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Japan Atomic Energy Agency

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## President's foreword

We are now in the midst of a major revolution of the peaceful use of nuclear energy. This is a movement to maximize the use of nuclear energy, with safety as a major premise, toward the realization of a decarbonized society, which is a common challenge for all humankind, discussed from various angles with a sense of concrete time frame both in Japan and abroad.

In response to these major trends, JAEA established the new vision in April 2023.

It is a clear statement of the direction of R&D that JAEA should challenge in the future, and consists of the following three areas:

- **Synergy:** R&D for pursuing synergy of nuclear and renewable energies;
- **Sustainable:** R&D for making nuclear energy itself sustainable; and
- **Ubiquitous:** R&D for applying nuclear technology widely to society, not limited to the energy field.

As for “**Synergy**”, we have been developing high-temperature gas-cooled reactors, which are deemed to be a promising

option for decarbonizing industrial areas along with renewable energies. In March 2024, we succeeded in demonstrating the autonomous stability of an HTTR through the world's first safety demonstration tests simulating a severe accident in a reactor operating at 100% output power using the HTTR installed at the Oarai Nuclear Engineering Institute.

We are also developing uranium redox-flow batteries which have nearly infinite durability to more efficiently store electricity generated by renewable energy sources. In November 2024, we developed the first “uranium rechargeable battery”. We will work on enlarging battery capacities with circulating electrolyte solutions.

In the area of “**Sustainable**”, we have taken on the challenge of a new theme of the volume reduction of high-level radioactive waste and recycling it as a resource, while also developing technologies for the safe decommissioning of existing nuclear facilities. Specifically, as for the decommissioning of the Fukushima Daiichi Nuclear Power Station, we will steadily fulfill our role as a third party to ensure the conformity of ALPS-treated water discharged into the sea.

For “**Ubiquitous**”, we are working toward the medical

use of Ac-225 (Actinium), which is highly effective in cancer treatment, for which expectations are growing, by making utmost effort to improve the environment, establish cooperative relationships with relevant entities, and plan to restart an experimental fast reactor Joyo which will serve as the core facility.

We have yet to comprehend the full potential of nuclear energy. In this sense, we are at the forefront of innovation every day to create new values.

We will persevere in our efforts to achieve our mission to contribute to welfare and prosperity of human society through nuclear science and technology by accurately catching the needs of society, responding flexibly to change, and fully demonstrating our capabilities.

Thank you for your continued understanding and support.

KOGUCHI Masanori

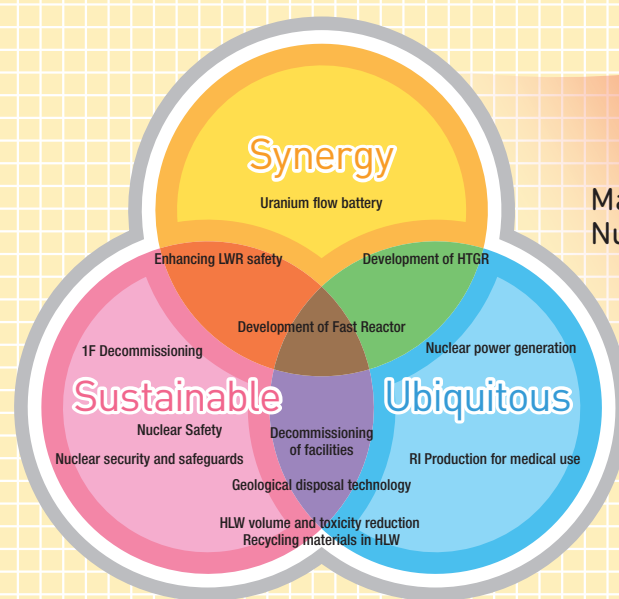
President  
Japan Atomic Energy Agency

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Achieving JAEA's vision

## Exploring the Future through the Synergy of Nuclear and Renewable Energies



Maximize the use of Nuclear Science and Technology

JAEA aims for a **sustainable** future society realized through the synergetic effect of **nuclear** and **renewable** energies.

Decarbonized society by FY2050

Synergy

## Pursuing Synergy of Nuclear and Renewable Energies

– Pursuing the synergy effects of pairing nuclear and various renewable energy sources –

- Locating HTGRs as an energy center and pairing with other renewable energy to decarbonize the entire industrial zone by supplying sources of hydrogen, heat, and electricity.
- Developing uranium redox-flow battery that can utilize incombustible uranium and be charged with surplus renewable energy

Sustainable

## Making Nuclear Energy Sustainable

– Aiming to make nuclear energy a long-term stable energy source while meeting the new demands of building a decarbonized society –

- Effective use of uranium resources (extending the period of use from approx. 100 years to thousands of years)
- Reducing the volume of high-level radioactive wastes and their toxicity, as well as recycling

Ubiquitous

## Making Nuclear Technology Ubiquitous

– Expanding the application of nuclear technology to various fields by taking advantage of its characteristics –

- Development of cancer drugs
- Practical application of technology to generate electricity directly from radiation and heat “spin-tronics”

# Development of High Temperature Gas-cooled Reactors (HTGRs)

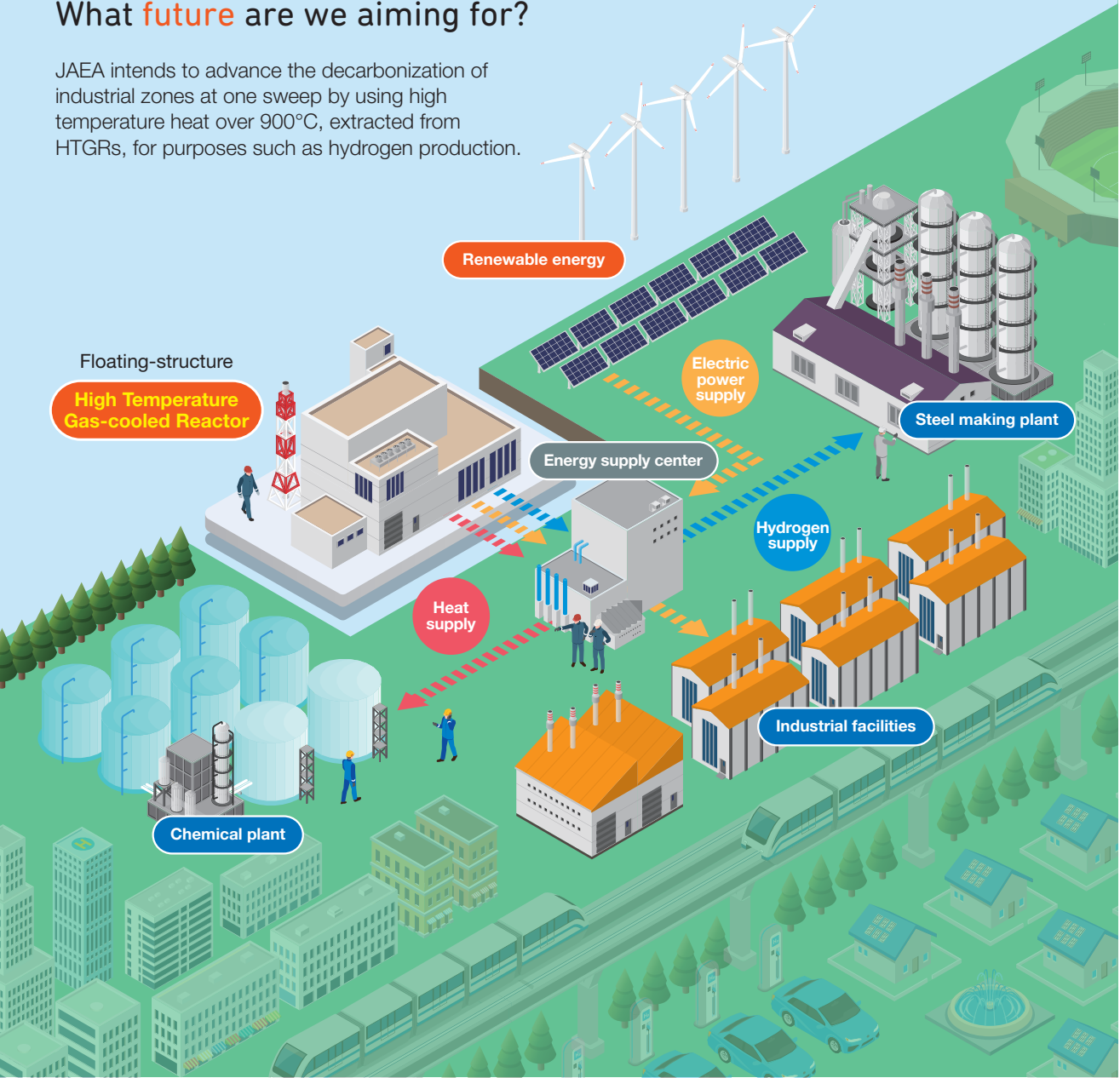
–Decarbonizing industrial zones at one sweep–

By combining HTGRs and renewable energies, JAEA can contribute to the realization of a decarbonized society by 2050.



## What future are we aiming for?

JAEA intends to advance the decarbonization of industrial zones at one sweep by using high temperature heat over 900°C, extracted from HTGRs, for purposes such as hydrogen production.



Key technologies for realization

- 1 Demonstration of superior safety
- 2 Establishment of various heat utilization technologies

- Synergy** Decarbonizing industrial zones with energy generated by HTGRs, and renewable energies
- Ubiquitous** Utilizing hydrogen produced by using high temperature heat in general industrial fields

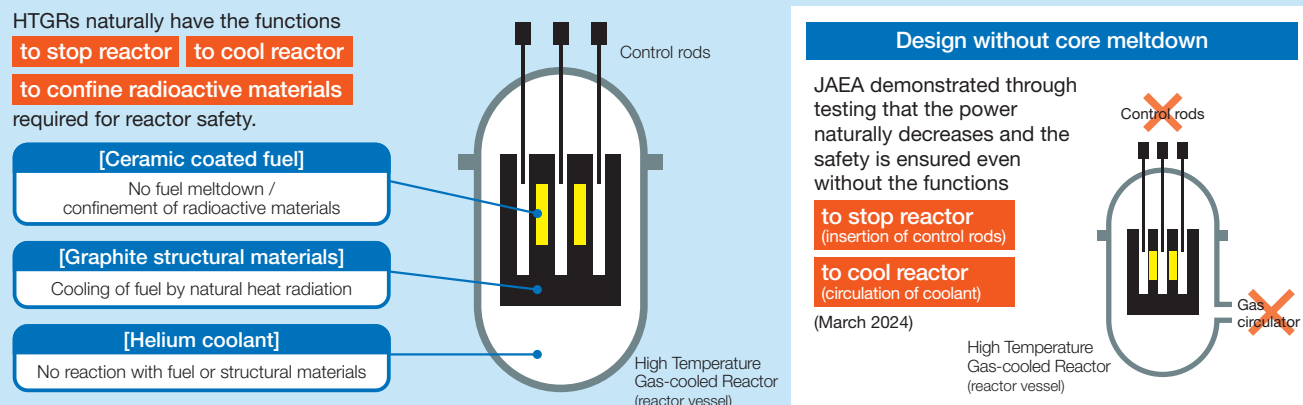
HTTR (High Temperature Engineering Test Reactor) is an HTGR (with a thermal power of 30 MW) located at the Oarai Nuclear Engineering Institute. Since HTTR is the only reactor in the world that can extract at a high temperature of 950°C to the reactor outside, heat in a wide range of temperature bands can be used. In addition, unlike light water reactors for power generation, the reactor core components (fuel, structural materials, and coolant) are designed to prevent the core meltdown and the release of large amounts of radioactive materials, thus ensuring high safety.



## What are the JAEA's initiatives for the future?

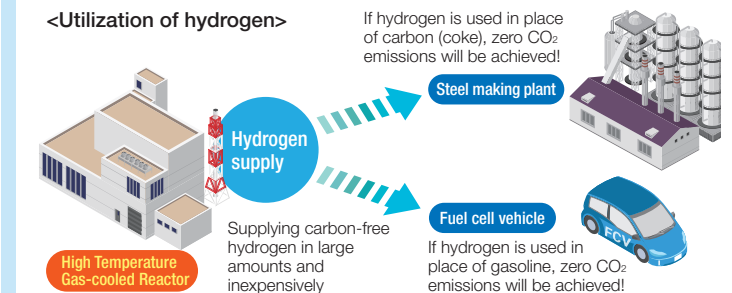
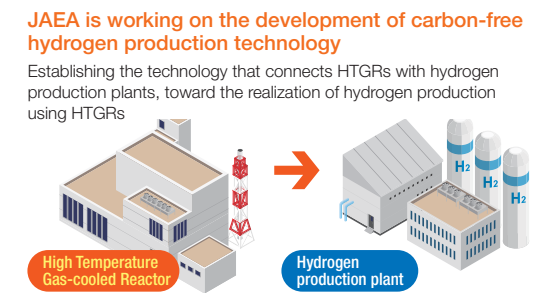
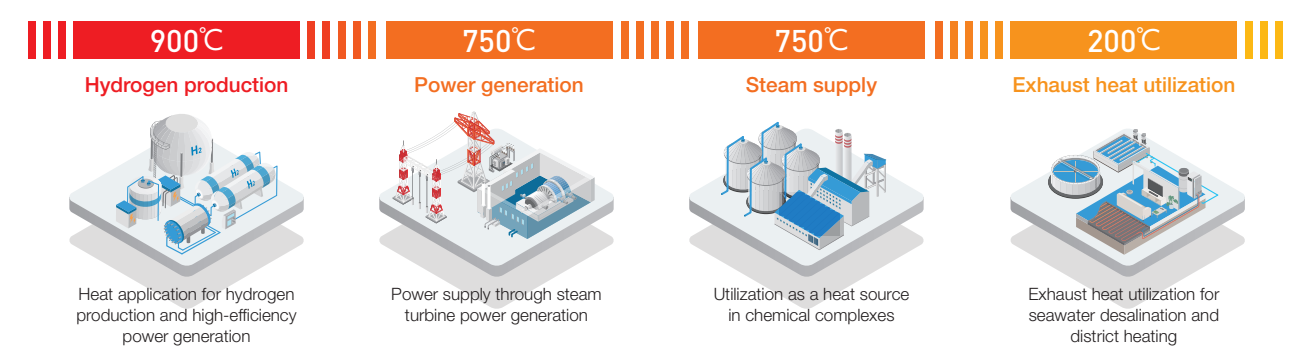
### 1 Demonstration of superior safety

JAEA demonstrates the safety of using HTGRs as energy supply centers in industrial zones.



### 2 Establishment of various heat utilization technologies

HTGRs can supply high temperature heat over 900°C, which can be used for various applications such as hydrogen production, electric power generation and seawater desalination.





# Development of Fast Reactors

—Striving to make nuclear energy sustainable—

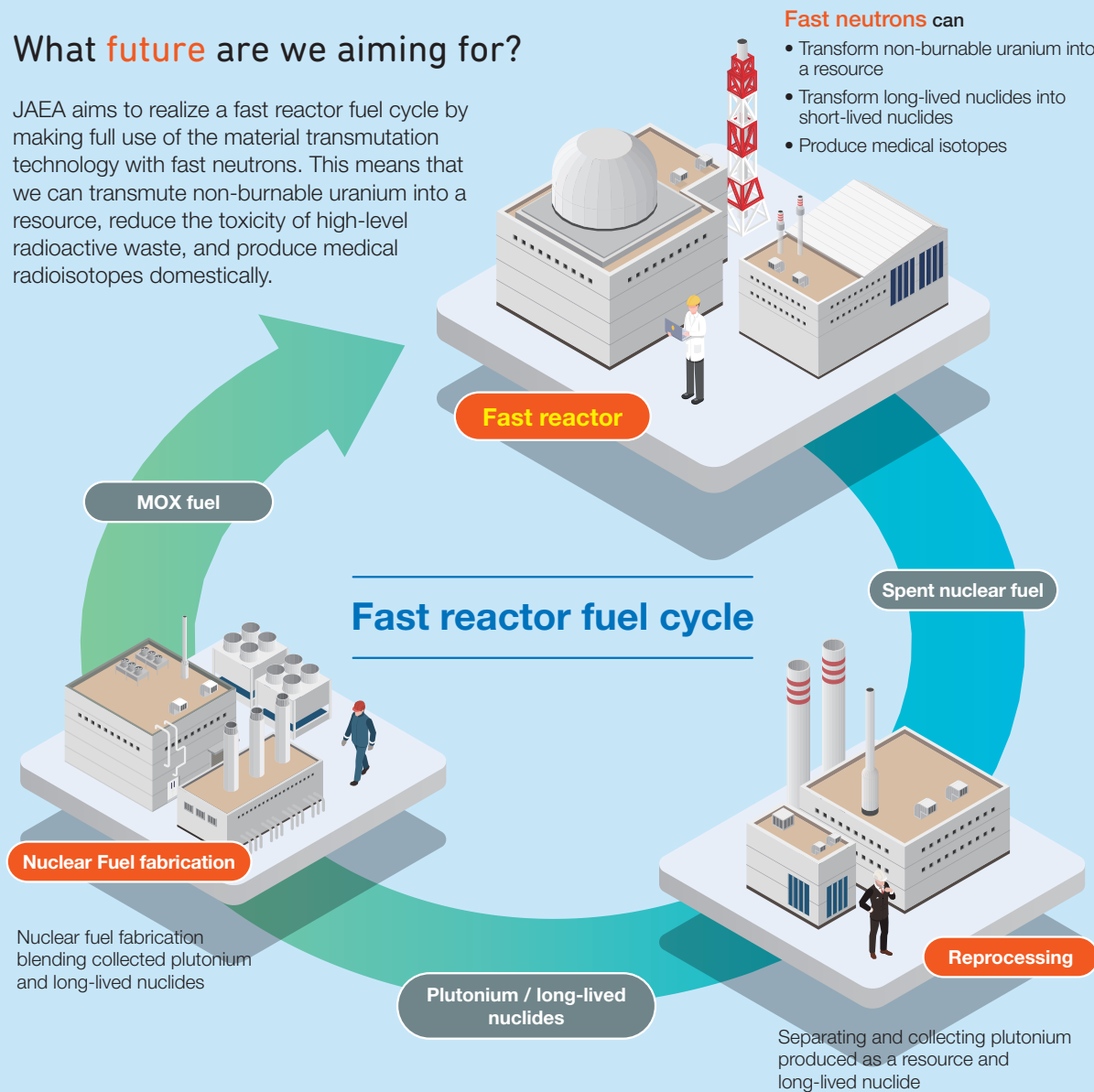


Fast reactors make it possible to effectively use of uranium resources and reduce the toxicity of high-level radioactive waste using fast neutrons\*.

\* High-energy neutrons

## What future are we aiming for?

JAEA aims to realize a fast reactor fuel cycle by making full use of the material transmutation technology with fast neutrons. This means that we can transmute non-burnable uranium into a resource, reduce the toxicity of high-level radioactive waste, and produce medical radioisotopes domestically.



## Key technologies for realization

- 1 Establishment of a fast reactor fuel cycle
- 2 Establishment of technology to reduce the toxicity of high-level radioactive waste
- 3 Establishment of production technology for medical radioisotopes (RIs)

- Synergy**: Optimization of power supply by combining renewable energy with fast reactors equipped with heat storage systems
- Sustainable**:
  - Ensuring energy security
  - Reducing the toxicity of high-level radioactive waste
- Ubiquitous**: Stabilization of domestic supply through the production of medical radioisotopes

Experimental Fast Reactor Joyo, located at the Oarai Nuclear Engineering Institute, is the only fast reactor that can provide a fast-neutron irradiation field in the OECD countries. In addition, Joyo can be utilized for the development of new fuels or materials to be used for next-generation fast reactors, conduct of safety-related experiments, and producing medical radioisotopes.



For details, scan the code

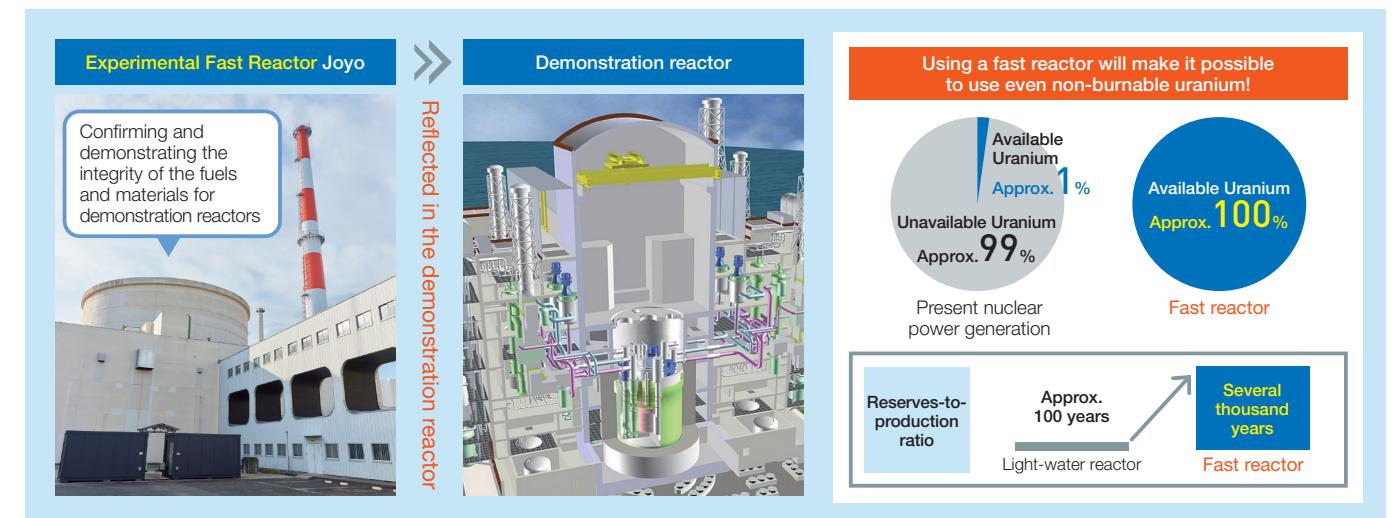


## What are the JAEA's initiatives for the future?

1

### Establishment of a fast reactor fuel cycle

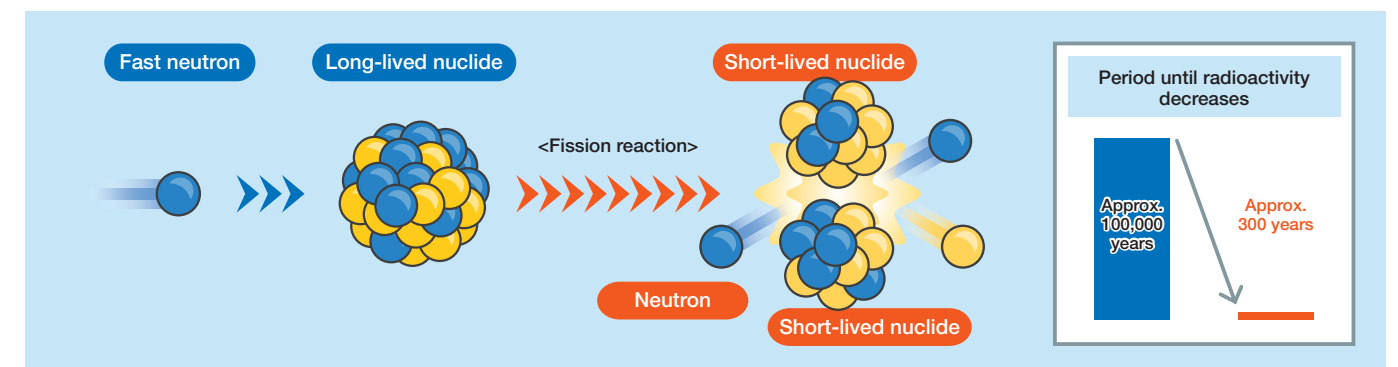
Using fast neutrons will make it possible to produce more fuel than consumed while generating electricity. In comparison to present light-water reactors, fast reactors can drastically increase the efficiency in using uranium resources.



2

### Establishment of technology to reduce the toxicity of high-level radioactive waste

Irradiating fast neutrons to highly toxic Long-lived nuclide, will transform it into Short-lived nuclide.



3

### Establishment of production technology for medical radioisotopes (RIs)

By using fast neutrons, it is possible to produce a radioisotope for medical use (actinium-225), which are expected as a therapeutic medicine for cancer.

For details, see page 13.



# Utilizing Valuable Resources Lying in Japan

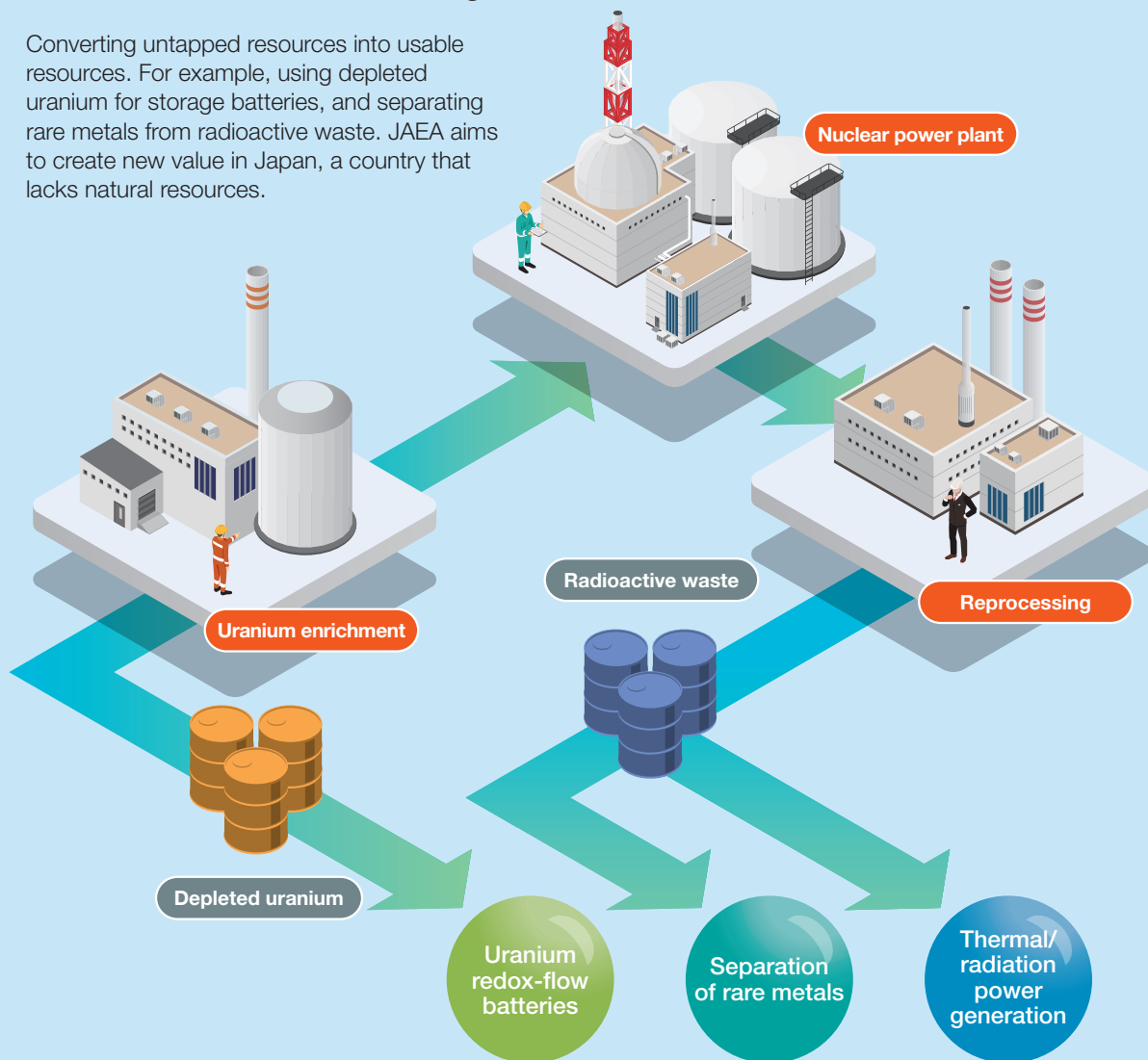
—Maximize utilization of unused resources—

Depleted uranium and radioactive waste, which are generated in the process of nuclear energy use, can be transformed into various resources.



## What future are we aiming for?

Converting untapped resources into usable resources. For example, using depleted uranium for storage batteries, and separating rare metals from radioactive waste. JAEA aims to create new value in Japan, a country that lacks natural resources.



Synergy

Optimizing the power supply by storing surplus electricity in uranium redox-flow batteries and transmitting the stored electricity when power shortages occur

Sustainable

Ensuring resource security by separating rare metals from radioactive waste

Ubiquitous

Utilizing heat and radiation, generated from radioactive material, as energy sources in general industrial fields

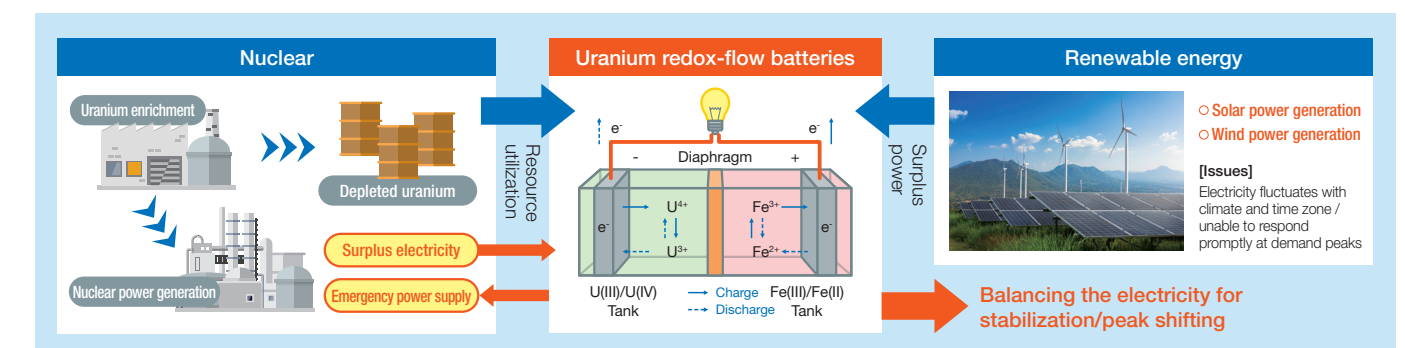
NXR Development Center is a new organization established in April 2024 to realize JAEA's vision of "Exploring the Future through the Synergy of Nuclear and Renewable Energies". To implement JAEA's research and development achievements at the societal level, the center is working on the development of uranium redox-flow batteries, technologies for separating rare metals, and thermal/radiation power generation, as a flexible and agile organization.

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## What are the JAEA's initiatives for the future?

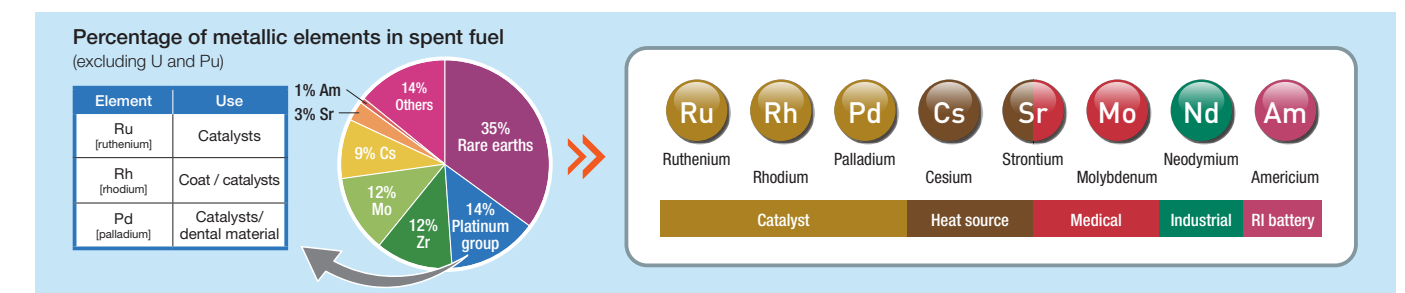
### 1 Development of uranium redox-flow batteries

To utilize depleted uranium, JAEA is developing high-efficiency, large-capacity storage batteries. The batteries will contribute to peak shifting and system stabilization by storing surplus electricity from nuclear power plants and renewable energies.



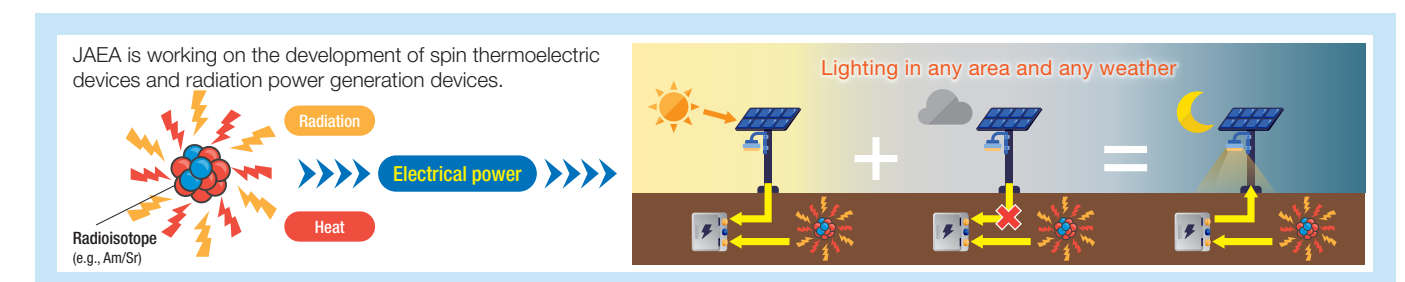
### 2 Development of separation technology for rare metals

JAEA aims to contribute to ensuring resource security by developing technology for separating rare metals, which have useful value in the industrial and medical fields.



### 3 Development of thermal/radiation power generation technology

Our goal is to develop a power source that utilizes the heat and radiation generated by radioactive materials. It can be used as a semi-permanent and maintenance-free energy source in any environment.



## Key technologies for realization

- 1 Development of uranium redox-flow batteries
- 2 Development of separation technology for rare metals
- 3 Development of thermal/radiation power generation technology



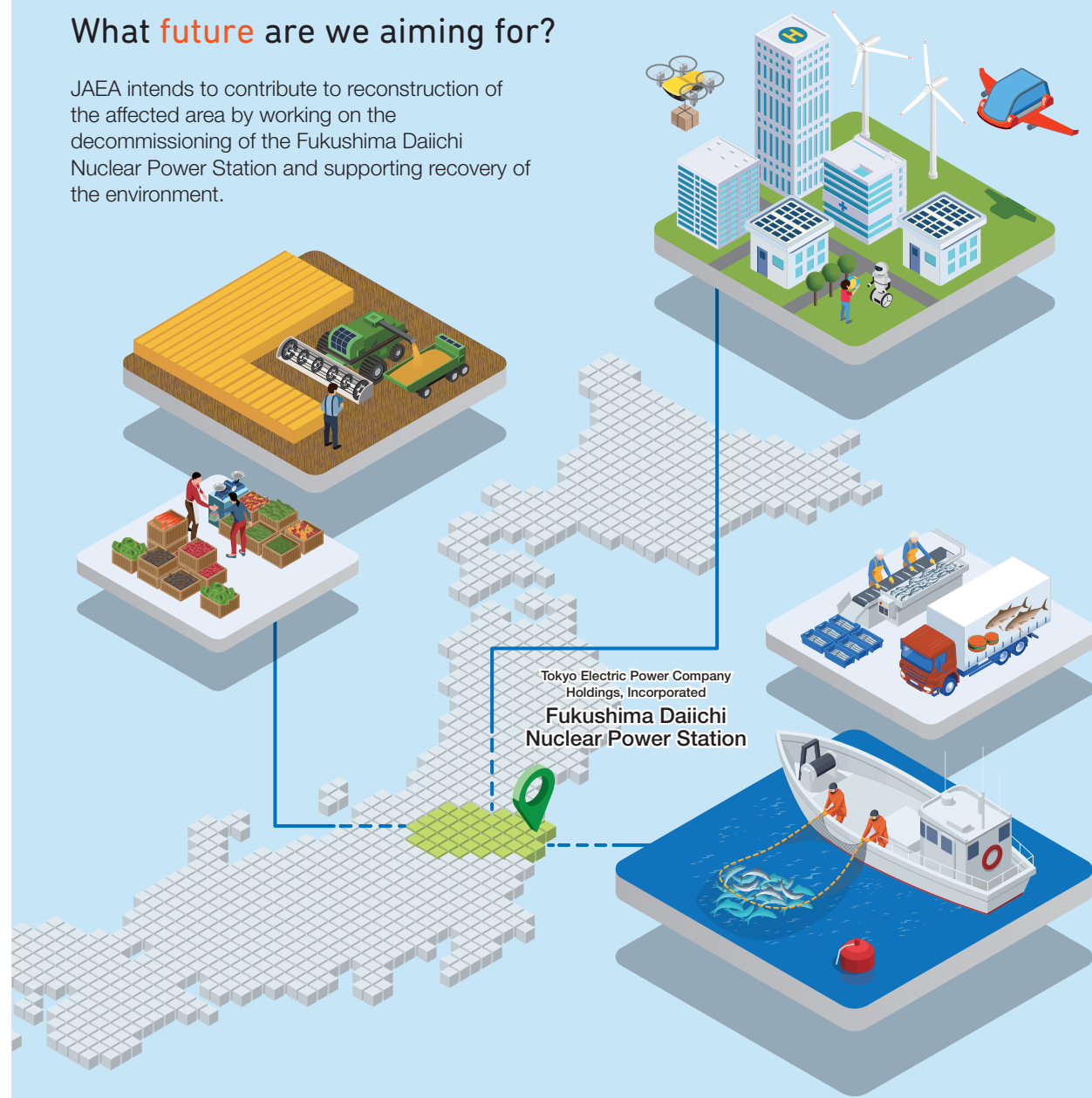
# Support for Decommissioning of the Fukushima Daiichi Nuclear Power Station and Efforts Toward Environmental Restoration

—Helping to reconstruct the affected area—

JAEA intend to contribute to decommissioning the Fukushima Daiichi Nuclear Power Station, and restoring the surrounding environment, through the achievements of our research and development.

## What future are we aiming for?

JAEA intends to contribute to reconstruction of the affected area by working on the decommissioning of the Fukushima Daiichi Nuclear Power Station and supporting recovery of the environment.



Key technologies for realization

1 Supporting decommissioning of the Fukushima Daiichi Nuclear Power Station

2 Supporting restoration of the environment

Sustainable

Supporting decommissioning of the Fukushima Daiichi Nuclear Power Station and the environment restoration

With regard to decommissioning the Fukushima Daiichi Nuclear Power Station, JAEA is working on research and development intended to move forward with highly challenging decommissioning processes safely, reliably, and promptly. JAEA is also working on environmental monitoring and other initiatives, toward creation of an environment where the people can live safely with peace of mind.



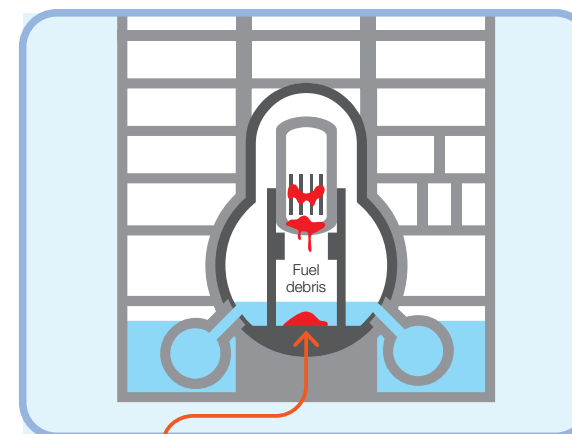
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## What are the JAEA's initiatives for the future?

1

### Support decommissioning of the Fukushima Daiichi Nuclear Power Station

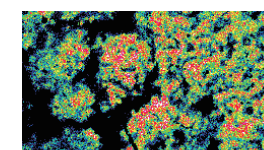


#### <Characterization of fuel debris>

For safe and reliable treatment and disposal of the fuel debris in the reactors of Fukushima Daiichi NPS, JAEA is analyzing its properties.



Fuel debris sample



Uranium distribution



Radioactive Material Analysis and Research Facility Laboratory-2 (being constructed in Okuma-machi)  
The laboratory analyzes high-dose radioactive materials such as fuel debris.

#### <Third-party analysis of ALPS treated water>

In accordance with the Government's policy, JAEA is conducting an analysis from the standpoint of a third party independent from Tokyo Electric Power Company Holdings, with the aim of ensuring highly objective and transparent measurement of radioactive materials contained in the ALPS treated water.

#### Flow of analysis

##### (1) Pretreatment

This treatment is to increase the purity of the nuclides to facilitate measurement.



##### (2) Measurement

Measurement is performed using an appropriate analyzer for each nuclide while considering the radiation emitted from the nuclide to be analyzed.



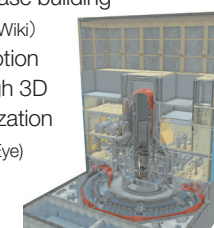
##### (3) Confirmation/evaluation

JAEA will confirm and evaluate the validity of the analysis data output from the analyzers, report the results to the Government and issue official publications.



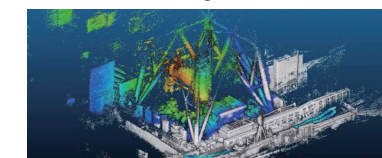
#### <Understanding the condition inside the reactor>

- Database building (debrisWiki)
- Promotion through 3D visualization (debrisEye)



#### <Remote controlled technology development>

- Radiation visualization technology (IRIS)
- "In situ" measurement of  $\alpha$ -dust
- VR data and digital twin



Radioactive contamination mapping

2

### Supporting restoration of the environment



#### <Environmental monitoring technology development>

To contribute to lifting the restrictions imposed on the Evacuation Order Areas and revitalizing the agriculture, forestry, and fishery industries, JAEA is developing environmental monitoring technologies for grasping the present state of radiation dose distribution.



# Establishing a Technology for Decommissioning Nuclear Facilities

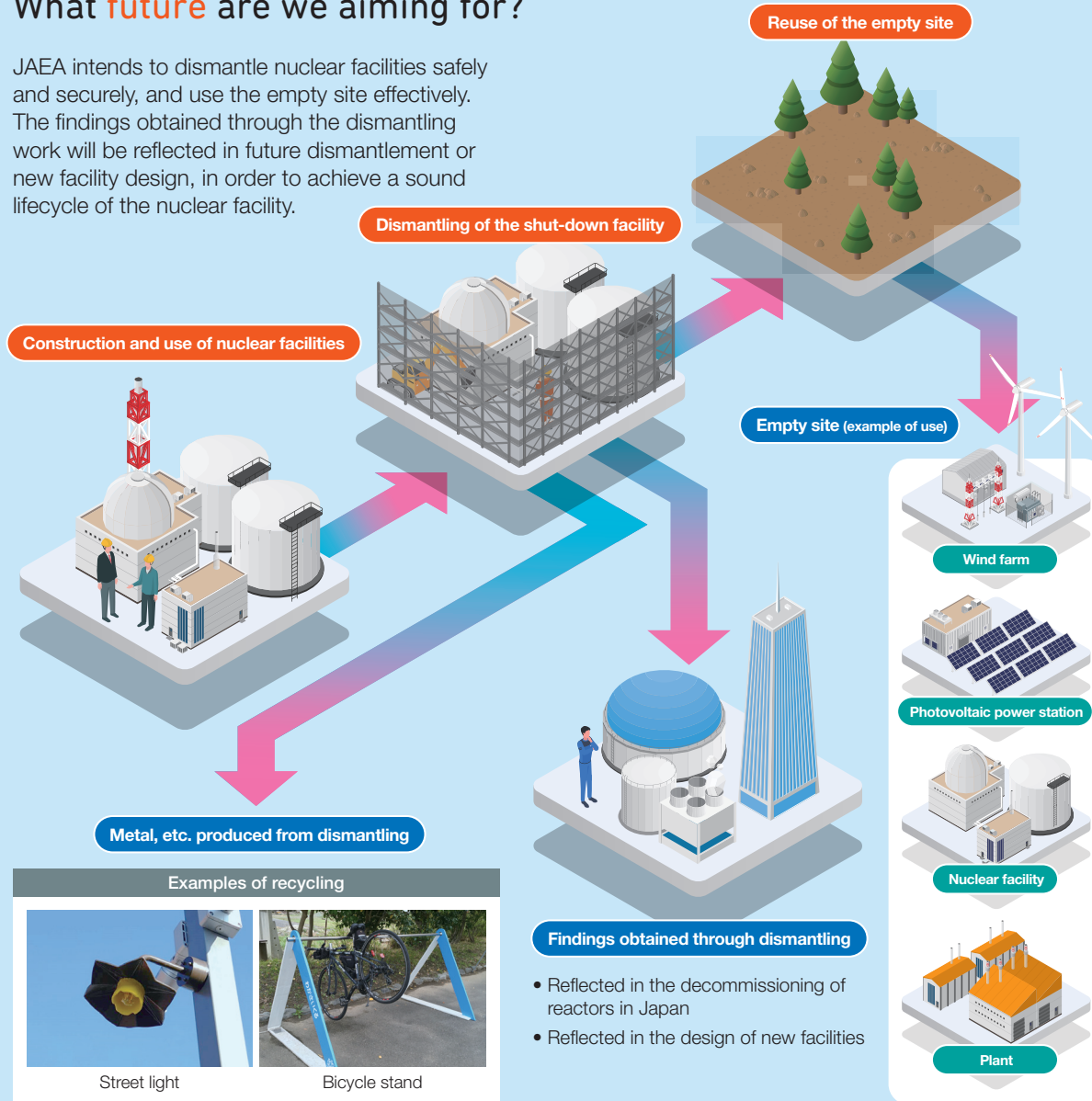
–Turning the lifecycle of nuclear facilities–



As with architecture and social infrastructure, nuclear facilities also need sound lifecycle management.

## What future are we aiming for?

JAEA intends to dismantle nuclear facilities safely and securely, and use the empty site effectively. The findings obtained through the dismantling work will be reflected in future dismantlement or new facility design, in order to achieve a sound lifecycle of the nuclear facility.



Key technologies for realization

Consolidating the findings on decommissioning technologies through the decommissioning of the JAEA's facilities

Sustainable

Achieving a sound lifecycle for nuclear facilities

Ubiquitous

Recycling metals produced from decommissioning, and utilizing the recycled metals in general industrial fields

To make the use of nuclear energy sustainable, JAEA is moving forward with activities such as the decommissioning of nuclear facilities that have completed their mission, and the treatment and disposal of radioactive waste, in a safe, efficient, and rational manner. JAEA is also working on helping to realize a recycling-oriented society by promoting the reuse of matters such as clearance metal generated, for example, through the dismantling of facilities.



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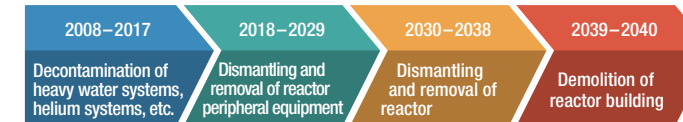


## What are the JAEA's initiatives for the future?

Consolidating the findings on decommissioning technologies through the decommissioning of the JAEA's facilities

### <Fugen Decommissioning Engineering Center>

Ahead of power utilities, JAEA has pursued the decommissioning of a water-cooled reactor. Currently, JAEA is working on the development of technologies for remote and automated devices in order to conduct the dismantling and removal of reactor peripheral equipment, and the dismantling of the reactor itself.

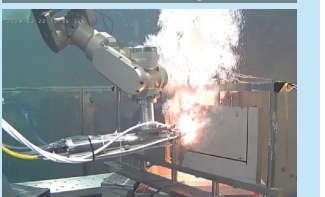


Dismantling and removal of large machineries around the reactor



Dismantling of pipes above the reactor

Technological development related to the reactor dismantling method



Underwater laser cutting test

### <Prototype Fast Breeder Reactor Monju>

JAEA is working on the decommissioning of a sodium-cooled fast reactor. Currently, JAEA is proceeding with activities such as the dismantling and removal of the electric power facilities with water and vapor systems, and the removal of the shields, etc., as a preparation for dismantling the sodium equipment.



Dismantling and removal of electric power facilities with water, vapor, and other systems



Dismantling of turbine generator



Dismantling of condenser

### <Tokai Reprocessing Plant (TRP), Nuclear Fuel Cycle Engineering Laboratories>

JAEA is moving ahead with the decommissioning of the reprocessing facility. JAEA is working on the vitrification of high-level liquid waste, development of technology for treating low-level liquid waste, and decontamination toward the dismantling of the facility.

Approx. 70 years



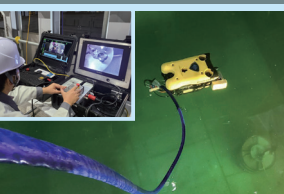
Safety improvement of high-level liquid waste storage



Vitrification high-level liquid waste



Recovery and reusage of high-level solid waste



Cementation of low-level liquid waste



### <Ningyo-toge Environmental Engineering Center>

JAEA is engaged in the decommissioning of uranium enrichment facilities that have completed their mission, the closure of mine facilities, and uranium waste engineering and environmental researches related to these activities.

### <Aomori Research and Development Center>

JAEA promotes the decommissioning of nuclear facilities on nuclear powered ship Mutsu, assay of trace elements (iodine, carbon) in environmental samples using an accelerator mass spectrometer, and development of relevant analysis technologies.



# Toward the Domestic Production of Medical Radioisotopes

## What are medical radioisotopes?

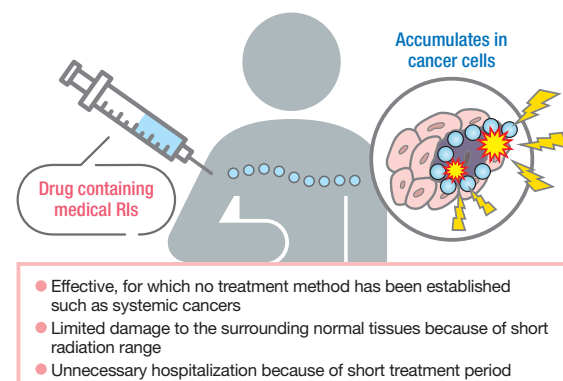
JAEA is moving ahead with research and development with a view to domestically producing medical radioisotopes (hereinafter “medical RIs”), which are used for applications such as cancer treatment and diagnostic imaging.

### With the Experimental Fast Reactor **Joyo**

JAEA aims to produce actinium-225 which is expected to be effective for various cancers such as leukemia and melanoma.

#### R&D Precisely killing only cancer cells with alpha rays emitted from medical RIs!

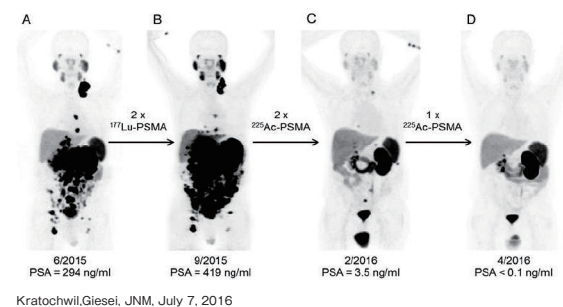
The method of killing cancer cells using radiation emitted from medical RIs administered in the body is called “internal therapy.” It is expected to be highly effective for cancer treatment.



**Eagerly anticipated for practical application in Japan and abroad!**

#### Example of application overseas The tumor in the late-stage metastatic prostate cancer has completely disappeared! (all signs of cancer disappeared)

The administration of actinium-225 to a patient with cancer that had spread throughout the body resulted in the disappearance of the cancerous tumors.



**Killing cancer cells** with actinium-225 radiation

### With **Japan Research Reactor-3**

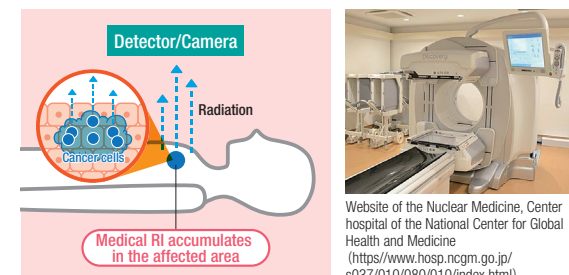
JRR-3 aims to produce molybdenum-99/technetium-99m, which is used in diagnostic imaging (SPECT examinations).

#### R&D Diagnosing illness by administering a drug containing medical RIs!

Japan relies on imports for medical-grade radioisotopes used in diagnostic imaging. JAEA will effectively utilize the performance of JRR-3 and promote the development of irradiation manufacturing technology for social implementation.

- Capturing an organ's functionality  
\* CT and MRI scans are intended to capture abnormalities in an organ
- Sometimes, they can detect illnesses that are hard to find with other tests
- Very few side effects

Administering the drug in the body by injection, and conducting the test with the principle as shown in the figure below.



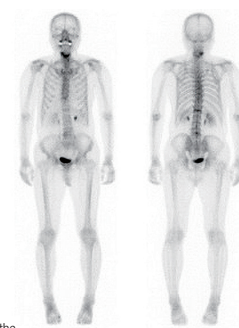
#### Example of achievement Early diagnosis with less impact on the body!

Bone scintigraphy is known as one of the most frequently conducted tests among nuclear medicine examinations.

##### Example of bone scintigraphy

#### [Advantages]

- Functional diagnostic imaging that reflects changes in bone metabolism
- Systemic search is easy (figure on the right)
- Effective for judging the effect after treatment, and in follow-up



Website of the Nuclear Medicine, Center hospital of the National Center for Global Health and Medicine  
(<https://www.hosp.ncgm.go.jp/s037/010/080/010/index.html>)

# Preparation of Neutron Supply Sources

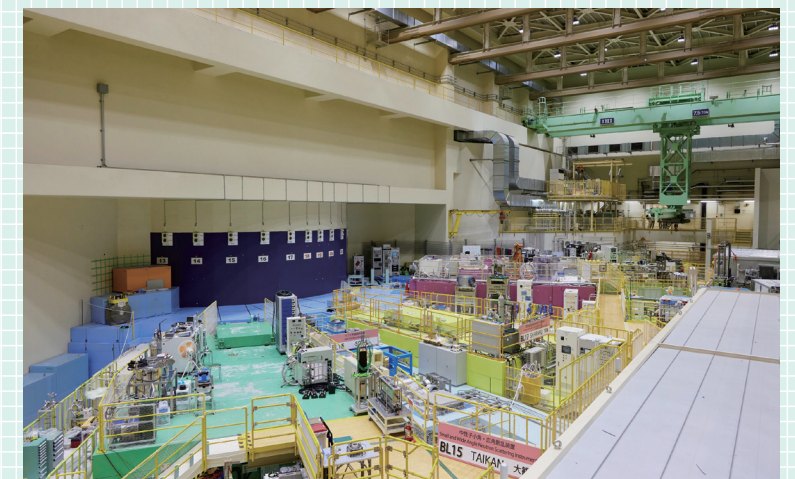
## Japan Research Reactor-3 **JRR-3**

The JRR-3 has applied properties of neutron to medical RI production and semiconductor manufacturing as industrial use, it also make use of the property of distinguish elements, for example, meteorite analysis, furthermore it has applied properties of cold neutron to elucidation of biological function with analysis of polymer structure. The reactor has provided high density source of thermal and cold neutrons, which has used as a wide range of fields from fundamental research to industrial fields.



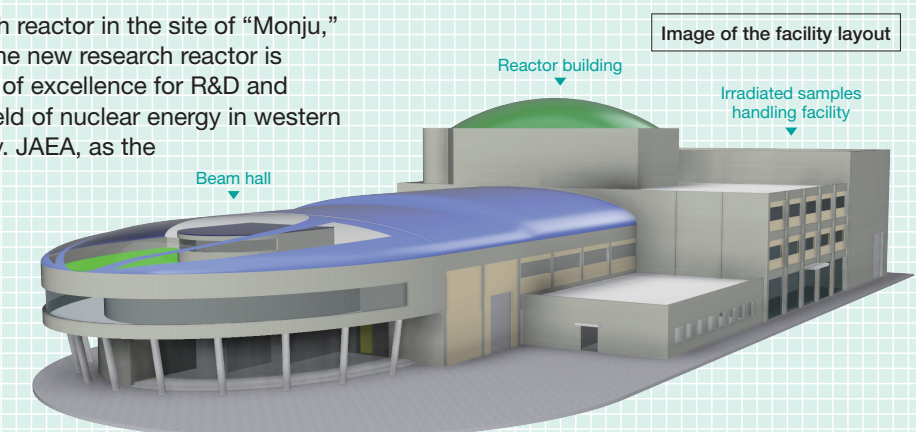
## Japan Proton Accelerator Research Complex **J-PARC**

At the research complex, J-PARC is pursuing activities research on the origin of matter and life from the structure of atoms and molecules in matter, and on solving the mystery of the beginning of the universe from the study of elementary particles and atomic nuclei. J-PARC has created a variety of secondary particle beams such as neutrons, muons, neutrinos and kaons by bombarding targets like mercury and carbon with the world's leading high-intensity proton beams accelerated almost to the speed of light, and various experiments are conducted there.



## New Research Reactor

JAEA plans to establish a new research reactor in the site of “Monju,” the Prototype Fast Breeder Reactor. The new research reactor is expected to play the role of the center of excellence for R&D and human resource development in the field of nuclear energy in western Japan and contributing to local society. JAEA, as the implementing body, conducts detailed design of the research reactor in collaboration with Kyoto University and the University of Fukui.



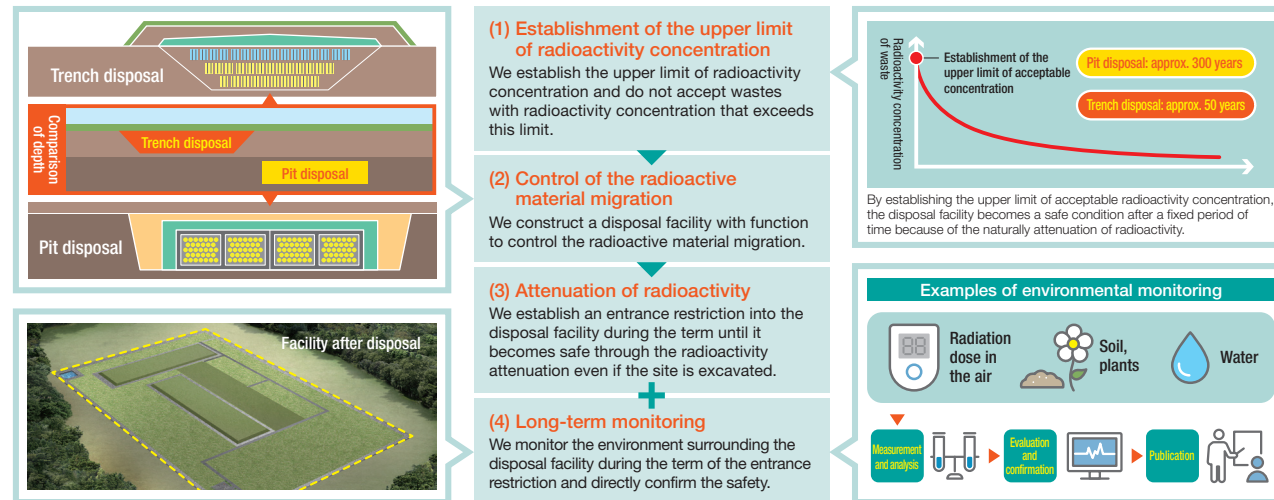


# Establishment of Technology for Disposing of Radioactive Waste

## Disposal of low-level radioactive waste

JAEA is engaged in disposal project of low-level radioactive waste from research and medical facilities. Currently, we are working to establish a technical base focusing on designing for the safe disposal facility.

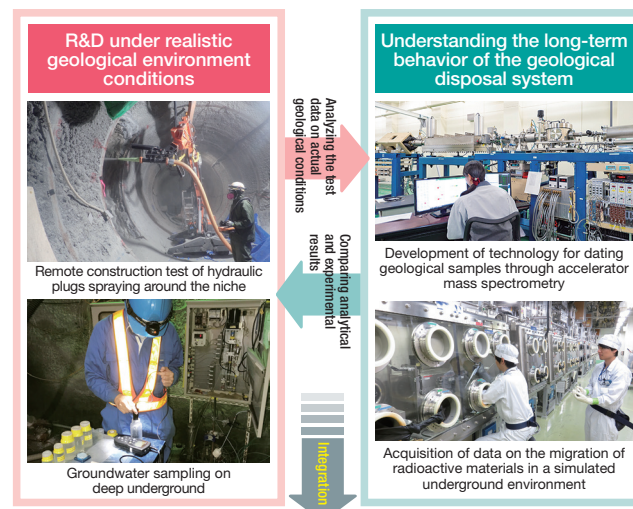
### Basic policies for ensuring safety



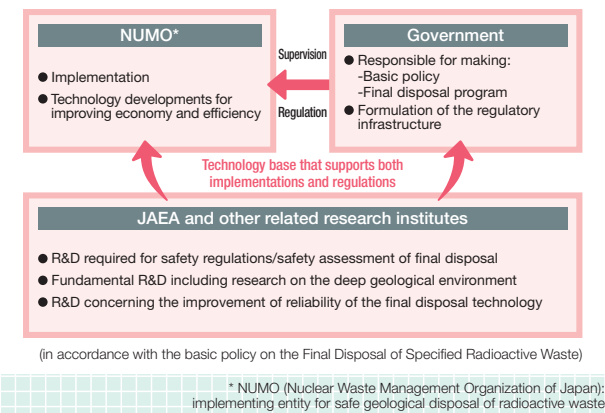
## R&D on geological disposal of high-level radioactive waste

JAEA conducts investigation and prediction of the geological environment, as well as research and development necessary for the design and safety evaluation of the geological disposal system.

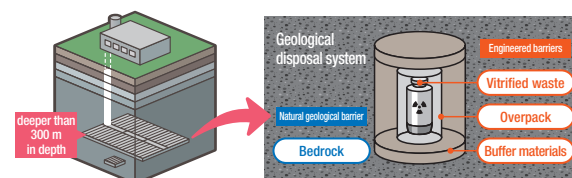
### R&D at JAEA



### Organizational structure for geological disposal in Japan



### Image of geological disposal

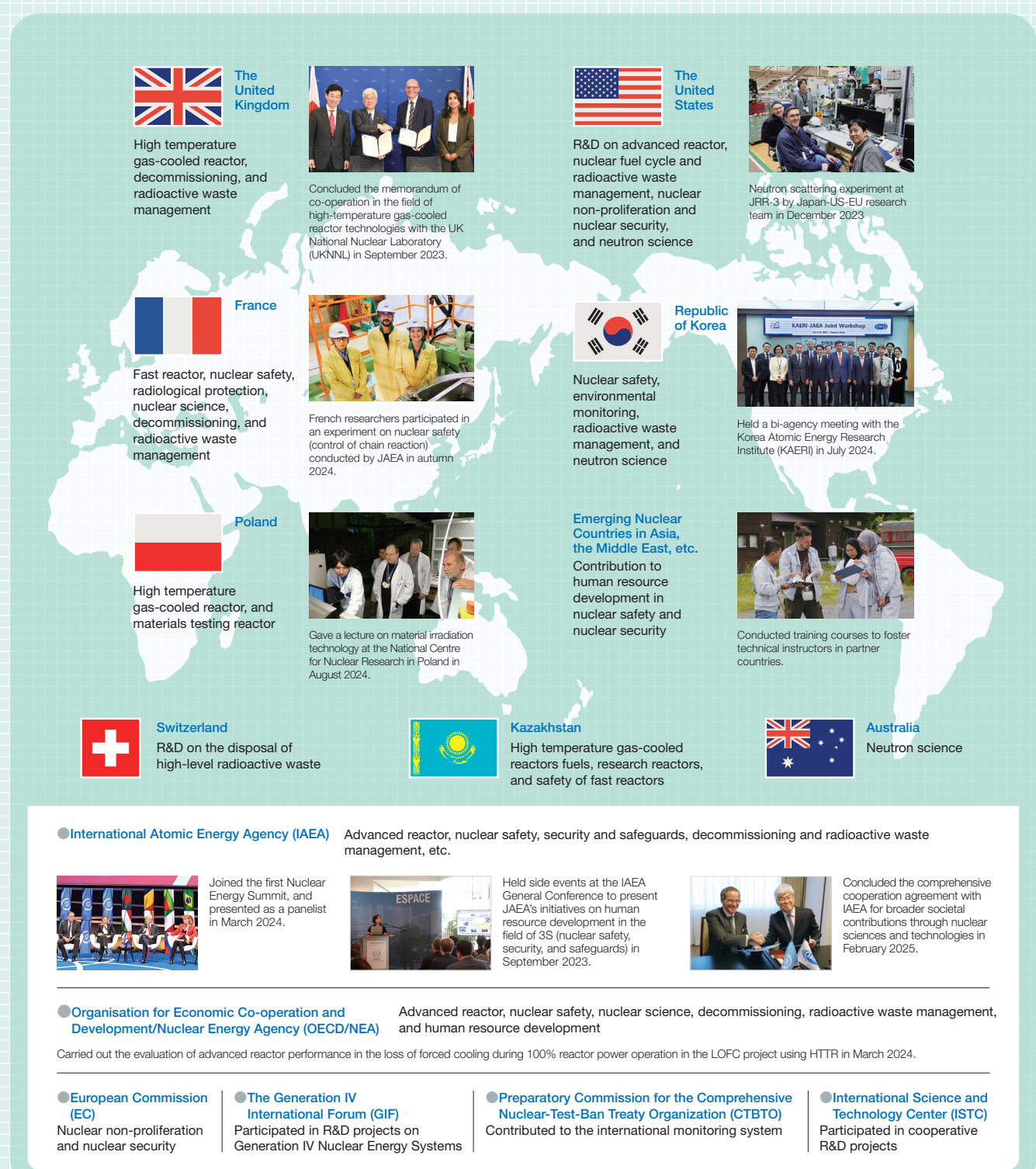


# International Efforts and Contribution

## International cooperation

Toward achieving a decarbonized society, JAEA aims to harness the power of nuclear science and technology to address a wide range of issues by enhancing collaboration with international partners.

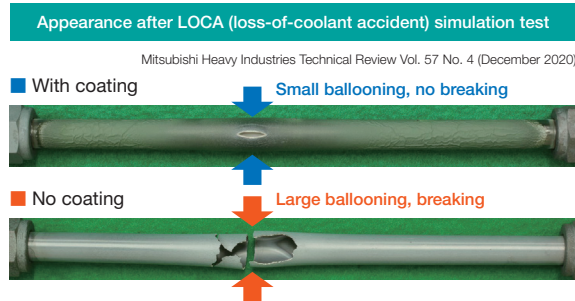
### Fields of collaboration with other countries and recent activities



## Introducing Our Initiatives 5

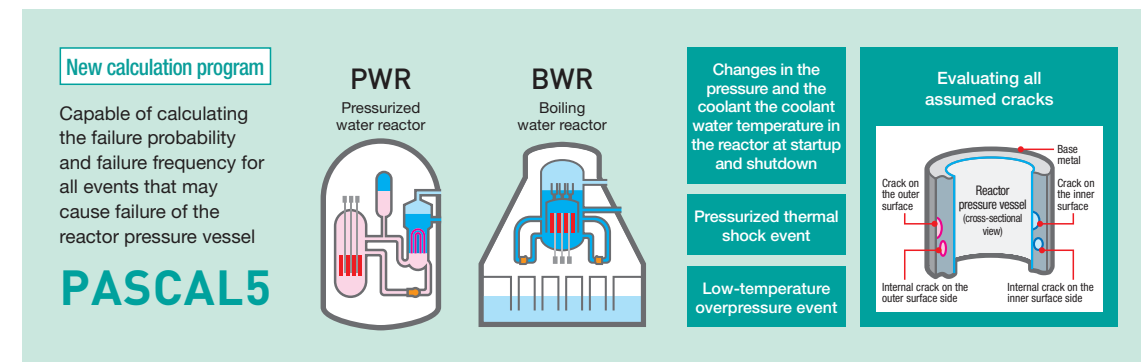
### Research on Light-water Reactors

JAEA is pressing ahead with basic and fundamental research and development, which is intended to accelerate the development of ATF (accident tolerant fuel) elements that is less subject to severe accidents and would mitigate the impact of severe accidents. In addition, JAEA plays the role of coordinating the development in Japan to give a boost to development by manufacturers.



### Safety Research

The integrity assessment of the reactor pressure vessel applying the probabilistic approach is expected to available quantitatively evaluating the safety margin in the existing evaluation method, and supporting more rational maintenance plans.



## Introducing Our Initiatives 6

### Fostering Human Resources for the Future of Nuclear Energy

For domestic human resource development, JAEA hold various training courses, cooperate in university education, and conduct human resource development activities in collaboration with related domestic organizations. For international human resource development, JAEA invite engineers and other professionals from Asian countries, and train them to become lecturers who will be responsible for human resource development in their home countries.



Practical training on dose measurement for engineers responsible for the safe use of nuclear energy

## Introducing Our Initiatives 7

### Strengthening Nuclear Non-proliferation and Nuclear Security

With the aim of realizing a world without nuclear weapons and nuclear terrorism, JAEA is working on activities in the field of nuclear non-proliferation and nuclear security, such as technological development, policy researches, support for human resource development, and support for the international verification regime of the Comprehensive Test Ban Treaty (CTBT).

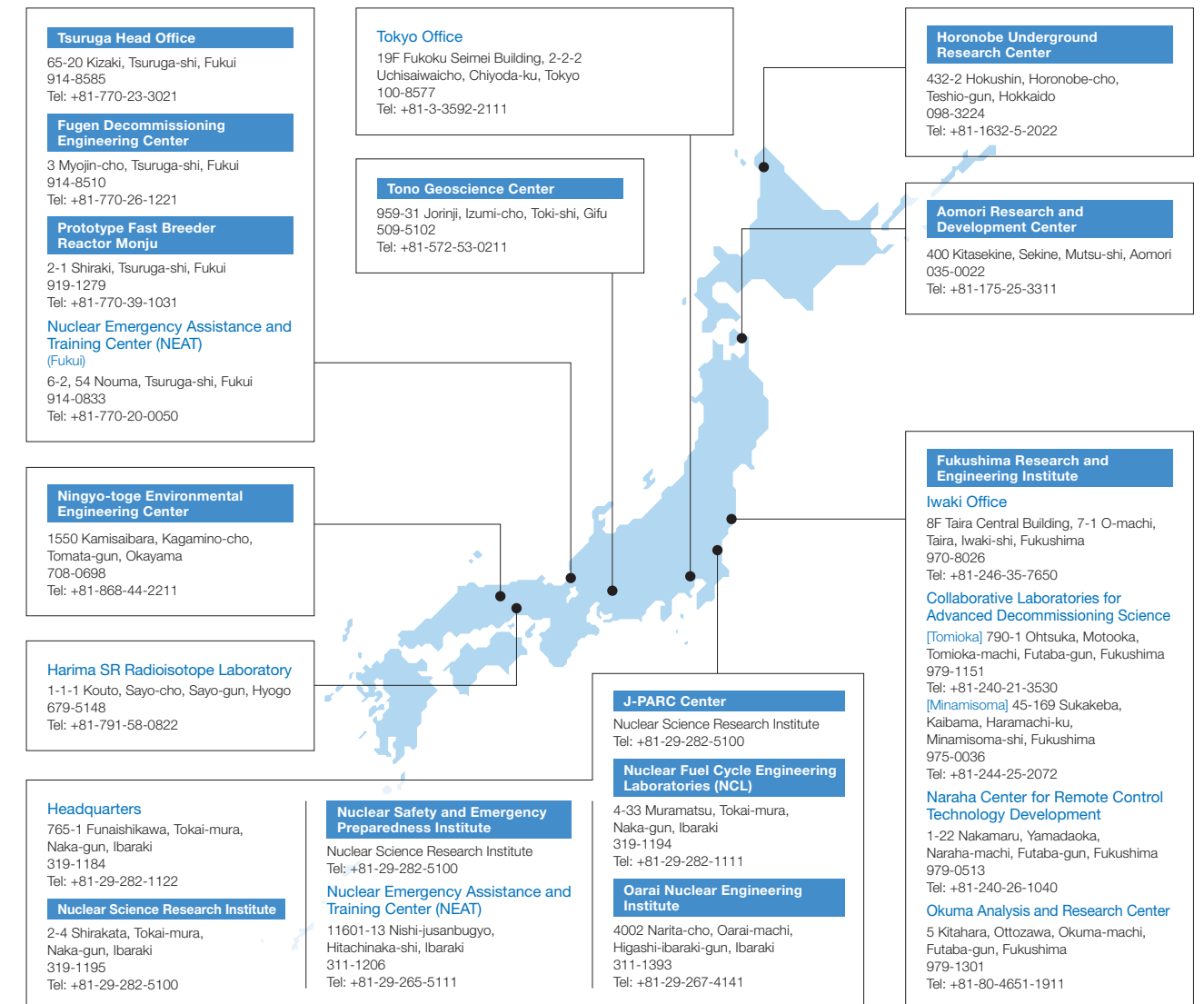


Experience-based exercise on nuclear non-proliferation and nuclear security using a VR system

## Location of R&D Sites

[as of April 2025]

● Number of staff: 3,105 people (end of fiscal 2024) ● Budget: 153.5 billion yen (fiscal 2024)







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