MEXT MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

Current Status and discussion on Japan's Nuclear R&D Policy

February 24, 2023

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Research and Development Bureau

MEXT MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

Agenda

1. Overview
2. Decommissioning
3. Research Reactors
4. Discussion on Advanced Reactor Systems
5. Conclusion

Government Organization on Nuclear Energy Policy

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Promotion

Cabinet Office

Atomic Energy Commission (AEC)

Discussion and form a plan on:
- Policy on nuclear energy research, development and utilization
- Important policy matters on nuclear energy utilization e.g. coordination among relevant ministries on nuclear research, development and utilization

Basic Guidelines

Other Related Ministries
- Ministry of Internal Affairs and Communications
- Ministry of Foreign Affairs
- Ministry of Health, Labor and Welfare
- Ministry of Agriculture, Forestry and Fisheries
- Ministry of Land, Infrastructure and Transport etc.

Ministry of Economy, Trade and Industry (METI)

Agency for Natural Resources and Energy
- Nuclear policies for energy use
- Development of nuclear engineering for energy use

Ministry of Education, Sports, Culture, Science and Technology (MEXT)
- **Nuclear policies on science and technology**
- **Nuclear development for the purpose of improving the level of science and technology**

Regulation

Ministry of the Environment

Nuclear Regulation Authority (NRA)

Chairman + 4 Commissioners

Secretariat of the Nuclear Regulation Authority

Oversight | **Oversight / Budget** | **Regulation**

Government & National institution

Japan Atomic Energy Agency JAEA

Electric Utilities, etc

Universities, Private Companies, etc.

MEXT's Mission to promote Nuclear R&Ds

MEXT is mainly in charge of R&D and capacity building in every science and technology field, including nuclear energy.

6th Strategic Energy Plan (Cabinet Decision in October 2021)

Position of Nuclear Energy

- Required scale of nuclear power is sustainably utilized on the premise of safety.
- Essential "Base-load power source," which contributes to stabilization of long-term energy demand structure.
- Expanding decarbonized renewable energy and reducing nuclear power dependency as much as possible, with prioritizing safety.

Nuclear fuel cycle

- Promoting a nuclear fuel cycle that reprocesses spent fuels and effectively utilizes the recovered plutonium from the viewpoint of effective utilization of resources and reduction of the volume and harmfulness of high-level radioactive waste.

Nuclear technologies and human resources

- Maintaining and developing high-level nuclear technologies and human resources is imperative for smoothly decommissioning aged nuclear power plants, of which the number is expected to increase in the future, as well as TEPCO's Fukushima Daiichi Nuclear Power Station.

Major nuclear R&D activities by MEXT and JAEA

- MEXT is responsible for basic and fundamental research and development and human resource development.
- MEXT promotes R&D on advanced reactors that contributes to carbon neutrality by 2050, diverse research that leads to nuclear innovation and human resource development in close collaboration with academia and industry.
- JAEA is the only nuclear R&D institute which promote advanced reactor and nuclear fuel cycle technologies also proceeds with decommissioning of Monju, Fugen, Tokai Reprocessing Plant etc. in a safe and systematic manner.

(1) Contribution to carbon neutrality

- High Temperature Gas-cooled Reactor(HTGR)
- Fast Reactor cycle technology

HTTR (HTGR test reactor)


Joyo and PIE facility

(2) Nuclear science and Human resource development

- Neutron utilizing research (i.e. visualization, isotope research)
- Simulation technology
- Establishing a Consortium of Japanese Nuclear Education and Training
- Construction of New Research Reactor at the Monju site.


Japan Research Reactor (JRR-3)

(3) R&D for decommissioning of Fukushima Daiichi NPS, TEPCO

- Promotion of the development of advanced technology for the decommissioning of TEPCO's Fukushima Daiichi NPS

(4) Decommissioning and Back-end Measures

- "Monju"(Fast Breeder Reactor)
- "Fugen"(Advanced Thermal Reactor)
- "Tokai Reprocessing Plant"
- R&D on geological disposal techniques


Monju


Fugen


Tokai Reprocessing Plant

(5) Nuclear safety research

- Research for reducing risks associated with nuclear facilities
- Research on prevention of and methods to evaluate severe accidents
- Research on radiation protection for humans and the environment


NSRR (Nuclear Safety Research Reactor)

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The prototype fast breeder reactor “Monju”

Current status

- Monju has been under decommissioning since FY2018.
- By October 2022, decommissioning Phase 1 (fuel unloading) has been completed.
- In FY2023, decommissioning will move to Phase 2 (Removing sodium as preparation for dismantling).
- Spent fuel should be evacuated in Phase 3, and currently JAEA consider reprocessing in France is a primary option but also does not exclude other options.

Monju

Phase	Phase 1 (Fuel unloading)	Phase 2 (Preparation for dismantling)	Phase 3 (Dismantling I)	Phase 4 (Dismantling II)
FY	2018 ～ 2022	2023	～	2047
Main Activities	Fuel unloading activities	Preparations for dismantling sodium-cooling equipment	Dismantling and removal of sodium-cooling equipment	Dismantling and removal of buildings
	Assessment of the radiation distribution			
		Dismantling and removal of power generation facilities such as water/steam systems		

Decommissioning plan

Electrical power	280 MW
Thermal power	714 MW
Fuel	MOX fuel
Coolant	Sodium
First Criticality	1994
Located in Tsuruga, Fukui Pref.	

Tokai Reprocessing Plant (TRP)

Current status

- The first reprocessing plant in Japan
- Reprocessing operations were carried out from 1977 to 2007. Recovered Pu and U were used for fuel fabrication and contributing to implementation of nuclear fuel cycle policy.
- TRP is under decommission due to financial reason **for about 70 years** since 2018.
- **Vitrification of highly radioactive liquid waste** and **implementing safety measures** against earthquake and tsunamis complying with new regulatory standard are top priorities.

  → Major reinforcement will be completed by 2024.
- 354 vitrified wastes were fabricated so far. Currently, vitrification has been halted to update the melter, and planned to be restarted in 2025.

Tokai Reprocessing Plant

Total reprocessing amount 1,140 tons
Located in Tokai, Ibaraki Pref.

<Main Plant overview>

Storing capacity	140tHM of SF
Method	PUREX process
Reprocessing Capacity	210 ton-U/year

<Tokai Vitrification Facility>

Method	Liquid-Fed Ceramic Melter(LFCM)
Maximum capacity	0.35m^3/day-HLW
Storing capacity	420 canisters

Center of World Intelligence Project for Nuclear S&T and Human Resource Development
- Basic Research Program for Accelerating Decommissioning of Fukushima Daiichi Nuclear Power Station -

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Overview The program promotes research and development that brings through concentrating wisdom, in order to contribute to accelerating the decommissioning of the TEPCO's Fukushima Daiichi Nuclear Power Station. For example, we are working on research on the field of the removal of fuel debris and management for radioactive wastes.

Management of the Program(Organizational Structure)

MEXT* (Japan)
* Ministry of Education, Culture, Sports, Science and Technology

Collaboration

Collaborative Institute

Subsidy

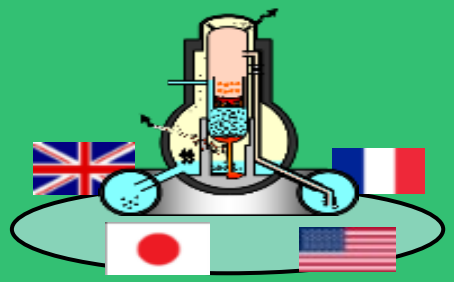
Steering Committee

Basic Policy

JAEA/CLADS

Program Director
Program Officer

Research Funding



Research Funding

DOE(2016 to 2019)
United States Department of Energy
EPSRC (Ongoing since 2016)
Engineering and Physical Sciences Research Council
ANR (2016 to 2020)
Agence nationale de la recherche

Research Institutes(Japan)
(Universities, etc.)

Joint Research

Research Institutes

Joint Research Teams

Japan-US joint research (Since FY2016)

【Collaborative Institute】United States Department of Energy (DOE)
【Funding】JPY 20 million per year, over 3 years
【Theme】Joint research on radioactive waste management
(FY2016) Tokyo Institute of Technology - Texas A&M University

U.S. DEPARTMENT OF ENERGY

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Trend in Japan's research reactors (including research reactor in Monju site)

- In December 2016, new research reactor plan on the Monju site was shown as a part of decision on Monju decommissioning.
  (Conceptual design 2020～2022)
- The majority of research reactors have been shut down mainly due to aging and conforming to the new regulatory requirements.
- Currently only 6 are in operation.
- Kyoto University Reactor (KUR, 5MW) is scheduled to end its operation in 2026.

1995

○Operational	△Temporary Shutdown	×Under Decom-missioning
20	0	6

2005

○Operational	△Temporary Shutdown	×Under Decom-missioning
16	0	11

2013

○Operational	△Temporary Shutdown	×Under Decom-missioning
0	13	11

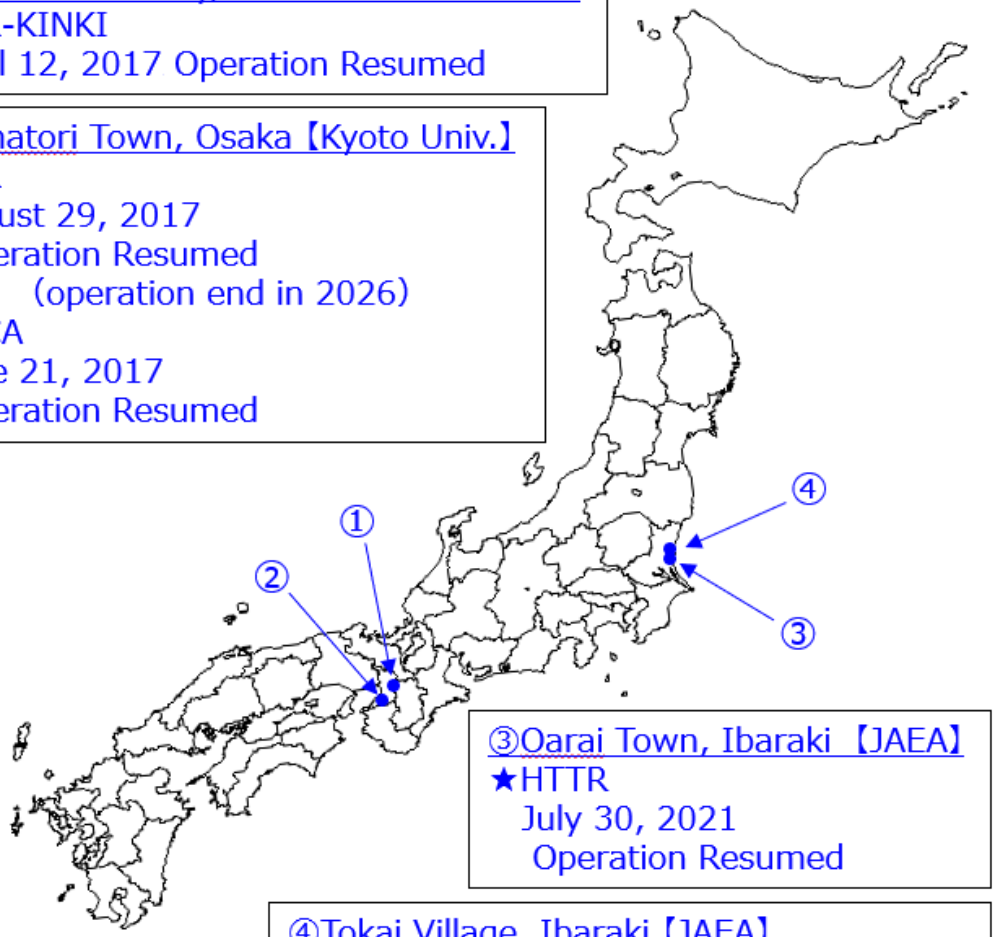
2023.1

○Operational	△Temporary Shutdown	×Under Decom-missioning
6	2	11

2 facilities are in preparation for restart

①Higashiosaka City, Osaka【KINDAI Univ.】
★UTR-KINKI
April 12, 2017 Operation Resumed

②Kumatori Town, Osaka【Kyoto Univ.】
★KUR
August 29, 2017
Operation Resumed
(operation end in 2026)
★KUCA
June 21, 2017
Operation Resumed



③Oarai Town, Ibaraki【JAEA】
★HTTR
July 30, 2021
Operation Resumed

④Tokai Village, Ibaraki【JAEA】
★NSRR
June 6, 2018 Operation Resumed
★JRR-3
February 26, 2021 Operation Resumed

Experimental fast reactor “Joyo”

Current status

- Joyo has been under NRA review with the new regulatory requirements since 2017.
- Expecting to obtain NRA approval for restart in 2023.
- Scheduled to restart in 2025 after seismic reinforcement.

Joyo

Role of Joyo

- Demonstrated basic sodium-cooled FR technologies.
- Irradiation testing of fuels and materials, and validation of innovative technologies for the development of future reactors.
- Basic research using high fast neutron flux.
- Various Irradiation uses. (eg. Production of medical RI such as Ac-225)

Thermal power	100MW
Fuel	MOX fuel
Coolant	Sodium
First Criticality	1977
Located in Oarai, Ibaraki Pref.	

Potential role of “Joyo” as a versatile research platform

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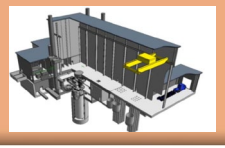
< Submitted from JAEA >

For the energy security and innovation to realize a “carbon net zero” society

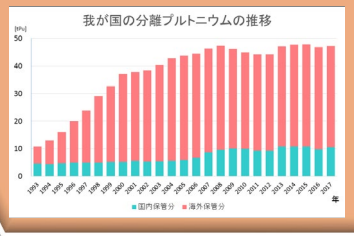
■SMR, next generation reactor development NEXIP
■support for private sector’s innovation
■ Advanced fuels & materials development, safety improvement
■collaboration with US and France



VTR

For a world free from the threat of nuclear proliferation and terrorism

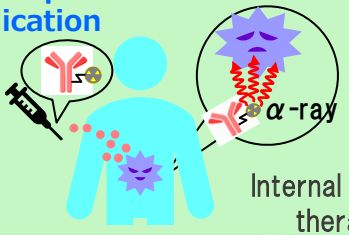
■Utilization of separated Pu
■Development of Pu burner reactor



Use of separated Pu

Production of medical and industrial isotopes

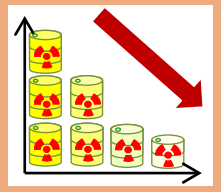
■Production of isotopes for medical purpose
■Isotopes for industrial application

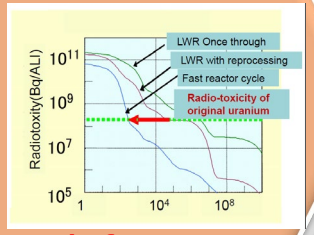


Internal cancer therapy

Experimental fast reactor “Joyo”

■ Minor actinide transmutation
■ Transmutation of LLFP





Reduction of Radiological hazard of waste

Sustainable use of nuclear energy

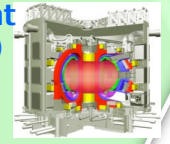
■Collaboration with universities
■ Acceptance of foreign engineers

Training

Internship for foreign researchers

Human resources development

■Basic research, multipurpose use
■International collaboration
■Fusion reactor development (R&D of first wall materials)



Pursuit of nuclear potential

High Temperature Engineering Test Reactor (HTTR)

Features of HTGR (High Temperature Gas-cooled Reactor)

- High inherent safety
- Multi-purpose heat applications including hydrogen production
- The power generation and heat utilization efficiencies are higher than those of LWR

Current status of HTTR (High Temperature Engineering Test Reactor)

- Conducted 50 days continuous 950°C operation in 2010
- Restarted its operation in July 2021 (currently halted since February 2022)
- The safety demonstration test will be performed on HTTR under the framework of OECD/NEA project.
- Demonstration plan of hydrogen production by the HTTR is started from last year.

HTTR

Thermal power	30 MW
Fuel	Coated fuel particle/ Prismatic block type
Core material	Graphite
Coolant	Helium
Outlet temperature	950°C
First criticality	1998
Located in Oarai, Ibaraki Pref.	

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Recent development on nuclear energy policy

Outline of Future Nuclear Energy Policy Direction and Draft Action Guidelines(Dec. 23rd, 2022)

Development/construction of next-generation advanced reactors

- Make efforts on development and construction of next-generation advanced reactors on the premise of regional understanding to realize the value of nuclear power and maintain and strengthen technology and human resources
- Promoting investment in next-generation advanced reactors to realize the value of nuclear power
- **Gathering public and private resources** to develop an effective development system
- **R&D of next-generation advanced reactors** and construction of foundations for **human resource development** for that purpose
- **Promoting production and R&D of radioisotopes** for medical use, etc.

Revised "Strategic Roadmap" for fast reactor development in Japan (Dec. 23rd, 2022)

◆ "Strategic Roadmap" for fast reactor development was decided at the Ministerial Meeting for Nuclear Energy Policy in 2018

→ Revised the roadmap to clarify the future support policy, etc., and to concretize the image of support targets and how to proceed in 2022.

Key points

- **Sodium-cooled fast reactor** was evaluated as the most promising for future development in terms of technology maturity, marketability, international collaboration, etc., since private companies have been conducting research and development on the reactor after the Joyo and Monju, and it has been introduced internationally.
- And the work plan for future development on demonstration reactor was shown, such as conceptual design and R&D of demonstration reactor will start from FY2024.

MEXT's committee discussion on advanced reactor systems(1)

- MEXT initiated the committee meeting on core R&D and fundamental infrastructure for the advanced reactors in last October, to discuss necessary R&D and infrastructure for future development of advanced reactors focusing on fast reactors and HTGR.
- Starting from January, the committee further discuss priorities and roadmap on technical development of such infrastructure in order to make recommendation for implementation.

Basic concept of R&D for advanced reactor development

【Advanced LWR】

- **Anticipating implementation** through efforts of the private sector.
- Continuing to consider **response to thermal neutron irradiation needs** for **upgrading LWR for long-term operation**.

【Fast Reactor (Sodium cooled)】

- Promoting R&D that responds to needs such as **reducing the volume and toxicities of high-level radioactive waste**, **producing strategic RI for medical use**, and **coexistence with renewable energy**.
- Starting operation of existing facilities such as **experimental fast reactor Joyo** and **advanced technology experiment sodium facility AtheNa** is essential.
- **Development of basic infrastructure for the entire fast reactor (FR) cycle is crucial.**

【HTGR】

- Promoting R&D to expand new possibilities including power generation use, such as **heat utilization and hydrogen production**.
- Promotion **international cooperation** and **exploring diverse users not limited to utilities are necessary.**

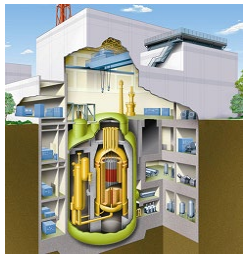
MEXT's committee discussion on advanced reactor systems(2)

Utilize existing infrastructure

Reactor system develop.

Experimental fast reactor "Joyo"
Scheduled to restart in 2025

Advanced Technology Experiment Sodium Facility (AtheNa)



High Temperature Engineering Test Reactor (HTTR)

Reprocessing technology develop.

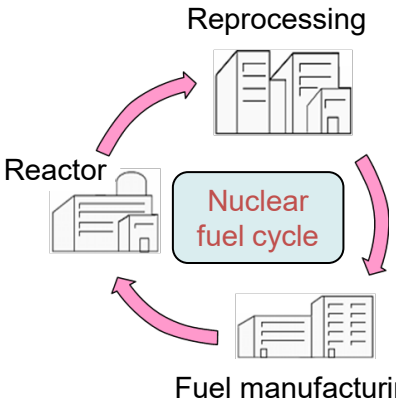
Chemical processing facility (CPF)

Fuel manufacturing technology develop.

Plutonium Fuel Production Facility (PFPF, Pu-3)

New infrastructure development

【HTGR】-> Utilize existing infrastructure centered on HTTR
【FR】 -> Need to consider engineering-scale demonstration facility, with technical flexibility



1. New fast neutron irradiation reactor
-> Demonstration of irradiation test for new fuel, MA, RI production, etc.

2. Fuel manufacturing facility for advanced reactors
-> Supply fuels to the new irradiation reactor and Joyo
-> Flexible to respond versatile demands such as MOX, metal fuel, etc.

3. Demonstration facility for spent fuel reprocessing of fast reactors
-> Demonstration of reprocessing technologies of spent fuel of innovative reactor and recover MA

MEXT's committee discussion on advanced reactor systems(3)

Notes for future development

- **Required flexibility to accommodate various scenarios**, fuel types, reprocessing methods and scale of advanced reactors.
- **While bold decision on government spending is inevitable**. How to utilize limited human resources is important to craft **a realistic R&D roadmap**.
- Development of new basic infrastructure, including the new fast neutron irradiation reactor, is **expected to contribute to rebuilding the supply chain**, and **providing of OJT opportunities for future engineers**.
- For effective use of resources and securing opportunities, it is also **important to promote international cooperation with like-minded countries such as the United States and France**.

Human resource development and knowledge hub for advanced reactors

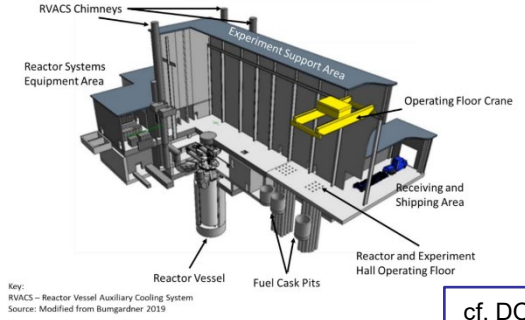
- In the development of advanced reactors **JAEA should act as a knowledge hub** and serve **as a bridge between universities and industry**, incorporating the needs of industry.
- Regarding projects to develop human resource, MEXT should expand the scale of the project, contribute to maintaining and rebuilding the supply chains and utilizing projects for recurrent education and reskilling.
- In order to secure nuclear human resources and support basic research, it is important to enhance test research reactors in Japan. **The test research reactor at the "Monju" site, that concept design is under way, will be utilized as a core base that supports R&D and human resource development in Japan.**

Expectation on US-Japan collaboration on advanced reactors

Collaboration on VTR and Joyo

Joyo

collaboration



VTR

cf. DOE/EIS-0542
Final Versatile Test Reactor Environmental Impact Statement Summary

- MOC with METI/MEXT and DOE regarding collaborate on development of Versatile Test Reactor was signed in June 2019.
- Look forward to discussing further collaboration on fast reactor including VTR and Joyo.

Collaboration on Natrium Reactor (DOE - ARDP program)

- JAEA and Japanese industrials signed MOU with TerraPower to collaborate on sodium-cooled fast reactor technology in January 2022.
- Japan has accumulated experience in fast reactor development such as Joyo, Monju and JSFR design.

TerraPower JAEA MITSUBISHI HEAVY INDUSTRIES MFBR Systems, Inc.

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Conclusion

- New infrastructures and R&D projects are vital not only in further development of advanced reactor but also for **human resource** development and **maintaining cultivated skills and technology.**
- Not only **reactor R&D** but also **fuel cycle technologies** are vital as well.
- Building new reactors and new research facilities is a key to success but **has to overcome financial challenge and regulatory requirement**.
- **Dialogue with regulatory authorities on advanced reactors** is becoming more and more crucial.
- **International collaboration with like-minded countries is also essential.**

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Thank you very much

for your attention!

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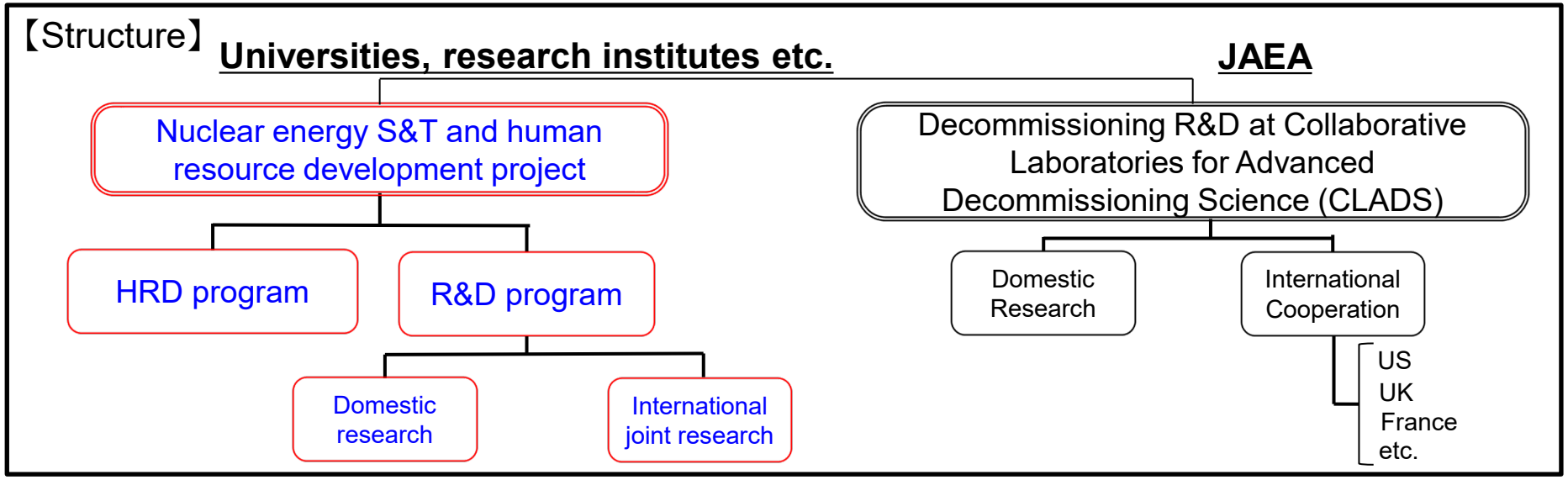
Appendix

Action Plan for Decommissioning Fukushima NPS



【Research topics】

- JAEA/CLADS-SRNL Collaboration

  Collaboration Research of "Measurement of alpha energy spectra of Pu-239 oxide particles".

  <BSRA: Battelle Savannah River Alliance>
- Waste management and other environmental measures (domestic, Japan-US, Japan-UK)
- Removal of fuel debris (domestic, Japan-UK)
- Basic and fundamental technologies for operation under extreme severe environment (Japan-France)

【HRD efforts】

- Lectures to students who help decommissioning Fukushima NPS
- Courses set up jointly by universities and private corporations in Japan and overseas

The Collaborative Laboratories for Advanced Decommissioning Science (CLADS)

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Sector of Fukushima Research and Development

Collaborative Laboratories for Advanced Decommissioning Science

-A platform to collect the wisdom of experts from around the world-

CLADS Main Building

Utilizing JAEA's special facilities for handling nuclear fuels and radioactive materials, and irradiation facilities at Tokai and Oarai in Ibaraki Prefecture.

OECD/NEA NEST*1 Framework

CLADS leads ARTERD*2 project of NEST Framework

Goals

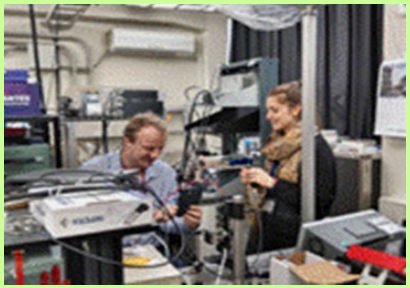
- *Maintenance and enhancement of practical knowledge and technical expertise in nuclear technology for decommissioning among young researchers*
- *Establishment of the international education network*

Objectives

- *To provide state-of-the-art science and technology for decommissioning*
- *To offer hands-on training opportunities to young researchers*
- *In cooperation with partners, to establish the international education network of R&D on decommissioning step by step*

*1 Nuclear Education, Skills and Technology
*2 Advanced Remote Technology and Robotics for Decommissioning

Educational Activities



HRD for “Nuclear Innovation”

Concerns about deterioration of nuclear education in Higher Education

- Lack of young faculty members to replace retiring faculty members
- Ageing research facilities, which are being closed and not replaced

Collective measures to maintain and strength nuclear education foundation are needed

ANEC: Advanced Nuclear Education Consortium for the Future Society

Consortium of Japanese nuclear education and training established in October 2021

University A

University B

National Institute of Technology

① **Constructing comprehensive educational programs and sharing lectures utilizing information technology**

② **Providing opportunities for practical training utilizing research reactors or other nuclear research facilities**

③ **Providing opportunities for international study through systematic collaboration with international organizations and overseas universities**

④ **Promotion of collaboration with industry and other fields**

Company D

Research institution C