Japan's prospects of spent fuel recycle and disposal after Fukushima

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Executive Director, JAEA
President, AESJ

1. Nuclear Severe Accident on March 11, 2011

Catastrophic Earthquake & Tsunami
attacked Japan's Tohoku-area on March 11, 2011

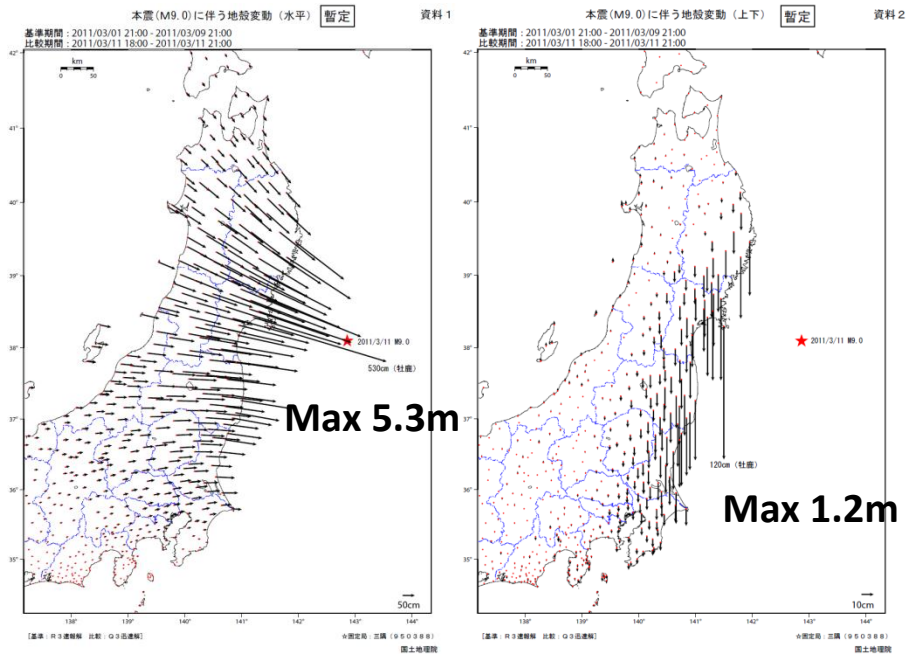
Tohoku Region Pacific Coast Earthquake

M9.0 scale

No.4 strongest in the world recorded history

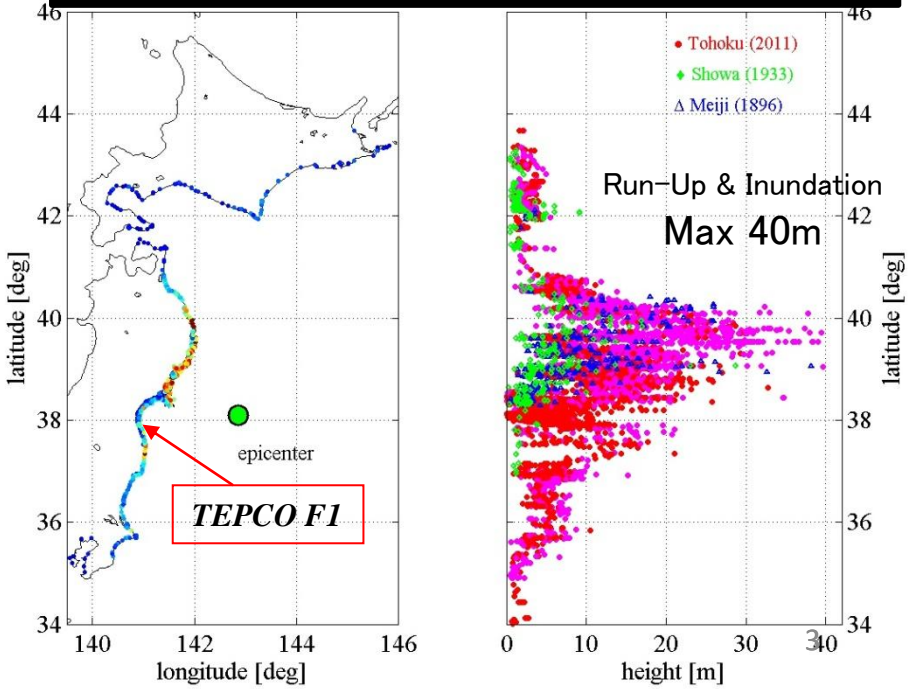
Wide range Crustal Movement
as identified by GPS based control station

HP Geospatial Information Authority of Japan



Wide range Huge Tsunami

The 2011 off the Pacific Coast of Tohoku Earthquake Tsunami Information, http://www.coastal.jp/ttjt/



Severe accident of TEPCO Fukushima Dai-Ichi NPPs

Core meltdown and Hydrogen explosion occurred sequentially by
1) Station Black Out, 2) Loss of Ultimate Heat Sink, 3) Uncontrollable operation, …..
due to Vulnerability of multi Plant Systems.

Tsunami Attack
~ 15 m height

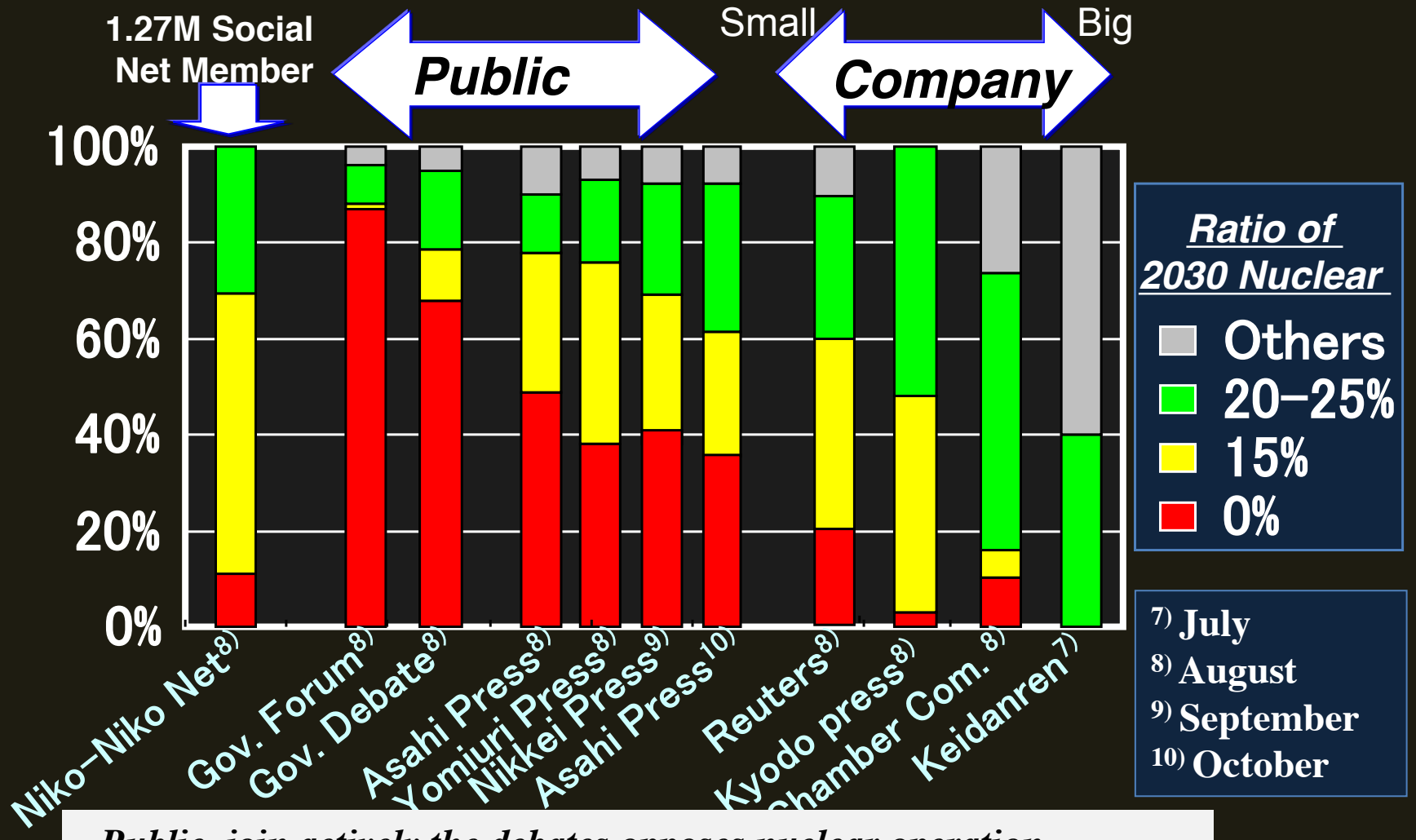
Fukushima Dai-Ichi NPPs after Hydrogen Explosion of Unit 1,3 & 4

- Destruction of containment systems by hydrogen explosion
- Environmental release of rad. gas & volatile elements

- Step wise efforts;
  close the detonated building,
  decrease the radiation level,
  investigate by decommissioning plan

2. Nuclear Strategy and Current Status of Fuel Cycle

Diverse Opinions for 2030 Forecast of Nuclear depending Stakeholders (July- October, 2012)



- *Public join actively the debates opposes nuclear operation .*
- *Small & medium companies agree to reduce nuclear dependency.*
- *Big companies insist on keeping the current level of nuclear.*

Mid-Term Reference Strategy on Nuclear

Planned by Government & Cabinet of Democratic Party in Sep. 2012

- Reduce domestic reliance on Nuclear Power to heavily subsidize renewable energy

1) Restart NPP to be checked safety by new Nuclear Regulation Authority
2) Apply 40 year life limit to NPP operation
3) Renounce the mid-term plan for building new NPPs

- Nuclear Fuel Cycle Strategy

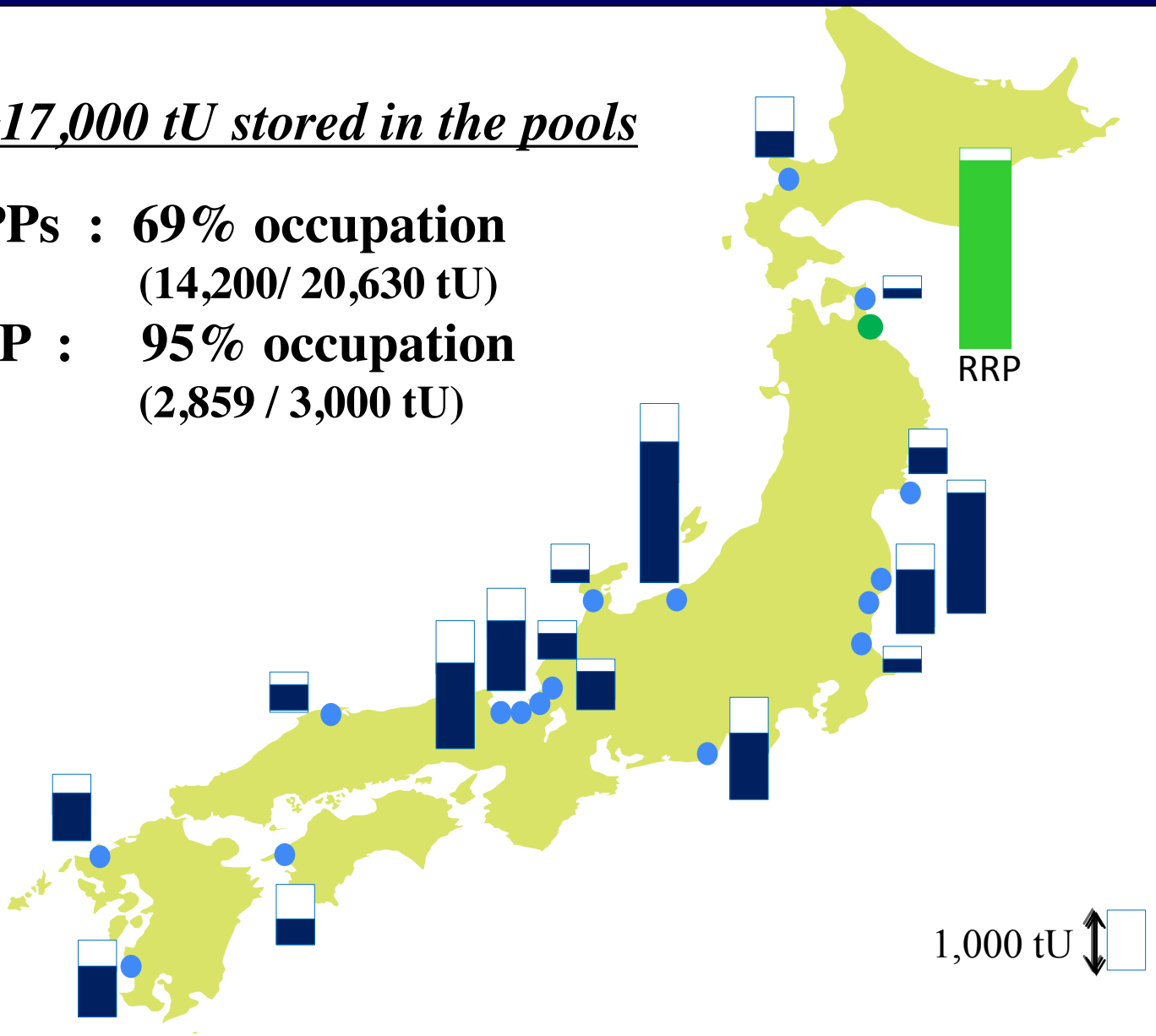
1) Keep nuclear fuel cycle project
2) Promote interim storage & repository project by the government
3) Aim for more flexible BE approach including 'Direct disposal R&D'
4) Implement R&D of FBR 'Monju' for waste reduction & transmutation

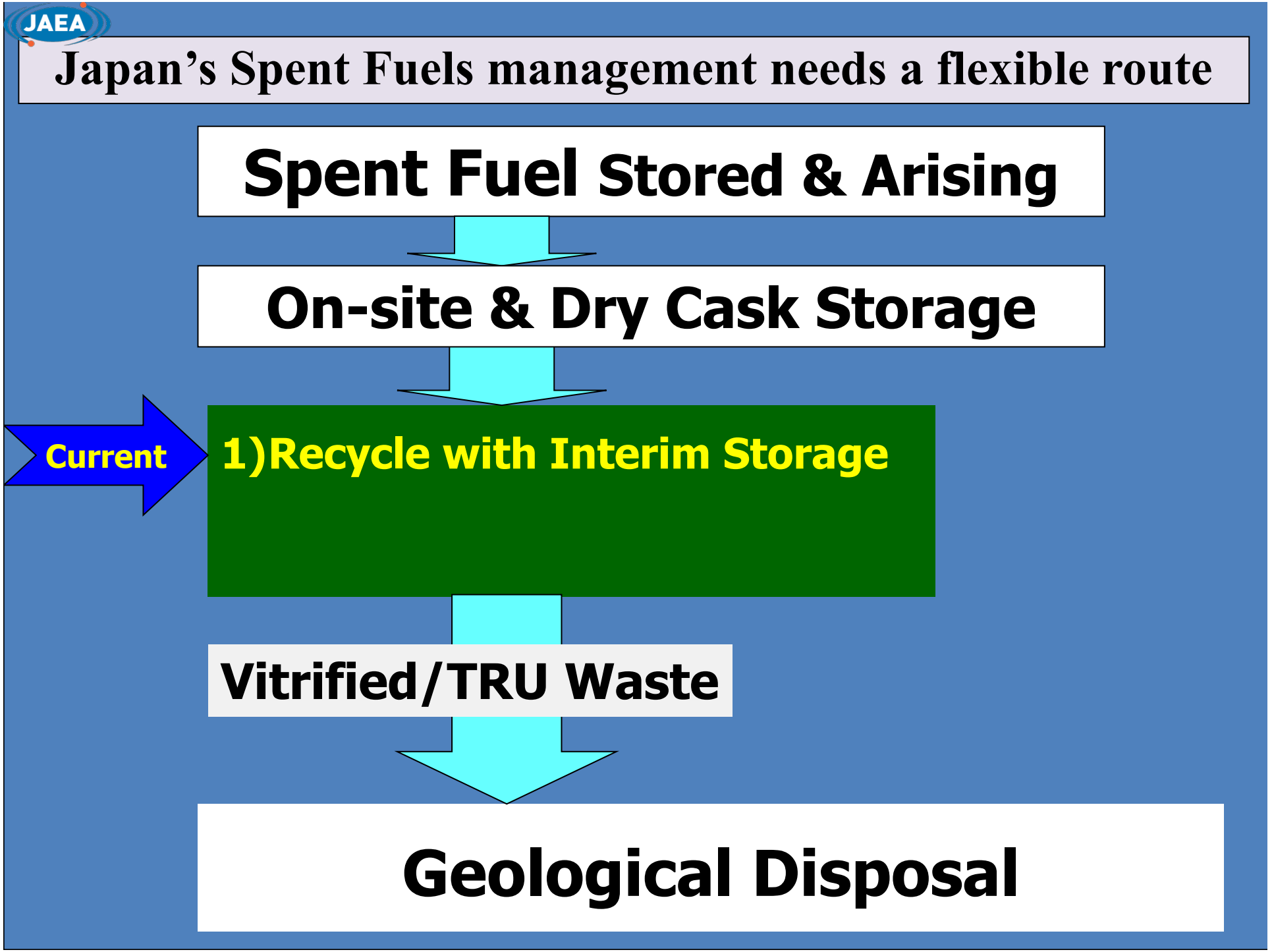
These strategies will be checked & reviewed periodically and flexibly.

Domestic LWR Spent Fuel stored in NPPs & RRP should be managed reasonably not to reach the full

Total amount ~17,000 tU stored in the pools

- **SF Pool of NPPs : 69% occupation**
  (14,200/ 20,630 tU)
- **SF Pool of RRP : 95% occupation**
  (2,859 / 3,000 tU)



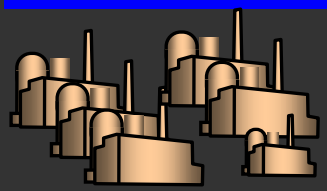

JAEA
Japan's Spent Fuels management needs a flexible route
Spent Fuel Stored & Arising
On-site & Dry Cask Storage
Current
1)Recycle with Interim Storage
Vitrified/TRU Waste
Geological Disposal

Keep SF Strategy on LWR Fuel Cycle Project after Fukushima

as valuable resources for mid-term nuclear optimization

On-site Storage

SF Arising ~ 800 t/y



LWR max 50 units

Recyclable-Fuel Storage Company
3,000+2,000 t
May 2010: Licensing
2013:Operation

JNFL RRP 800 t/y
2013: Operation

U+Pu

Vitrified Waste(HLW)

LWR-MOX
16～18 units by 2015 ?

JNFL-MOX Plant 130 t/y
2016: Operation

NUMO Geological Disposal
～40,000 canisters

Takahama, Hamaoka

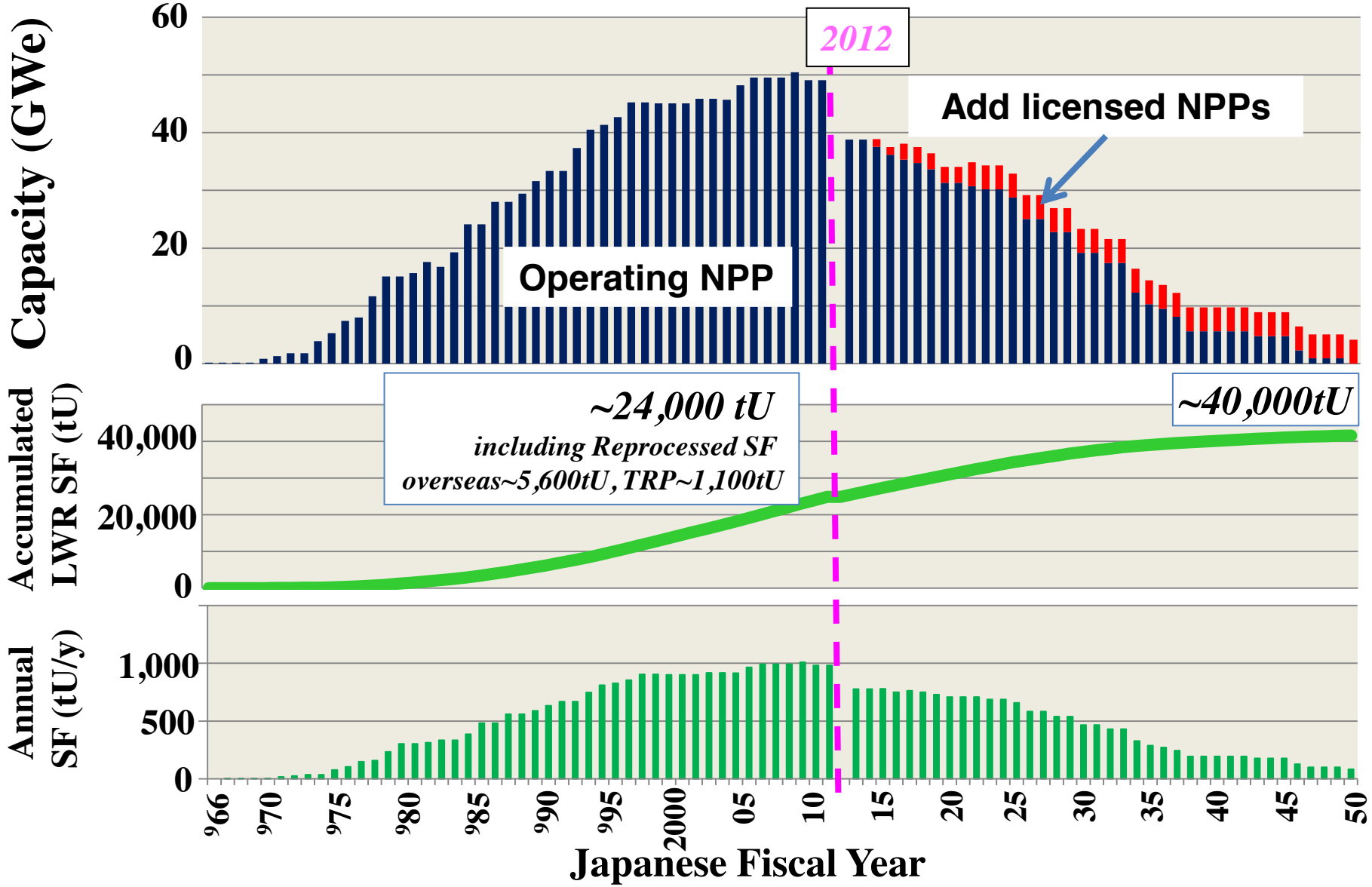
Overseas MOX

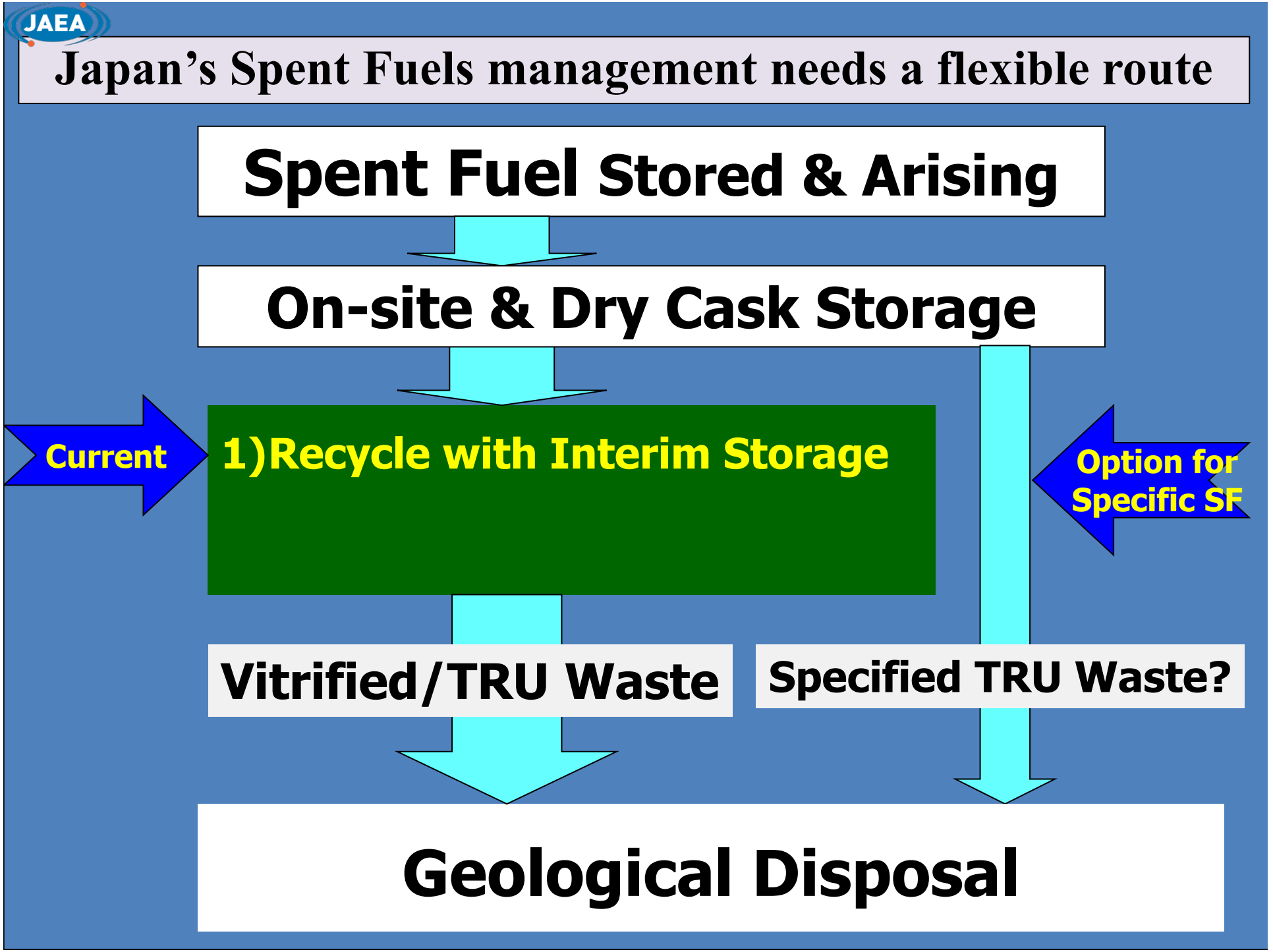
FBR

Trend of NPP capacity & SF accumulation in Japan

*assumed under **40 year life limit & No new plan built***

Can alternatives replacing nuclear cover the electricity shortage ?

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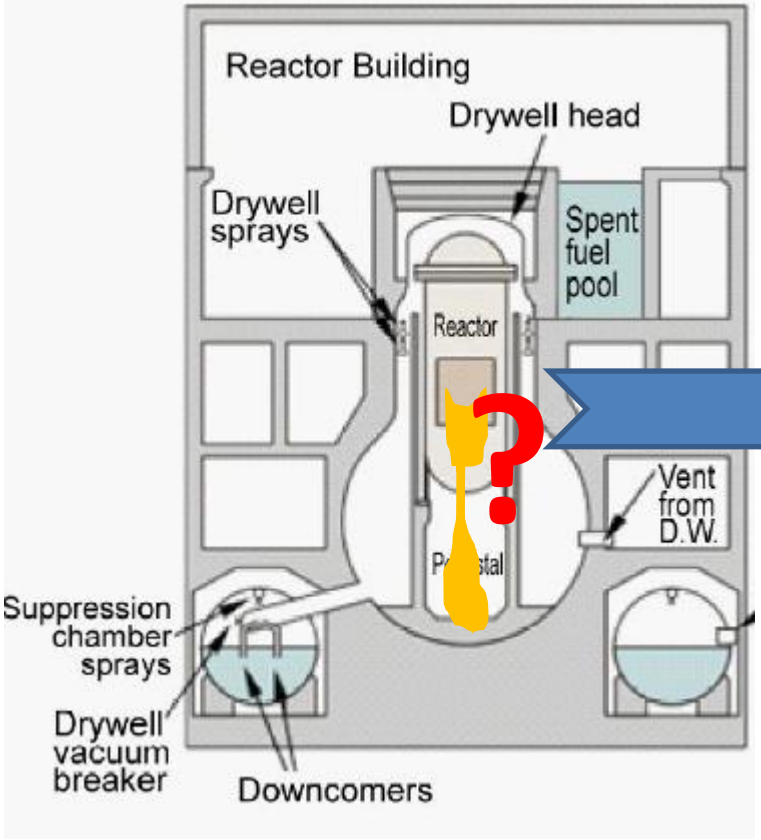
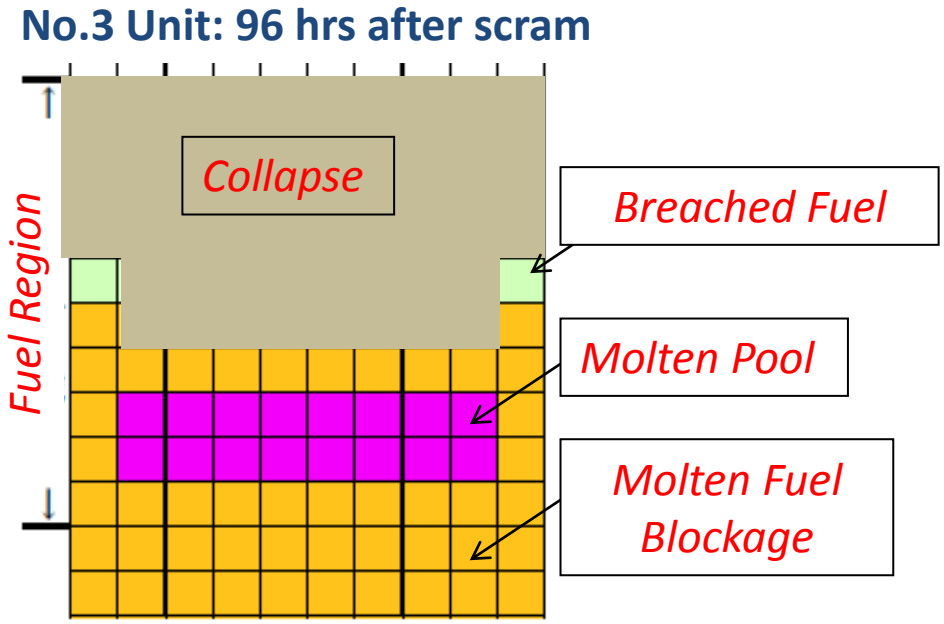
Option for Specific SF
Vitrified/TRU Waste
Specified TRU Waste?
Geological Disposal

Large amounts (～260t U) of Fuel Debris in F1 need 'Removal, Conditioning & Direct Disposal'

Analysis of F1 core melt [1] suggests the existence of molten & reacted fuel compounds 'Debris' through reactor vessel.

TEPCO Report 3/12/2012





- *No.1 Unit: 400 UOX Fuel S/A*
- *No.2 : 548*
- *No.3 Unit : 548 (include32MOX)*

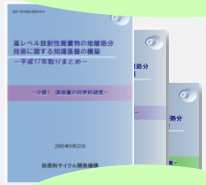
[1] Analysis by MAAP (Modular Accident Analysis Program)

HLW geological disposal project in Japan

URLs Phase I Synthesis Report

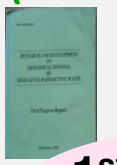
CoolRep 2010 JAEA-KMS

R&D



2005 Report

2nd Progress Report HLW (Technical Reliability)



1st Progress Report HLW (Technical feasibility)

R&D Programme for Supporting Organisations

1976 Start of R&D

1992

2000

2002

2005

2010

2020

2030

2040

Operation (around 2035)

Select DIA Site

Select Repository Site

Revise Basic Policy & Plan (2008)

Amendment of "Act" & Regulation Laws (2007)

NUMO: Commence Open Solicitation

NSC: "Environmental Requirements to be considered at Selection of PIA"

"Specified Radioactive Waste Final Disposal Act"

Establish NUMO

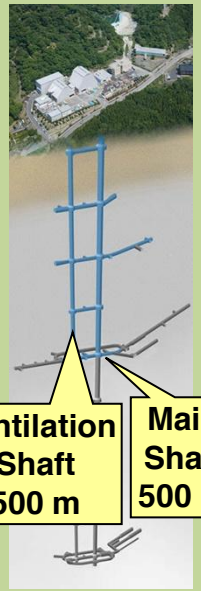
PIA: Preliminary Investigation Area
DIA: Detailed Investigation Area

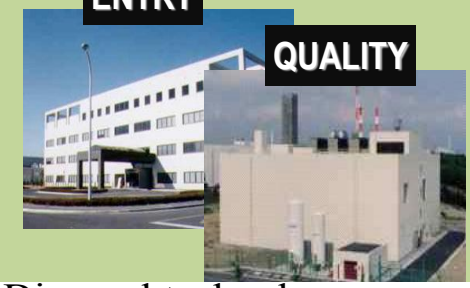
Implementation & Regulation

JAEA R&D for Geological Disposal

- *Develop technical basis for supporting the geological disposal project by NUMO and contributing safety regulations*

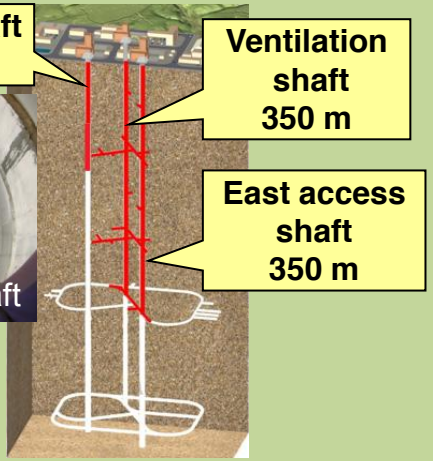
Mizunami URL
Crystalline rock, Fresh water





- Disposal technology
- methodology for safety assess.

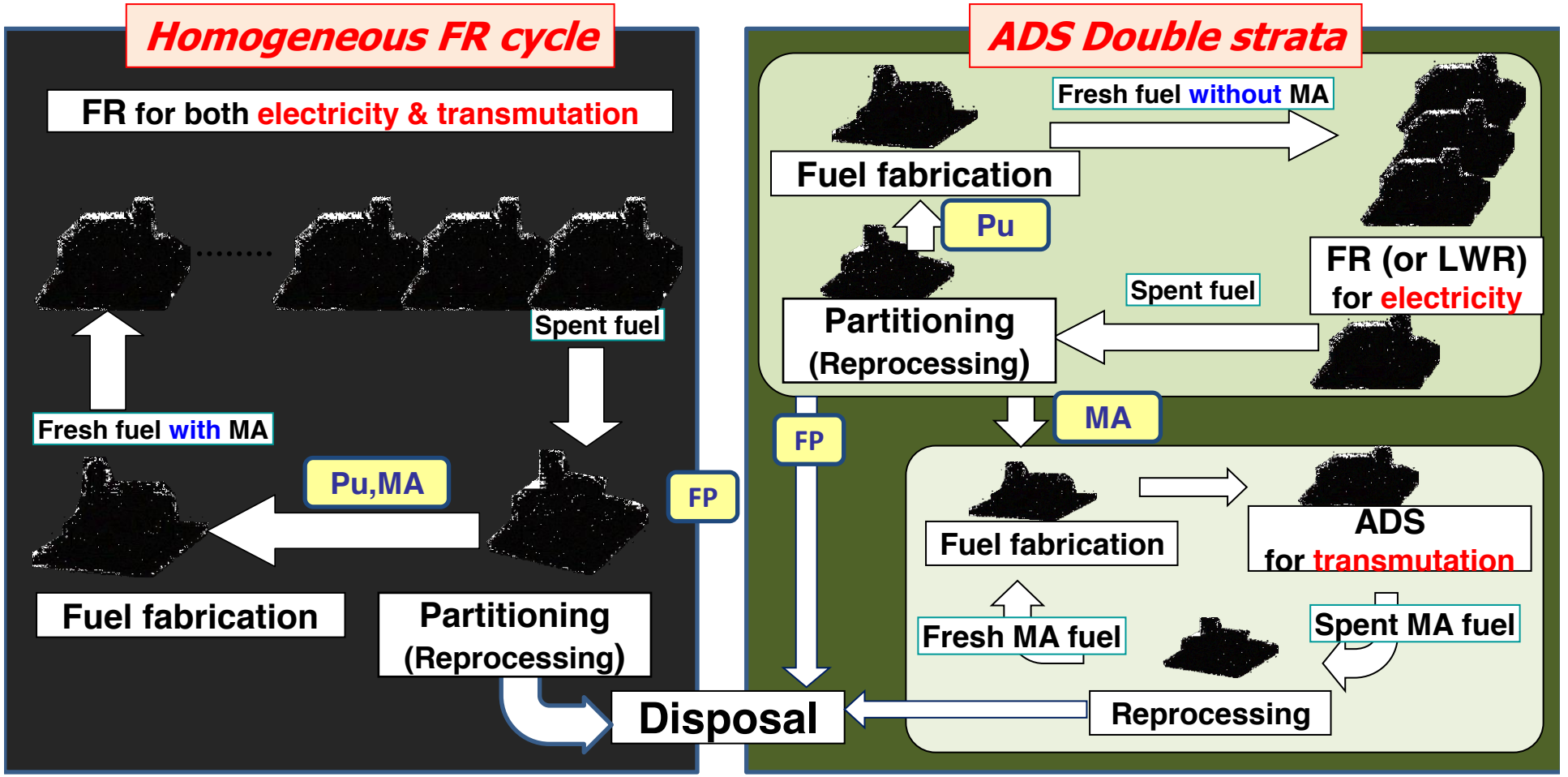
Horonobe URL
Sedimentary rock, Saline water



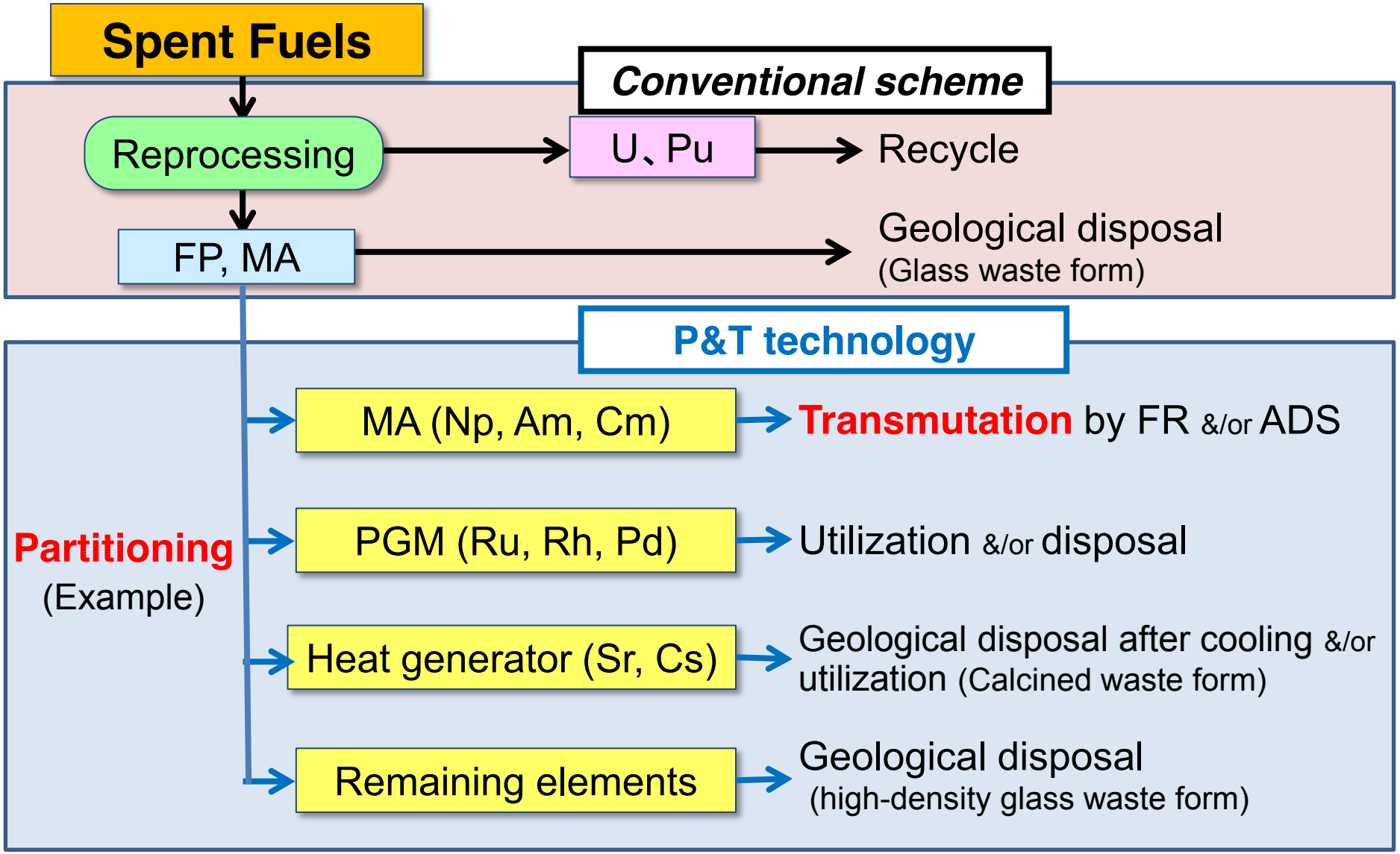
3. Long range prospects on SF management by Partitioning & Transmutation (P&T)

R&D on Partitioning and Transmutation

- "OMEGA" Program was launched in1988,
  and reviewed by the Atomic Energy Commission (AEC) in 2000 & 2009.
- There are two concepts for P&T, conducting by JAEA
  - ◆**Homogeneous recycling of MA using FR cycle.**
  - ◆**Double-strata concept using ADS.**



Partitioning and Transmutation (P&T) Scheme

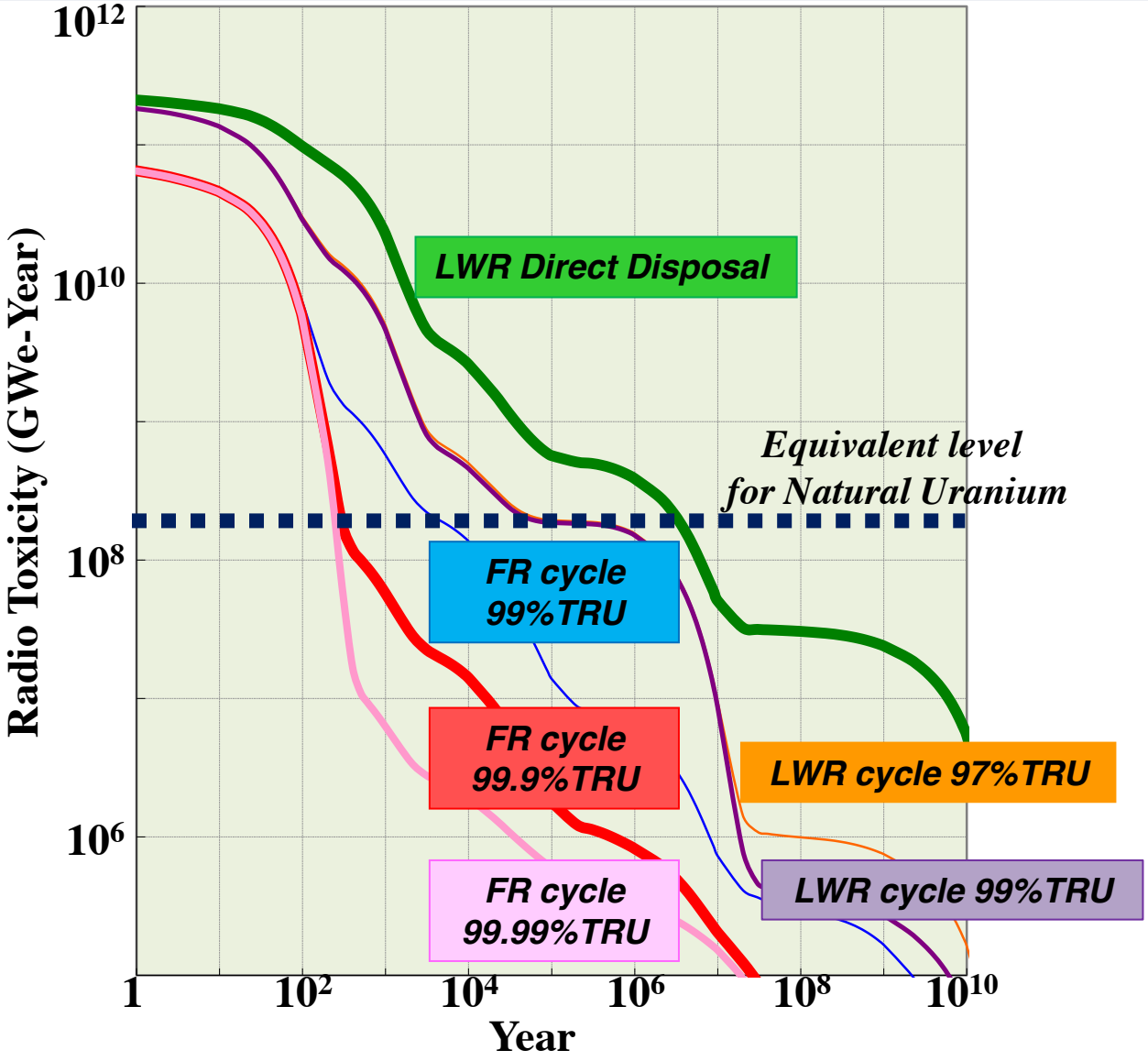


MA : Minor Actinides, FP : Fission Products, PGM : Platinum Group Metal, FR : Fast Reactor, ADS : Accelerator Driven System

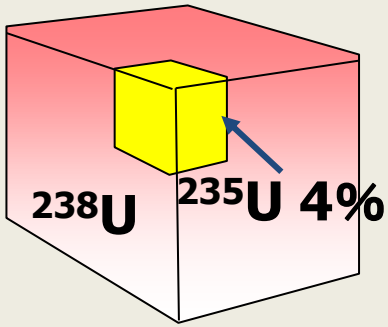
Preliminary Evaluation of Spent Fuel Management from Waste Disposal Views

	Direct Disposal	LWR cycle	FR cycle	ADS *Double strata*
Space for HLW disposal	1	1/4 (low decay heat)	1/10 (burn U,Pu, MA)	1/100 (transmute MA, store Cs/Sr)
Space for TRU waste disposal	none	Several % of HLW	Several % of HLW	Several % of HLW
Radio-toxicity (Years to reach U ore)	10^6	10^5	$< 10^3$	$< 10^3$

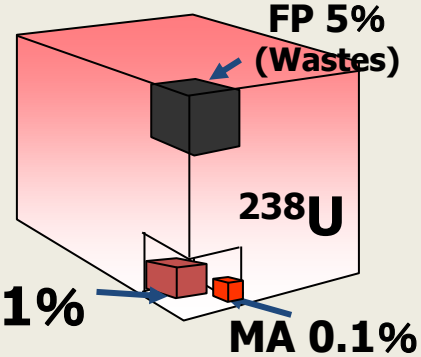
Radio toxicity can be reduced efficiently by P&T to 1,000 yrs order



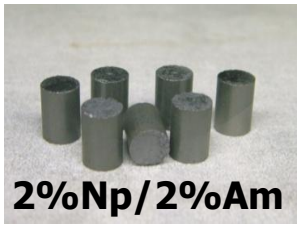
Fresh UO_2 Fuel

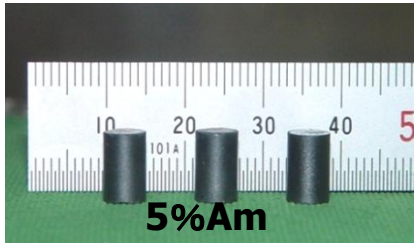


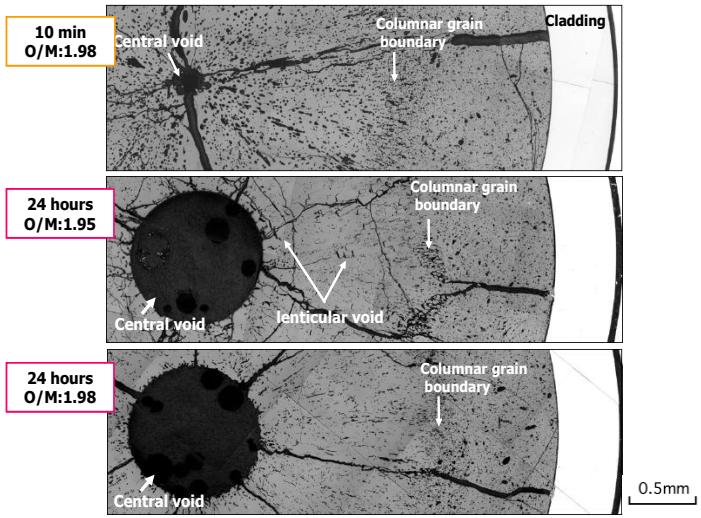
Spent UO_2 Fuel
2-4 yrs, 55 GWd/t



Fabrication & FR Irradiation Tests of MA-MOX fuels







Irradiation programs of MA & LLFP are planned after repairing core structure of JOYO.

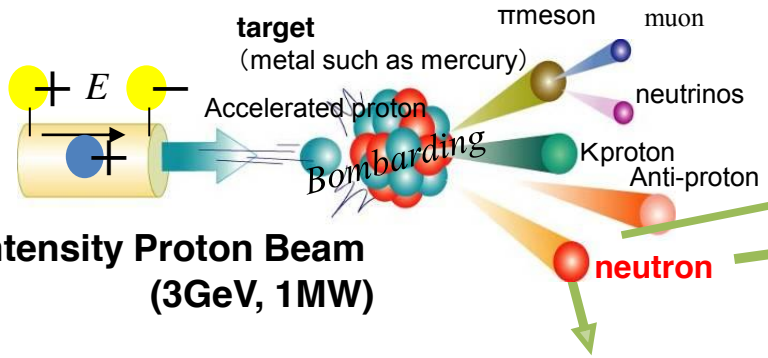
Now waiting 40% power test operation, making program with a deadline

- *Am-MOX fuel assembly irradiations*
- *Burning of recycled and degraded Pu*
- *International GACID project* ***(CEA-USDOE-JAEA)***
- *MA burning Demonstration test*

J-PARC Project (High-Intensity Proton Accelerator)

Joint project of JAEA & KEK completed in 2008

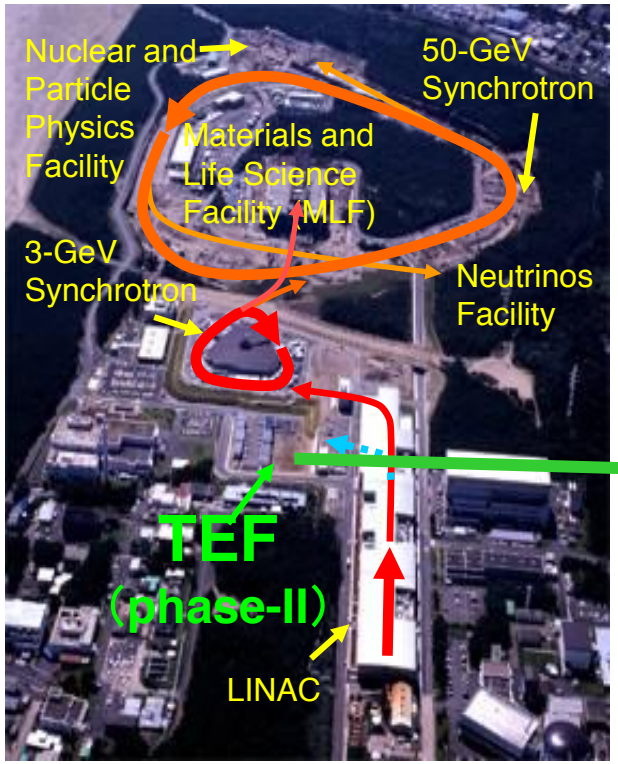
Multi-purpose facility for use of secondary particle beams



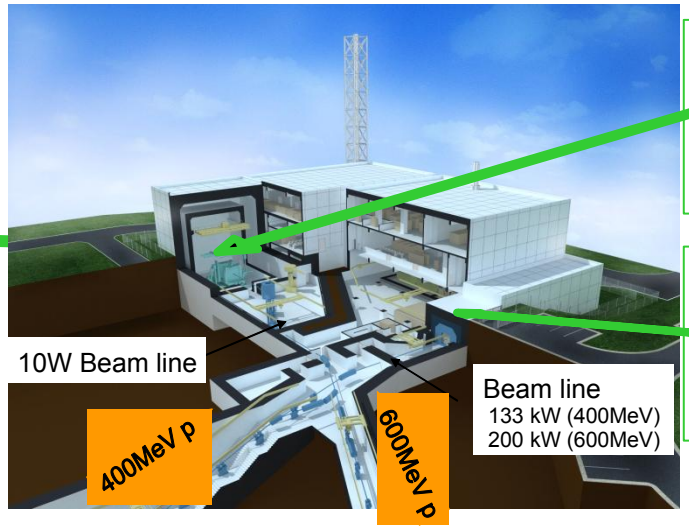
High Intensity Proton Beam (3GeV, 1MW)

Pure Physics
- Neutrino oscillation
- Elementary particle
- Nuclear physics

Material Science
- Bio-material
- Medicine develop
- Super-conducting
- Hydrogen storage

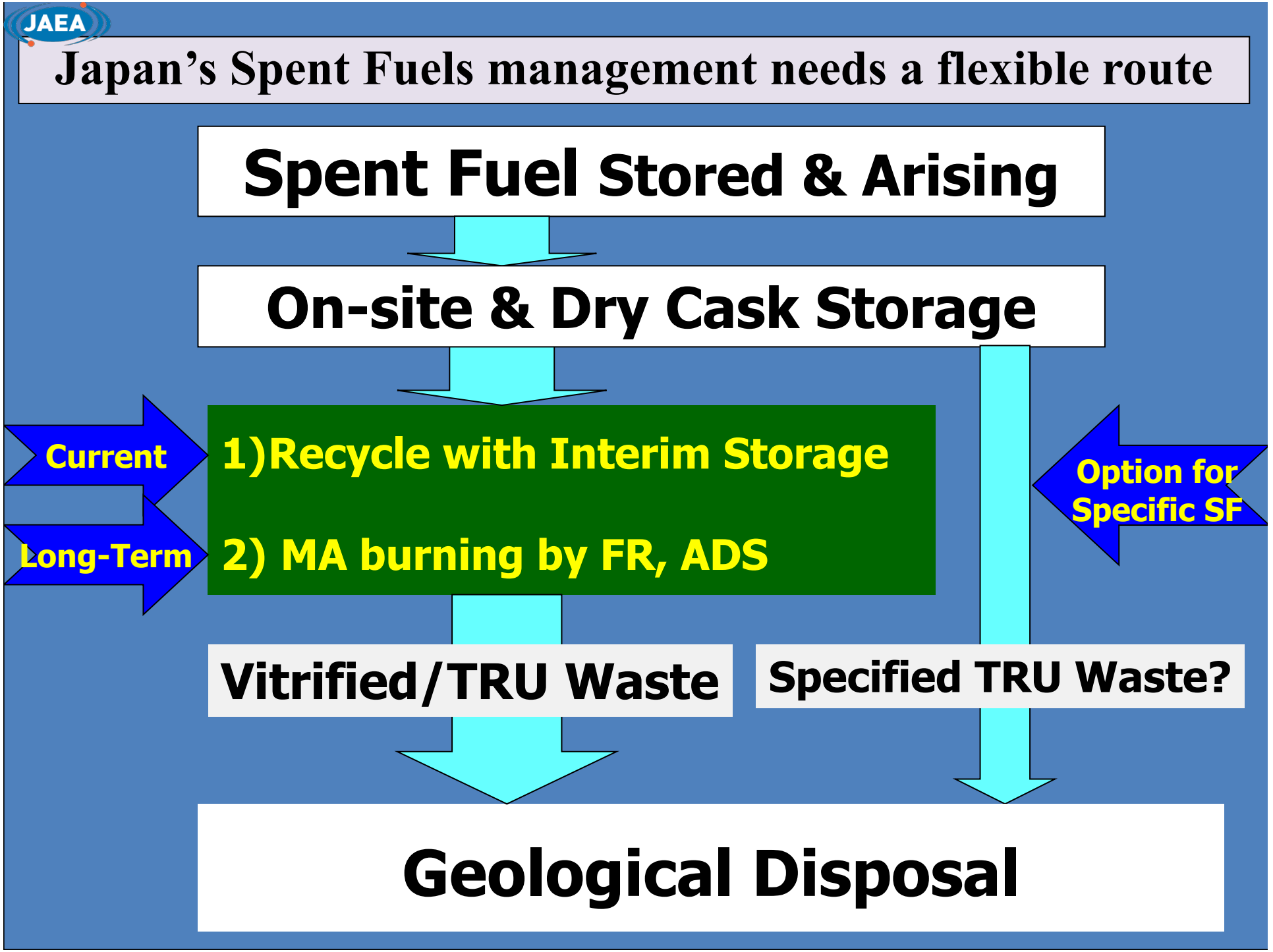


Transmutation Experimental Facility (TEF) proposed for J-PARC Phase II project.



Transmutation Physics Experimental Facility (TEF-P)

ADS Target Test Facility (TEF-T)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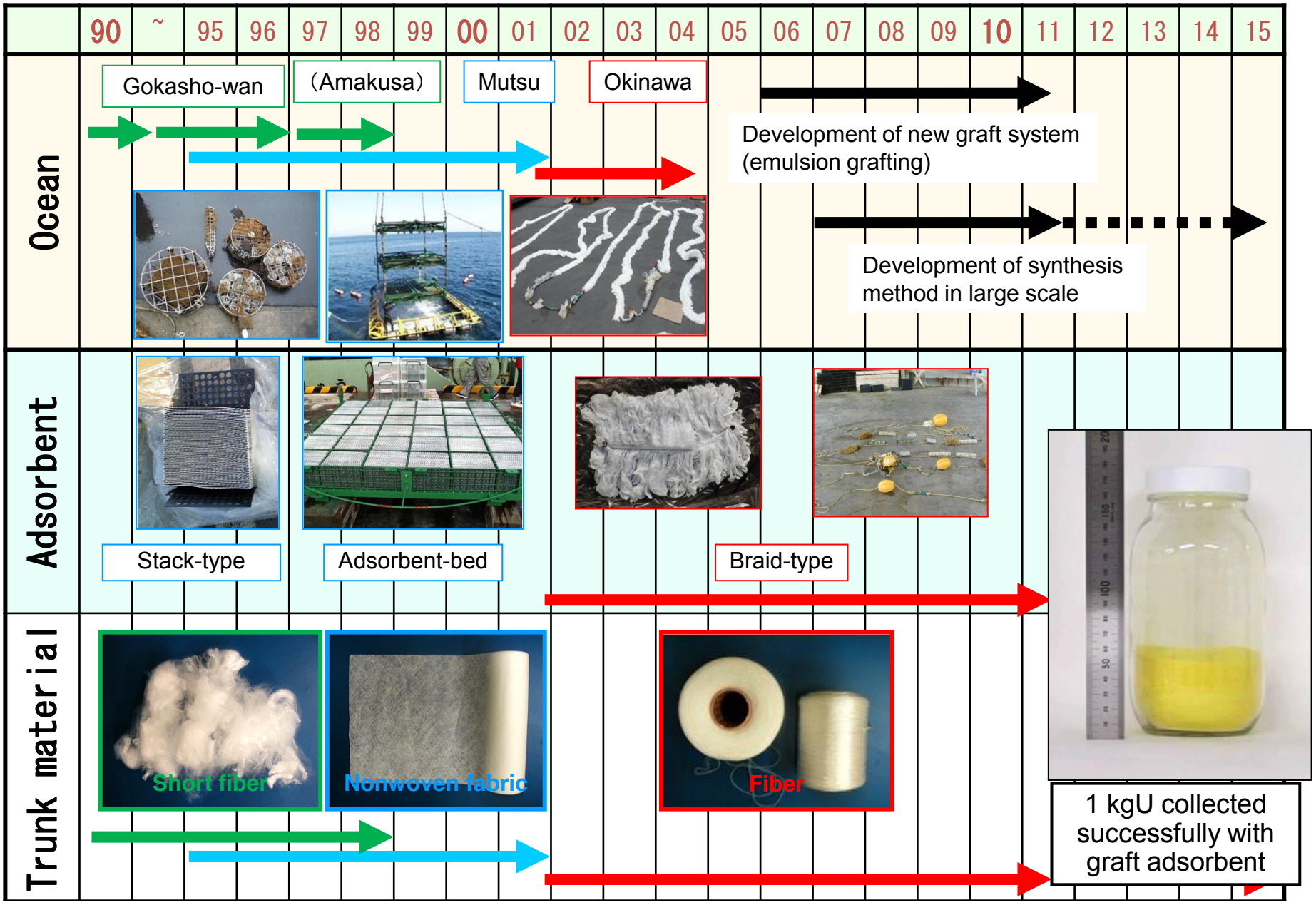
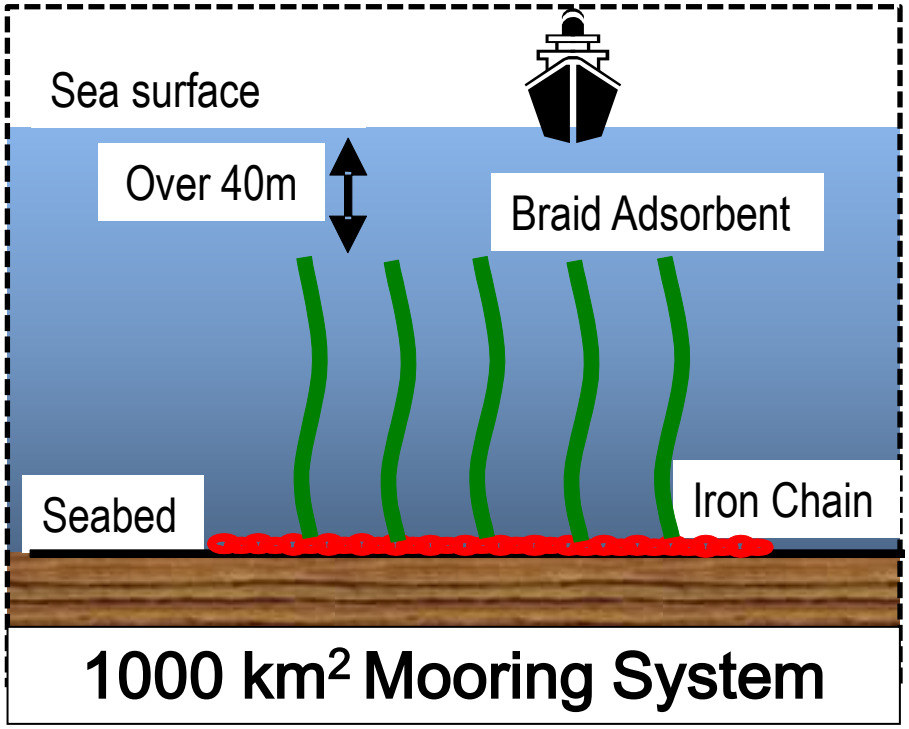
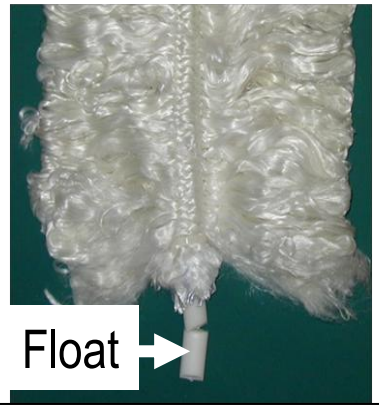
History of U Recovery from Seawater in JAEA

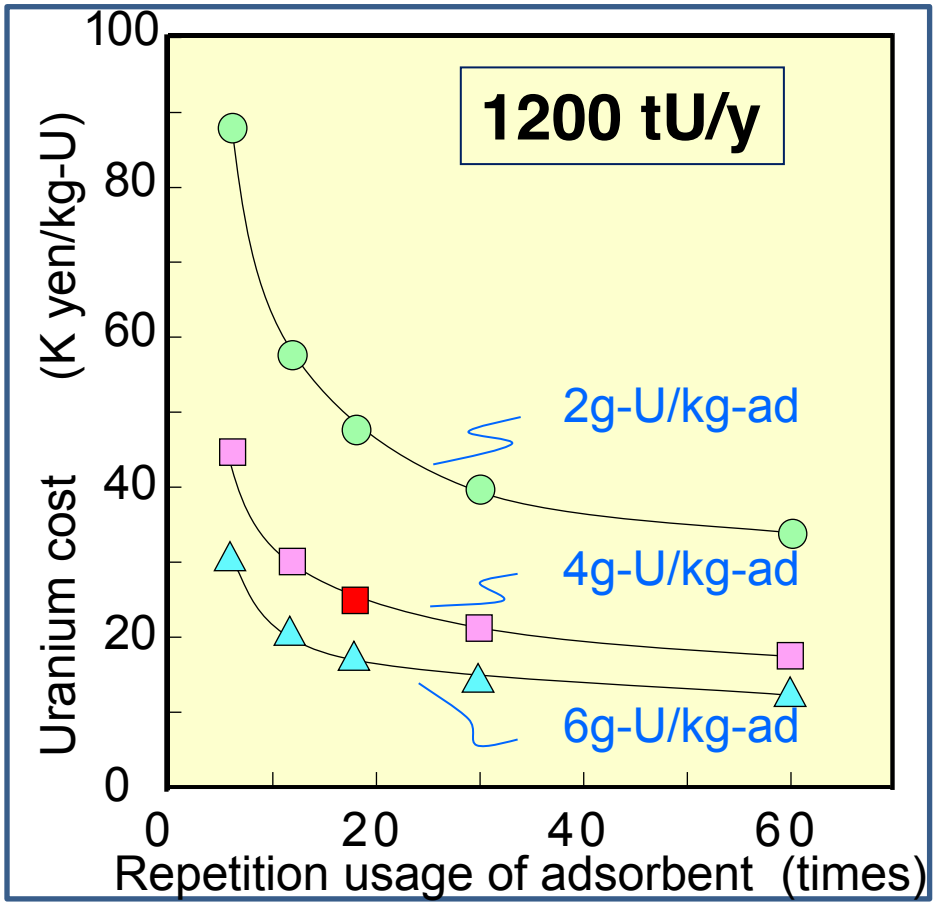


Cost Estimate for Advanced Uranium Extraction from Sea Water





Braid Grafted Adsorbent



- ***Recent long-term contract is $60-70/lb-$U_3O_8$, correspond to 16-19Kyen/kg-U.***
- ***Promising collection cost is 25Kyen/kg-U, almost 1.5 times of commercial price.***

M. Tamada, N. Seko, N. Kasai and T. Shimizu, Trans. AESJ, 5 (4) (2006) 358-363.

Japan's Prospect for SF Treatment & Disposal

1. **Realistic path for SF management, which obtained by the historical achievements with local stakeholders is 'the Steady implementation of on-going nuclear fuel cycle project'.**

2. **Also in order to prepare 'Changes' arising from cleanup of F1 & 'Uncertainties' during long-term nuclear forecast, challengeable R&D options such as direct disposal, P&T are feasible for SF management.**

In the progress of such multi and flexible activities, a clear picture of 'benefit or burden on SF' will be drawn out for Japan's nuclear power strategy.