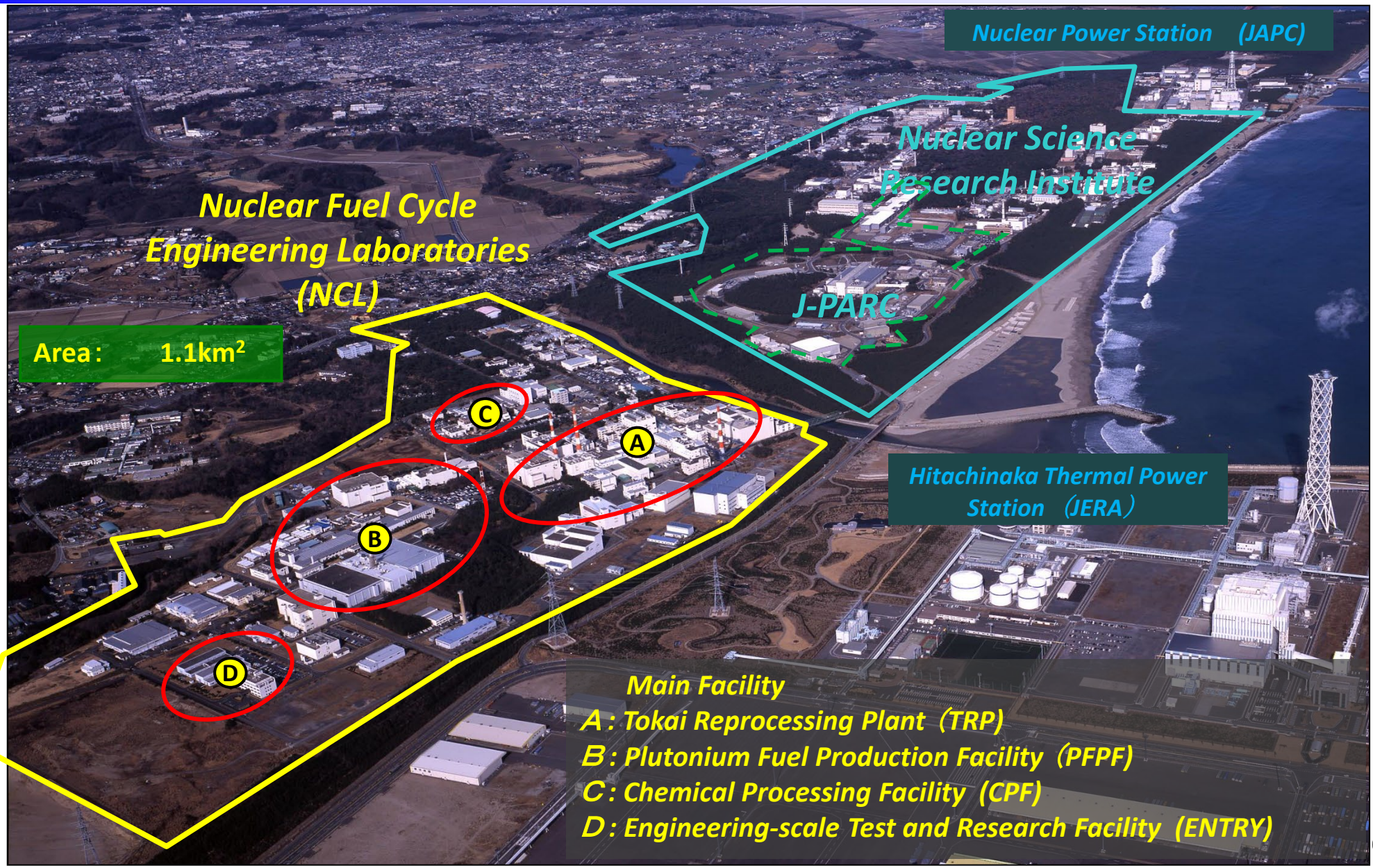
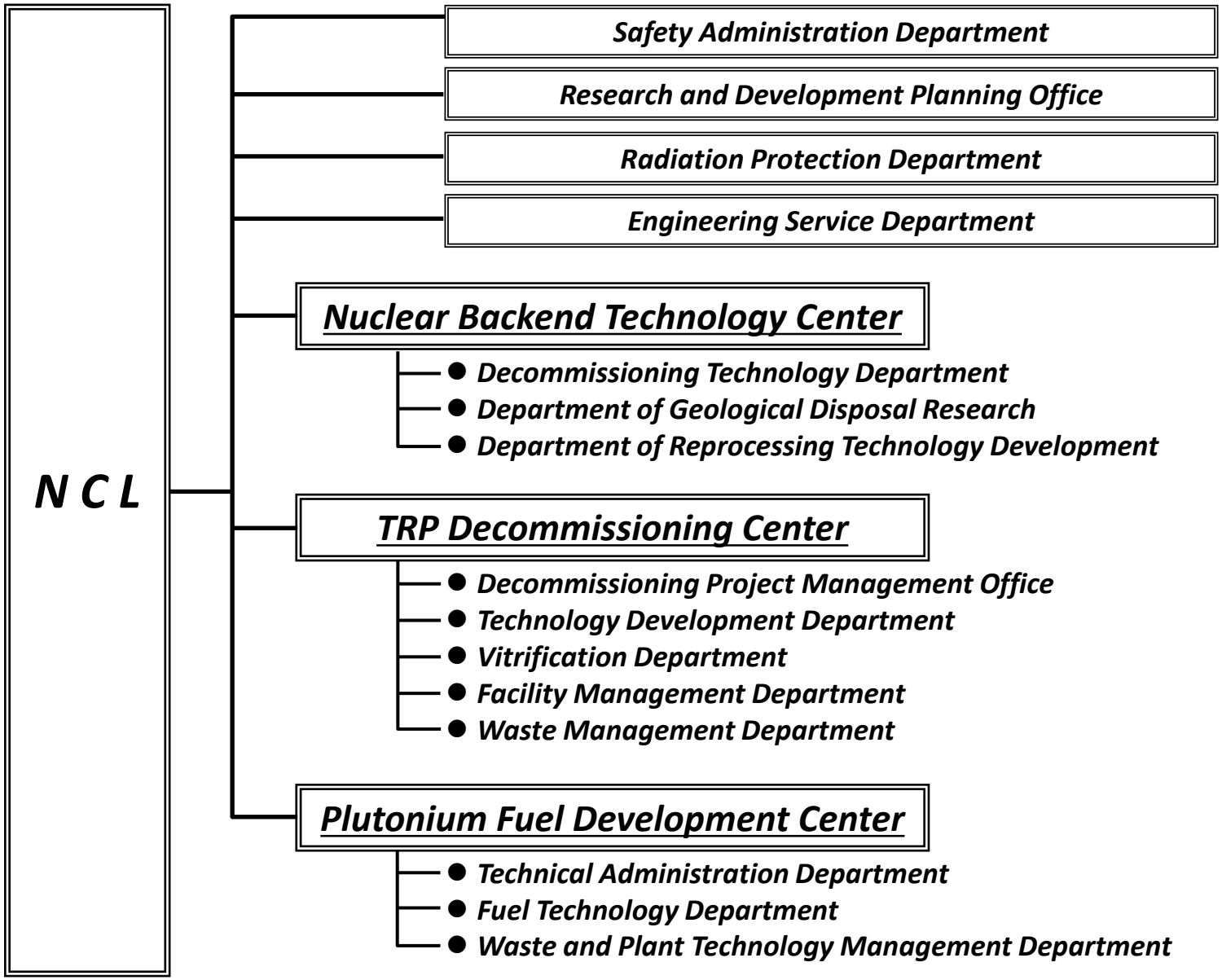
Overview of Nuclear Fuel Cycle Engineering Laboratories (NCL)

R&D Site of Ibaraki Area (Tokai-mura)



Organization of NCL



Main Activities of NCL

TRP Decommissioning Center *(Reprocessing Technology Development)*

- In decommissioning（Its Plan approved in Jun,2018 ）
- Verify the first decommissioning of the large nuclear fuel facility in Japan
- Adopt a WBS to manage the long term plan(70 years) and Establish a project management system
- Reduce the risk in TRP by conducting;
  / Vitrification of the high radioactive liquid waste
  / Cement encapsulation of the low radioactive liquid waste
  / Recovery and storage of the high active solid waste (legacy waste)

Plutonium Fuel Development Center *(Development of MOX Fuel)*

- Basic research on MOX fuel and MOX fuel containing Minor Actinide
- Development of pellet fabrication method
- R&Ds on decommissioning technology for MOX fuel facilities
- Consolidating MOX to Pu-3 and fabrication of Scrap Assemblies
- R&Ds on incineration technology for TRU waste
- Technical cooperation to Japan Nuclear Fuel Limited

Nuclear Backend Technology Center
*(R&D for Reprocessing Technology, Fukushima D&D[*1] , Geological disposal, D&D Technology)*

- R&D for Reducing radioactive waste volume and its potential hazard by MA separation
- R&D related to Fukushima D&D[*1]
  - ✓ Preparation for debris retrieval (Research characteristics of simulated debris)
  - ✓ Processing/disposal of secondary waste generated from contaminated water treatment
- R&D for radioactive waste processing technology
- R&D for geological disposal of radioactive waste

*1 D&D: Decontamination and Decommissioning

Common Mission Sector

Safety Administration Department
- Emergency management
- QA and Licensing window
- PP of Nuclear material

Research and Development Planning Office
- Coordination of NCL activities
- Budget execution management
- Coordination of Back-end measures

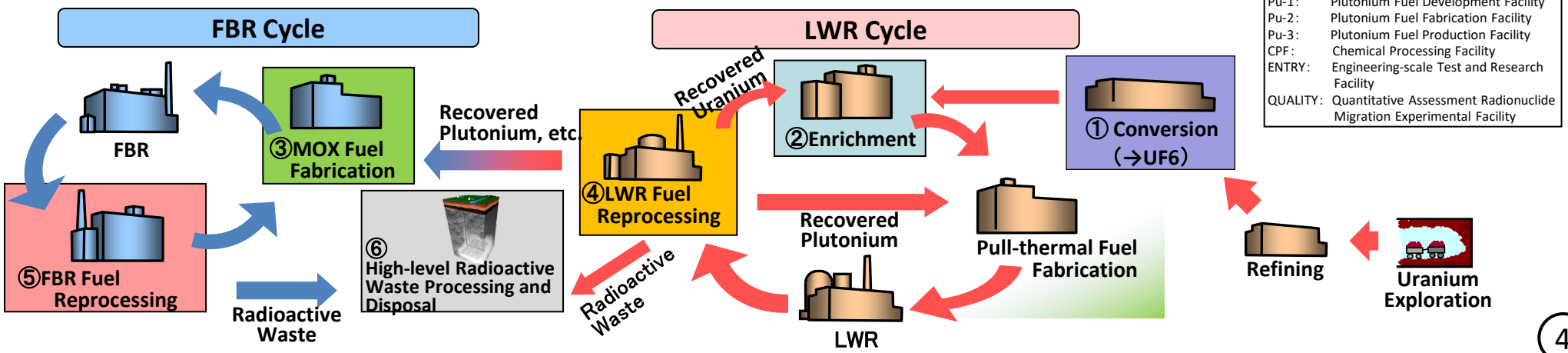
Radiation Protection Department
- Radiation Control
- Radiation Monitoring
- Fukushima related activities

Engineering Service Department
- Operation of utility facilities
- Facility construction
- Facility repair

R&D on Nuclear Fuel Cycle of NCL

Nuclear Fuel Corporation (NFC) Tokai Refinery ('57.6~) ▼ | Power Reactor and Nuclear Fuel Development Corporation (PNC) ▼ Tokai Works ('67.10~) | Japan Nuclear Cycle Development Institute (JNC) Tokai Works ('98.10~) ▼ | Japan Atomic Energy Agency (JAEA) Nuclear Fuel Cycle Engineering ▼ Laboratories (NCL) ('05.10~)

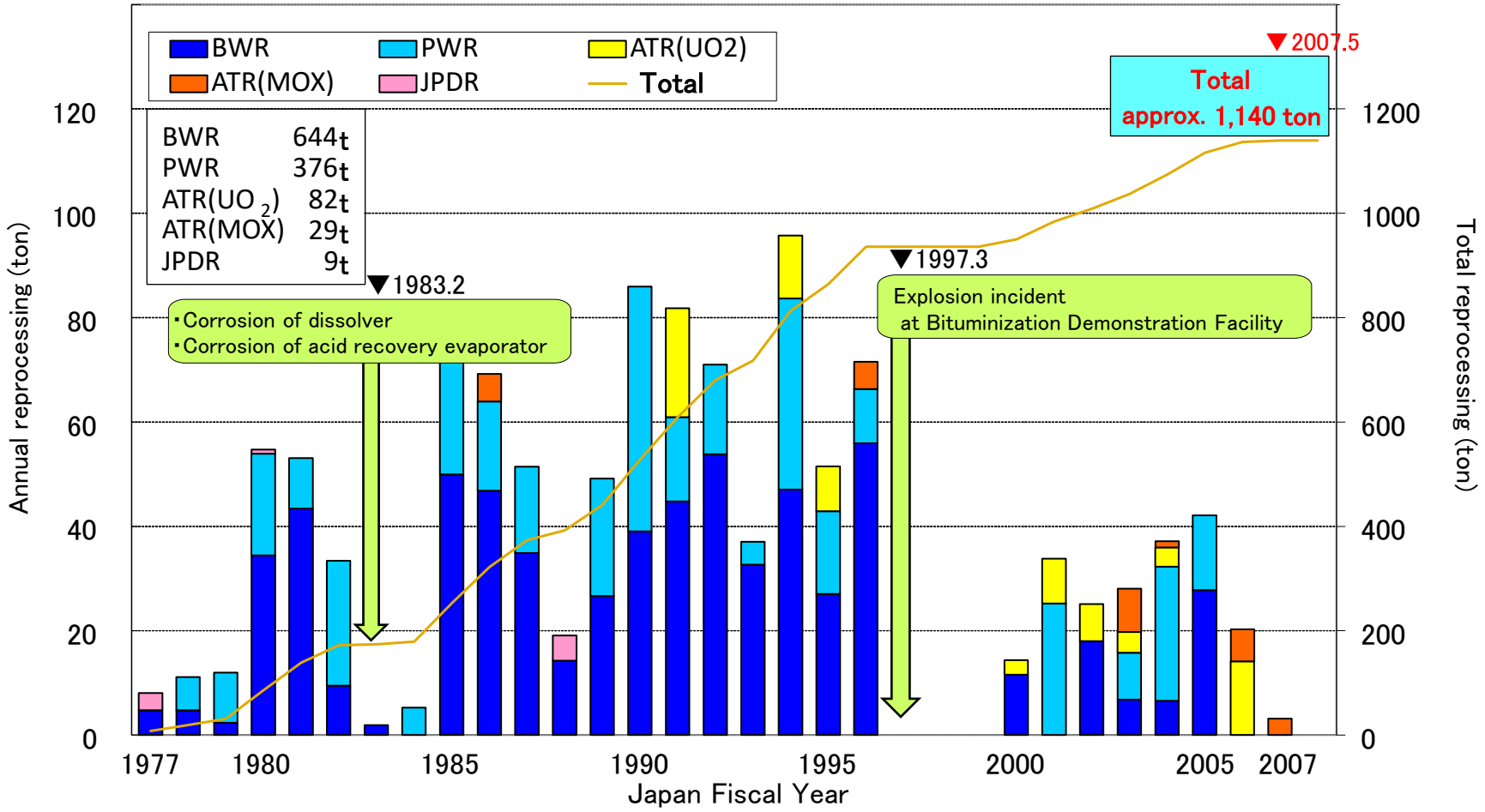
Classification \ Date	1950	1960	1970	1980	1990	2000	2010 ~
① Uranium Conversion	1959 ▼ First successful production of metallic Uranium						
② Uranium Enrichment			1969 ▼ First successful Uranium enrichment test using the centrifugal separation method			2001 ▼ Completion of R&D for Uranium enrichment	(Decommissioning)
③ MOX Fuel Fabrication	1966 ▼ Start of plutonium fuel development at Pu-1		1972 ▼ Start of fuel fabrication at Pu-2 ("Joyo" and "Fugen")	1988 ▼ Start of fuel fabrication at Pu-3 ("Joyo" and "Monju")	1998 ▼ Start of Minor Actinide fuel development	2008 ▼ Start of development of the simplified MOX pellet fabrication process	2010 ▼ Start of decommissioning for Pu-2
④ LWR Fuel Reprocessing (TRP)			1971 ▼ Start of construction of the Tokai Reprocessing Plant (TRP) / 1977 ▼ Start of test utilizing spent fuel		2002 ▼ 1000t of accumulation reprocessing at TRP / 2006 ▼ Accomplishment of LWR spent fuel reprocessing at TRP / 2014 ▼ Expression of shifting to decommissioning stage		2018 ▼ Approval for TRP decommissioning plan
⑤ FBR Fuel Reprocessing				1982 ▼ Start of Hot test at CPF		2014 ▼ Start of SmART cycle development	
⑥ Radioactive waste Processing and Disposal					1993 ▼ Start of test at ENTRY	1999 ▼ Start of test at QUALITY	
⑦ Fukushima Daiichi NPS decommissioning						2011 ▼ The Great East Japan Earthquake	Fukushima Research and Development (Fuel Debris Retrieval, Radioactive Waste Processing, etc.)



Pu-1: Plutonium Fuel Development Facility
Pu-2: Plutonium Fuel Fabrication Facility
Pu-3: Plutonium Fuel Production Facility
CPF: Chemical Processing Facility
ENTRY: Engineering-scale Test and Research Facility
QUALITY: Quantitative Assessment Radionuclide Migration Experimental Facility

Achievement of reprocessing

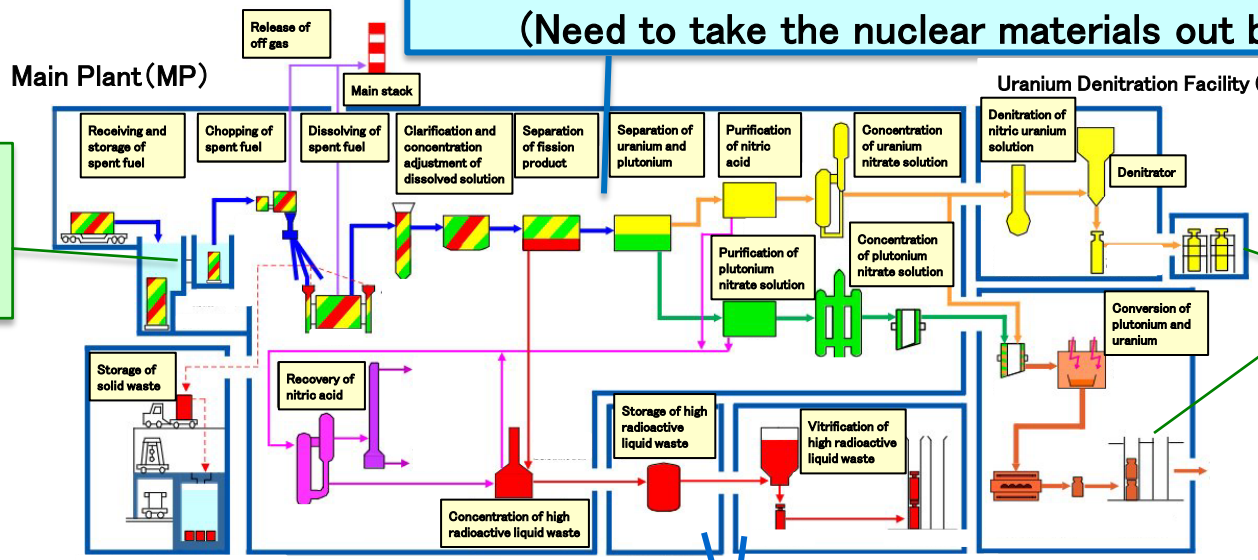
Spent fuel (approx. 1,140 ton) generated by domestic nuclear power plant (BWR, PWR, ATR, JPDR) was reprocessed from 1977 to 2007 and plutonium/uranium that can be recycled as fuel were recovered.
A part of recovered plutonium was supplied to ATR again, which contributed to the demonstration of the nuclear fuel cycle.



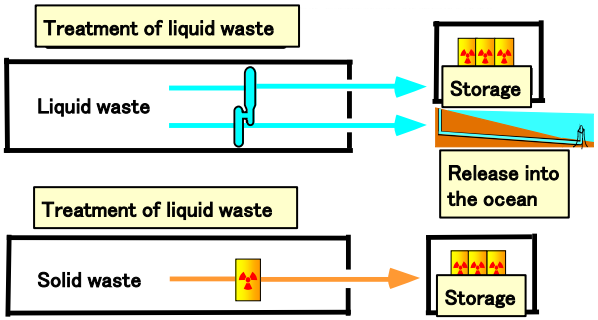
Current status of TRP

Nuclear materials are remained in process.
(Need to take the nuclear materials out by flash-out)

Spent fuels will be transferred until 2026

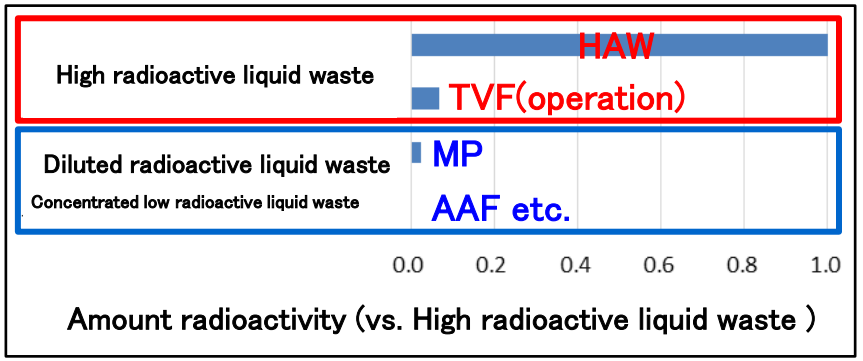


Nuclear materials will be transferred as needed



High radioactive liquid waste will be vitrified to reduce the risk

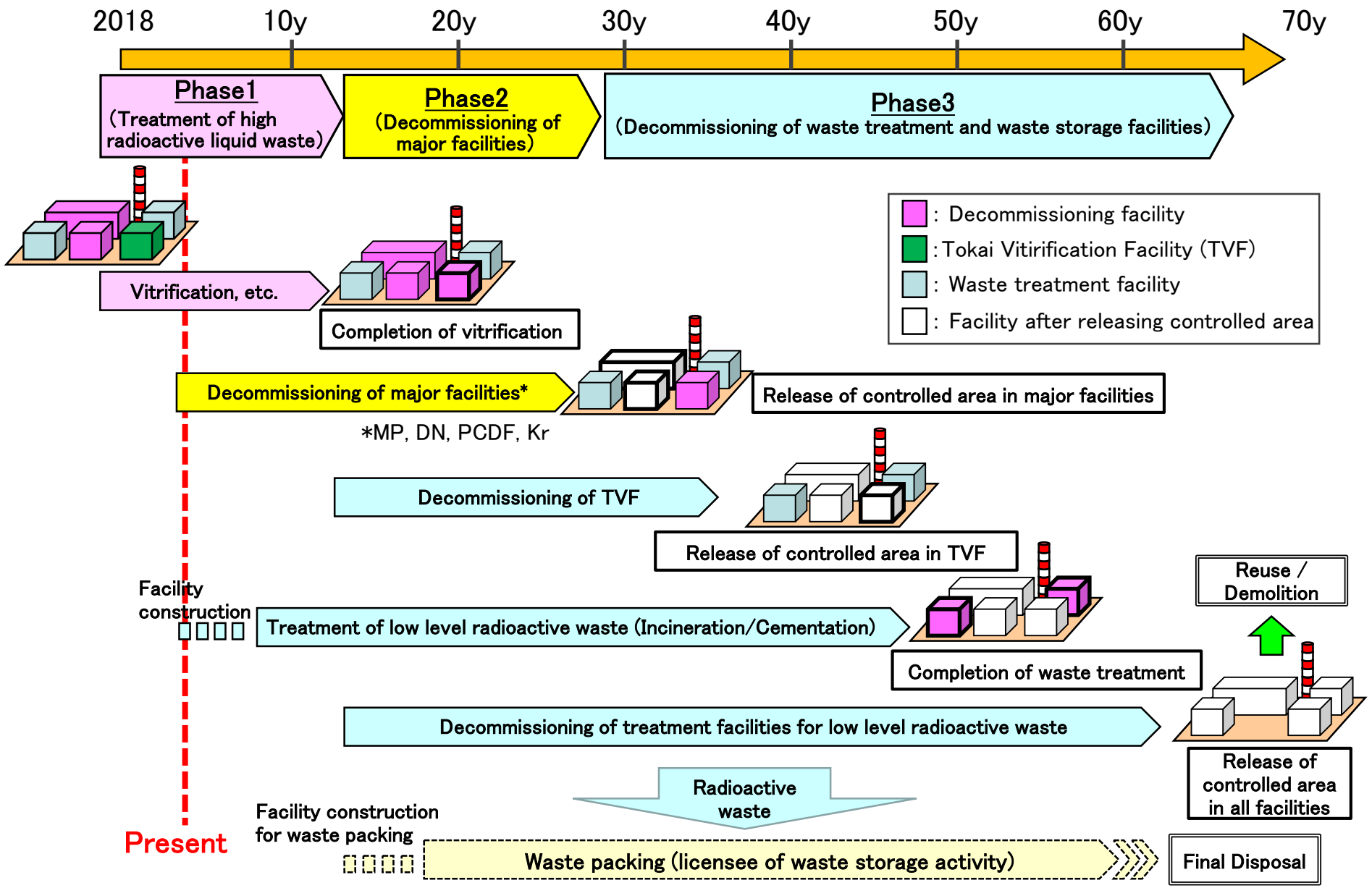
Safety improvement measures based on new regulatory standards



In addition to stored waste, generated waste in the future will be treated

Vitrified waste etc. will be transferred after final disposal site start operation

Schedule of TRP decommissioning

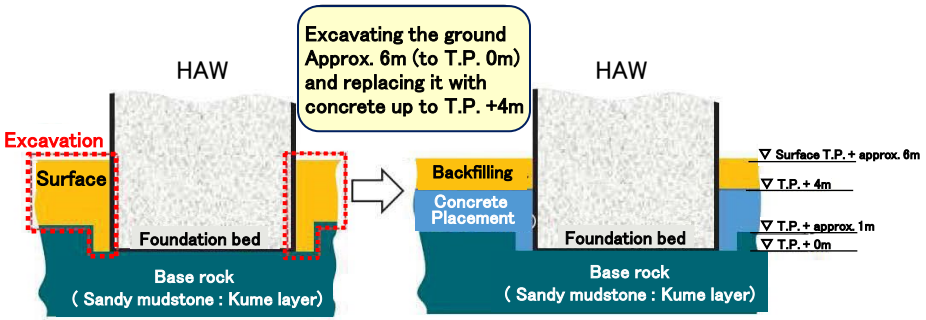


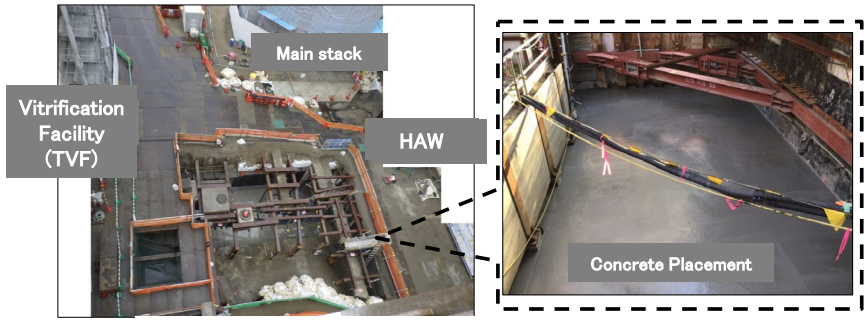
Reprocessing Technology Development (1/2)

Safety measures based on the new regulatory standards

○ The ground improvement works of surrounding of High Activity Liquid Waste Storage Facility (HAW) and Piping trench (T21)

In order to improve the seismic performance of HAW and T21, the replacement of the ground around the underground external wall of HAW to concrete is conducting to reduce the rolling of earthquake.

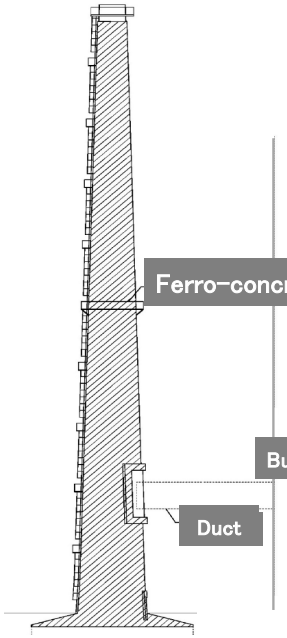




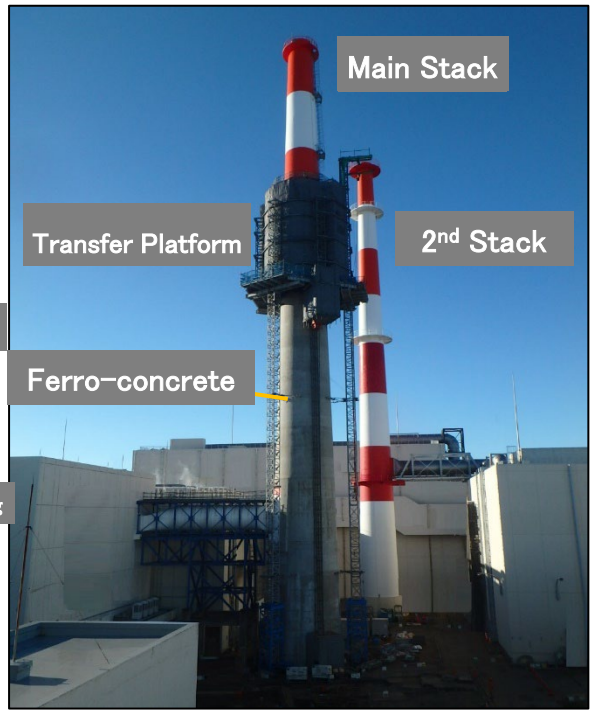
The status of the ground improvement works

○ Seismic reinforcement work of Main Stack

As for the main stack (height: 90m), in order to ensure seismic performance to the design earthquake ground motion specified in the TRP decommissioning plan, the ferro-concrete reinforcement for the foundation and the stack shell has conducted.



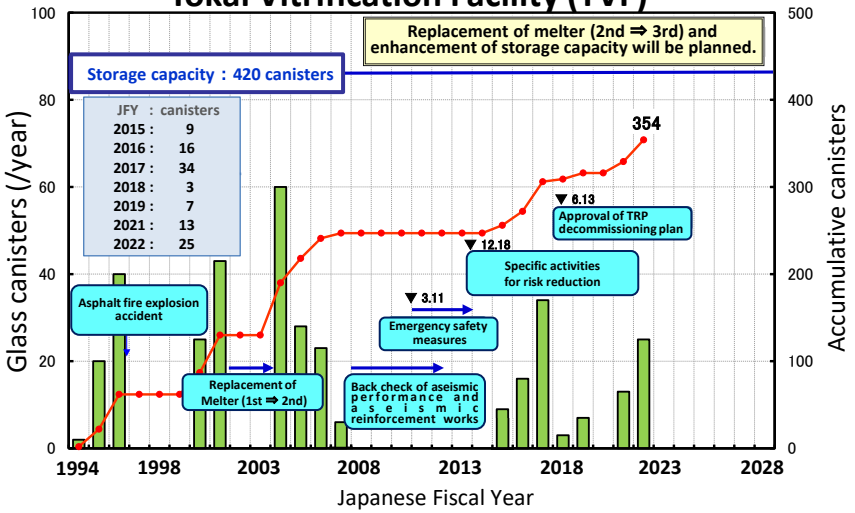
Reinforcement with ferro-concrete



The state of Main Stack reinforcement work

Reprocessing Technology Development (2/2)

○ Vitrification of High Active Liquid Waste
- Tokai Vitrification Facility (TVF) -



○ Recovery /restorage of high radioactive solid waste
– High Active Solid Waste Storage (HASWS) –

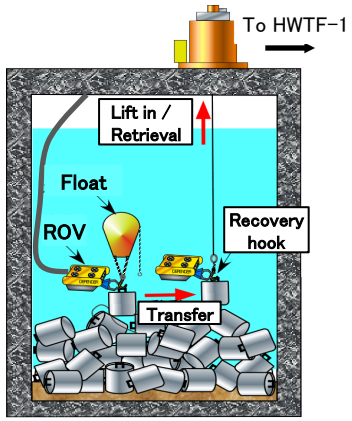
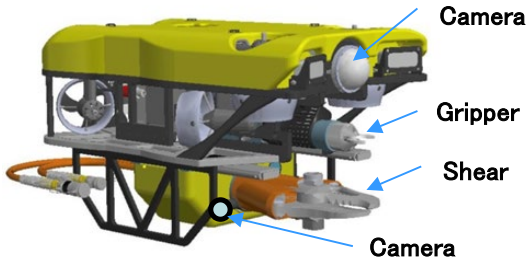


Image of remote retrieval method

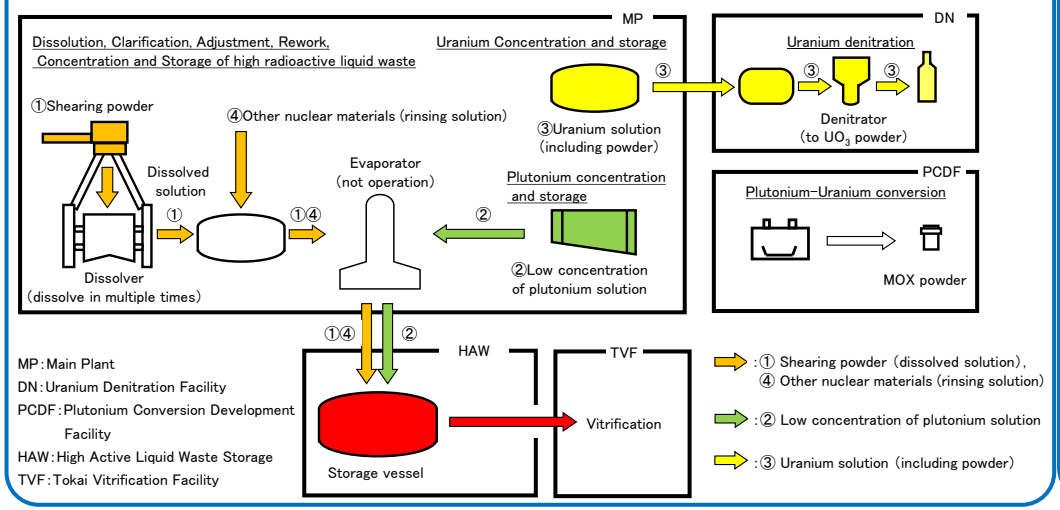
In order to improve the storage condition of waste, Remotely Operated Vehicle (ROV) etc. are being verified as remote retrieval equipment.



Underwater ROV (Gripper, Shear, Camera)

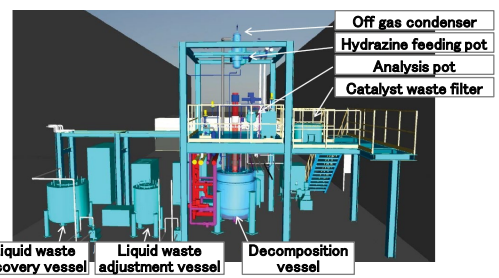
○ Flash-out in MP etc.

Remained uranium solution will be denitrated to uranium trioxide , and the others will be mixed with high active liquid waste and vitrified.



○ Cementation of low radioactive liquid waste.

Low Active Waste Treatment Development Facility(LWTF)



Layout of 1/1 scale demonstration plant scale test equipment

Cement mixing equipment

Uniaxial compressive strength test equipment

Denitration test equipment

R&Ds of MOX Fuel Fabrication Technology (1/2)

【MAJOR ACHIEVEMENTS】

- Independent development of MOX fuel fabrication technology
  - ✓ The world's first demonstration of remote and automated MOX fuel fabrication technology on a large scale
- Development and establishment of peaceful use of Plutonium
  - ➢ Development of MOX fuel fabrication technology having superior nuclear nonproliferation resistance
  - ➢ Development and demonstration of safeguards system harmonized with remote and automated MOX fuel fabrication

【HISTORY】

- Plutonium Fuel Development Facility (PFDF), Plutonium Fuel Fabrication Facility (PFFF), Pu-contaminated Waste Treatment Facility (PWTF) and Plutonium Fuel Production Facility (PFPF) started their operations in Jan., 1966, in Jan., 1972, in Dec., 1987 and in Apr.,1988, respectively.
- PFFF already finished MOX fuel fabrication and switched to decommissioning stage in Nov., 2001.

	1960s	1970s	1980s	1990s	2000s	2010s
PFDF	• Constructed with the introduction of the Pu handling techniques from USA (NUMEC) • Received the PuO_2 (approx. 260gPu) from USA (NUMEC) in 1966 and started the R&D regarding the Pu					
PFFF		• Constructed as the partially automated MOX fabrication facility based on the operational experiences obtained in the PFDF • Fabricated the MOX fuels for Fugen & Joyo Finished the fabrication for Joyo (1988) ▼ Finished the fabrication for Fugen (2001) ▼				
PFPF				• Constructed as the fully automated & remote MOX fuel fabrication plant using the experience of PFDF & PFFF • Fabricated the MOX fuels for Joyo & Monju		
PWTF				• Development and demonstration of incineration technology for TRU waste		

【Plutonium fuel fabrication technology】

PFPF
- Development and demonstration of MOX fuel fabrication on a large scale

PFDF
- Basic research on MOX fuel and MOX fuel containing Minor Actinide on a laboratory scale

【Processing technology for TRU waste】

PWTF
- Development and demonstration of incineration technology for TRU waste

【Decommissioning technology for MOX facilities】

PFFF
- R&Ds on decommissioning technology for nuclear fuel facilities

Fuel type	Fuel assembly & pin	Amount
MONJU	366 assemblies	12 tonMOX
JOYO	676 assemblies	8 tonMOX
FUGEN	773 assemblies	139 tonMOX
Others & Irradiation Test Pin	4 assemblies & 3,903 pins	14 tonMOX
Total	**1819 assemblies & 3,903 pins**	**173 tonMOX**

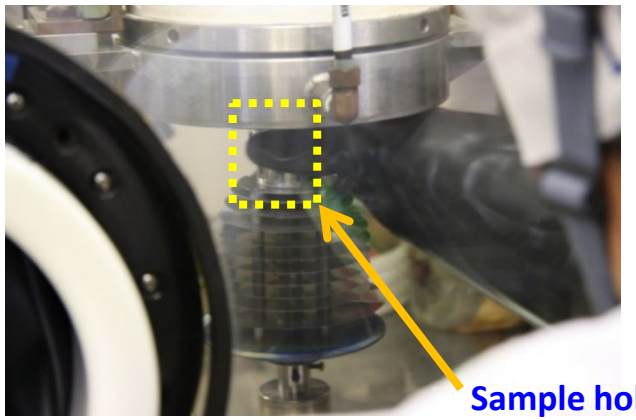
MOX Fuel Production Results (As of Jan. 2023)

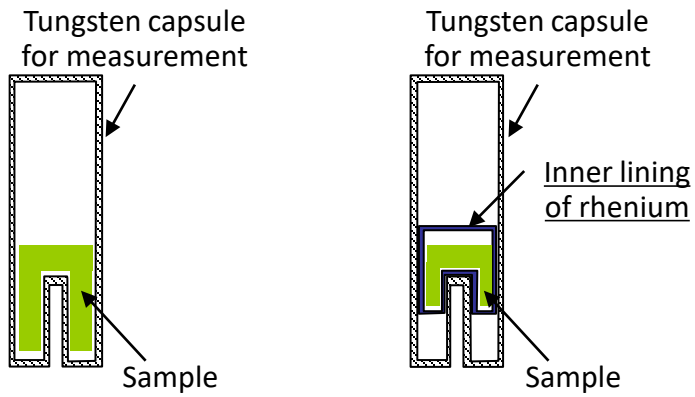
R&Ds of MOX Fuel Fabrication Technology (2/2)

Basic research on MOX fuel

Introduction of inner lining of rhenium into measurement to prevent interactions between tungsten capsule and sample at high temperatures.

Accurate Measurement of Melting Point



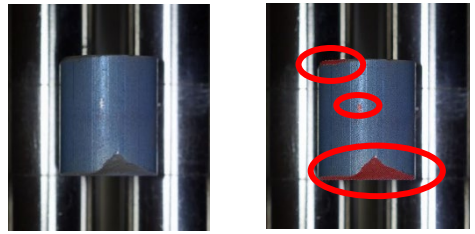


Prior capsule *Improved capsule*

Development of the MOX pellet fabrication method

○AI Pellet inspection

In order to improve the efficient of pellet inspection for surface appearance, pellet inspection using AI technology has been developed.



Identification of chip on MOX by AI

○Dry recycling by collision plate type jet mill

For using recycled MOX powder more efficiently, development of collision plate type jet mill which can control particle size of dry recovery powder has been performed.

Collision plate type jet mill

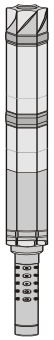
R&Ds on incineration technology for TRU waste

Development and demonstration of incineration technology for TRU waste contained chlorine with the corrosion proof incinerator

Consolidating MOX to Pu-3 and Fabrication of Scrap Assemblies

- **MOX which is stored at Pu-1, Pu-2 and TRP is being consolidated to Pu-3 for reducing the risk of contamination accident and decommissioning of each facilities.**

Scrap Assembly (Monju Type)



In order to make storage space for canisters, some MOX powder is processed to scrap assemblies

MOX is enclosed into canisters after palletization or heat treatment

Canister

MOX is stored in SUS can wrapped with PVC bag

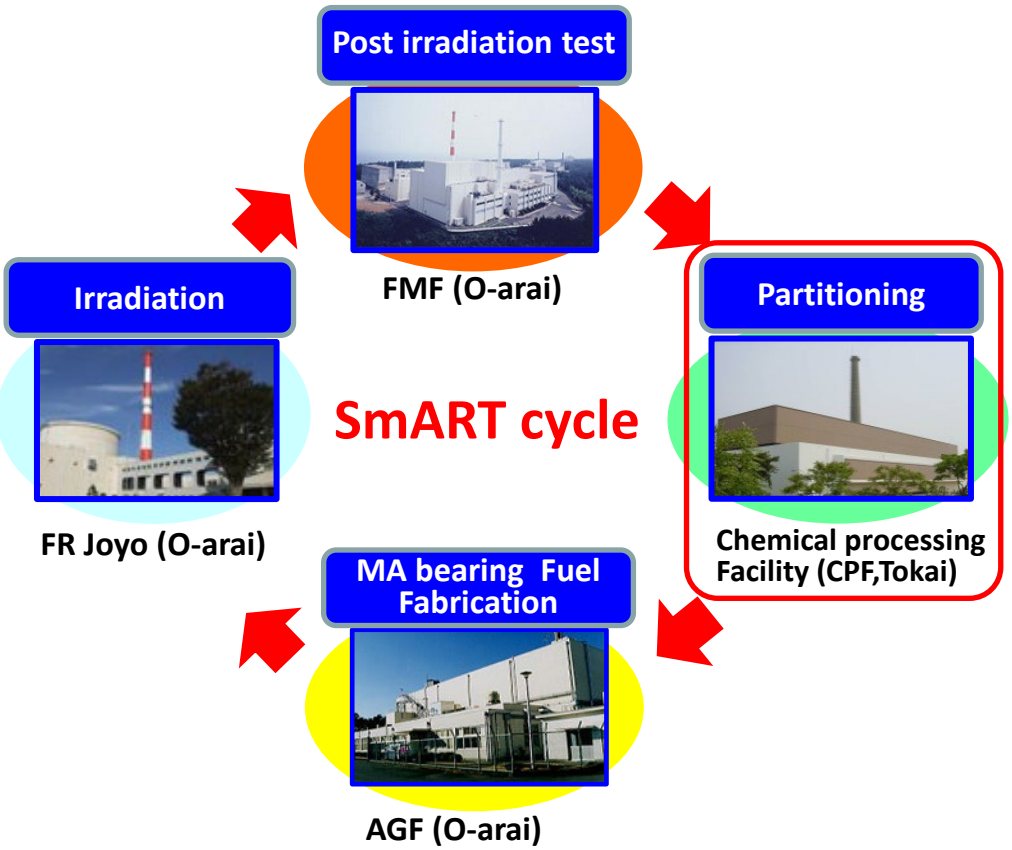
MOX powder is pelletized and stored as scrap assemblies

Scrap Assembly (Fugen Type)

R&Ds for Fast Reactor cycle technologies

SmART Cycle
(Small Amount of Reuse Fuel Test Cycle)

Carry out a series of tests (from partitioning, recovery and conversion to MA-bearing fuel fabrication, irradiation and post irradiation test) on MAs from spent fuel using existing facilities



2g of MA was recovered from irradiated fuel in JFY 2016.
MA yields are the top level in the world.

Reduction of the volume and potential hazard of radioactive wastes by applying MA partitioning technology (Improvement of reprocessing technology)

【MA Partitioning】
⇒ Significantly reduction of environmental load

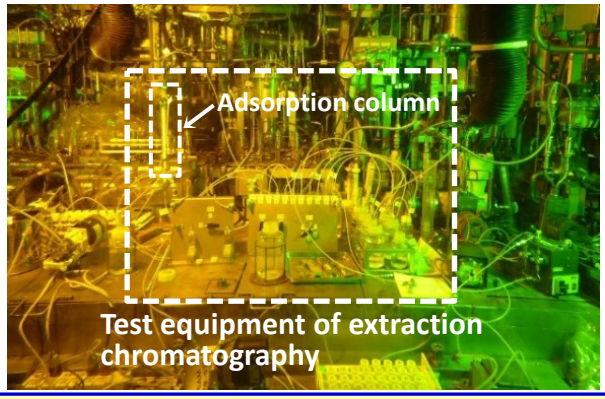
➢ Generating amount of radioactive waste

Reduce the area of disposal site to a fraction

➢ Reduction of potential hazard

Shorten significantly the period for reduction of potential hazard equivalent to natural uranium

Hundred thousand years → Several hundred years



MA-partitioning test using high level liquid waste

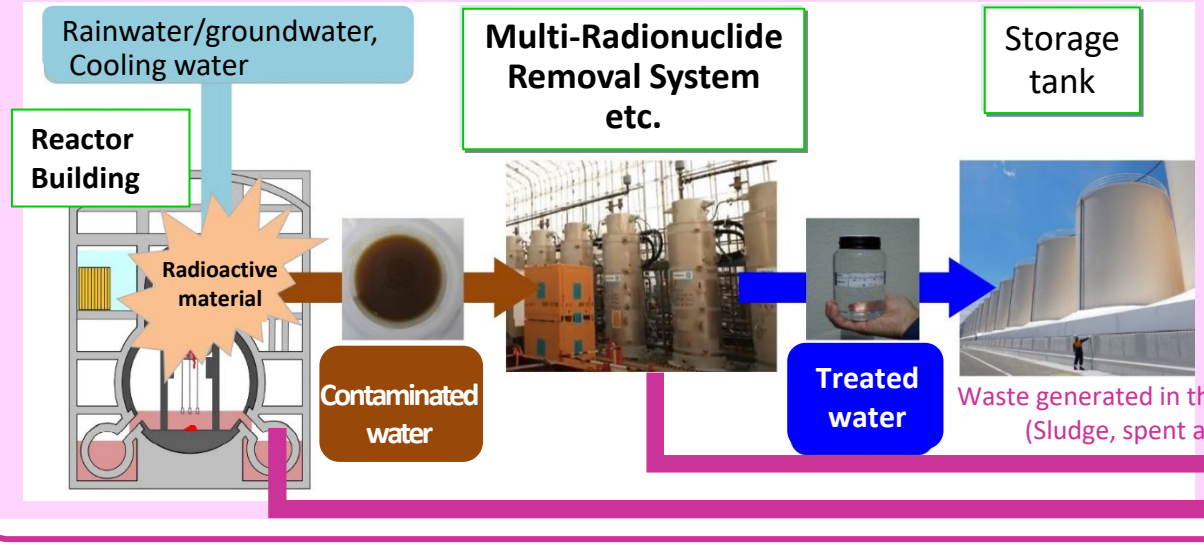
- MA adsorption test using new extractant TPDN
- Separation property of MA/Ln was obtained

R&Ds for decommissioning of Fukushima Daiichi NPP

Disposal for radioactive waste generated from treatment of contaminated water

Characterization for secondary waste of contaminated water treatment

Treatment process for contaminated water



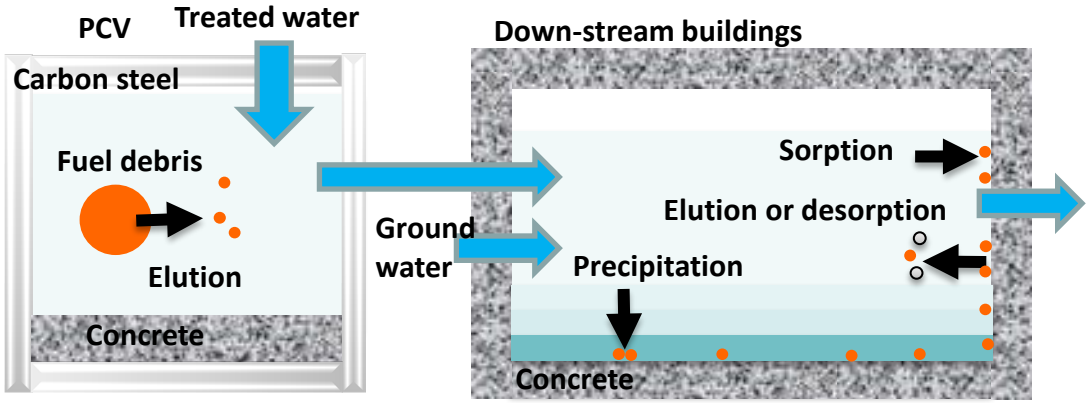
The waste generated in the process of treating contaminated water has different characteristics from conventional waste, thus it requires the development of treatment and disposal methods.

Radionuclides and radioactivity concentrations of wastes were analyzed and collected, and data were organized for evaluation.

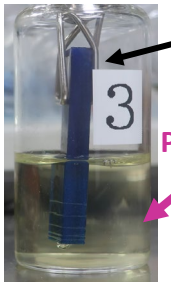
Spent adsorbent.

Sludge collected from the bottom of reactor buildings.

Migration of radioactive nuclides in accumulated water to structural materials



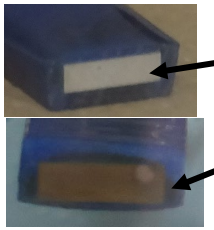
Migration behaviors of alpha nuclides on the constructional materials were evaluated.



Cement test piece

Plutonium soln.

Immersing a test piece.



Before immersion

After immersion

The surface of cement test pieces.

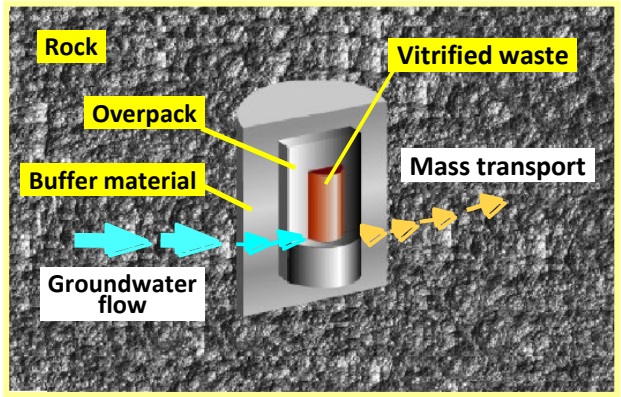
Penetration of the plutonium into the cement interior was difficult.

R&D on Geological Disposal Technology

Improvement of radionuclide migration model

Engineering test and research facility (ENTRY)

Integrity evaluation test for engineering barrier system



- Thermodynamic, sorption & diffusion databases
- Buffer material database
- Grout database
- Glass dissolution database
- Overpack database

Database development (open to the public on JAEA's HP)

Quantitative assessment radionuclide migration experimental facility (QUALITY)

Concentration analysis of radioactive materials

Data acquisition using atmospheric controlled chamber under reduced condition

Laboratory tests for evaluating long-term performance of engineering barriers and database development

Research on dissolution and migration of radioactive materials

Development of knowledge management system

Synthesis as technical basis by integrating achievements from research and development

Reflection to development of guidelines and criteria

Reflection to implementation of geological disposal

Nuclear regulation authority (NRA)

Nuclear waste management organization of Japan (NUMO)

Decommissioning of Plutonium fuel fabrication facility and U Enrichment Facilities

○ Decommissioning of Plutonium fuel fabrication facility (PFFF)

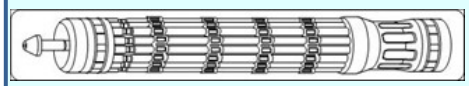
PFFF

Remaining Nuclear material in the facility

Many inactive equipment such as GB

Activity for the safety storage of the remaining nuclear materials after fuel fabrication of fugen, etc.

Pelletizing



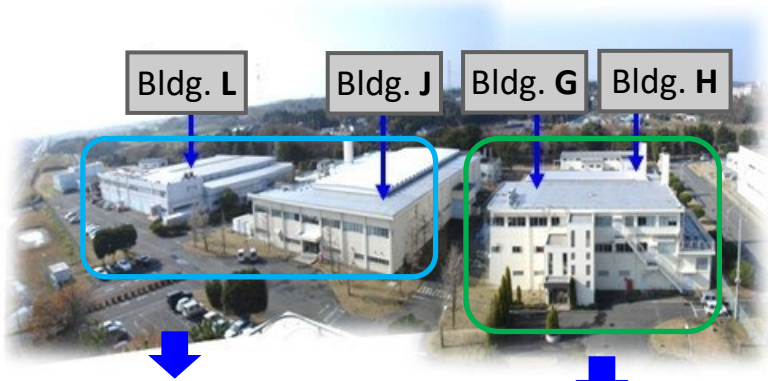
To fuel assembly

Necessary to dismantle inactive equipment for safety control

Many wastes will be generated by the dismantlement of GBs

Generated solid wastes (~10000drums) from the decommissioning of PFFF will be stored in PFFF in order .

○ Decommissioning of U enrichment facilities



Preparation for decommissioning of bldg. L/J

Decommissioning for bldg. G/H

Dismantlement of equipment in bldg. L

Dismantle of bldg. G/H (vacant lot)

Former site redevelopment
（Construction of TWTF (Tokai Waste Treatment Facility) (planned)）