(5) Nano-Science and Material Science

MEXT is implementing basic/fundamental research at RIKEN regarding the control and creation of nano-level physicality and functions, technological renovation of electronic materials by using cross-correlation of electrons, and basic research on nano-scale structural observation using light. Moreover, the ministry is implementing basic research in a wide range of fields at universities and independent administrative institutions.

Major research subjects conducted in FY 2010 in the nanotechnology/materials field are as shown in Table 2-2-5.

Table 2-2-5/ Major Research Projects in Nanotechnology/Materials (FY 2010)

Ministry	Research organization	Subject
Ministry of Internal Affairs and Communications	Affairs and Communications National Institute of Information and Communications Technology (NICT), etc.	-Research and development related to nano-ICT
Ministry of Education, Culture, Sports, Science and Technology		-Strategy for Rare Elements -Development of environmental functional catalyst based on nanotechnology -Development of microstructure-controlled materials -Project for the creation of innovations for advanced research facilities (Nanotechnology Network) -Development of environmental technologies utilizing nanotechnology [literal translation]
	National Institute for Material Science	-Development of common fundamental areas in the nanotechnology field -Creation and nano-structural control of new materials on a nano-scale -Development of information and communication materials utilizing nanotechnology -Development of biomaterials utilizing nanotechnology -R&D for improving environmental/energy materials -R&D on materials ensuring high reliability and safety
	RIKEN	-Research for material function creation [literal translation] -Advanced optical science research [literal translation] -Molecule ensemble research -Research on dynamic hydration structures and molecular processes [literal translation] -Material creation research [literal translation] -R&D on an ultimate energy particle observation device [literal translation]
Ministry of Health, Labour and Welfare	Health and Labour Sciences Research Grants (Nano medicine research)	-Research on the application of nano-level imaging in healthcare -Research on the development of low invasive and non-invasive medical equipment [literal translation]
Ministry of Agriculture, Forestry and Fisheries		-Development of technologies for nano-scale processing/evaluation of food materials

Ministry of Economy, Trade and Industry		-New material power semiconductor project for low carbon society -Project on ultra light, durable and innovative fusion materials for low carbon society -Project for development of alternate rare metal materials -Development of technologies for new nano-electronics semiconductor materials/new structures
	National Institute of Advanced Industrial Science and Technology	-Design of soft materials and development of functional materials [literal translation] -Development of energy-saving rare metal application technology [literal translation] -Development of nano-simulation technologies [literal translation] -Technology development on large-scale synthesis of nano-carbon materials [literal translation] -Accumulative technology development and MEMS device production from minute casting -Development of multi-functional material using suitable organic and inorganic nano-materials
Ministry of Economy, Trade and Industry	New Energy and Industrial Technology Development Organization (NEDO)	-Research and development of infrastructure for the innovation of high-strength/high-function ferrous materials - Comprehensive R&D project on device for early diagnosis and treatment of cancer -Project on the development of carbon nanotube capacitor -Spintronics nonvolatile function technology project -Challenges to nanotechnologies achieved through fusion of different fields and businesses -Development of technologies for new nano-electronics semiconductor materials/new structures. In particular, development of technologies for substrates/epitaxial growth of nitride-based chemical compounds -Development of technologies for new nano-electronics semiconductor materials/new structures. In particular, development of technologies for nano-electronic devices in new materials and structures -Project for creation of photocatalyst industry to help establish a recycle-oriented society -Technology for highly-efficient manufacturing of three-dimensional optical devices -Forged Magnesium Parts Technological Development Project -Development for fundamental technology of materials for textiles featuring new structures with advanced functional expression -Development of sophisticated evaluation base for semiconductor-like functional materials [literal translation] -Technology development for low-loss optical materials with new functions -Technology for next-generation electro-optical materials and element synthesis -Development of technologies for components using the innovative micro reaction field -Development of technologies for innovative components using high-function composite metallic glass -Development of sustainable hyper-composite technology
Ministry of the Environment		-Development of simplified all printed water quality test chip via the creation of chemical sensing nanoparticles

5 Energy

Japan stipulated the “Basic Energy Plan” (Cabinet decision: June 2010) based on the “Basic Act on

Energy Policy" (Act No. 71 of June 2002) and is promoting measures concerning the stable supply of energy, adaptation to the environment and effective supply and implementing policies on energy technology development and applications to realizing economic growth in Japan's environment and energy fields in a comprehensive and systematic manner[1]. Below are the policies established in FY 2010 in the energy field.

Prototype Fast Breeder Reactor "Monju" (Tsuruga, Fukui)
Photo: Japan Atomic Energy Agency

(1) Diversification of energy sources

(Use of nuclear energy)

Research, development, and utilization of atomic energy in Japan have been conducted according to the Atomic Energy Basic Act (enacted in December 1955), "solely for peaceful purposes, based on the premise of ensuring safety." The government has been implementing the research, development and utilization of nuclear energy based on the "Framework for Nuclear Energy Policy" (October 2005) and the "Basic Energy Plan." The nuclear energy in Japan accounts for approximately 30% of total energy consumption today.

1) Next-generation light water reactors (LWRs)

In FY 2010, evaluation on the achievements and progress of the first two years of development of next-generation light water reactors (LWRs) was conducted. As a result, the original development targets have been mainly achieved and insight on the feasibility of the plant concept was achieved.

2) Fast Breeder Reactor (FBR) cycle technology

The Fast Breeder Reactor (FBR) remarkably improves the efficiency of uranium resource use while generating significantly more fuel than what is consumed while generating electricity, the Fast Breeder Reactor (FBR) cycle technology that contributes to a stable long term energy supply for Japan. Reusing minor actinide contained in the used fuel has a potential to decrease the yield of high-level radioactive waste. Therefore, FBR cycle technology is positioned as strategically prioritized S&T a key technology of national importance in the 3rd Basic Plan.

Regarding R&D for FBR cycle technology, the "FBR Cycle Commercialization R&D project (FaCT)" is now underway for the commercialization of FBR technology, and the development of key technology for commercialization and the concept designs of the actual and demonstration plants were carried out in FY 2010.

In May 2010, the FBR "Monju" restarted its test operation after about 14 years and five months and complete the first stage of the test in July of the same year. Later on, although an accident had occurred whereby a part of the fuel exchange device (In-vessel transfer machine) had dropped while working on the fuel exchange, JAEA announced a schedule of start-up tests and the retrieval of the FBR "Monju" in-vessel transfer machine in December 2010. It is conducting necessary inspections and retrieval operation of the

1 Due to the Great East Japan Earthquake and the accidents that occurred at the Tokyo Electric Power Company, Incorporated (TEPCO) Fukushima Daiichi and Daini Nuclear Power Plant, "Energy Basic Plan" is under review in FY 2011. With regards to "Framework for Nuclear Energy Policy", establishment of new framework was under review in December 2010, however, suspended due to aforementioned accidents.

aforementioned machine, aiming to start 40% output confirmation test within FY 2011, implementation of power-rising tests around FY 2012 and to start full-scale operation in FY 2013. After starting full-scale operation, JAEA is aiming to achieve the initial goal of establishing its reliability as a power generation plant as well as the development of sodium-handling technologies within about 10 years.

In addition, five-way talks including MEXT, METI, electric power utilities companies, manufacturers, and JAEA reached an agreement to consider appropriate measures for the preparation of safety inspections, how international cooperation should be, construction of demonstration reactors, manufacture of demonstration reactor fuels, and roles on development of technologies which were set forth in the document, "Early Commercialization of Fast Breeder Reactor Cycle," announced in July 2010.

3) Uranium enrichment and advanced fuel

Since Japan relies on imports for most of its energy resources, the government has steadily promoted efforts to establish the nuclear fuel cycle through effective utilization of recovered plutonium, etc., from the reprocessing of spent nuclear fuel, in order to secure long-term energy supply stability in view of future energy supply and demand throughout the world.

Tokai reprocessing facilities
Photo: Japan Atomic Energy Agency

The government strives to ensure the transparency of plutonium use, not only through the rigorous management of nuclear materials, but through clear observation of the principle of never holding plutonium that is not required to implement current programs, so as to avoid arousing international concerns regarding the proliferation of nuclear weapons. The Cabinet Office therefore reports and discloses the use and management status of plutonium in Japan to the Atomic Energy Commission every year (reported on September 8, 2009).

From the viewpoint of assuring stable energy supply, Japan promotes the development of domestic uranium enrichment projects to obtain the enriched uranium used as fuel in nuclear power generation, while endeavoring to maintain economic efficiency, in order to secure uranium resources and the respective processes of the nuclear fuel cycle that are required for light-water nuclear reactors in Japan. The Japan Nuclear Fuel, Ltd. has been developing the new advanced centrifugal machine, featuring higher performance and excellent economic efficiency since FY 2002 with governmental support. Renewal of the new advanced centrifugal machine has been underway since March 2010, and plans are in place to start producing enriched uranium in September 2011.

4) Spent fuel reprocessing technology

In Rokkasho-mura, Aomori Prefecture, construction is underway on Japan's first private-sector reprocessing facility (with an annual reprocessing capacity of 800 tons). On submission of the application for project planning in March 1989, construction was slated to start in December 1998. However, due to the problems such as enhancement of earthquake-resistant construction and the process of vitrification of high level radioactive liquid waste, the construction is now due to start on October 2012, with the final stage (active testing) using spent fuel currently underway. In addition to R&D to enhance vitrification technology for high-level radioactive liquid waste, JAEA is providing technical assistance, including human resources, for the Rokkasho reprocessing plant, and construction and operation of the plant aims at the steady establishment of reprocessing technology on a commercial scale, as well as progression toward establishing the nuclear fuel cycle.

5) Geological disposal of high-level radioactive waste

On geological disposal technology for high-level radioactive waste, by continuous implementation of R&D for greater improvement of reliability, disposal project by Nuclear Waste Management Organization of Japan and maintenance of basic infrastructure that supports national safety regulations have been executed. Such R&D is conducted by JAEA in close cooperation with the relevant research institutions. JAEA is promoting investigation on geological environment and evaluation on modeling methods and its validity on deep underground, in Mizunami City, Gifu Prefecture and in Horonobe-cho, Hokkaido Prefecture.

6) Technologies for decommissioning nuclear facilities and treatment/disposal of radioactive waste

It is important that decommissioning of nuclear facilities and treatment/disposal of radioactive waste should be conducted under the responsibility of nuclear facility establishers and radioactive waste generators in a planned and efficient manner. JAEA is developing the technologies needed to achieve safe and reasonable treatment, disposal, and reduction of the generated radioactive wastes as well as the recycling of resources. The Decommissioning Engineering Center (reorganized from the Advanced Thermal Reactor “Fugen” in 2008) is executing investigations and research on safety demonstrations; the dismantling of equipment is on schedule and the project will be completed by FY 2028.

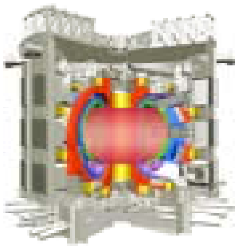
7) Fusion energy

Fusion energy is expected to be one of the future solutions for both a plentiful energy issue and global environmental problems for the following reasons: (1) fuel resources are abundant, (2) no greenhouse gases are emitted during the process of electric generation, and (3) it generates large amounts of electric power from small quantities of fuel. Fusion energy R&D has been promoted using three types of reactors in Japan, including a tokamak reactor[1] (critical plasma test equipment JT-60, JAEA; operations have been stopped since August 2008 for replacement to superconductive type); a helical reactor[2] (large helical device LHD, NIFS); and a laser type reactor[3] (GEKKO XII, Institute of Laser Engineering at Osaka University). The research achievements are leading the world in fusion energy technology.

Furthermore, Japan takes an active role in the ITER (International Thermonuclear Experiment Reactor) Project[4], which aims for demonstrating S&T feasibility of fusion energy. Japan (Rokkasho-mura, Aomori Prefecture and Naka city, Ibaraki prefecture) also implements, “Broader Approach” Activities

1 Method in which nuclear fusion reaction occur on closing in the heated plasma which is created by twisted magnetic field where magnetic field is formed by coils and plasma electric current.
2 Method in which nuclear fusion reaction occur on closing in the heated plasma, created by twisted magnetic field by twisting the coils itself.
3 Method in which nuclear fusion reaction occur by implosion of nuclear fusion fuel utilizing highly concentrated laser.
4 International collaborative research and development project that conducts construction and operation of nuclear fusion test reactor in France under the cooperation between Japan, Europe, United States, Russia, China and Korea.

(advanced R&D projects), that complement and support the ITER Project within the country through Japan-Europe cooperation.



International Thermonuclear Experiment Reactor (ITER)
Photo: JAEA/ITER Organization

International Fusion Energy Research Center (Rokkasho, Aomori)
Photo: JAEA

8) Basic and fundamental R&D for atomic energy

Basic and generic R&D for atomic energy is important to support utilization and development of atomic energy, such as maintaining a high-level technical basis concerning atomic energy utilization, as well as to create new knowledge and technologies. JAEA conducts basic and generic research projects concerning nuclear and reactor engineering, irradiation material science, actinoid and radiation science, environmental science, radiation protection, computer science technology, separation and conversion technology, and advanced basic, and other basic and generic research. In addition, MEXT determined strategic program themes that clarify policy needs for the enhancement and strengthening of basic and generic research, following the "Initiatives for Atomic Energy Basic and Generic Strategic Research" [literal translation], aiming at the promotion of research conducted in a competitive environment.

9) Innovative nuclear energy system including a high-temperature gas-cooled reactor

JAEA is promoting performance evaluation of the high temperature gas-cooled reactor the High Temperature Engineering Test Reactor (HTTR) test operation, as well as R&D of the IS process in which hydrogen is produced by pyrolysis of water, in order to establish high temperature gas-cooled reactor technology, which allows for various types of energy supply and heat utilization technologies such as hydrogen production. In FY 2010, based on the test results that the nuclear core becomes naturally stable on losing coolant flow in the reactor core, JAEA confirmed the safety of high temperature gas reactor.

(Enhancement of nuclear security and nuclear non-proliferation and peaceful use of nuclear power)

Japan concluded that the full-scope safeguards agreements between IAEA in 1977 for the purpose of peaceful nuclear energy activities of all nuclear substances are under the safeguard of the applicable countries, in response to the ratification of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1976 and accepted the "safeguards" of IAEA, which is a measure for preventing nuclear materials from being diverted to nuclear weapons.

In 1999, on top of the conventional safeguard agreement, Japan also additionally concluded an additional act to enhance safeguard measures and as a result of her proactive actions, IAEA first concluded in its Safeguards Statement in 2004 that "all nuclear materials remained in use in peaceful activities" and the conclusion has been maintained ever since. Based on the conclusion, IAEA applied the "Integrated Safeguards," which is a more effective safeguard method by conducting less inspection through inspections without any notification to Japan. In 2008, the world's first Site-Level Integrated Safeguards Approach, for facilities handling plutonium, once applied only to the individual facility were introduced and developed as comprehensive safeguards applied to multiply facilities at once.

In addition, to contribute to the realization of more effective international safeguards, in FY 2009, Japan initiated implementation of evaluation and acknowledge of original safeguard activities.

Furthermore, at a Nuclear summit that took place in April 2010, Japan proposed the establishment of a "nuclear security and nuclear non-proliferation support center[1]" to train personnel and provide technical supports to implement the safeguards steadily and enhance the nuclear security and nuclear non-proliferation for Asian countries considering the introduction of nuclear energy. Japan also proposed initiatives including measurement of nuclear substances, detection technology, and to develop nuclear forensics technology to identify the source of nuclear substances used in terrorist activities.

By utilizing Japan's rich experiences on nuclear power applications, in order to contribute to the enhancement of global nuclear security and nuclear non-proliferation system, these activities are more effective under international cooperation. In November 2010, at the Japan-U.S. Summit, Japan worked on taking the initiative by establishing the Japan-United States nuclear security working group, etc.

(Ensuring nuclear safety)

Safety is the indispensable prerequisite for the research, development, and utilization of nuclear energy. Efforts such as stringent regulations and management, as well as execution of safety-related research, are essential to ensuring safety. Moreover, assuming the premise that the accidents cannot be 100% eliminated, countermeasures are needed to ensure that devastation to the lives and health of local residents can be minimized, should an accident occur.

As for research, development and utilization of nuclear energy in Japan, the government imposes safety regulations on nuclear facilities at every stage of design, construction and operation, in accordance with the "Nuclear Reactor Regulation Act." In addition, regarding radioactive isotopes and radiation generators used in the medical, agricultural, and industrial sectors, among others, the government implements safety regulations based on the "Act Concerning the Prevention from Radiation Hazards" to prevent radiation damage resulting from the use of the above. In 2010, the new law to revise the part of the Act Concerning the Prevention from Radiation Hazards including the introduction of a clearance system, strengthening of introduction and abolition measures on regulations on radioactive substances was enacted at the 174th ordinary session of the Diet and promulgated in May of the same year.

As for nuclear emergency countermeasures, based on the "Act on Special Measures concerning Nuclear Emergency Preparedness," measures including dispatch of specialists in nuclear emergency preparedness, designation and maintenance of Off-site Emergency Centers and implementation of emergency drills are being taken.

For assessments of environmental radiation, MEXT and other relevant ministries and agencies, prefectural governments and nuclear operators conduct radiation surveys in areas surrounding nuclear

1 Established in JAEA in December 2010

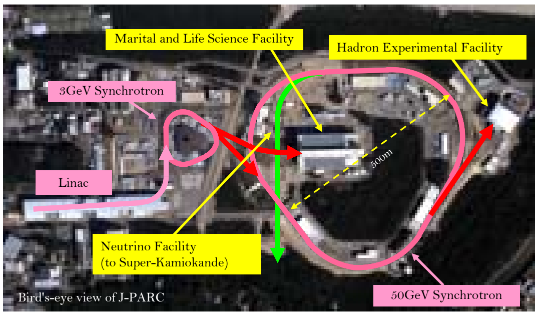
facilities, additionally surveying environmental radioactivity levels in Japan and nuclear-powered military vessels upon entry into Japanese ports. In August 2009, the Nuclear Safety Commission of Japan set forth the “Prioritized Nuclear Safety Research Program (2nd term),” in effect for five years from FY 2010, considering the domestic and international trends and issues regarding research into the safety of atomic energy.

Actions taken on the Tokyo Electric Power Company, Incorporated (TEPCO) Fukushima Daiichi and Daini Nuclear Power Plant accidents that occurred due to the Great East Japan Earthquake on March 2011 are reported on Part 1 “Great East Japan Earthquake.”

(Promotion of nuclear S&T, and development of infrastructure for research, development and utilization of nuclear power)

1) Promotion of quantum beam technology

Quantum beam technology using an accelerator or high power laser has broad applications in areas ranging from academic research, such as exploration of the fundamental principles of nature, to industrial use.



Japan Proton Accelerator Research Complex (J-PARC) (Tokaimura, Ibaraki)
Photo: J-PARC Center

The Japan Proton Accelerator Research Complex (J-PARC Project), built and operated jointly by JAEA and the High Energy Accelerator Research Organization (KEK) is contributing to R&D spanning a variety of fields including life science, material science, nuclear physics and particle physics through the application of various secondary particles, such as neutron, meson, and neutrino, released from the proton accelerator with a global maximum level of beam intensity. In addition, RIKEN is promoting research on clarifying the origin of elements, construction of ultimate atomic nucleus model and application of RI that contribute to the society and industry, by using advanced heavy ion accelerator facility “RI Beam Factory” which generates beams of all types of radioactive isotopes (RI), from hydrogen to uranium, with the highest intensities in the world..

2) Dissemination of radiation utilization

Since radiation is used in a wide range of fields from basic and applied research to practical areas such as medicine, engineering, and agriculture, it is important to promote radiation usage while conducting research and development.

In terms of broad utilization, radiation is employed to some degree in diagnosis and cancer treatment in the medical arena. For example, treatment using particle beams has the advantage of levying fewer burdens on patients since the anesthesia and incisions with surgery are not required. In the agricultural sector, radiation is used for the extermination of harmful insects and improvement of crop varieties. Academic research has been conducted on the movement of water and the accumulation of harmful metals in plants, for example. In the industrial field, radiation is used for the production of semiconductor devices and radial tires. In addition, radiation is actively used in the reform and manufacture of various types of industrial products, and in the sterilization of medical devices.