Nuclear Fuel Cycle Engineering Laboratories

Japan Atomic Energy Agency
Tokai Research and Development Center

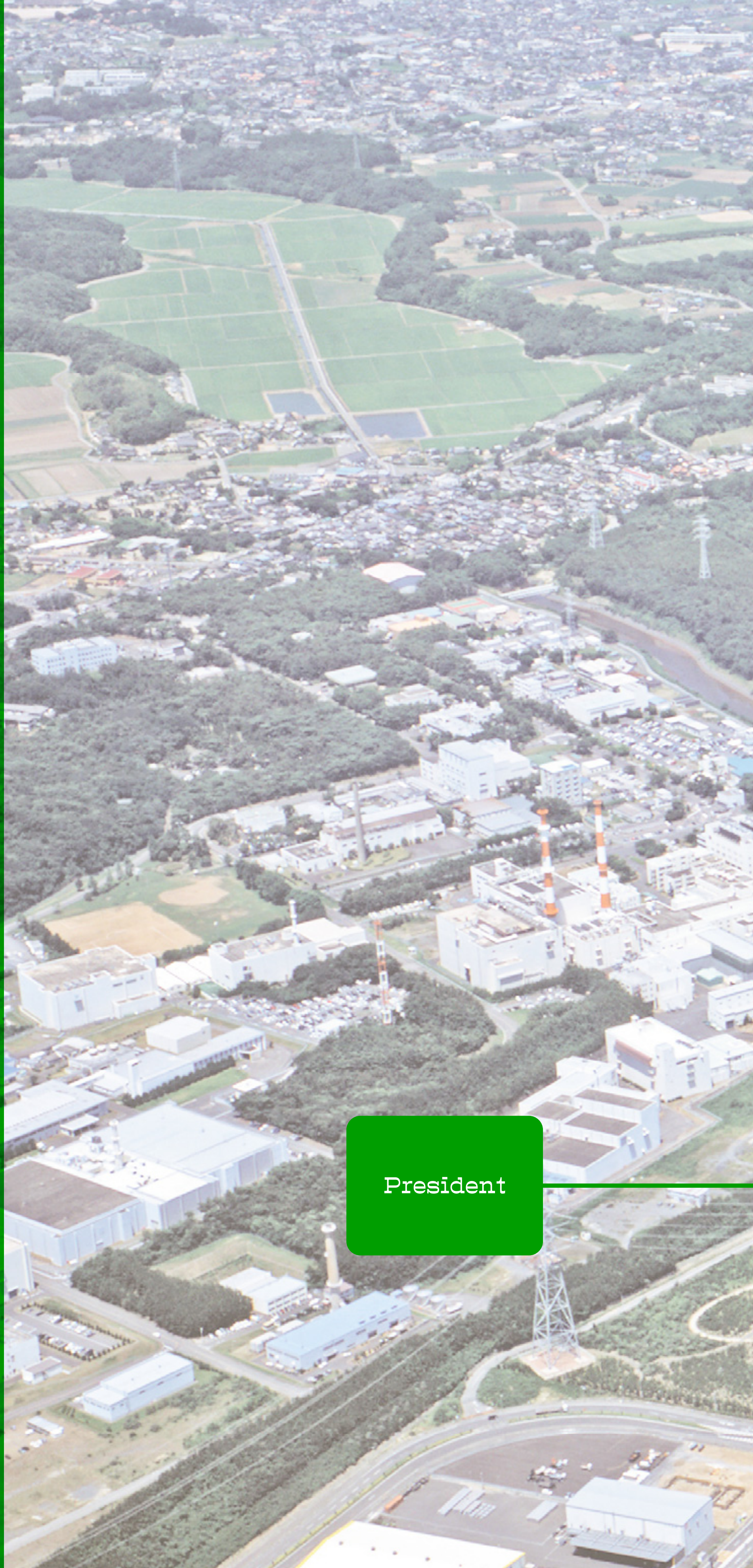
Tokai Research and Develop
Nuclear Fuel Cycle Engi

Tokai research and development center is the biggest institute in Japan Atomic Energy Agency (JAEA), which consists of following parts, Nuclear Fuel Cycle Engineering Laboratories, Nuclear Science Research Institute and the administration Department.

We perform various R&D programs for the nuclear fuel cycle, reprocessing technologies, MOX fuel technologies, advanced fuel cycle technologies, treatment and disposal of radioactive waste. These are important tasks for ensuring security of Japan which is a country that lacks energy resources.

We promote technology transfer between JAEA and the private nuclear fuel cycle sector, technological assistance and technical cooperation.

We promote R&D program for security cooperation with regional communities.



President

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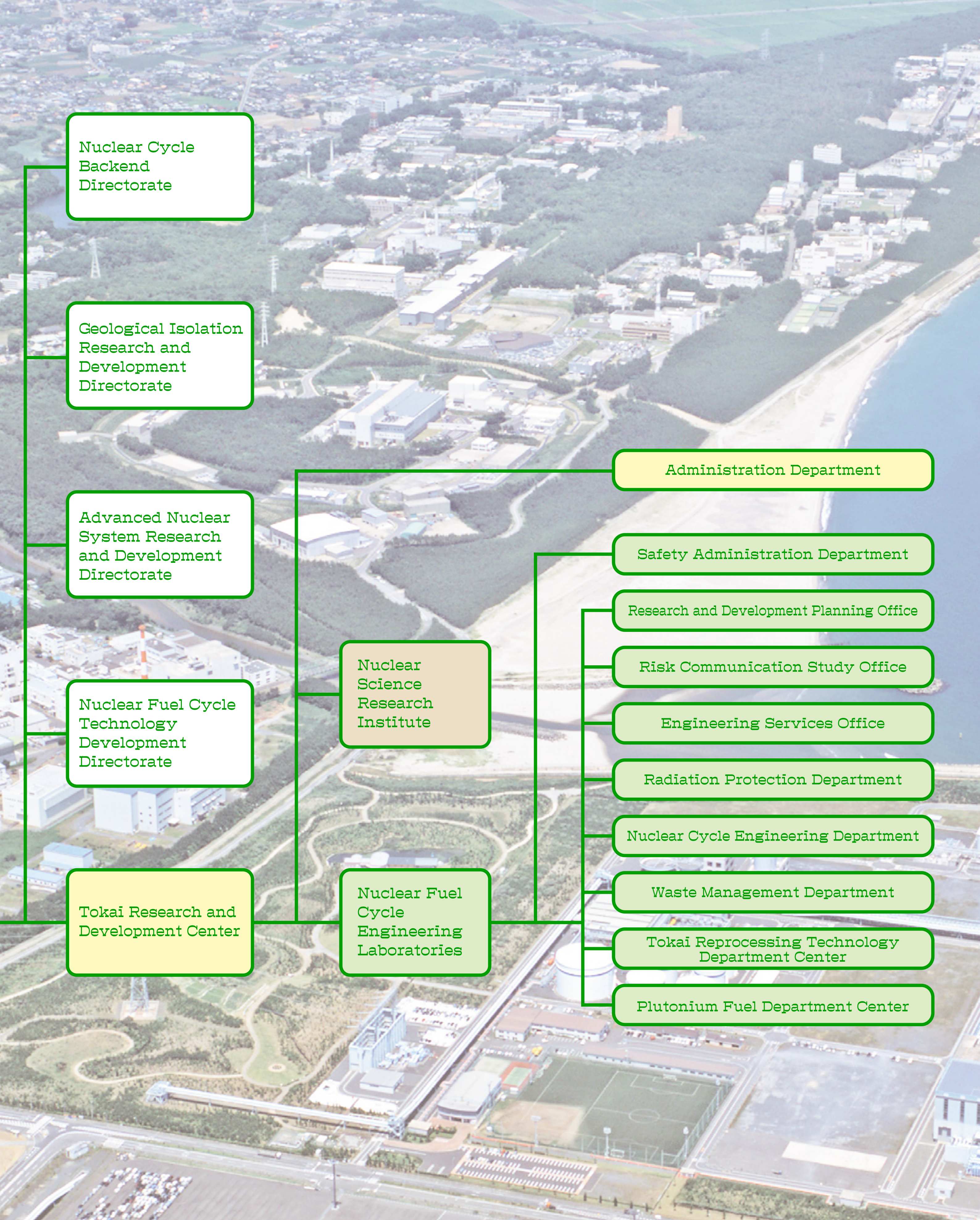
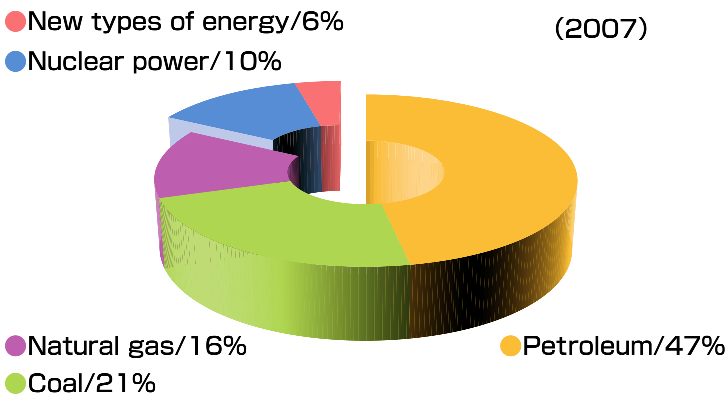


Realization of the Nuclear Fuel Cycle

Stable energy supply is essential to maintain and improve our living standard now and in the future.
Japan imports about 80% of energy resources due to a lack of resources. So, nuclear energy is one of the most viable options for long term energy security.
Japan Atomic Energy Agency（JAEA）promotes R&D programs to establish a nuclear fuel cycle system which can utilize nuclear energy more efficiently. The Tokai Research and Development center is active in this field and will continue to be active in future.

Structure of primary energy supply in Japan

Domestic resources 16%

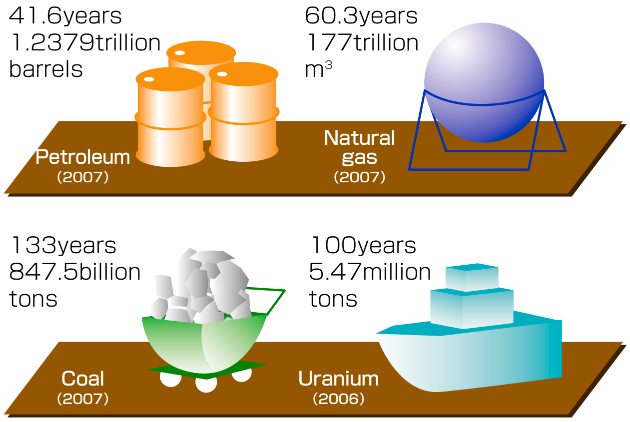


※ Values are rounded off

Primary energy

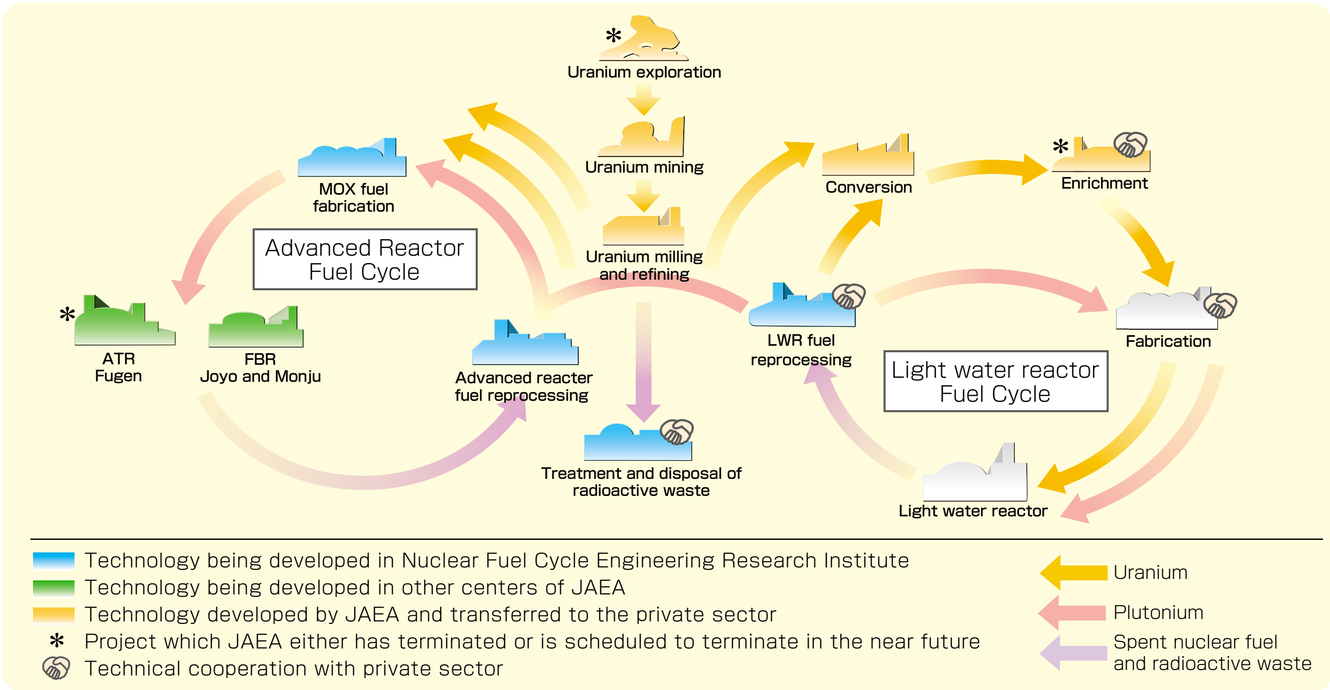
Petroleum, coal and other energy sources that can be directly used as energy in their natural state.

Current World Energy Resources



- The minable years of petroleum,natural gas,coal=the amount of proven mining reserves/the amount of annual production.
- Uranium mining years= the amount of proven mining reserves/the required amount for 2006
- By utilizing plutonium,the number for years that uranium can be utilized will increase 2570 years.

Nuclear Fuel Cycle



Uranium ore is converted to nuclear fuel through mining, refinement, conversion, enrichment and fabrication.
Nuclear fuel used to generate is electricity at nuclear power stations.
After use, spent nuclear fuel reprocessed to separate uranium, plutonium and waste. Recovered uranium and plutonium refabricated as new fuel assemblies for the nuclear power stations.
This is called the nuclear fuel cycle.

Chronology

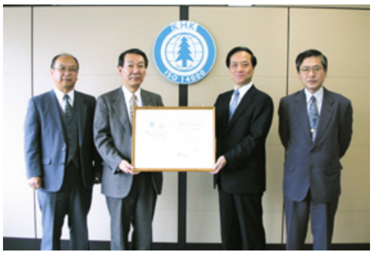
June	1957	Establishment of the Tokai Refinery, Nuclear Fuel Corporation (NFC)
March	1959	First successful production of metallic uranium in Japan
March	1959	Inauguration ceremony for the Tokai Refinery, NFC
January	1966	First receipt of plutonium . Start of plutonium fuel development at the Plutonium Fuel Development Facility.
October	1967	Establishment of the Power Reactor and Nuclear Fuel Development Corporation (PNC) which succeeds NFC
May	1969	First successful uranium enrichment test using the centrifugal separation method
June	1971	Start of construction of the Tokai Reprocessing Plant
November	1972	Start of fuel fabrication for the experimental fast reactor "Joyo" at the Plutonium Fuel Fabrication Facility
July	1975	Start of fuel fabrication for the advanced thermal reactor "Fugen" at the Plutonium Fuel Fabrication Facility
September	1977	Start of test utilizing spent fuel at the Tokai Reprocessing Plant
January	1981	Start of full scale operation I at the Tokai Reprocessing Plant
September	1982	Start of reprocessing test using fuels from the experimental fast reactor "Joyo" at the Chemical Processing Facility
December	1982	Start of basic vitrification test using high-level radioactive liquid waste at the Chemical Processing Facility
October	1989	Start of fuel protection for the prototype fast breeder reactor "Monju" at the Plutonium Fuel Production Facility
January	1993	Arrival of Akatsukimaru containing returned plutonium carried from France
August	1993	Completion of the Engineering-scale Test and Research Facility
January	1994	Completion of production of the initial loading fuel for the prototype fast breeder reactor "Monju" at the Plutonium Fuel Production Facility
January	1995	Start of construction of the Recycle Equipment Test Facility
January	1995	Start of vitrified waste production at the Tokai Vitrification Facility
March	1997	Fire and explosion at the Bituminization Facility
October	1998	Establishment of the Japan Nuclear Cycle Development Institute (JNC) which succeeds PNC
August	1999	Completion and start of operation of the Quantitative Assessment Radionuclide Migration Experimental Facility
November	2000	Resumption of the operation of Tokai Reprocessing Plant
March	2001	Plutonium Fuel Production Facility obtained the certificate of ISO9001
March	2002	Tokai Works obtained the certificate of both OHSAS18001 and ISO14001
June	2002	Accumulative total of 1000t reprocessed at the Tokai Reprocessing Plant
July	2004	Start of the dry process reprocessing test using plutonium
October	2005	IIntegration of Japan Atomic Energy Research Institute and Japan Nuclear Cycle Development Institute, establishment of Japan Atomic Energy Agency (JAEA) Nuclear Fuel Cycle Engineering Laboratories
March	2006	Accomplishment of LWR spent fuel reprocessing at the Tokai Reprocessing Plant.
April	2008	Execution of Agreement between the Japan Atomic Energy Agency and Idaho National Laboratory for cooperation of personnel training in fuel cycle area by exchanging personnel.


Establishment of the Power Reactor and Nuclear Fuel Development Corporation


Start of test utilizing spent fuel at the Tokai Reprocessing Plant


Arrival of Akatsukimaru with returned plutonium from France


Completion of the Engineering scale Test and Research Facility


Tokai Works obtained the certificate of both OHSAS18001 and ISO14001

Accumulative total of 1000t reprocessed at the Tokai Reprocessing Plant

Reprocessing Technology Development

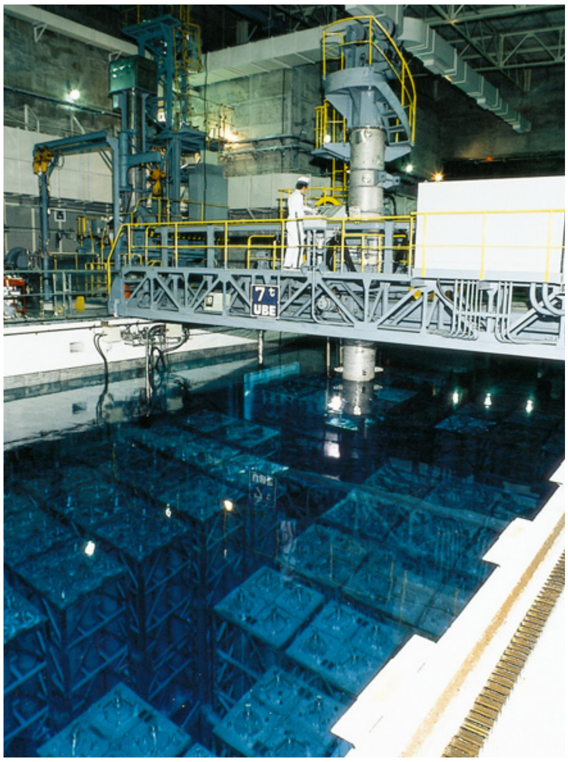
Spent fuel which has been used at nuclear power plants contains residual uranium, newly produced plutonium, and high-level radioactive waste.
At the Tokai Reprocessing Plant, reprocessing technologes have been developed to separate and recover uranium and plutonium from spent fuel for the purpose of efficient use of available uranium resources.
The recovered uranium and plutonium can be reused as new fuel, therefore, the reprocessing plays a key role in the nuclear fuel cycle.

▲Tokai Reprocessing Plant (TRP)

Jun. 1971	Start of construction of the Tokai Reprocessing Plant
Sep. 1975	Start of uranium testing
Jul. 1977	First acceptance of spent fuel
Sep. 1977	Start of a test run using spent fuel
Nov. 1977	First extraction of plutonium
Jan. 1981	Start of first actual run using spent fuel
Feb. 1983	Completion of the Plutonium Conversion Development Facility (PCDF)
Nov. 1990	500t reprocessed
Jun. 2002	1000t reprocessed
Mar. 2006	Accomplishment of LWR spent fuel reprocessing

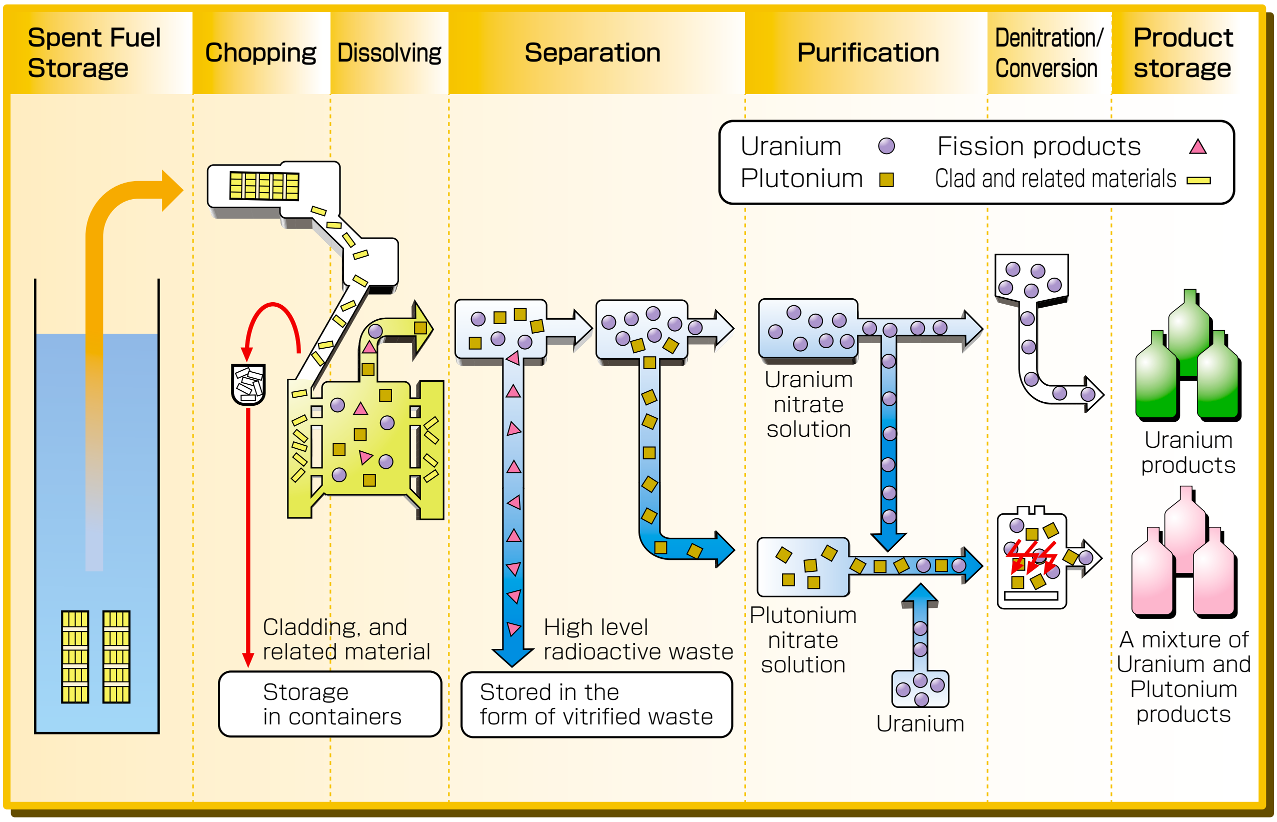
▼Control room

The fuel storage pool of Tokai Reprocessing Plant has a capacity to store about 140tHM of spent fuel.
Stored and cooled fuel assemblies contained in a fuel basket are moved to the fuel storage pool, and one assembly is taken out from a fuel basket, and sent for mechanical treatment processing.



▲Fuel storage pool

Process of Reprocessing



Future roles of the Tokai Reprocessing Plant

The Tokai Reprocessing Plant will provide comprehensive assistance to the Rokkasyo Reprocessing Plant, and will continue research and development toward the advancement of reprocessing technologes, carrying out the reprocessing of high burn-up fuel and Fugen fuel.

Plutonium Conversion Development

▲Plutonium-Uranium Mixed Oxide

Plutonium and uranium recovered from spent fuel is converted to the mixed oxide by the microwave heating direct denitration process (MH process) developed in JAEA.
The mixed oxide is sent to the plutonium fuel facilities, and converted to MOX fuel.

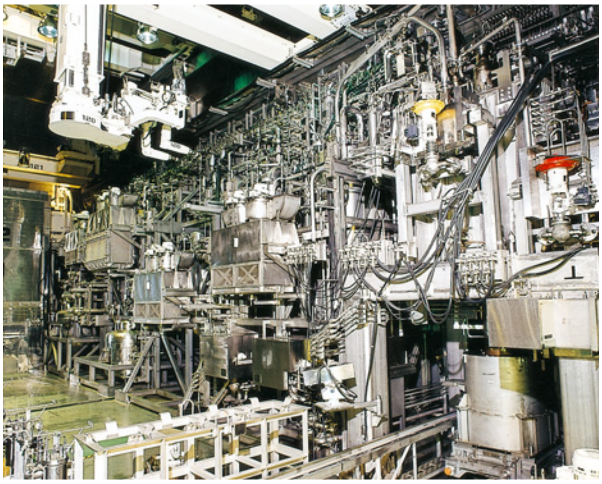
Reprocessing Technology Development

Vitrification technology Development

After reprocessing of spent fuel, high-level radioactive liquid waste (HLW) is left behind. In Japan, high-level radioactive waste will be solidified into vitrified waste for stabilization and easy handling. After this treatment, the vitrified waste will be disposed of in a deep underground repository.
Vitrification technology has been developed at the Tokai Vitrification Facility to stabilize separated high-level radioactive liquid waste into vitrified waste.

▼Tokai Vitrification Facility (TVF)

▼Vitrification cell



▼Control room

▼Vitrified waste

Specifications

Contents	Borosilicated glass
Weight	Approx.400kg
Volume	Approx. 110ℓ

Canister

Shape	Cylinder
Outside diameter	430mmφ
Overall height	1040mmH

Low-level waste treatment technology Development

Low-level Radioactive Waste Treatment Facility are being constructed in order to advance the technology
development for volume reduction and stability of low-level radioactive waste.

◀Low-level Radioactive Waste Treatment Facility (LWTF)

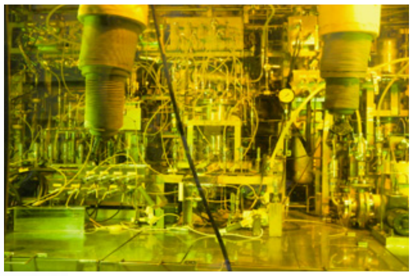
Research & Development on Advanced Fuel Cycle Technologies

JAEA is carrying out Fast Reactor Cycle Technology Development (FaCT) Project on commercialized fast reactor cycle systems. As a part of this study, Nuclear Fuel Cycle Engineering Laboratories is responsible for R&D on the advanced reprocessing technologies, such as advanced aqueous process (U/Pu/Np co-extraction, crystallization, etc.) and advanced equipment (centrifugal contactors, etc.), to establish economic competitiveness, enhancement of nuclear non-proliferation, and reduction of environmental impacts. And also non-aqueous technologies such as pyrochemical process, are currently under development. And in the FaCT project, the simplified pelletizing fuel fabrication technologies to rationalize the fuel fabrication process step, which would make it possible to operate stable in FBR fuel fabrication process and to be economically competitive, and the fabrication technologies of TRU-MOX fuel with low decontamination are being developed.

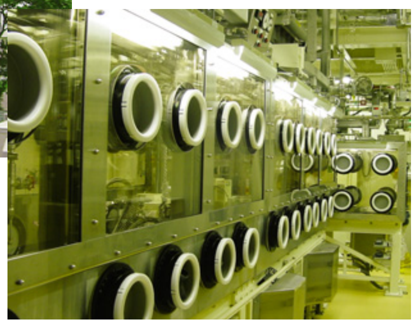
▲Hot-Cell Test

▼Chemical Processing Facility (CPF) Overview

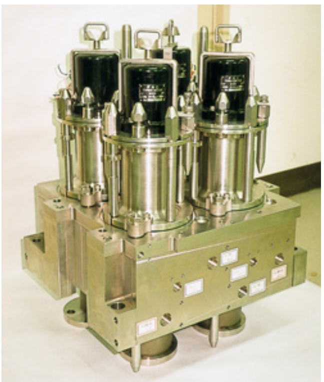
Hot laboratory tests for basic research on reprocessing processes using irradiated fuel mainly from fast experimental reactor "Joyo".



▲A cell for advanced aqueous reprocessing test



▲Glove boxes for pyrochemical reprocessing test



▲Centrifugal Contactor

◀ Recycle Equipment Test Facility (RETF)

Construction of RETF's Test Building and auxiliary facility except for advanced equipment has been finished. RETF will be utilized as a international facility playing a central role in the development of next generation fuel cycle technology, remaining consistent with the results of the FaCT Project.

The outcome of Phase II of "Feasibility Study on Commercialized Fast Reactor Cycle Systems" (FS) was evaluated by the Study, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and MEXT presented the results of this evaluation to the Atomic Energy Commission (AEC). The AEC decided on "Basic Policy on Research and Development of FBR Cycle Technologies over the Next Decade" on December 26th, 2006. Based on these evaluations and policy, the technologies of combination of the sodium-cooled FBR with MOX fuel core, the advanced aqueous reprocessing process and the simplified pelletizing fuel fabrication as currently the most promising conceptual system of the FBR cycle technologies are being developed intensively for commercialization in the FaCT project.

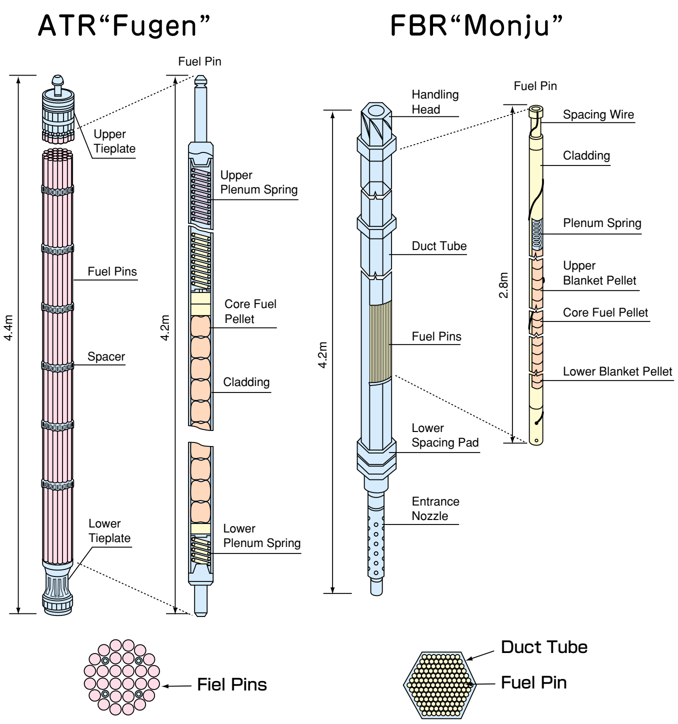
MOX Fuel Technology Development

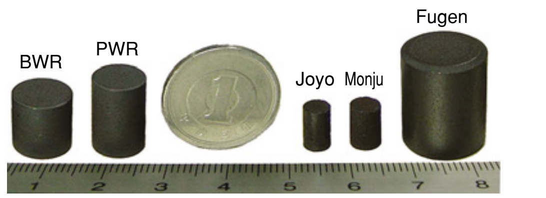
JAEA has developed plutonium fuel fabrication technologies through MOX (Mixed Oxide) fuel production for the experimental fast reactor "Joyo", the prototype FBR "Monju" and the advanced thermal reactor "Fugen" at the Plutonium Fuel Development Center. The accumulated number of the MOX fuel assemblies fabricated in these facilities has amounted to approximately 1,700.

▲Overview of Plutonium Fuel Production Facility

January '65	Start of operation of the Plutonium Fuel Development Facility
January '72	Start of operation of the Plutonium Fuel Fabrication Facility
November '72	Start of fabrication of the initial loading fuel for the experimental fast reactor "Joyo"
July '75	Start of fabrication of the initial loading fuel for the ATF "Fugen"
April '83	Start of operation of the Plutonium Fuel Production Facility
October '83	Start of fabrication of the initial loading fuel for the FBR "Monju"
November '00	Start of fabrication of the initial loading fuel for the experimental fast reactor "Joyo" MK-Ⅲ
November '01	Completion of fabrication of the MOX fuel for the ATR "Fugen" (Total number of assemblies : 773)
April '03	Start of fabrication of the first exchange fuel for the experimental fast reactor "Joyo" MK-Ⅲ

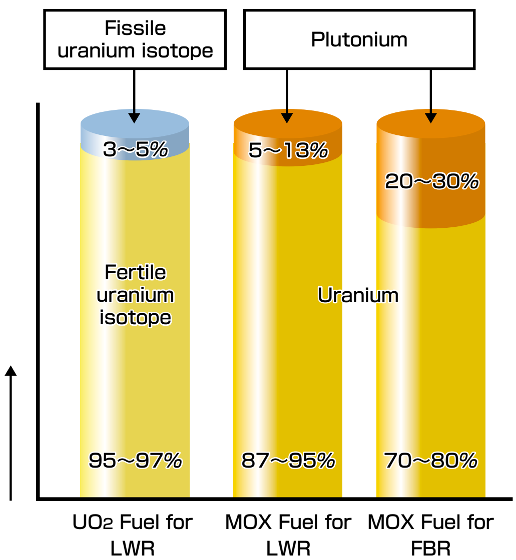
MOX Fuel Assembly





One fuel pellet for the FBR Monju is capable of generating approximately 1200KWh electricity, which is equivalent to the amount of electricity consumed in one household for a period of about four months.
(Household power consumption : 290KWh/month)

MOX fuel



The spent fuel from the reactor includes residual uranium and newly produced plutonium. The plutonium and the uranium recovered through reprocessing of spent fuel are available as the MOX fuel, which is the sintered ceramic state of the mixture of plutonium oxide and uranium oxide for the power generation.

MOX Fuel Fabrication

Homogenizing

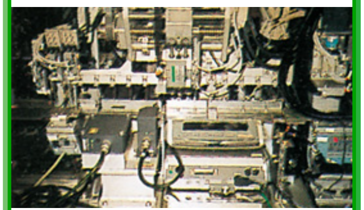
Plutonium and uranium are blended for homogenization

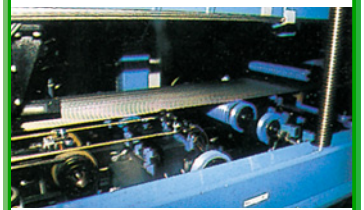
Pelletizing

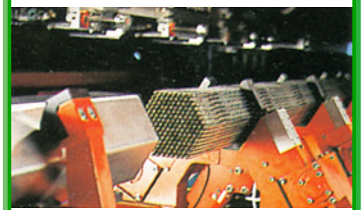
The homogenized powder is compressed into pellets

Sintering

Pellets ara sintered at about 1700℃

Inspection

Dimension,density and appearance of pellets are inspected

Pellet loading

Finished pellets are inserted into a cladding tube(fuel pin)

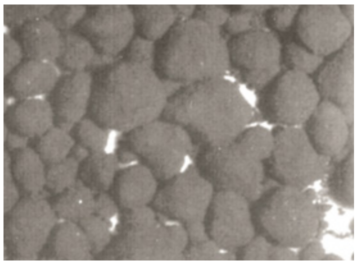
Assembling

Fuel rods are bundled into a fuel assemblies

Future roles of MOX fuel technical development facility

① Development of the Simplified Pellet Fabrication Process

In JAEA, Simplified Pellet Fabrication Process, is developed to reduce fuel fabrication cost drastically. This process has a concept of accurately adjusting plutonium content in the solution mixing step of plutonium nitrate and uranyl nitrate, converting from the mixed solution to MOX powder by using the microwave direct denitration method, and directly pelletizing the flowable MOX powder without mixing in additives. By introducing this process, it is possible to omit the powder preparation steps such as ball-milling in the conventional process.


Conventional powder


Flowable powder
(Simplified Pellet Fabrication Process)

② Technical development of MOX fuel Fabrication with TRU and research physical properties

JAEA has developed MOX fuel fabrication techniques with transuranium elements of Np, Am and Cm for an advanced nuclear recycle, which is expected to reduce the high level radioactive waste and to utilize effectively resources. The development of remote-automation fabrication and investigation of physical properties has been carried out as a new technology for the fuel. Fuel pins of MOX and Np and Am were fabricated and irradiated in Joyo.

③ Technical cooperation for Japan Nuclear Fuel Ltd.(JNFL)

Japan Nuclear Fuel Ltd. (JNFL) applied for the approval of nuclear fuel material processing to construct the MOX fuel processing facility for light water reactor (LWR) "J-MOX" at Rokkasyo-mura, Aomori Pref. in April 2005.
JAEA has supported J-MOX project with over 40 year's experience of MOX fuel fabrication.
JAEA has technical corporations with JNFL e.g. implementation of demonstrated tests for the MOX fuel processing (small-scale and full-scale demonstration test with MOX powder), consultation for the plant design of J-MOX, offering technical information, sended JAEA engineers to JNFL, and education and training of J-MOX operators.
These technical corporations are based on the technical corporation agreement with JNFL (concluded in December 2000).

Research on Geological Disposal

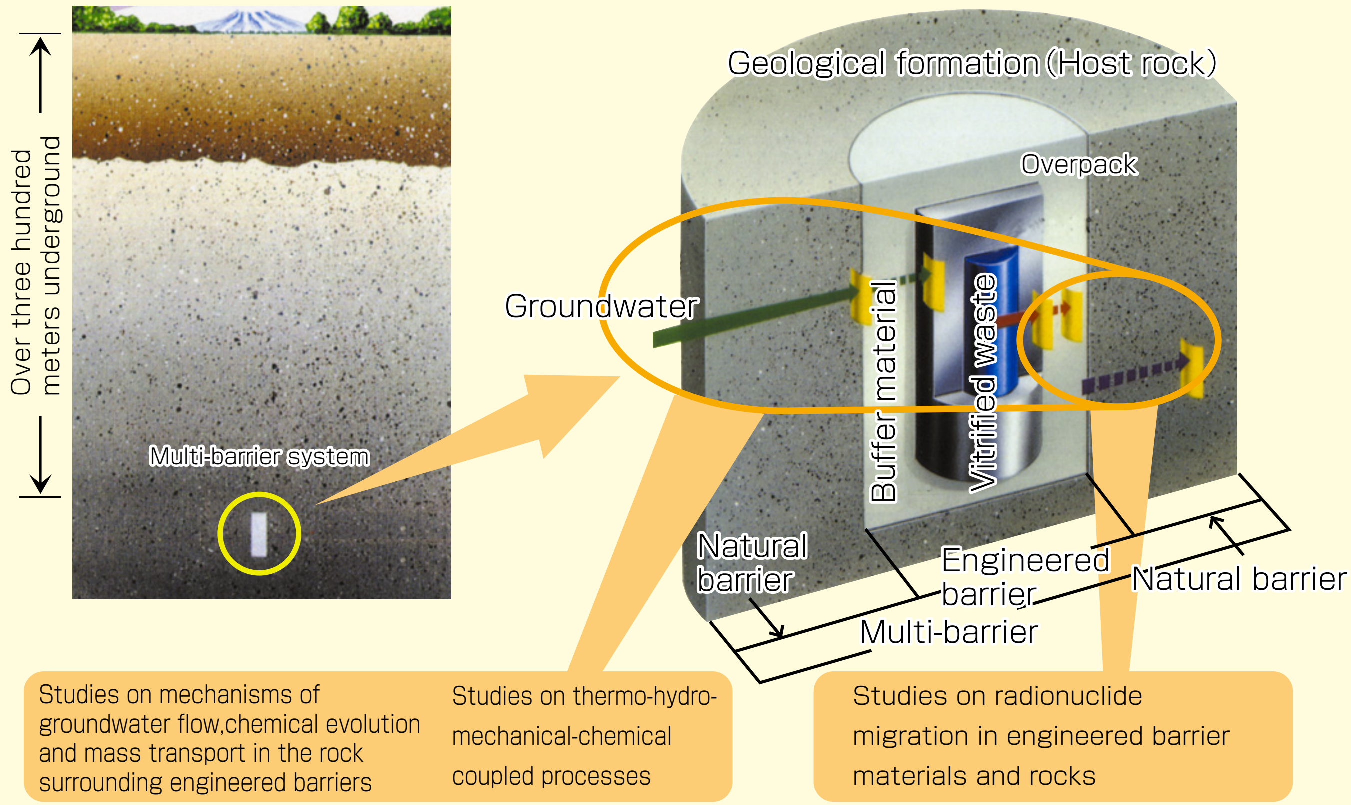
The basic concept of geological disposal of high-level radioactive waste in Japan is to construct a multi-barrier system in a stable geological environment .The multi-barrier concept provides multiple layers of protection by combining carefully selected engineered barriers with a suitable geological environment.
This system ensures the safety of human beings.

▼Stable geological environment

- To isolate the waste from biosphere

▼Multi-barrier concept

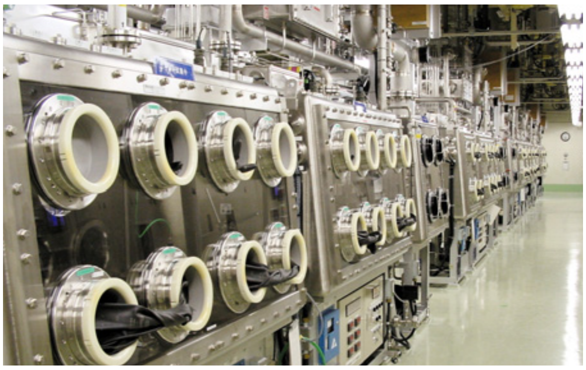
- To protect humans from radionuclides transported by groundwater



Equipment in Engineering-scale Test and Research Facility（ENTRY）

ENTRY was designed to perform a set of relatively large scale, non-radioactive experiments and to assess the performance of the multi-barrier system. The scientific and technical findings will be used for the establishment of the basis of safe geological disposal.

Equipment in Quantitative Assessment Radionuclide Migration Experimental Facility（QUALITY）



QUALITY was designed to investigate the radionuclide migration behavior under anaerobic conditions. This facility contains atmosphere-controlled glove boxes which are used to obtain basic data of radionuclide migration in engineered barrier materials and rocks at the laboratory scale. A variety of analytical equipment is available in this facility.

Radiological Safety

Environmental Monitoring

Environmental monitoring is implemented around the Tokai Reprocessing Plant to ensure environmental safety. In the terrestrial environment, environmental radiation is measured continuously using monitoring stations, and the concentration of radioactive materials contained in soil and vegetables are also analyzed. In the marine environment, the concentration of radioactive materials contained in sea water, seabed sediment ,and marine products are regularly analyzed. The results of the environmental monitoring have been openly published and disclosured to the public after authorization by the technical committee. The monitoring data are available at the following Internet web site.

URL http://www.jaea.go.jp

Analytical methods and assessment techniques are also investigated continuously to improve the qualification of environmental radiation monitoring. For example, the picture shows the result of the atmospheric dispersion of the simulation of radioactive gas discharged from the main stack of the Tokai Reprocessing Plant by SIERRA-Ⅱ (Simulation System (Ⅱ) for Emergency Dose by Released Radioactive Substances), which was developed by JAEA.

▲Monitoring boat “Seikai”

▲Environmental radiation monitoring information

▲Monitoring station

Radiological Monitoring of Personnel and Working Environment

The levels of external radiation and radioactive materials in the air are continuously monitored by radiation monitoring apparatus in order to ensure safety in the working environment.
Personal monitoring is implemented with the JAEA original designed TLD badge system and other internal monitoring devices.
Radiation monitoring instruments and dose assessment techniques are also investigated to improve the monitoring performances and applied to the occupational monitoring in nuclear fuel cycle facilities.

▲Area monitor
(Monitoring of the working environment)

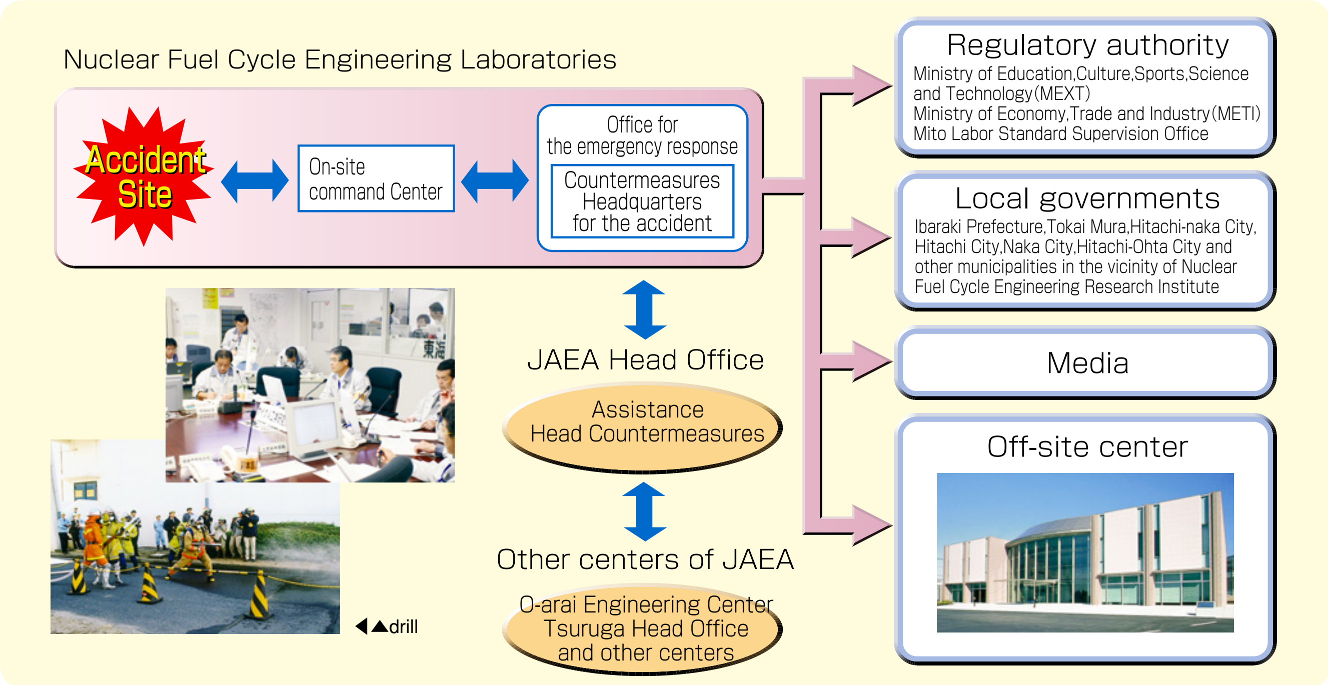
▲Mobile whole body counter system

▲TLD badge
(Personal monitoring)

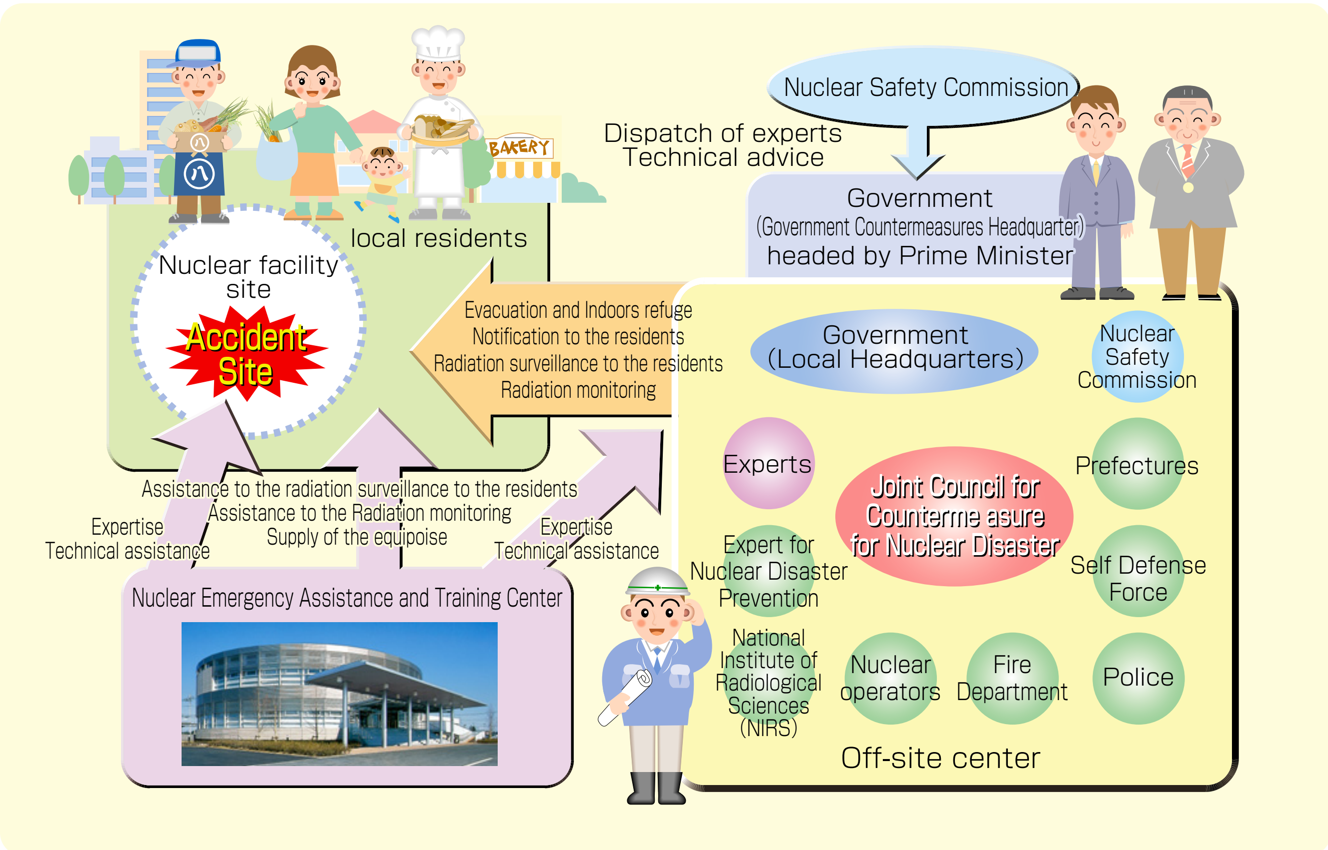
▲α/β Contamination monitor
(Monitoring of the surface contamination)

We constructed the Emergency Preparedness Building in the site of Nuclear fuel cycle Engineering Laboratories to quickly communicate necessary information and provide appropriate response.
We are also making a lot of effort to improve our emergency preparedness through such activities as drills, establishing the scheme for the emergency response.

Organizations involved in the emergency response for the accidents within Nuclear Fuel Cycle Engineering Laboratories



Governmental scheme for the emergency response

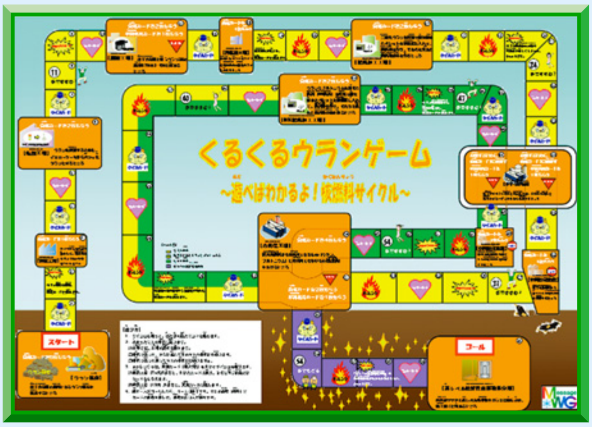


Risk Communication

Nuclear Fuel Cycle Engineering Laboratories have been implementing risk communication activities since January 1, 2001. The purpose of the activities is to promote mutual understanding between the local residents and the Laboratories.

Making risk information materials in the viewpoint of local residents

Leaflet to explain radiation



Board game to learn nuclear fuel cycle

Risk information made in collaboration with local residents

Provision of risk information for the public

Exhibit on risk information

Portal website, "Risk Information Navigator"

(Provision of information about risks that exist in our daily life)

http://www.jaea.go.jp/04/ztokai/katsudo/risk/risknavi/

Interactive communication

Community Council

(The Council members exchange their views with the executives.)

Friendly Talk

(Direct dialogue with local residents)

Education of young generation

(Students learn about radiation and experience the measurement of natural radiation.)

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Tokai Research and Development Center
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