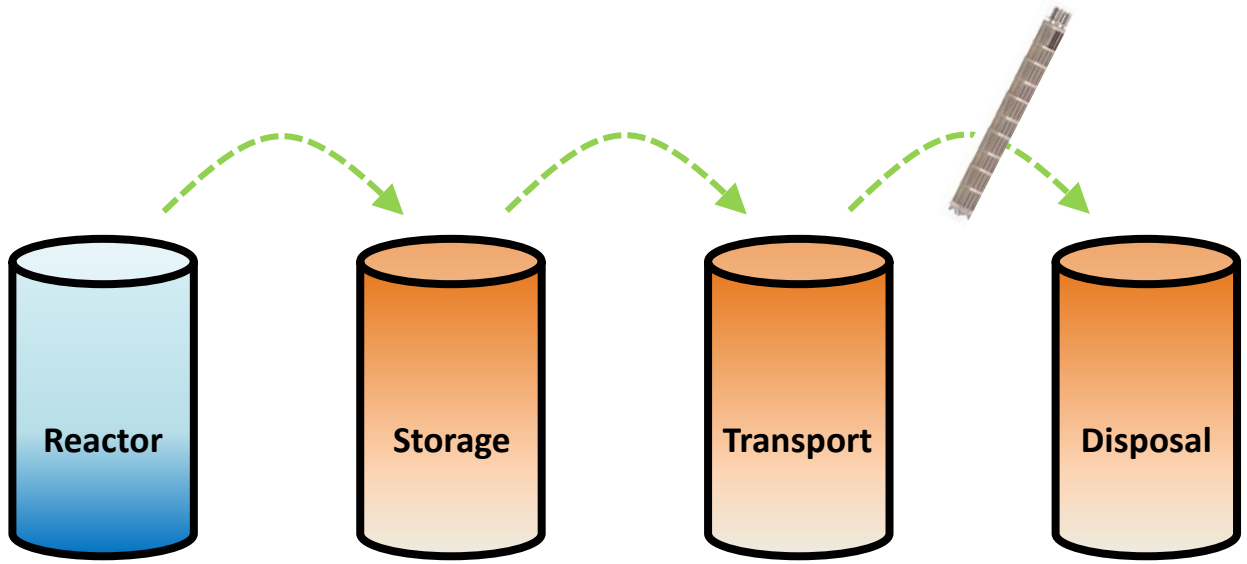
향후 사용후핵연료

건전성 평가 방향 제언

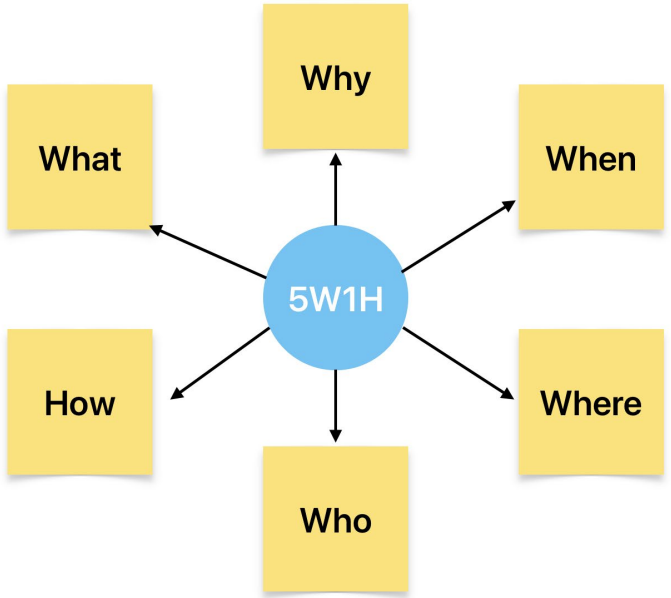


국 동 학

영화, '더 킹'

" 역사적으로 흘러가듯 가~ "

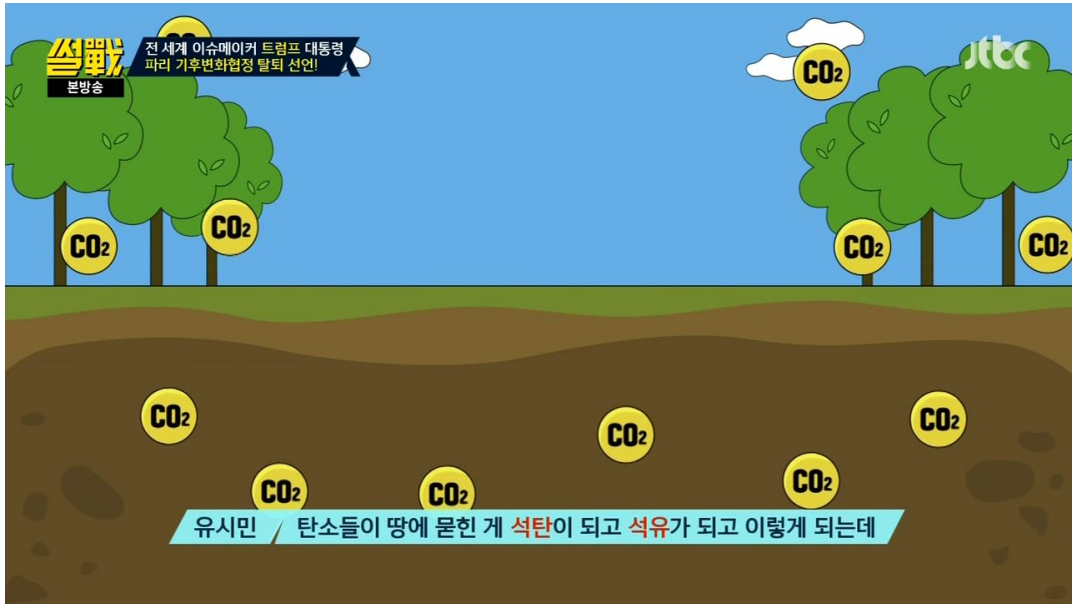
Contents



What is Spent Fuel Integrity?

1

탄소 기반 에너지원



땅 속의 CO_2 (석탄, 석유)

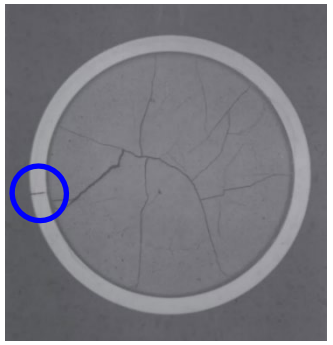
땅 위의 CO_2 (나무)

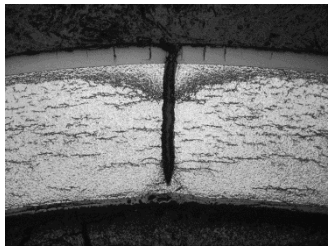
연소 후 공기중으로 배출

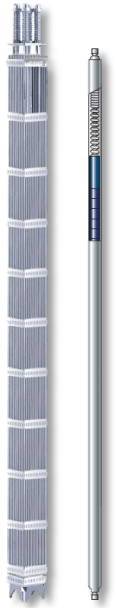
온실가스 급증에 따른

지구온도 상승 및 기후변화

환경에 대한 원자력의 위험은



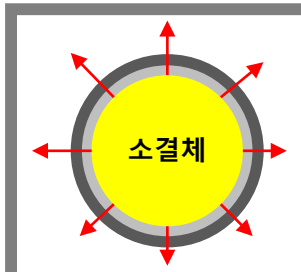




원자력 에너지 사용에 따라 발생한 환경 위험 요인들은 모두 **핵연료 봉 내에 갇혀 있음**

핵연료봉 건전성 유지는 안전한 원자력 에너지 전반에 대한 가장 핵심적인 항목임

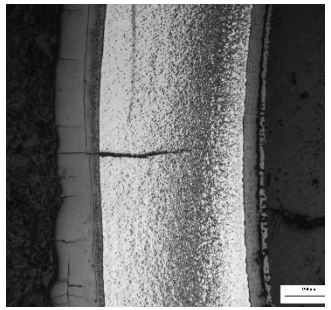
What is 'Integrity' ?

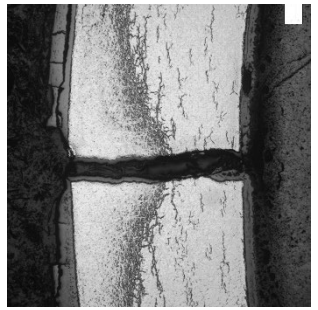


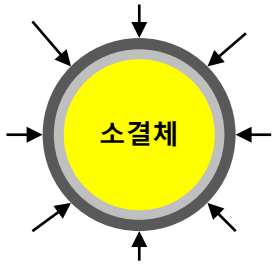
건식저장 시

피복관 외부: He 기체
He 온도: 300 °C
피복관 온도: 350 °C
외부 압력: 1~2기압

Gap 내부: 봉내압: 60기압







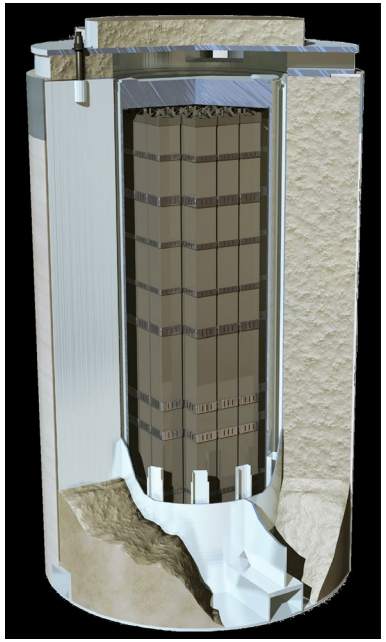
원자로 운전 시

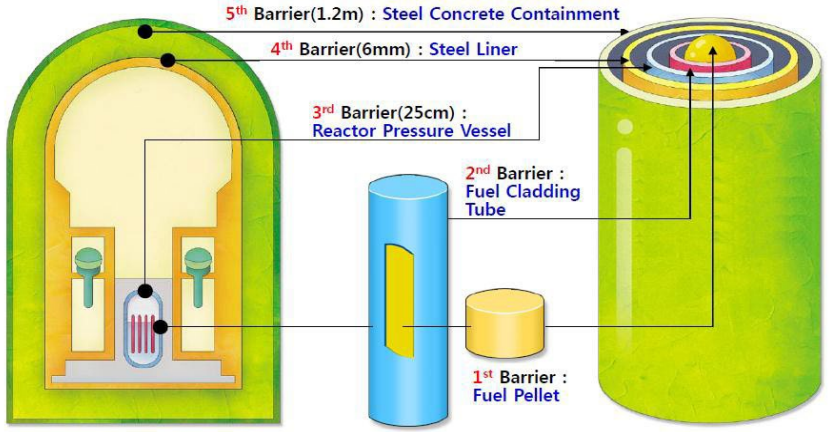
피복관 외부: 노심냉각수
냉각수 온도: 320 °C
피복관 온도: 350 °C
외부 압력: 150기압

Gap 내부: 봉내압: 60기압

Tangible & Control

vs

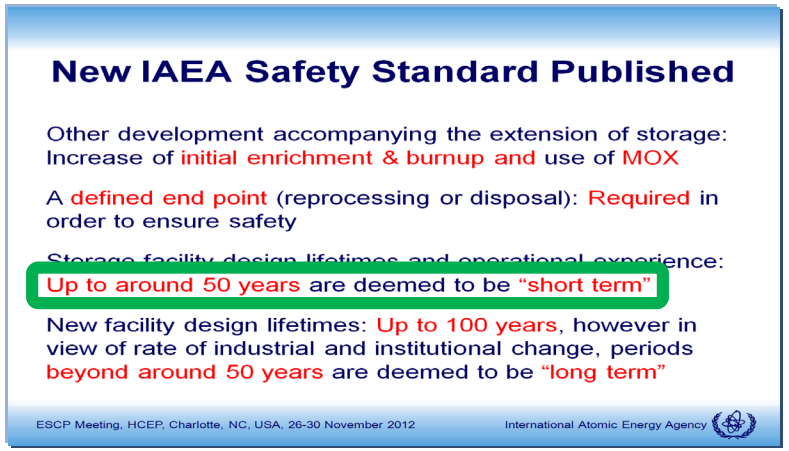




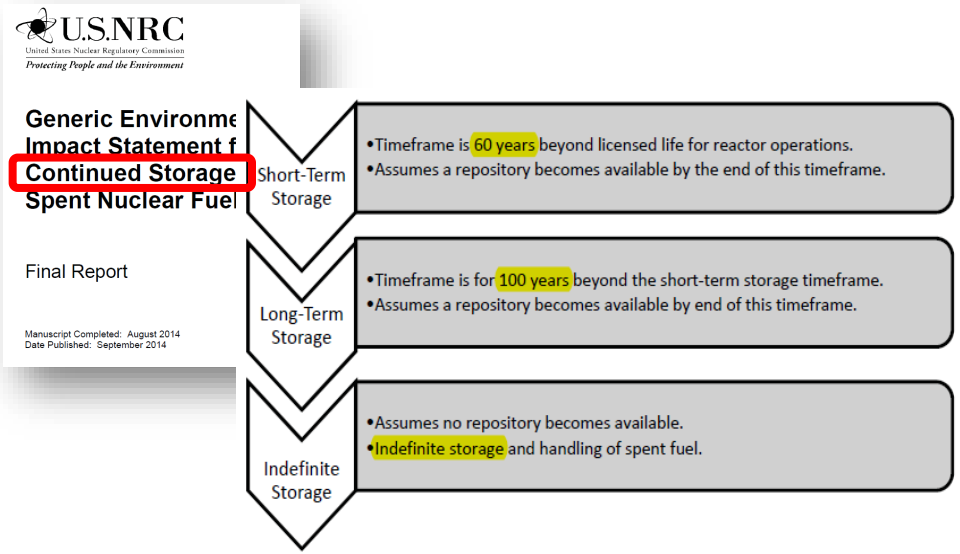
Why is it important?

2

건식저장 기간의 장기화



"Extending Storage in the Framework of the IAEA. Progress Update 2012", Arturo Bevilacqua, ESCP Meeting, Charlotte, NC, USA, 26~30 Nov. 2012



▪ 배경

✓ 원전의 **SF 저장조 포화 임박**

✓ 각 국의 **처분장 확보 어려움**

✓ 재활용: 단기간내 실용화 어려움

▪ 건식저장

✓ **초기에 20년 저장을 Long-term**으로 생각

✓ 그러나, 처분장/재활용 기술의 현실화 지연

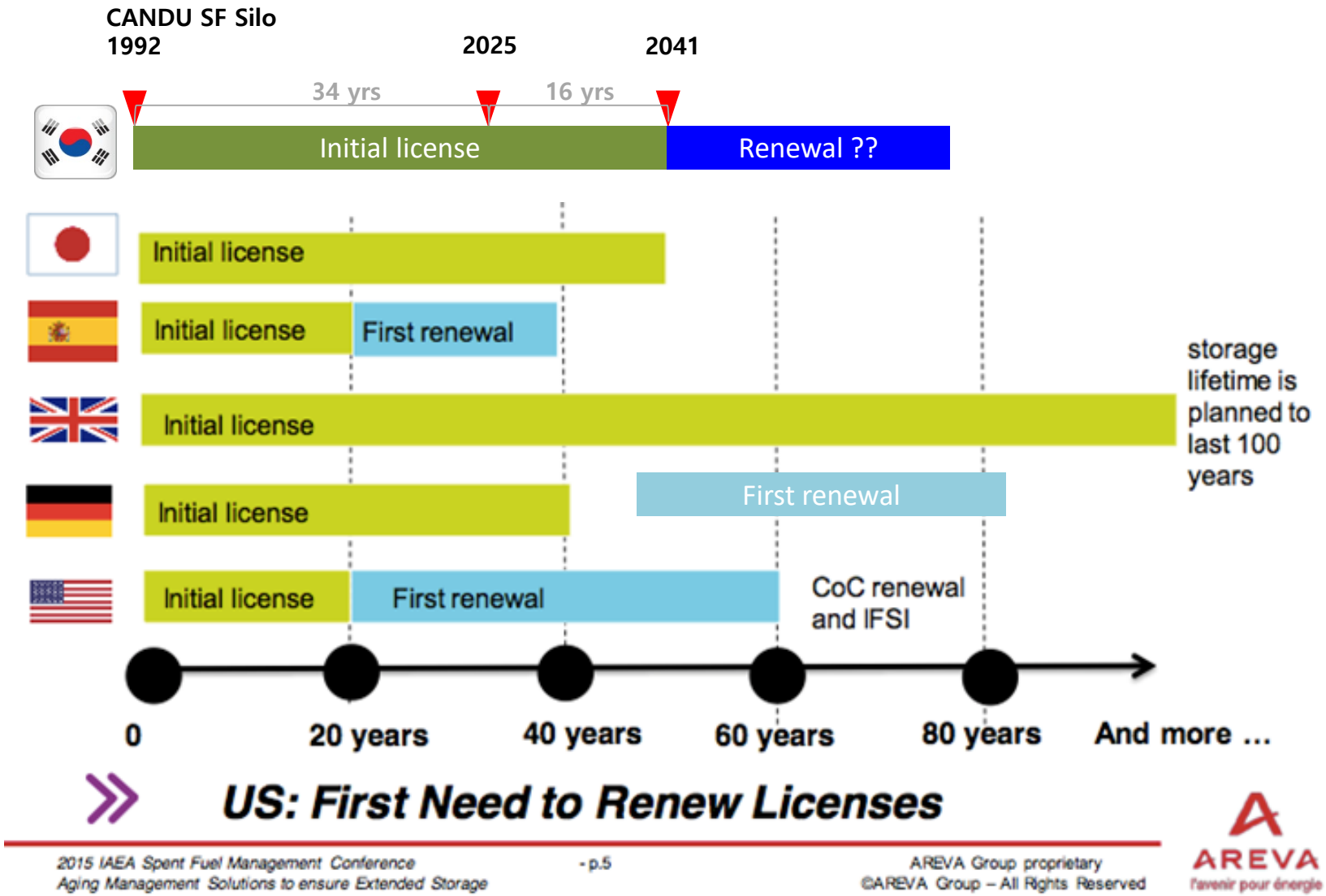
✓ 습식저장에 비해 경제성/안전성이 우수한 건식저장의 초장기 운영이 현실화되고 있음

✓ 새롭게 **100년 단위를 Long-term으로 고려**

✓ **Waste Confidence Rule ➔ Continued Storage**

"Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel-Final Report", NUREG-2157, 2014.9, US NRC

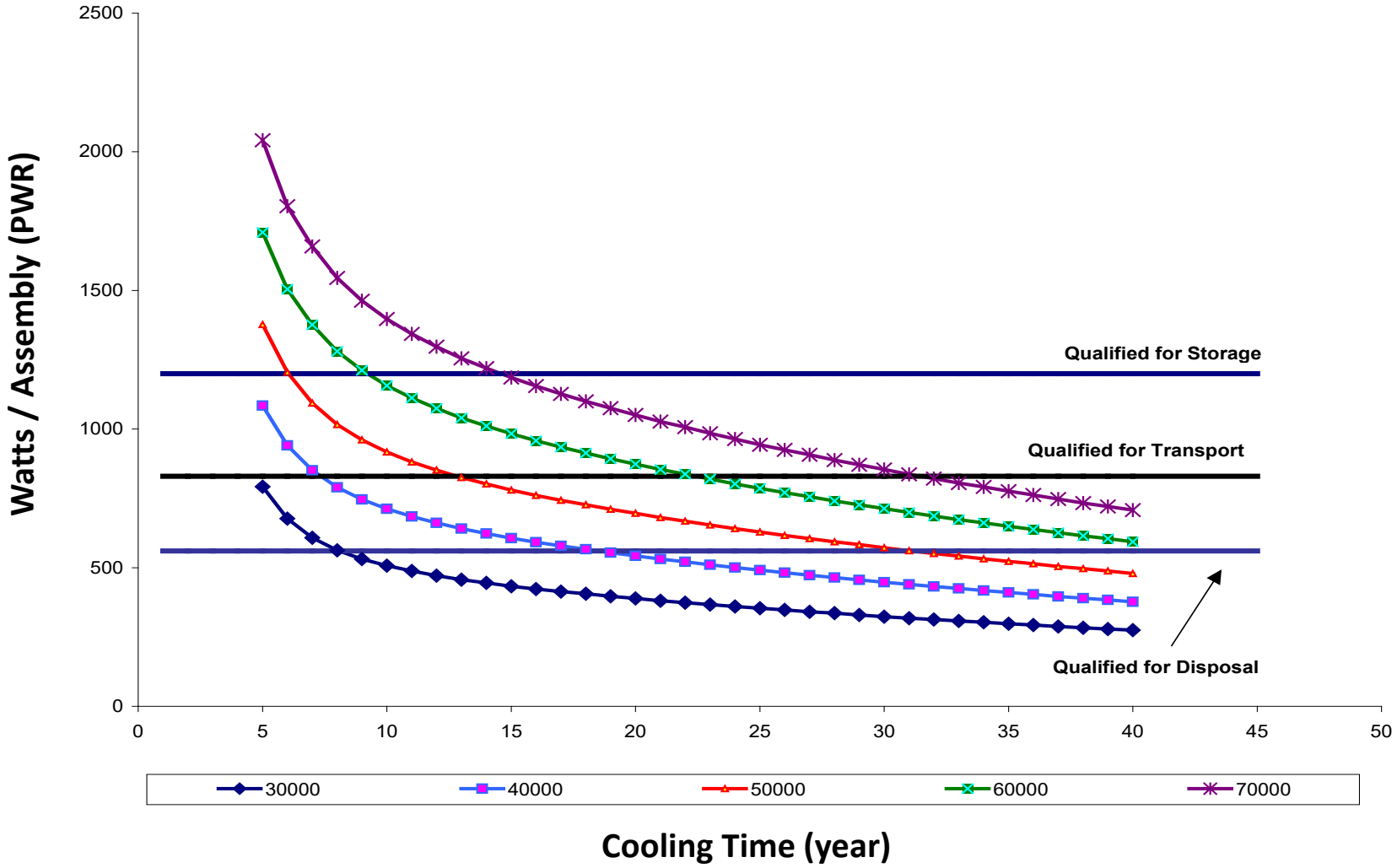
Dry Storage Licenses Period & Renewals



"Aging Management Solutions to Ensures Safety of Extended Dry Fuel Storage" , International Conference on The Management of Spent Fuel from Nuclear Power Reactors, Catherine Shelton, June 2015

Burnup & Cooling Time Consideration

PWR Watts/Assembly As a Function of Burnup (MWd/MTU) & Cooling Time for Storage, Transport & Disposal – EXAMPLE ONLY



DOE/EPRI/NRC Priorities of Concerns

Comparison of Priorities for Main Areas

1. **Condition of used fuel at the time of transport**
   - **Main issues:** hydride reorientation; creep
2. **Condition of the welded canisters**
   - **Main issues:** canister general corrosion and stress corrosion cracking
3. **Structural and shielding properties of concrete**
   - **Main issues:** behavior of concrete under elevated temperatures and radiation fields

- **NWTRB: No prioritization, identified as gaps**

SNF를 인수받아야 하는 DOE는 SNF에 관심이 높음

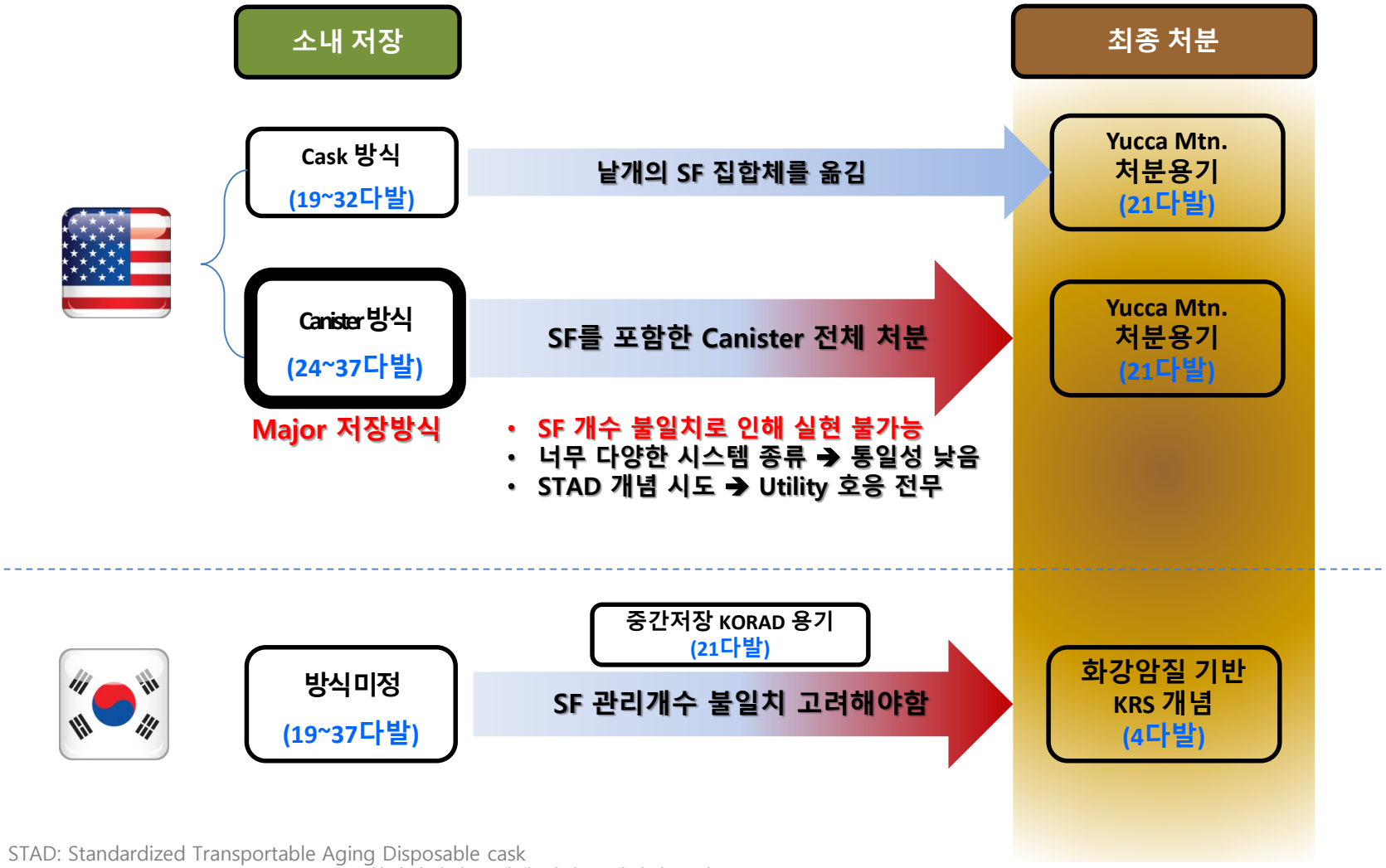
	DOE	NRC	EPRI
Fuel/Clad	High	Medium	Medium
Internal/Canister	High	High	High
Overpack/ISFSI	Medium	M/L	Low

저장이 초장기화되면서 얇은 금속 두께의 Canister에 대한 염려가 커지고 있음

EPRI ELECTRIC POWER RESEARCH INSTITUTE

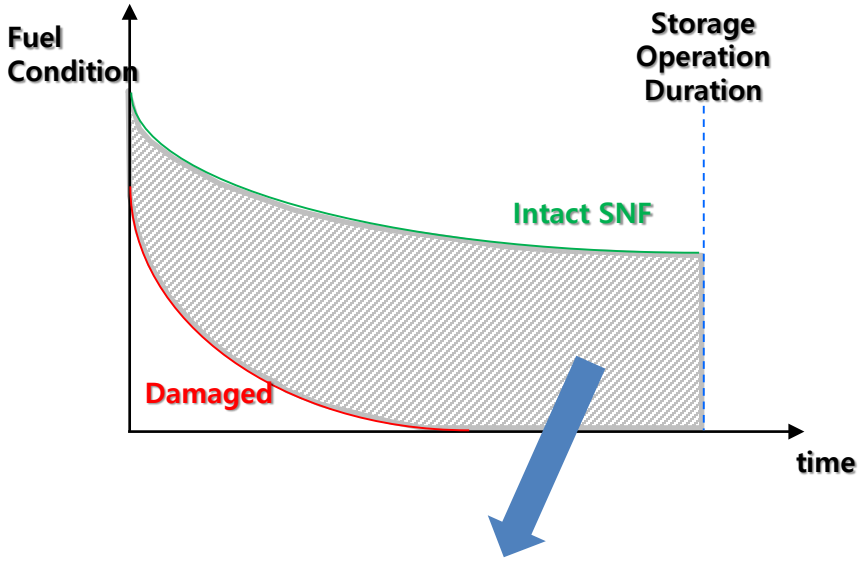
"**Review of Data Gap Analysis for Extended Storage and Transportation of Used Fuel**", NRC Division of Spent Fuel Management Regulatory Conference, EPRI, Nov., 2014

관리 방식간 핵연료 취급



STAD: Standardized Transportable Aging Disposable cask
KRS: Korea Reference disposal System (화강암질의 스웨덴/핀란드 개념과 유사)

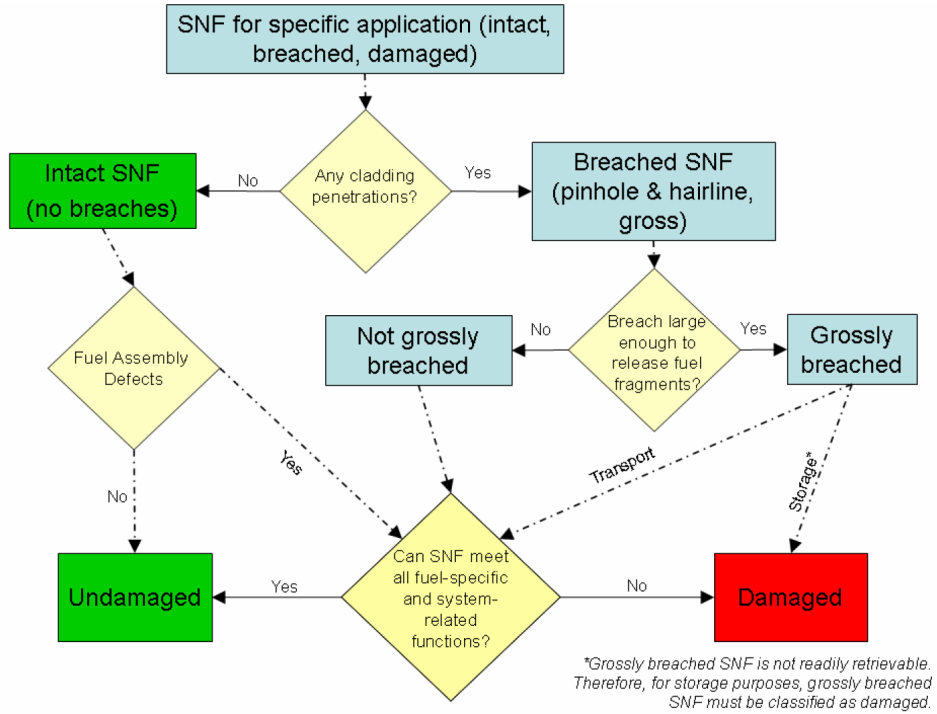
How to define storable SNF



✓ Intact SNF는 저장시스템 운영기간까지 문제없음

✓ Damaged SNF는 특별 관리(canning)의 대상임

✓ 두 경계 사이의 핵연료에 대한 선정 범위가 문제



Interim Staff Guidance - 1, Revision 2, "Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation", US NRC, 2007

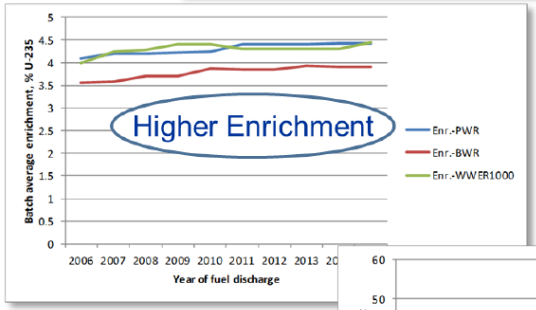
구체적인 사업에 적용할 수 있는 핵연료 선정 범위 기준 마련이 시급

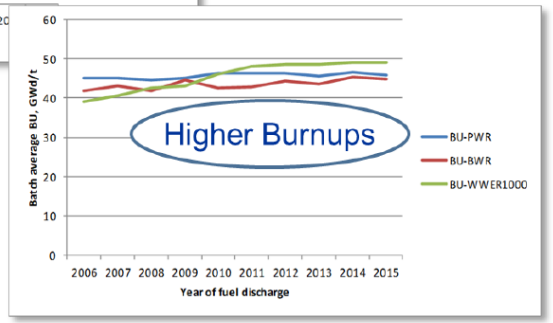
국내 SNF에 대한 상태 분석 및 건전성 분석 과정 수행 필요

Challenges in Spent Fuel Storage

Challenges in Spent Fuel Storage

- Planned storage durations are increasing:
  - In 1980s 20-50 years
  - In 1990s up to 100 years
  - In 2000s 100+ years
- Maintenance and inspection of Systems Structures and Components (SSCs)
- Ageing management of deployed storage systems (beyond design basis for most)
- Confirming on-going spent fuel behaviour & integrity
- License renewal for storage systems
- Transportability after long storage durations
- Accommodating new developments and designs in fuel engineering to improve economics and enhance safety





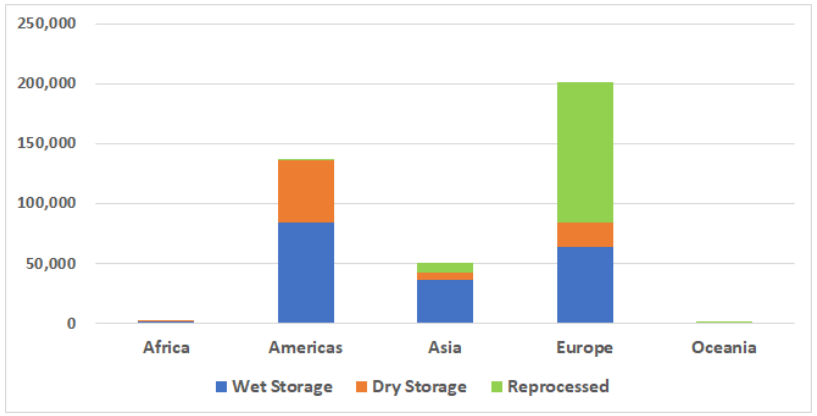
Who has the Lessons Learned?

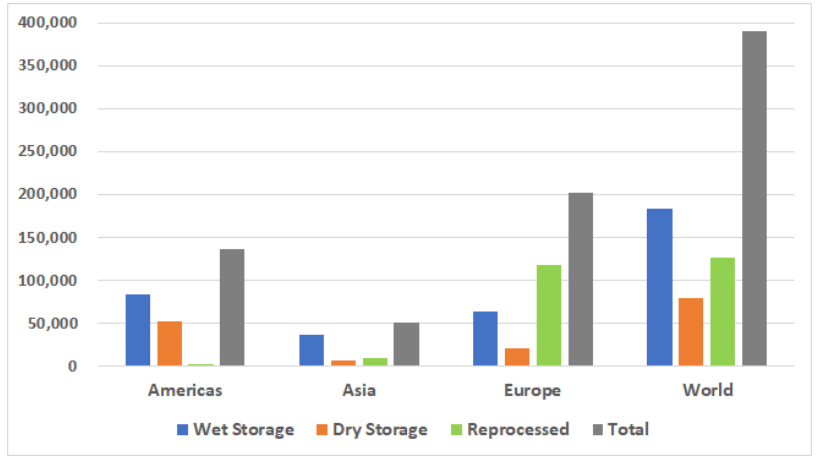
3

National Policies of SNF Management

Nation	SNF Management Policy
USA	Dry Storage & Disposal
Germany	Dry Storage & Disposal
Canada	Dry Storage & Disposal
Spain	Dry Storage & Disposal
Korea	Dry Storage & Disposal (Recycling by Pyro-processing is under consideration)
France	Reprocessing (Wet) & Disposal
Japan	Dry Storage & Reprocessing (Wet) & Disposal
Russia	Dry Storage & Reprocessing (Wet) & Disposal
China	Dry Storage & Reprocessing (Wet) & Disposal
UK	Dry Storage & ~~Reprocessing (Wet)~~ & Disposal
Sweden	Disposal
Finland	Disposal

SNF Inventory Distribution



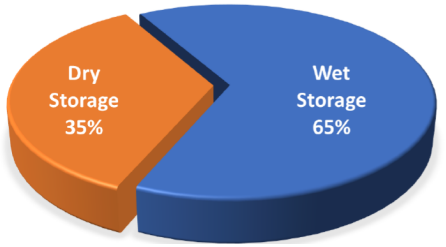


[2022] [IAEA NW-T-1.14 Rev.1] Status and Trends in Spent Fuel and Radioactive Waste Management

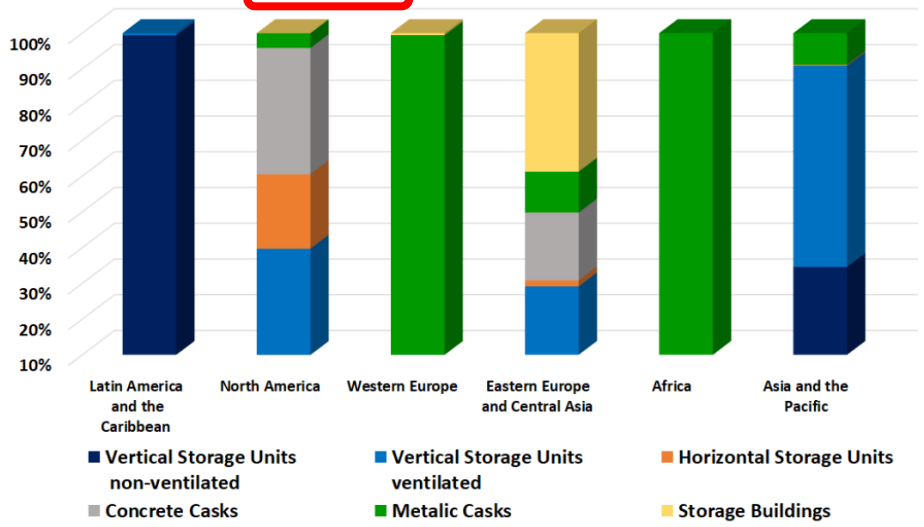
Annual Discharge ~ **10 000 tHM**

Global Inventory by the end 2020
~ 430 000 tHM

Global Spent Fuel Inventory in Storage (~ 301 320 tHM)



Dry Storage Systems by Region (~ 105 880 tHM)



[2021] [IAEA] Challenges and Solutions for Long Term Storage - Spent Fuel from Power Reactors

Observations on Current Practice

- Current practice is safe and secure
  - Extending current practice raises data needs; e.g., canister integrity, fuel integrity, aging management practices
- Current practice is optimized for reactor site operations
  - Occupational dose
  - Operational efficiency of the reactor
  - Cost-effective on-site safety
- Current practice is not optimized for transportation or disposal
  - Thermal load, package size, and package design

Placing spent fuel in dry storage in dual purpose canisters (DPCs) commits the US to some combination of three options

1) **Repackaging spent fuel in the future**
2) **Constructing one or more repositories that can accommodate DPCs**
3) **Storing spent fuel at surface facilities indefinitely, repackaging as needed**

Each option is technically feasible, but none is what was originally planned

[2020] [DOE] Prospects for Permanent Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste in the US

Big Question for Retrievablity

Independently separated regulation

btw storage and transportation

⇨ BRC recommended pilot & consolidated storage

⇨ WCS is preparing pilot storage for stranded SF of already decommissioned site

⇨ **Centralized storage becomes a real** situation

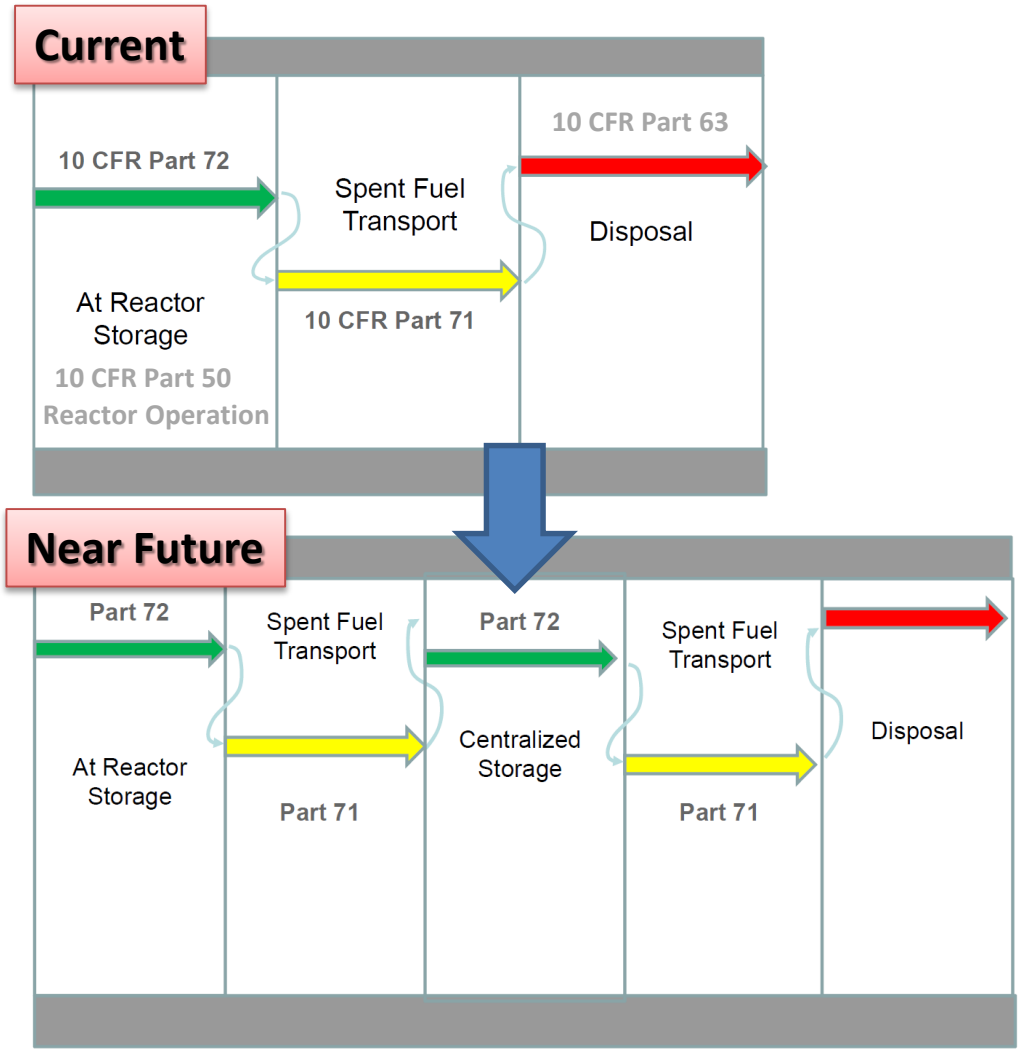
⇨ **Twice for transportation, Twice for storage**

⇨ No definition of retrievability after transportation

⇨ Big question for 'Retrievablity'

⇨ More detail definition will be introduced

pilot storage : centralized storage for stranded SF
consolidated storage : centralized storage for NPP SF



"**Compatibility of Requirements for Storage and Transportation of Nuclear Spent Fuel**", Bernard White, US NRC, Meeting to Obtain Stakeholder Feedback on Enhancements to the Licensing and Inspection Programs for Spent Fuel Storage and Transportation, August 16, 2012

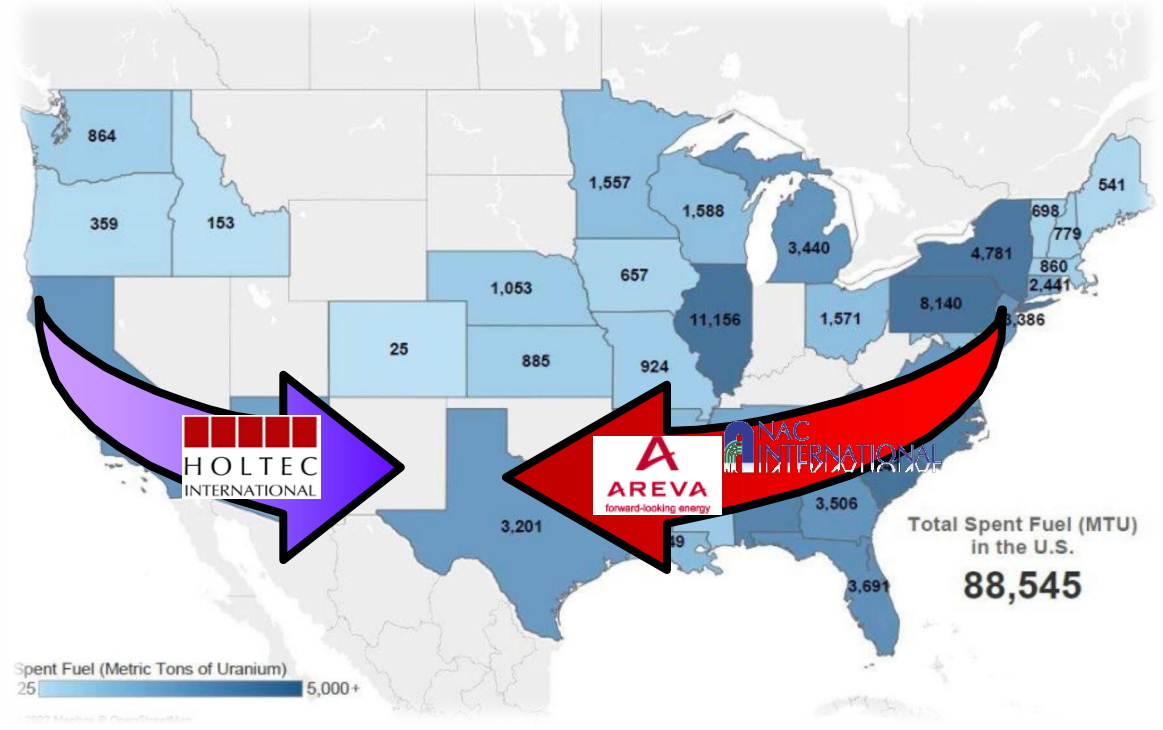
중간 저장

차이점

구분	핵심	수행자	부지 (공간)	국가	SF인도인수
중앙집중식 저장	공간	발전사업자	단일	미국, 일본	민간 ➔ 민간
중간 저장	시간	국가기관	단일 / 분산	스페인, 한국	민간 ➔ 정부

미국의 중앙집중식 저장

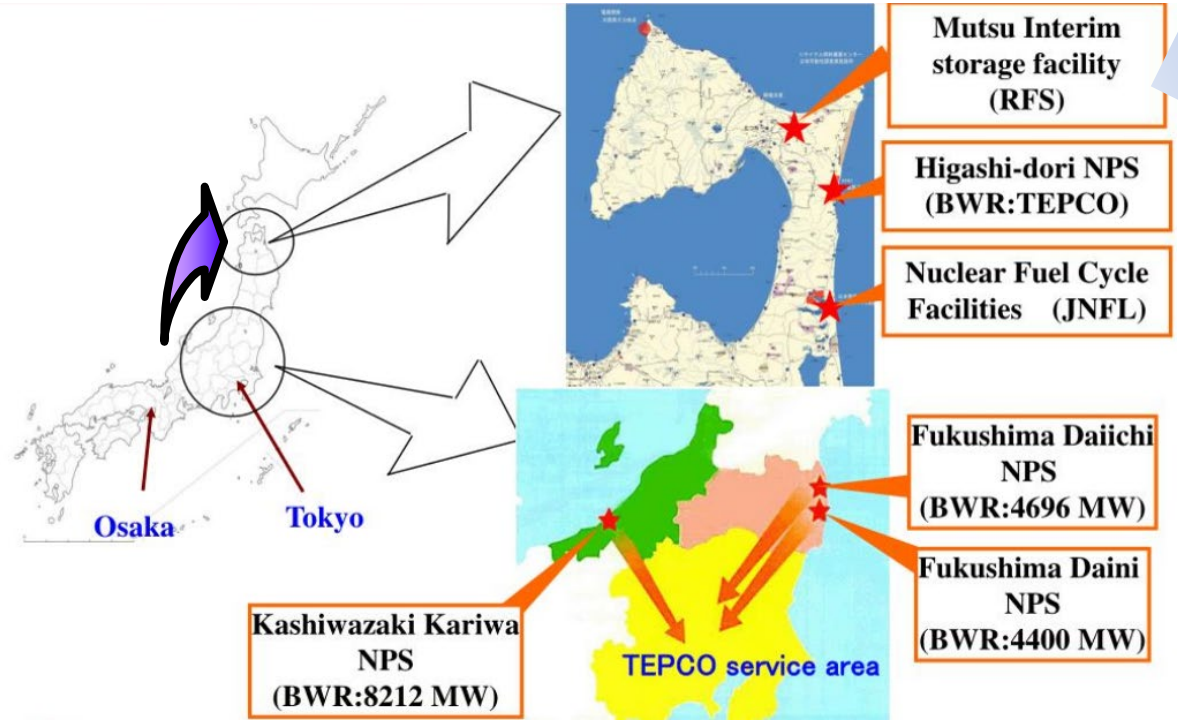
원전부지	중앙부지	원전부지	중앙부지
Holtec	Holtec	Areva	Areva
Private	Private	Private	Private



발전사업자와 정부간의 SF인도인수가 아님 → **SF 상태 점검 과정이 없음**

"Update on WCS' Plans for Consolidated Interim Storage of Used Nuclear Fuel", 2015 NEI Used Fuel Conference, WCS, May, 2015

일본의 중앙집중식 저장



Recycable Fuel Storage (RFS)
Tokyo Electric Power Company Holdings, Inc.
The Japan Atomic Power Co., Ltd.

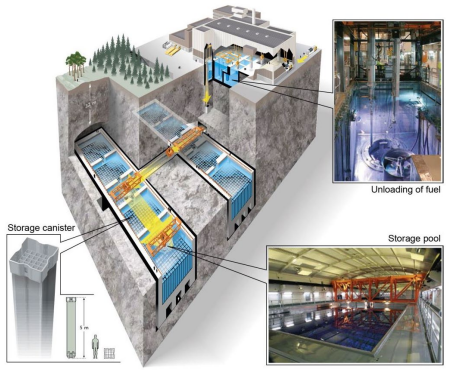
RFS는
발전사업자의 자회사
(Private)

원전부지		중앙부지 (Mutsu)
TEPCO	→	TEPCO
Private		Private

발전사업자와 정부간의 SF인도인수가 아님 → **SF 상태 점검 과정이 없음**

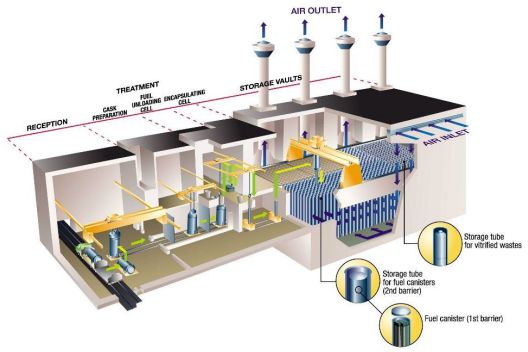
스웨덴의 중앙집중식 저장

원전부지	중앙부지 (Clab)	처분 (Forsmark)
NPP	SKB	SKB
Private	Private	Private

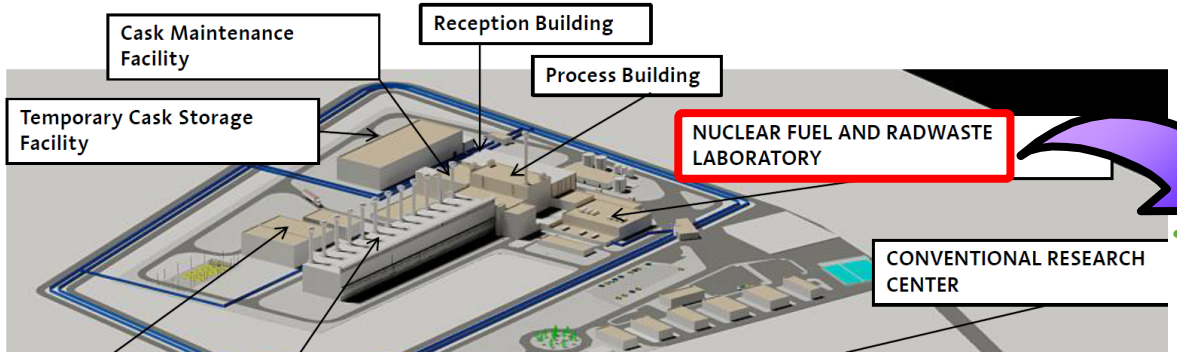


발전사업자와 정부간의 SF인도인수가 아님 ⇒ **SF 건조는 처분 직전에 수행**

스페인의 중간저장



ATC LAYOUT

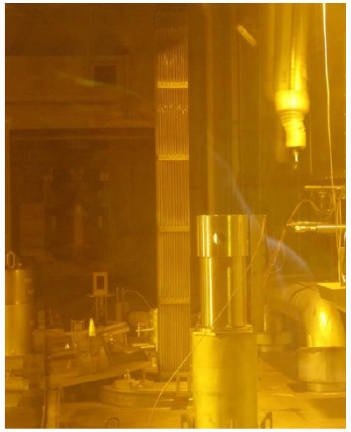


[2016] [ENRESA] R&D Projects on SNF Interim Storage and Transportation

원전부지 → **중간저장 (ATC)**

NPP → **ENRESA**

Private → **Government**



- **Transportation:**
  - Low and High Burnup Spent Fuel Transportation from the NPP to the ATC (HBU: "case by case")
- **With NPPs:**
  - Characterization and Classification of SNF (damaged/undamaged)
  - Fuel Acceptance Procedures

- **ATC:**
  - Very tight schedule for designing, licensing, construction, testing, and commissioning the Facility.
    - Proposed early operation of the Loaded Cask Storage Facility to provide flexibility.
  - Technical issues:
    - Regulation based on NPPs + Fukushima + 9/11
    - "Zero-liquid-effluent" policy
  - Unloading cell atmosphere:
    - Failed cladding fuel
    - Fuel handling issues
    - Crud deposition
  - Remote operations – Harsh conditions
  - Aging Management Plan

시사점

- 발전사업자와 정부간의 SF인도인수는 스페인이 좋은 예
- 정부기관의 핵심업무는 **SF 상태 확인**
- **발전사업자의 용기 밀봉 전 KORAD의 SF상태 확인 필요**

SF 실증

High Burnup DEMO (USA)

Objectives

- Confirmatory data to support
  - Thermal models
  - Behavior of cask internal components (fuel, cladding, assembly hardware, baskets, neutron absorber)
- Avoid rewetting the fuel after initial loading
- *NOT* an objective of this Demo: test welded stainless steel canisters for degradation
  - **Only** about the high burnup fuel

High Burnup Demo Activities

Industry desire to keep this short

- Obtain "t=0" data from sister rods
  - Profilometry
  - Cladding properties (hydrogen content and initial orientation, mechanical, internal gas content)
- Modify existing cask with a special lid that includes
  - Thermocouples
  - Gas sampling
- Load cask and emplace modified lid
- ***Data collection through lid begins immediately***
  - Capture temperature and gas evolution during drying
  - Continue temperature measurements and periodic gas sampling
- After X years (TBD), re-open, remove rods, visually inspect for degradation
  - Rods for destructive exams to compare to "t=0"
  - Option to perform exams on internals

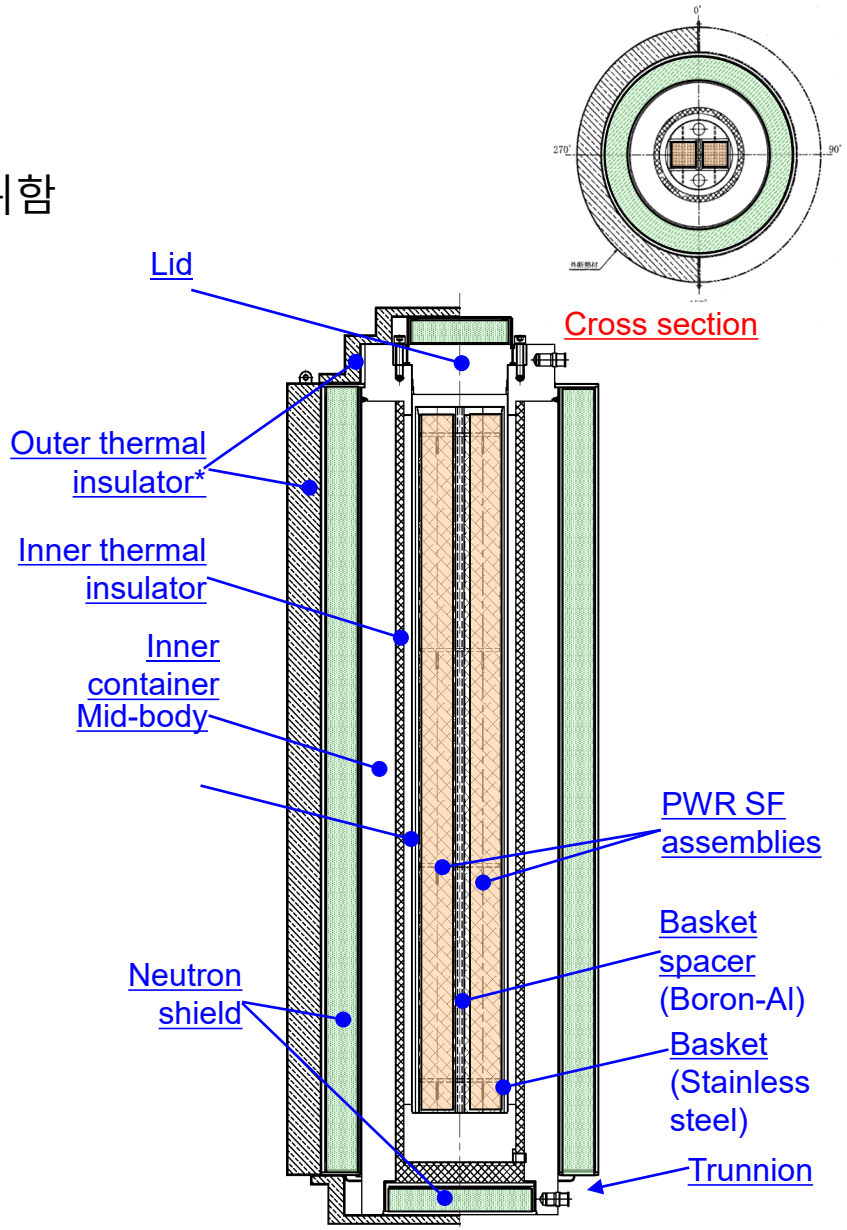
EPRI ELECTRIC POWER RESEARCH INSTITUTE

시사점

- **최초 건식저장(1986년) 시점의 t=0가 아님** ➔ 고연소도 SF 핫셀 자료 생산 목적이 큼
- Re-Open 및 SF 핫셀자료 Comparison은 수행 못할 가능성이 큼

SF DEMO (Japan)

- 배경: 일본의 원자력 최고 의결기관인 NSC(Nuclear Safety Commission)이 지시
- 목적: Dry storage 수행시 PWR SF의 장기 건전성에 대한 지식과 경험을 축적하기 위함
- 주관: 발전 사업자 (JAPCO, Kansai전력, Kyushu전력)
- 수행: Mitsubishi Heavy Industries, Nuclear Development Corporation (핫셀 보유)
- 기간: 60년
- 방법: 실제 48GWd/t SF 1개, 55GWd/t SF 1개 저장
- 관심: 사용후핵연료의 건전성만을 확인, 저장용기는 관심의 대상이 아님



시사점

- 발전사업자가 강제로 수행하는 DEMO라서 추진의지가 약함
- **정부기관에 의해 수행되는 연구가 아님**
- 만일 부정적인 결과가 도출되었을 시에 대한 신뢰성 부족 가능성

SF DEMO (Canada) - Hotcell Test History

1980년에 t=0 핫셀자료 생산함

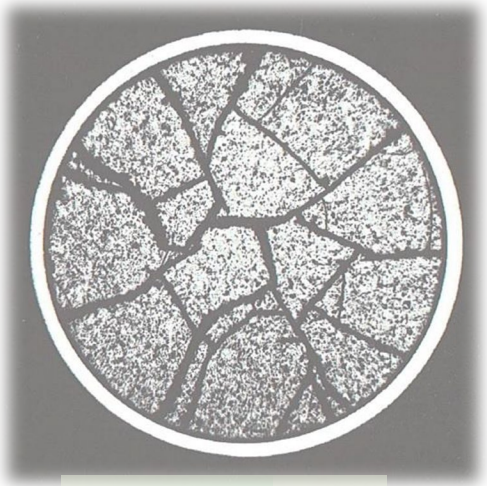
Event	Date
Baseline	Loading: 1980-10-30
ISE-1	Open: 1984-03-29 Return: 1984-05-28
ISE-2	Open: 1989-04-12 Return: 1989-10-02
ISE-3	Open: 1993-03-08 Return: 1993-04-02
ISE-4	Open: 1997-05-22 Return: 1997-06-26
ISE-5	Open: 2026

NDE

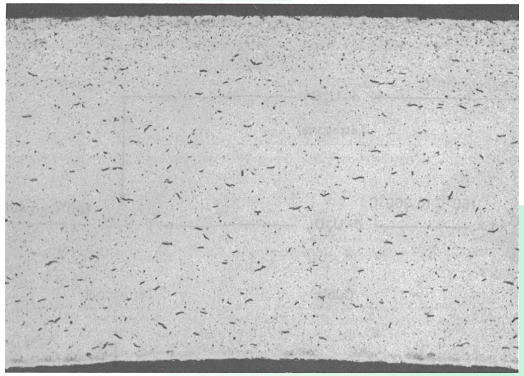
DE

Power Station	PNGS																						BNGS																							
Bundle	sum	19558C					26244C					11147W					11171W						sum	E04313C					E04323C					F06584C						F06605C					
ISE (Interim Storage Examination)		B	1	2	3	4	B	1	2	3	4	B	1	2	3	4	B	1	2	3	4	5		B	1	2	3	4	B	1	2	3	4	B	1	2	3	4	5	B	1	2	3	4	5
Visual Examination	16	X	X		X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	17	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X
Profilometry	12	X	X				X	X		X		X	X			X	X	X		X	X	X	13	X	X				X	X		X		X	X			X	X	X	X	X	X	X
Gamma Scan	10	X	X				X	X		X		X	X				X	X		X		X	11	X	X				X	X		X		X	X				X	X	X	X		X
Torque Test	8	X	X					X					X			X		X		X	X	X	7		X					X		X			X			X	X		X			X
Weight	4		X					X					X					X				X	4		X					X					X				X		X				X
Gas Puncture	7		X			X	X					X	X			X	X					X	7	X	X				X					X	X			X	X	X				X
Void Volume	0																					X	4	X					X					X					X	X					X
Burnup Analysis (U)	2	X					X																4	X					X					X					X	X					
Burnup Analysis (Pu)	2	X					X																4	X					X					X					X	X					
H/D	12	X	X				X	X		X		X	X			X	X	X		X	X		13	X	X				X	X		X		X	X			X	X	X	X	X	X	
Ring Tensile Test	9	X					X	X		X		X				X	X			X	X		9	X					X			X		X				X	X		X	X	X	
Metallography	12	X	X				X	X		X		X	X			X	X	X		X	X		13	X	X				X	X		X		X	X			X	X	X	X	X	X	
SEM	5	X						X		X						X				X			4									X						X			X	X			
XPS	6		X					X		X			X					X		X			7		X					X		X			X				X	X	X			
XRD	6		X					X		X			X					X		X			7		X					X		X			X				X	X	X			
O/U Ratio	2							X										X					2							X									X					
FTIR	1							X															1																					X	

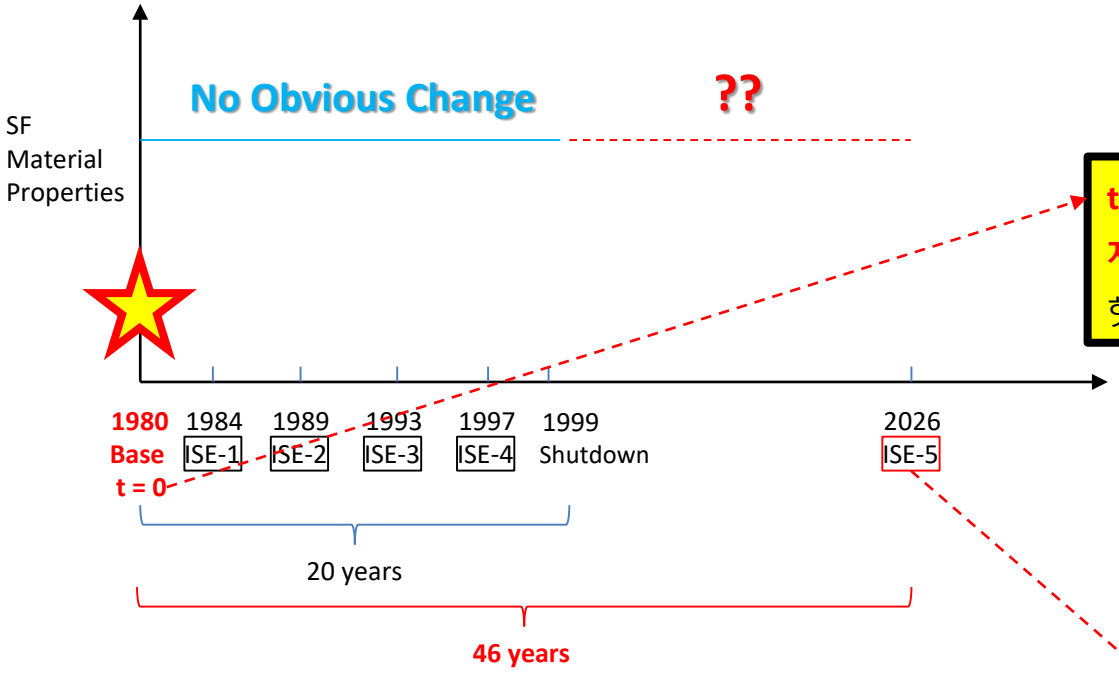
SF DEMO (Canada) - Hotcell Test History



ISE-1, UO2 Oxidation

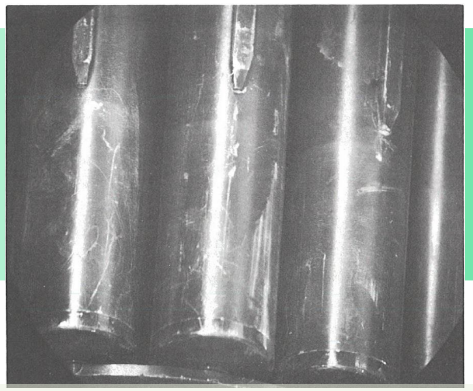


ISE-2, Cladding(sheath) Hydride Distribution
(No Obvious Change over Baseline)



시사점

t=0 핫셀자료를 생산했기 때문에,
저장기간이 얼마가 되더라도
핫셀자료의 상대비교 가능



ISE-3, Periscope Photos
after 140 Months of Dry Storage.

ISE-4, Endplate ➔ Laminar cracks

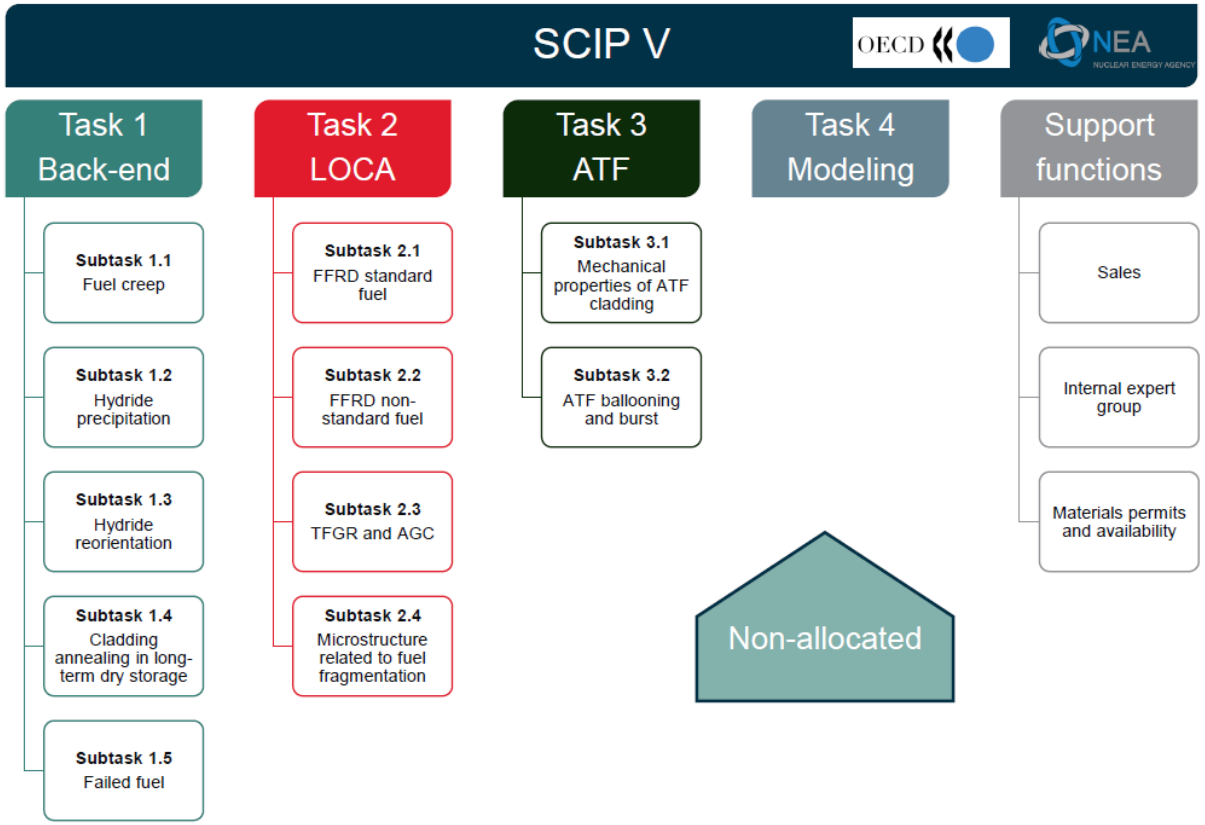
ISE-5 after 46 years dry storage

SF 핫셀 시험

SCIP V program

Studsvik Cladding Integrity Project, phase V

- **Project overview**
  - Task overview presentations will follow this presentation



Studsvik

- OECD-NEA project with Studsvik as the operating agent
  - ✓ 5-year program running from 1st of July 2024 to 30th of June 2029
  - ✓ Funded by the project members
- Continuing work on Back-end and LOCA, and introducing ATF

시사점

건식저장 환경(**Back-end**)에서의 **사용후핵연료 핫셀 시험자료 생산**이 최근 주요 이슈

SCIP V program

SCIP V – Organisations intending to join (only signatories)

Bold font indicates signed agreement and/or invoice sent, last updated 2024-11-25

- **BASE**
- **BEL V**
- BGZ
- CEA
- CNPRI
- CRIEPI
- CSN
- **DOE**
- EDF
- EDF Energy
- **ELECTRABEL**
- **ENRESA**
- **ENSI**
- ENUSA
- EPRI
- **EWN**
- **Framatome**
- GNF-A
- **GRS**
- **HUN REN and MVM Paks**
- IRSN
- **KAERI**
- KHNP
- **KINS**
- **KNF**
- MHI
- **NFD**
- **NFI**
- NNL
- NPIC
- **NRA**
- NRC
- NSC
- OKG
- **ONPU**
- **Sellafield**
- SNERDI
- **SSM**
- **Studsvik**
- Swissnuclear
- **ÚJV Řež**
- **VNF**
- VTT
- Westinghouse

Studsvik

Membership
44 Organisations
15 Countries

Fuel vendors
Utilities
Regulators
R&D Org.
Back-end

SCIP V Proprietary Information 2024-11-25 3

시사점

- 참여중인 **한국기관**
  (KAERI, KHNP, KINS, KNF)
- 해외 **규제기관**들도 참여중
  (ENSI, IRSN, NRC)
- 해외 **방폐기관**들도 참여중
  (BGZ, DOE, ENRESA, GRS)
- **KORAD도 적극 참여 필요**

How was Korean R&Ds in the past?

4

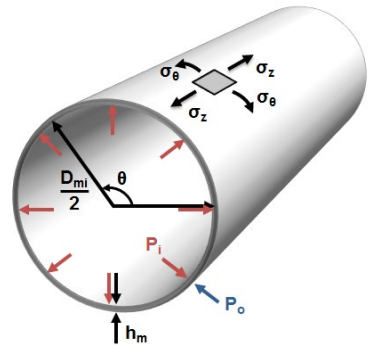
SNF Integrity Evaluation

	General	SNF Management
Material Degradation	Stress	Cladding Hoop Stress
	Material Properties	Cladding Condition
	Temperature	Storage Condition

- Initial Helium fill pressure (P_i)
- Fission Gas Release (P_i)
- Void Volume (P_i)

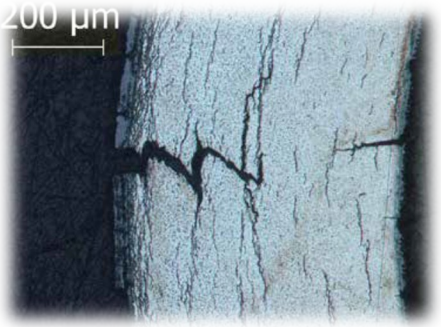
Rod Internal Pressure (RIP) at EOL

- Cladding Diameter (D_{mi})
- Cladding Thickness (remaining metal area after oxidation) (h_m)
- Cladding Hydrides
- Temperature (P_i)



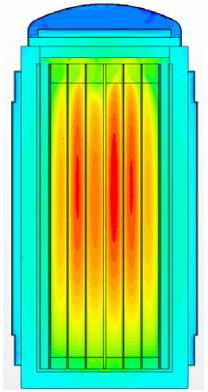
1. Cladding Hoop Stress

[2018] [NRC] Dry Storage and Transportation of High Burnup Spent Nuclear Fuel (ML18214A132)



2. Cladding Hydrides

[2018] [ANL] Results of Ring Compression Tests

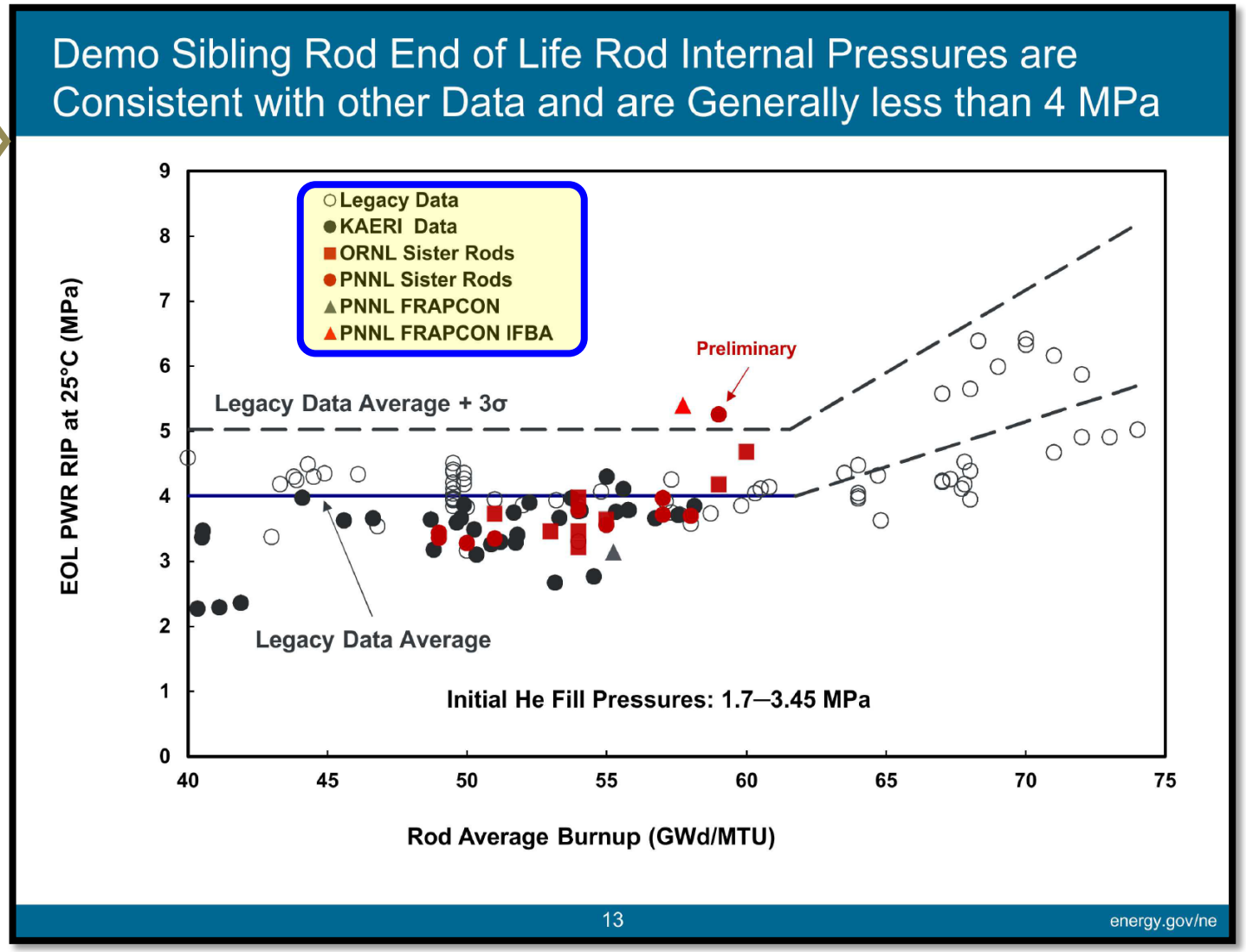


3. Thermal

[2019] [PNNL] Thermal Modeling of the TN-32B Cask for the High Burnup Spent Fuel Data Project

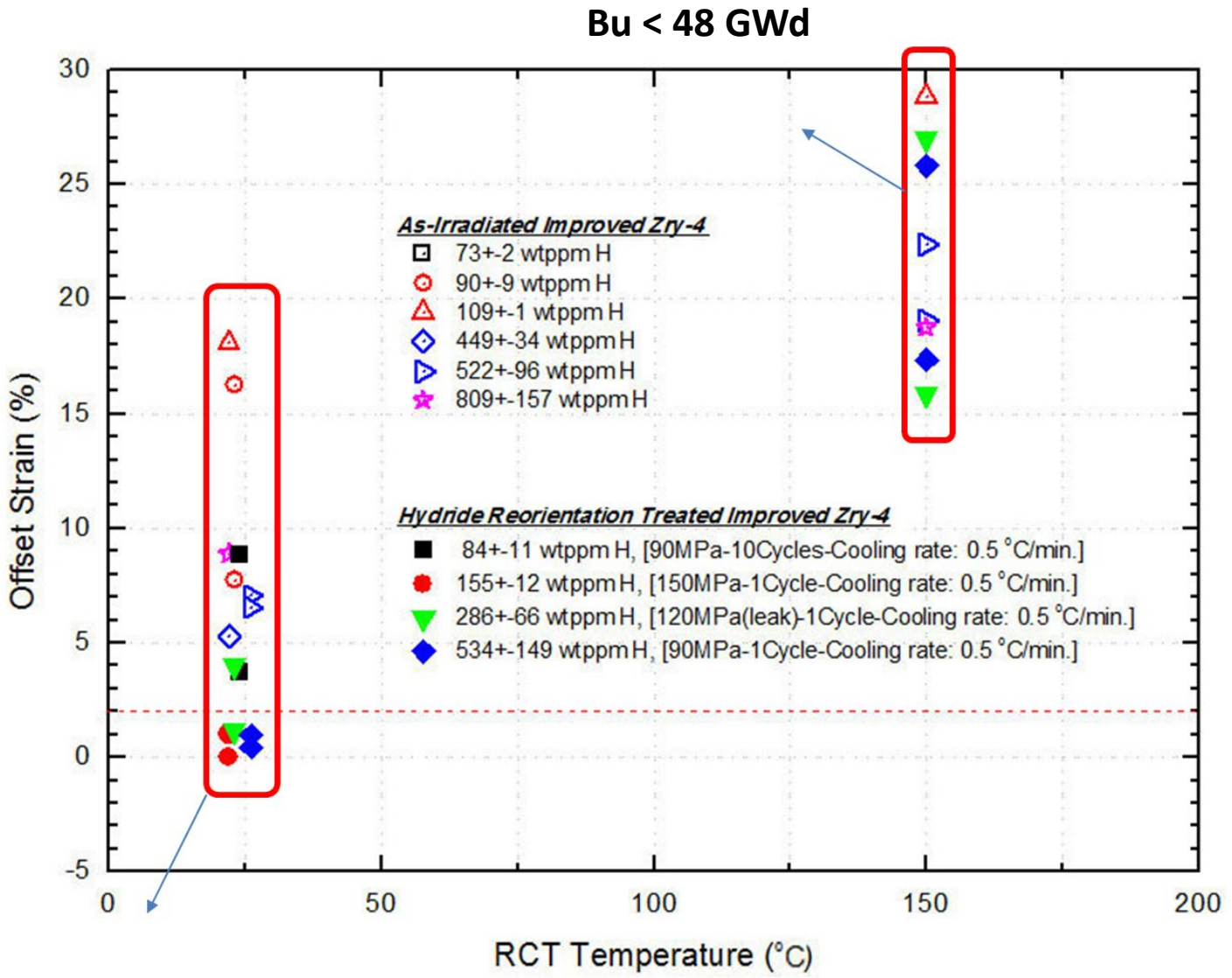
1. Cladding Hoop Stress

General	SNF Management
Stress	Cladding Hoop Stress (RIP)
Material Properties	Cladding Condition (Hydrides)
Temperature	Storage Condition (Thermal)



2. Cladding Condition - SNF Zry-4 RCT after HRT

General	SNF Management
Stress	Cladding Hoop Stress (RIP)
Material Properties	Cladding Condition (Hydrides)
Temperature	Storage Condition (Thermal)



3. Temp. & Storage Condition

General	SNF Management
Stress	Cladding Hoop Stress (RIP)
Material Properties	Cladding Condition (Hydrides)
Temperature	Storage Condition (Thermal)

CANDU SNF Dry Storage Temperature Evaluation

• Leading the Project by CANDU SF Dry Storage System Operator (KHNP)

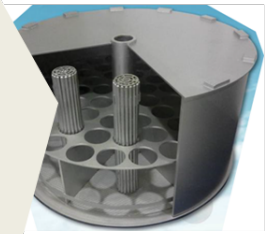
Spent Fuel

Unirradiated Cladding
- Oxidation Experiment by a University

Spent Fuel Cladding before Dry Storage
- Initial Condition Evaluation by a Fuel Company

Spent Fuel Cladding during Dry Storage
- NDE & DE Post Irradiation Examination at Hotcell by CNL

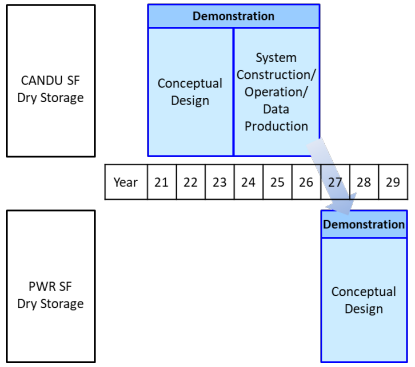
Storage System

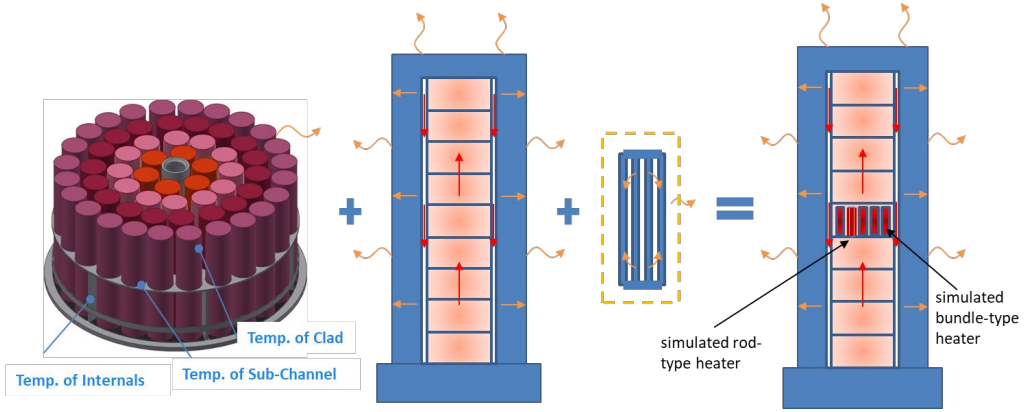


Thermal Analysis
- Thermal Modeling by a University

System Construction
- System Design and Construction by a Engineering Company

System Inspection
- Inspection Tech. by CNL





Where to go?

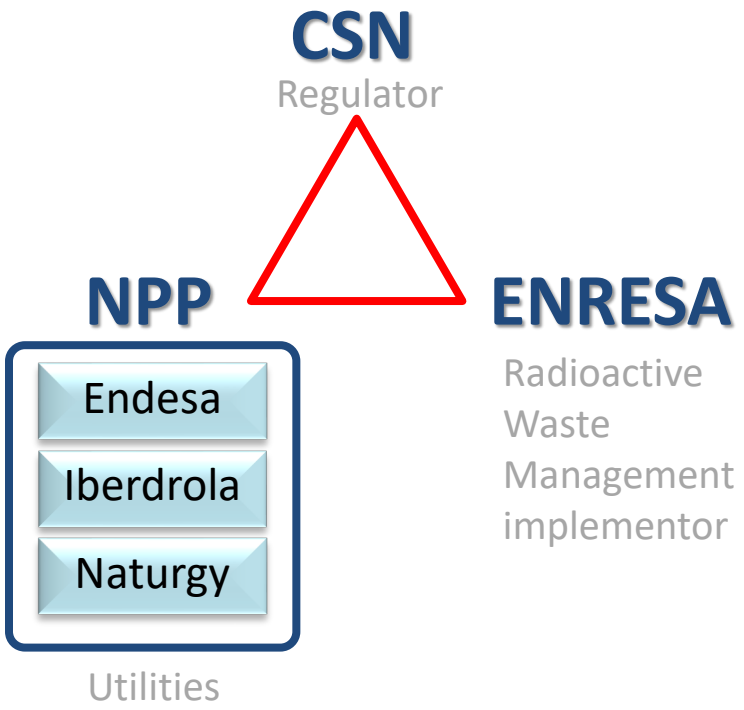
5

Without data,
You're just another person
with an opinion

- W. Edwards Deming

Spanish SF Title Transfer Process

- ENRESA takes part into SNF Characterization, in agreement with the NPPs.
- Agreeing with them on a set of defects that NPPs have to check prior to include any FA into a Loading Plan.
- ENRESA can attend to characterization campaigns, if they wish to, although they do not usually attend as they rely on the records of NPPs characterization activities.
- Then, the Spanish Regulator(CSN) requires to receive the Loading Plan of a cask at least 3 months in advance to the physical loading of it.
- CSN also require that the Loading Plan must get ENRESA's acceptance before, too, because ENRESA has directly or indirectly all the cask licenses in NPPs
- In order for the Utility to develop such a Loading Plan, they have to include all the characterization evaluations to support the classification of the FAs included in it.
- ENRESA then check the characterization evaluations and, if everything is clear enough, ENRESA can formally accept the Loading Plan.
- With that acceptance, NPPs send the Loaded Plan accepted by ENRESA to the Regulator.
- During the Loading Campaign, the last visual and confirmatory inspection is performed prior to seal the cask.
- ENRESA, in this last step, tries to attend the Loading Campaign just for confirmatory purposes.



SF DEMO (Korea)

KHNP

◆ 원전부지내 경수로 사용후핵연료 건식저장시설 사업계획(안)

본부	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32
한빛본부 (금속용기)	기본설계		상세설계		인허가		제작/시공		운영		
고리/한울본부 (모듈)	기본설계			상세설계			인허가		제작/시공		운영

Courtesy of KHNP

관리부지 확보

DEMO Concrete Cask Operation

SF Title Transfer

KORAD

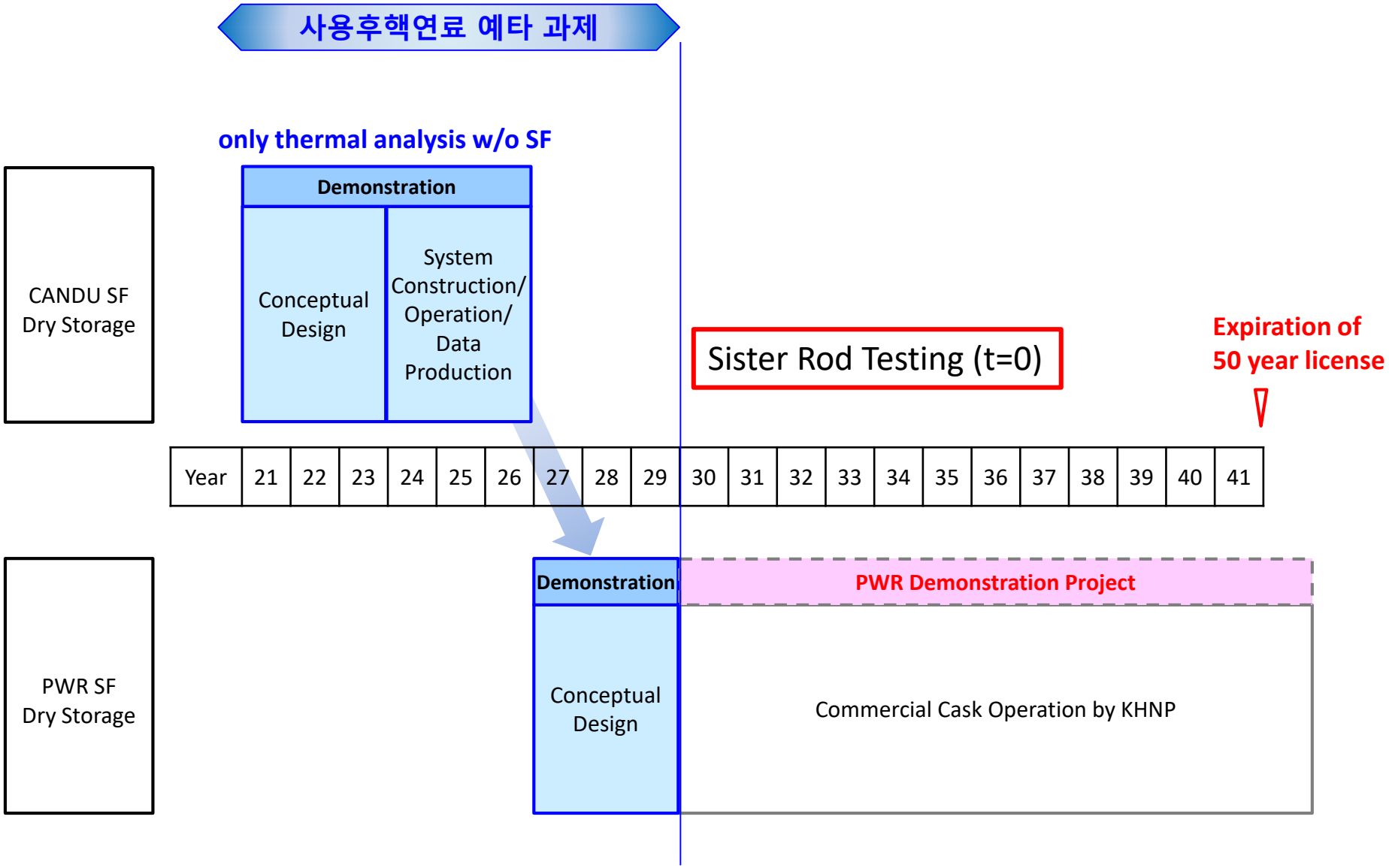
Sister Rod Testing (t=0)

Comparison Rod Testing (t= xx)

- DEMO는 최초 건식저장(한수원의 소내 저장)부터 시작해야함 (← 미국의 교훈)
- DEMO는 국가기관이 주도적으로 수행해야함 (← 일본의 교훈)
- DEMO t=0 핫셀자료 생산해야함 (← 캐나다의 교훈)
  - ✓ 만일 PWR SF의 t=0 핫셀자료를 한국이 생산하면 세계 최초
  - ✓ 저장기간이 장기화되어도 SF자료 비교에는 문제 없음
  - ✓ SF자료 비교값은 SF인도인수 시에 큰 도움

- 경수로 SF DEMO 시스템의 기본설계는 기존 SF 예타 3단계의 성과물 예정 ('29)
- 따라서, DEMO의 t=0 자료 생산 연구 준비 필요

PWR SF Demonstration



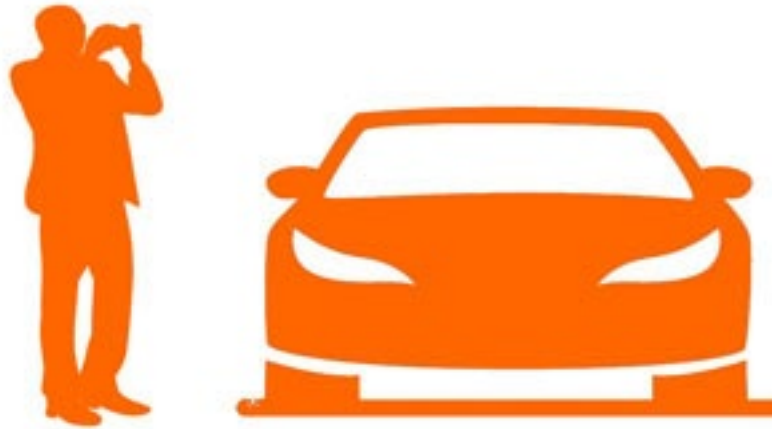
산업부 고준위 방폐물 R&D 기술로드맵 - 운반/저장

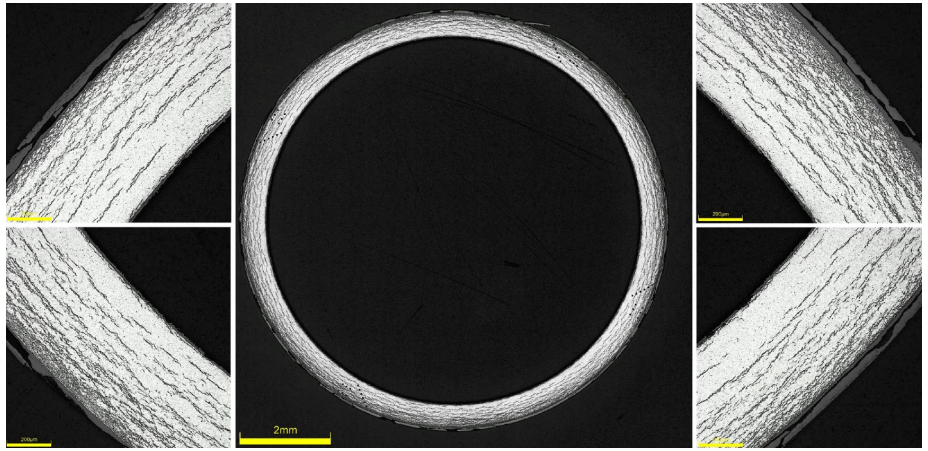
구분	요소기술 기술명		우선순위
국내 자체 개발	운반	**(운반)** 경수로형 운반용기 설계기술	高
		(운반) 육해상 운반위험도 및 최적 운반경로 평가 기술	高
	중간저장	**(중간저장)** 저장안전성 입증을 위한 Safety Case 구축 기술	高
		(중간저장) 경수로형 저장시스템 설계 기술	高
		(중간저장) **결함핵연료** 보관용기 설계 기술	高
		(중간저장) 중간저장 실증시스템 설계 기술	高
국제 공동 연구	운반	**(운반)** **결함핵연료** 운반시스템 설계 기술	高
		(운반) 육해상 운반조건에서의 **사용후핵연료 건전성 평가 기술**	高
	중간저장	**(중간저장)** **사용후핵연료 및 피복재 장기건전성 평가 기술**	高
		(중간저장) **핵연료(봉 및 집합체 단위) 연소도 평가 및 실증기술**	高

When?

6

" Before "





[2023] [PNNL-33781] PNNL FY 2022 Sibling Pin Testing Results

Take a Photo
of the Rented Car
Before Leaving

(Several Days)

Take t=0 Data
of the Dry Stored SF
Before Starting

(Several Decades)

Do it,

Do it right,

Do it right now.

- Spencer W. Kimball

영화, '더 킹'

" 요즘 애들은 왜 역사 공부를 안하니? "

Questions & Answers


KAERI
한국원자력연구원
Korea Atomic Energy Research Institute
Thank you for attention