Chapter 2 Realization of Sustainable Growth and Social Development in the Future

Section 1 Recovery from and Reconstruction after the 2011 Great East Japan Earthquake

1 Promotion of Measures to Address Critical Issues

(1) Industrial recovery from, and reconstruction after, the Great East Japan Earthquake in the afflicted regions

The various problems that surfaced as a result of the earthquake disaster are being resolved through the full use of science and technology (S&T), towards realizing the vigorous revival of the afflicted regions. Advanced R&D that takes advantage of the strengths and characteristics of each region is being pursued, leading to the creation of new growing industries and employment, which are expected to help the reconstruction in the disaster areas.

The Ministry of Internal Affairs and Communications (MIC) is planning to establish new facilities for R&D and empirical experiments at Tohoku University and other institutions, with the aid of the National Institute of Information and Communications Technology (NICT). The plan is to actively share information about the results at home and abroad so as to organize a new R&D and innovation base with industry-academia-government collaboration in the fields of information and communications.

For the restoration of the offshore marine ecosystem, which was damaged by tsunamis on the Pacific coast of Tohoku, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has established the Tohoku Marine Science Center in collaboration with local municipalities and national ministries. The center has been conducting surveys and other research on the offshore marine ecosystem. The center also conducts R&D of technology to foster new industries. The results have been used to draft a local fishery plan and to select the locations of fish farms.

MEXT is also promoting the Tohoku Innovative Materials Technology Initiatives for Reconstruction, with the aim of driving the development of the materials industry in Tohoku area by forming a nanotechnology R&D center through industry-academia-government cooperation and of developing cutting-edge materials using world-leading technologies in the nanotechnology and material fields, in which universities and industries in Tohoku excel.

Moreover, through the Japan Agency for Medical Research and Development (AMED), MEXT is also implementing the Tohoku Medical Megabank Project, which promotes population-based cohort study in areas affected by the GEJE. The project aims to restore medical services in the disaster areas and to provide advanced medical care, such as preventive methods that contribute to personalized medicine. The project is being organized in close collaboration with a regional medical information center that is being developed with the support of MIC and the Ministry of Health, Labour and Welfare (MHLW).

Aiming at revitalizing agriculture, forestry and fishery, which are the main industries in the areas affected by the disaster, at accelerating the restoration and reconstruction of farm and fishery villages, and at fostering new types of agriculture, forestry and fishery that have high growth potential, the

Ministry of Agriculture, Forestry and Fisheries (MAFF) has been conducting large-scale empirical research by applying cutting-edge technologies in agriculture, forestry and fishery, analyzing the effects of such technologies and promoting the dissemination of the research results. In doing so, MAFF has established empirical research sites for agriculture at farming villages in Iwate, Miyagi and Fukushima prefectures and has established empirical research sites for fishery at fishing villages in Iwate and Miyagi prefectures. Empirical research topics include land-extensive farming; greenhouse horticulture; and shellfish and fish culture, release and processing. These unique empirical research efforts have been conducted in coordination with farmers and fishermen in the afflicted regions in accordance with the conditions of each afflicted prefecture.

The Ministry of Economy, Trade and Industry (METI) is assisting in a joint project to develop and demonstrate medical equipment made by manufacturers and medical institutions in Fukushima Prefecture and a project led by Fukushima Medical University to found a drug discovery center through the Recovery Fund Concerning Nuclear Emergency Preparedness in Fukushima, established for restoration from nuclear hazards.

The Fukushima International Research and Industrial City (Innovation Coast) Initiative aims to create new industries that are founded on leading-edge technologies for nuclear reactor decommissioning and robotics in the Hamadori area of Fukushima Prefecture. Proposed outlines and schedules for each project, including a robot test field, were presented at a meeting for the promotion of the Innovation Coast Initiative in June 2015. Upon this announcement in August 2015, Project No.1 for the Fukushima Hamadori Robot Demonstration Area was conducted at the Ota Industrial Site in Minamisoma City. (By February 2016, five demonstration sites will have been determined.) In September 2015, Naraha Remote Technology Development Center started partial operation. The initiative is being steadily realized. METI will be supporting the development of robots, robot test fields and robotics facilities that are to be shared by companies and universities, and will be supporting the commercialization of robots, which will contribute to regional revitalization. Furthermore, METI has also supported an industry-academia-government project for the founding of a renewable energy R&D center, a project targeting the commercial operation of the largest floating offshore wind power plant in the world and an initiative to build a disaster-resistant smart community focusing on the use of renewable energies.

In addition, METI has supported the development of an advanced ICT laboratory at Aizu University. The lab will consolidate the knowledge that is possessed by industry, academia and government both within and beyond Fukushima Prefecture and will serve as a center for empirical research on data science that supports the development of renewable energy and medical care.

(2) Restoration and rehabilitation of infrastructure

The damage in the disaster area was devastating. The earthquake, tsunamis and soil liquefaction caused many structures, including civil engineering structures, to be washed away or otherwise destroyed and caused infrastructure to be blocked. In light of such damage, technical advice for the restoration of bridges and banks that suffered from the tsunamis is being provided. R&D on restoring lifelines and improving the seismic capacity of structures is also being conducted.

The intensive use of telephones and the widespread, severe damage to communication facilities made it impossible to secure the necessary lines of communication during the disaster. In light of this, MIC has

been conducting R&D on information and communications technology (ICT) for improving the disaster-resistance of information and communications facilities, and for collecting data on damage at times of disaster.

MIC is also developing the following technologies: disaster-resistant wireless mesh network technologies that will allow local wireless networking even when the communication infrastructure is devastated, and a wireless relay technology that uses aerial drones as virtual communication towers. Together with the municipality, MIC is conducting field demonstration experiments of these technologies.

Having learned lessons from these problems, MIC has vigorously applied its research results, such as communication capacity reallocating technology to rectify increased telephone demand (network virtualization technology) and a communication system that can be carried in disaster-stricken areas for emergency restoration of communications (a movable and deployable ICT resource unit) in communities in Japan and worldwide. A demonstration test project for the Movable and Deployable ICT Resource Unit in the Philippines is an example of one of these activities that is being conducted in collaboration with International Telecommunication Union (ITU) and the Ministry of Science in the Philippines.

The NICT has been conducting R&D on an airborne polarimetric and interferometric synthetic aperture radar system (Pi-SAR2[1]) that can clarify the situation on the ground in disaster-stricken areas as needed, regardless of weather conditions, and on electromagnetic wave sensing technology for the non-destructive diagnosis of structures that may have suffered earthquake damage.

MEXT launched the Special Project for Reducing Urban Vulnerability to Mega Disasters, in order to investigate urban resilience and assess the seismic collapse capacity of buildings using the 3-D Full-Scale Earthquake Testing Facility (E-Defense).

The National Research Institute for Earth Science and Disaster Prevention (NIED) has investigated the destruction process of actual structures such as buildings and other infrastructure in large-scale shaking experiments using E-Defense and has conducted R&D on effective disaster mitigation technologies to minimize damage from disasters

In addition, the National Institute for Materials Science (NIMS) has comprehensively conducted R&D in the material field, in which Japan excels, for technologies and new structural materials to inspect, diagnose, repair and upgrade infrastructure with the aim of extending the service life and enhancing the earthquake resistance of the social infrastructure.

The National Institute for Land and Infrastructure Management (NILIM) of MLIT has conducted R&D on technologies to support infrastructure recovery and TEC-FORCE[2] activities using airborne portable SAR, conventional camera sensors, real-time observations and surveillance data, in order to accelerate the initial response to a large earthquake. The institute also studies the appropriate post-quake supply of emergency temporary housing and provides technical support to local governments concerning housing recovery.

Aiming at prompt responses to damage from tsunamis and soil liquefaction, the Public Works Research Institute (PWRI) is conducting research on the behavior of bridges subjected to tsunamis, including their tsunami resistance; on technologies that address issues associated with such behavior; and on

1 Polarimetric and Interferometric Airborne Synthetic Aperture Radar System 2
2 Technical Emergency Control Force of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

methods for improving the accuracy of judgments on soil liquefaction state.

Towards early recovery and reconstruction after a major earthquake, the Port and Airport Research Institute (PARI) is conducting research on forecasting earthquake- and tsunami-related deformation and performance degradation for structures in coastal areas and the areas behind them, and on improved safety and reliability for facilities in coastal areas.

(3) Realization of safe living in the disaster areas

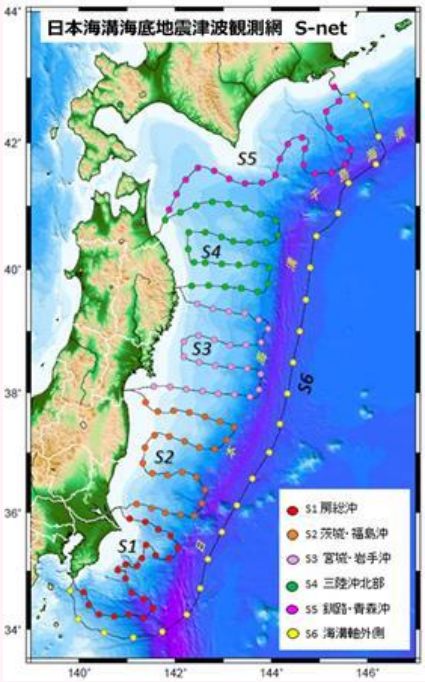
① Reinforcing efforts for disaster prevention and mitigation measures in the disaster areas

Major earthquakes similar to the Great East Japan Earthquake can occur in other areas in Japan. Therefore, efforts have been made towards the improvement and enhancement of studies and observations of earthquakes and tsunamis.

In FY 2011, MEXT launched the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench, for the detection of earthquakes and tsunamis off the coast of the Tohoku Region. Construction was conducted off the coasts of Ibaraki and Fukushima prefectures and off the coasts of Kushiro and Aomori cities in FY 2015, aiming for a launch of operations in FY 2015 (Figure2-2-1).

The Fire and Disaster Management Agency (FDMA) is developing surveillance and monitoring technology that uses an unmanned helicopter for the rapid location and saving of survivors at tsunami-hit sites, for reconnaissance technology applicable to fire-fighting in debris or water-covered areas and for rescue technology. A prototype has been developed, test operated and improved in advance of practical application. In preparation for interrelated massive earthquakes, the agency collected knowledge from studies on the prediction of strong ground motion at petrochemical complexes and on preventive measures against and estimation of petroleum tank damage caused by tsunamis, to establish technical standards for tsunami countermeasures and a petroleum tank damage estimation system. Furthermore, the agency is collecting information on fires that broke out during the GEJE and is conducting studies on preventive technology and fire-prevention measures by determining the characteristics of fires depending on the presence or absence of tsunami damage based on survey analyses of fires and the causes of their spread. The FDMA conducted a fire experiment to clarify the risk factors related to fighting fires that involve solar power systems and to formulate a policy for safe fire-fighting. Also, the agency analyzed the gases generated by the combustion

■ Figure 2-2-1 / Seafloor observation network for earthquakes and tsunamis along the Japan Trench



Source: MEXT

Fire whirls, which occur leeward of the flame

Source: National Research Institute of Fire and Disaster (NRIFD)

of solar power systems and studied the development of power generation control technology.

② Efforts to address issues associated with the disaster at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company, Inc. (TEPCO)

(i) Implementation of radiation monitoring

With respect to the radiation monitoring necessitated by the accident at the Fukushima Daiichi Nuclear Power Station of TEPCO, ministries, local municipalities and other authorities are measuring air dose rates at monitoring posts, analyzing radioactive substances in soil in terms of nuclides, analyzing radioactive substances in the water and deposit in rivers and seas, and monitoring radioactive substances in food and tap water. This is being done in line with the Comprehensive Monitoring Strategy (adopted by the Monitoring Coordination Meeting in August of 2011 and revised in April 2015) (Figure 2-2-2).

The Nuclear Regulatory Authority is the governing body for radiation monitoring. It confirms and analyzes monitoring data from organizations concerned and publishes a weekly summary on its website[1]. In FY2015, to clarify the distribution of radioactive substances released as a result of the accident at the TEPCO Fukushima Daiichi Nuclear Power Station, the ministry collated information concerning the distribution radiocesium and the like (Figure 2-2-3). The ministry also published the results of travel surveys conducted in cooperation with local governments.

In addition, the ministry conducted aerial monitoring within and beyond an 80-km circumference from the TEPCO Fukushima Daiichi Nuclear Power Station and announced the air dose rates (Figure 2-2-3). In coastal areas, sea water, seafloor beds and marine life off the coasts of Fukushima, Miyagi and Ibaraki prefectures were jointly monitored by the relevant ministries and local governments in line with the Marine Area Monitoring Procedure formulated on April 1, 2015.

Air dose rates are measured by a real-time dose measurement system set up in Fukushima Prefecture, using portable monitoring posts set up in the whole of the prefecture and neighboring prefectures and by fixed monitoring posts set up in all prefectures throughout Japan in order to strengthen the nationwide radiation survey system. These measurements are displayed on the website on a real-time basis4) (Figure 2-2-4).

MAFF conducted surveys on the distribution of radioactive materials in farmland soil to advance efforts to restart farming. These include farmland decontamination.

1 http://radioactivity.nsr.go.jp/ja/index.html

■ Figure 2-2-2 / Monitoring system implementation by ministries in accordance with the Comprehensive Monitoring Strategy

Major monitoring targets in the Comprehensive Monitoring Plan (modified on April 1, 2014) * Monitoring systems of ministries according to the Comprehensive Monitoring Plan

Monitoring of the environment in general throughout Japan (Nuclear Regulation Authority, relevant prefectural authorities)
- Real-time publication of measurement results of air dose rate at monitoring posts in each prefecture
- Monthly concentration measurement of radioactive substances for precipitation composition (dust in rain or the air), once three months for clean water (at the faucet) to the same accuracy of analysis as the level research before the accident
- Aerial monitoring in the area of a relatively-high level of deposition amount of radioactive substances in the prefectures adjacent to Fukushima Prefecture

Monitoring of the environment in general throughout Fukushima Prefecture (Nuclear Regulation Authority, Nuclear Emergency Response Headquarters, Fukushima Prefecture, TEPCO and others)
- Real-time publication of measurement results of air dose rate at portable monitoring posts placed in Fukushima Prefecture and the prefectures adjacent to Fukushima Prefecture.
- Continuous measurement of air dose rate, airborne dust etc. around the NPP
- Check of distribution of air dose rate and deposition situations of various radioactive substances on the ground as well as survey of radioactive substances transfer in the land areas
- Periodical aerial monitoring within 80 km of the NPP
- Detailed monitoring of the evacuation order areas

Monitoring in marine areas (Nuclear Regulation Authority, MLIT, MAFF, Japan Coast Guard, MOE, Fukushima Prefecture, TEPCO and others)
- Concentration measurement of radioactive substances in marine water, soil and organisms in (1) marine areas adjacent to TEPCO Fukushima Daiichi NPS, (2) coastal areas, (3) offshore areas, (4) oceanic regions and (5) Tokyo Bay, centering on Fukushima Prefecture and neighboring prefectures

Monitoring of water environment (MOE, Fukushima prefecture)
- Concentration measurement of radioactive substances and measurement of the air dose rate in water, sediment and environment samples from rivers, lakes, marches, water sources, ground waters and coastline areas in Fukushima prefecture and neighboring prefectures

*** The results of each monitoring as shown above are collectively published via the portal site set up on the Nuclear Regulation Authority website.**

Monitoring of schools and nursery centers (Nuclear Regulation Authority MEXT, MHLW and Fukushima Prefecture)
- Real-time publication of measurement results of air dose rate at about 2,700 real-time dose measurement systems placed at schools in Fukushima Prefecture
- Concentration measurement of radioactive substances in water in outdoor pools
- Check of radioactive substances concentration in school lunches

Monitoring of seaports, airports, parks, sewage etc. (MLIT, Fukushima Prefecture, local authorities and others)
- Concentration measurement of radioactive substances in sewage sludge
- Measurement of air dose rate at seaports, airports, urban parks etc.

Monitoring of waste in natural parks, etc. (MOE, Fukushima prefecture, municipalities, TEPCO and others)
- Analysis of concentration measurement of radioactive substance in wild plants and animals
- Concentration measurement of radioactive substances in final effluent from waste disposal and treatment facilities and measurement of the air dose rate at site boundary pursuant to the Act on Special Measures in relation to Measures for Environmental Pollution by Radioactive Materials

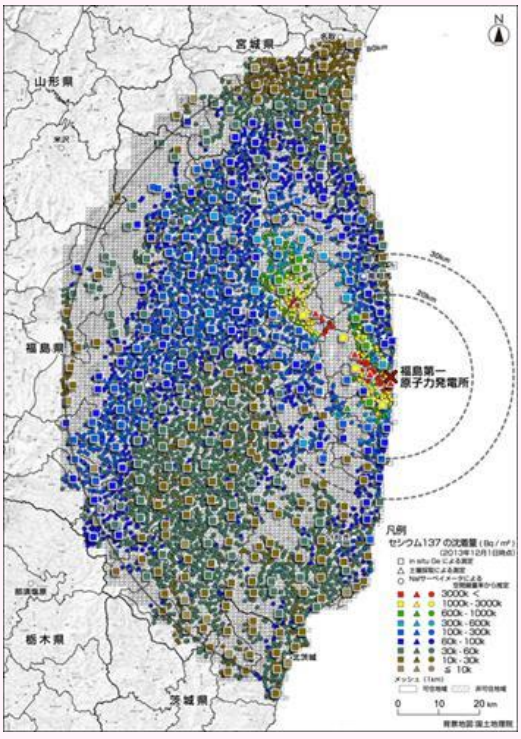
Monitoring of farm soil, forests and pasture (MAFF, Forestry Agency, relevant prefectural authorities Prefecture)
- Understanding of alteration in concentration of radioactive substances and clarification of the transfer characteristics in Fukushima Prefecture and neighboring prefectures
- Concentration measurement of radioactive substances in forest soil, branches, leaves, bark, forests wood and others in test areas in Fukushima Prefecture
- Concentration measurement of radioactive substances in pasture by prefectures
- Concentration measurement of radioactive substances in reservoirs in Fukushima Prefecture.

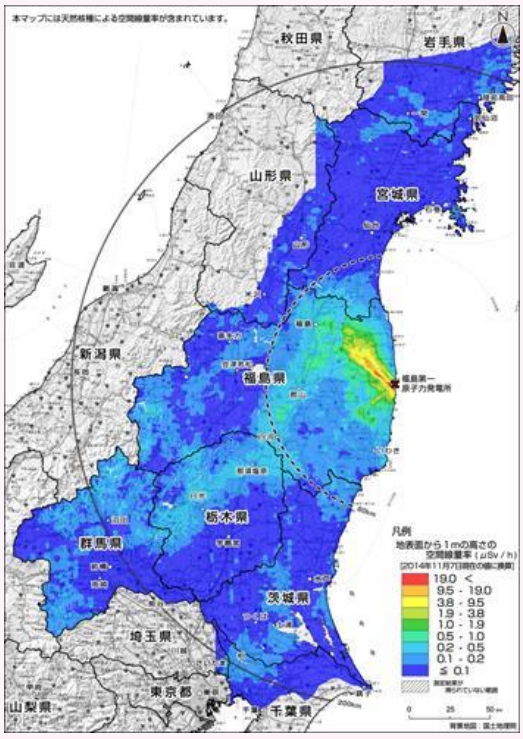
Monitoring of tap water (MHLW, Nuclear Emergency Response Headquarters and relevant prefectural authorities)
- Concentration measurement of radioactive substances in pure water from purification plants or raw water from intake sources by prefectures and in tap water by water sources in Fukushima Prefecture

Monitoring of foods (MHLW, MAFF, Fisheries Agency, Fukushima Prefecture and relevant prefectural authorities)
- Concentration measurement of radioactive substances in foods
- Measurement of actual exposure dose due to ingestion of contaminated foods

Source: Nuclear Regulatory Agency (NRA)

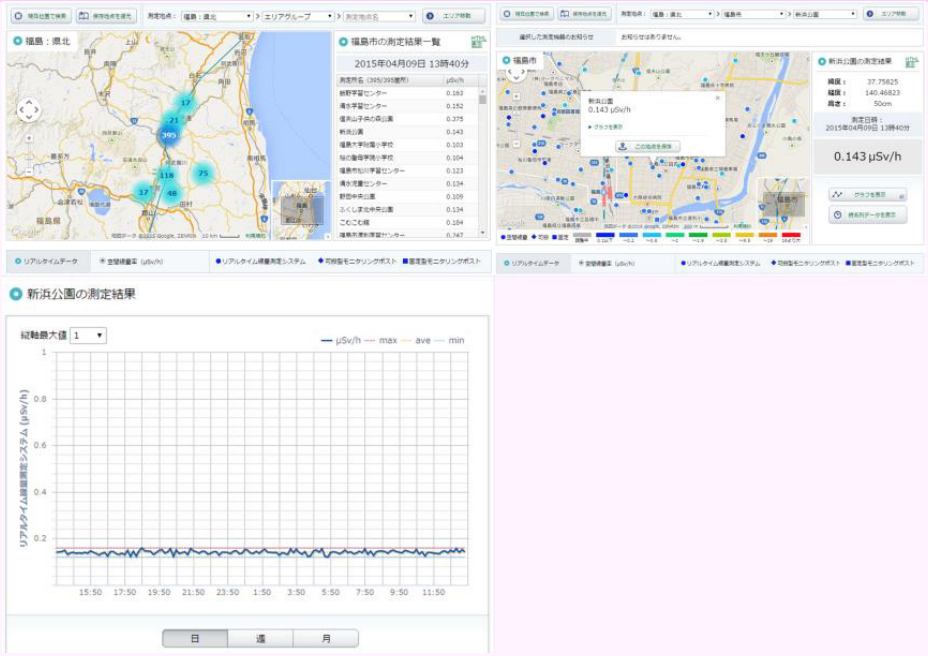
■ Figure 2-2-3 / Radioactive substances distribution map





* Cesium 137 soil concentration map (left)
* Spatial dose rate map of Fukushima and neighboring prefectures (as of November 4, 2015: 56 months after the accident) (right)
Source: Nuclear Regulatory Agency (NRA)

■ Figure 2-2-4 / Radiation measurement map



* The system has been managed by the Nuclear Regulation Authority (NRA) since April 2013
Source: NRA

(ii) Efforts for measures against radioactive substances

The organizations concerned are working together on development of technology and research and study towards establishing measures to deal with radioactive substances, for the purpose of remediating the environment contaminated by radioactive materials released in the accident at the TEPCO Fukushima Daiichi Nuclear Power Station.

The Ministry of the Environment (MOE) has been reviewing a strategy for developing technologies regarding the volume reduction and recycling of radioactive substances, towards the disposal of soil derived from decontamination within Fukushima Prefecture outside the prefecture. The ministry has also been carrying out a project to verify technologies for volume reduction from the viewpoint of assessing the effectiveness, economy and safety of technologies that can be utilized in fields including the volume reduction of radioactive substances.

In coordination and cooperation with the Fukushima Environment Creation Center, which opened in October 2015, and the National Institute for Environmental Studies, the Japan Atomic Energy Agency (JAEA) is conducting R&D into technology for measuring radiation doses, research on the behavior of radioactive substances in the environment and R&D on technologies for the decontamination/volume reduction of radioactive substances. The aim is to restore environments that were contaminated by radioactive substances released in the accident at the TEPCO Fukushima Daiichi Nuclear Power Station.

Not only does MAFF develop decontamination technologies aimed at the effective and efficient decontamination of forests and farmlands, but it also demonstrates decontamination technologies for farmland and forestry so far developed, to establish them as methods applicable in the needed places. Their results are published swiftly.

MAFF is also developing technologies to deal with various post-decontamination challenges, such as

technologies for controlling the luxuriant growth of weeds and for controlling soil runoff after the decontamination of agricultural land.

The National Institute of Advanced Industrial Science and Technology (AINST) developed equipment for greatly shortening the time required for the analysis of small quantities of radioactive cesium in environmental water by developing a zinc-substituted Prussian blue (an inorganic compound) impregnated nonwoven fabric. The equipment is expected to be used for long-term assessment of the environment at various sites. In addition, AINST carried out the standardization of technologies including these for monitoring radioactive cesium in water with low concentration of radioactive cesium, conducted tests to assess the accuracy of these technologies and prepared technical materials.

(iii) Efforts toward the decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company, Inc.

In these measures, these ministries have been supporting R&D conducted by business operators on technologies that are technically difficult and that need the government to spearhead work on them. Such R&D includes a technology for extracting fuel debris and a technology for examining the inside of reactor containment vessels.

The Naraha Remote Technology Development Center, a test facility for the smooth decommissioning of the TEPCO Fukushima Daiichi Nuclear Power Station, started partial operation in September 2015.

MEXT announced the Plan for Accelerating R&D on Reactor Decommissioning for the TEPCO Fukushima Daiichi NPS (hereinafter the acceleration plan) in June 2014. Based on the acceleration plan, MEXT set up the International Collaborative Research Center on Decommissioning under the JAEA in April 2015 to consolidate knowledge in Japan and overseas for safe, steady decommissioning. As a place for gathering knowledge within and beyond the country, an international joint research building will be completed for that center in Tomiokamachi, Fukushima Prefecture, in March 2017.

International Collaborative Research Center on Decommissioning

International joint research building (rendering)
Source: JAEA

Furthermore, based on the acceleration plan, the Research Program for Accelerated Reactor Decommissioning and the Program for Enhancing Research on Measures for Decommissioning and for the Development of Human Resources started in 2015.

Under the Research Program for Accelerated Reactor Decommissioning, to contribute to the accelerated decommissioning of the TEPCO Fukushima Daiichi Nuclear Power Station, R&D has been carried out by amalgamating and coordinating studies in various fields, including international collaborative research, and by gathering a wide range of knowledge. In coordination with the International Collaborative Research Center on Decommissioning, MEXT has been conducting basic research that addresses onsite needs in the decommissioning of nuclear power stations and has been fostering human resources who will be able to play a leading role in such a decommissioning.

(iv) Regarding compensation for nuclear damage

Since the accident at the TEPCO Fukushima Daiichi and Daini Nuclear Power Stations (hereinafter:

the accident), a number of residents have been forced to live in evacuation shelters or to give up business activities such as manufacturing and sales. It is essential that these victims receive compensation promptly, equitably and appropriately, so that they may return to safe, secure living as quickly as possible.

In accordance with the Act on Compensation for Nuclear Damage (Act No. 147 of 1961), MEXT instituted the Dispute Reconciliation Committee for Nuclear Damage Compensation. The committee has been formulating guidelines to indicate the damaged items that can be classified with certain criteria and the extent of compensation, with the input of local opinions, and it has been reviewing these guidelines as needed. Furthermore, the Nuclear Damage Compensation Dispute Resolution Center, established in August of 2011, has been conducting reconciliation of alternative dispute resolutions while improving its operations and increasing in personnel.

The government approved the New Comprehensive Special Business Plan in January 2014 (followed by revisions in April and July 2015), which made mention of providing prompt and appropriate compensation for nuclear damage and streamlined management in TEPCO. The government has been providing assistance to TEPCO through the Nuclear Damage Compensation and Decommissioning Facilitation Corporation for providing compensation smoothly. Furthermore, based on the provisions of Article 19, Paragraph 1 of the Act on Compensation for Nuclear Damage, the situation of nuclear damage from the accident and the measures taken by the government in accordance with the Act were reported in the Diet in June 2015.

The Advisory Committee on Nuclear Damage Compensation System was established within Atomic Energy Commission in May 2015. It has been studying the most desirable system to prepare for a possible nuclear accident, using specialized and cross-sectional viewpoints.

2 System Reform for Restoration and Recovery from Earthquake Disasters

To quickly and effectively realize industrial revival and rehabilitation in the disaster areas, Japan is promoting the foundation of R&D bases to accelerate industry-academia-government collaboration in and around the disaster areas.

In particular, Japan is improving its R&D bases through collaboration between industry, academia and government in an effort to create new industries to contribute to the restoration of the disaster areas.

■ Table 2-2-5 / Major projects for recovery and reconstruction from the earthquake disaster (FY2015)

Ministry/ Agency	Implemented by	Project
Reconstruction Agency	Reconstruction Agency	Expenses needed for the promotion of R&D on the environment
		Tohoku Ecosystem-Associated Marine Sciences program
		Maintenance for National Universities and Inter-university Research Institute Corporations
		Tohoku Innovative Materials Technology Initiatives for Reconstruction
		Scheme to Revitalize Agriculture and Fisheries in the Disaster Area by Deploying Highly Advanced Technology
		Forest Decontamination Demonstration Project
		Verification of the Radioactive Decontamination of Forests and the Recovery of the Forestry Industry
		Project for measures to address issues regarding radioactive containments (the development and evaluation of technology)
		Promotion of projects for industry-university-government collaboration and for regional scientific technology
	AIST	Projects to establish Fukushima as a base for renewable energy R&D
	AMED	Grants for promoting the development of medical and health care research
MEXT	MEXT	Expenses for the expansion of the earthquake and tsunami observation/surveillance system

Section 2 Promotion of Green Innovation

It is necessary for Japan to strongly promote green innovation so as to address two issues: 1) ensuring a stable energy supply and 2) responding to climate change. These issues are faced by Japan as well as the international community. Taking a long-term view and with the aim of building a stable energy supply-demand structure and the world's most advanced low-carbon society through further enhanced environmental and energy technology innovation (in which Japan has a decided advantage), Japan will actively promote the expansion and spread of such technologies and systems at home and abroad to realize sustainable growth in Japan. The Energy and Environment Innovation Strategy was formulated after an announcement by Prime Minister Shinzo Abe at the Global Warming Prevention Headquarters that took place before the UN Framework Convention on Climate Change (COP21). The key to achieving both climate change countermeasures and economic growth is the development of innovative technology.

With a target year of 2050, R&D on innovative technologies in promising fields will be strengthened in order to realize the dramatic reduction of greenhouse gas emissions around the world.

1 Promotion of Measures for Accomplishing Critical Issues

(1) Realizing a stable energy supply and a low-carbon society

To realize a stable energy supply and a low-carbon society, R&D on innovative technologies aimed at accelerating the spread of renewable energy and on innovation of the energy transmission system is being promoted throughout Japan in a manner consistent with energy security, economic efficiency, the environment and energy supply safety. In addition, measures for the promotion of biomass utilization have been undertaken according to the Basic Plan for the Promotion of Biomass Utilization (decided by the Cabinet in December 2010), which sets forth the basic policies and objectives of Japan.

① R&D on renewable energy technologies

MEXT is promoting R&D toward the improvement of technology for biomass utilization and other renewable energies. In particular, in the fields of plant science and advanced environmental materials, the ministry is promoting a comprehensive program in which universities in Japan collaborate strategically to share research targets, experimental facilities and human resources while conducting the world-leading research and fostering human resources.

To realize the restoration of the areas affected by the Great East Japan Earthquake, as well as innovative R&D on renewable energy, not only is the ministry establishing an R&D base for super-efficient solar cells in Fukushima Prefecture, but it is also implementing R&D on renewable energy technologies in cooperation with the local governments, industry and research institutes, including universities, in the affected areas based on the Basic Guidelines for Reconstruction in Response to the Great East Japan Earthquake (decided by the Reconstruction Headquarters in Response to Great East Japan Earthquake, July 29, 2011) (hereinafter: "the Restoration Basic Plan").

Under a project called the Development of Environmental Technology Using Nanotechnology, the ministry has also established a research center for collaborative fundamental R&D by industry, academia and government in order to develop technical seeds for solar power generation and other technologies, and in order to support human resource development for advanced environment technology.

The Japan Science and Technology Agency (JST) has selected technological fields, such as solar cell and solar energy systems and biotechnology, in which to promote R&D on innovative technologies within a competitive environment. The targeted technologies are aimed at developments that have a high potential for greenhouse gas reduction and that are not merely extensions of conventional technologies.

The National Institute for Materials Science (NIMS) conducts R&D on the creation of new materials to boost the efficiency of next-generation solar cells, which are essential for the diffusion of renewable energy utilization.

Ministry of Agriculture, Forestry and Fisheries (MAFF) is focusing on R&D for technologies that produce biofuels from wood, microalgae and other plant biomass, and that use renewable energy efficiently in the protected cultivation of horticultural crops.

METI is implementing R&D on the cost reduction and increased efficiency of renewable energy-related technologies, including solar power generation, wind power generation, biomass utilization, small- to medium-sized hydropower generation and ocean energy power generation. For example, regarding solar power generation, the ministry is conducting R&D on component technologies, toward the commercial application of innovative technologies such as Perovskite solar cells, the development of advanced peripherals and the maintenance technology toward improving the efficiency of the solar power generation system and developing low-cost recycling technology.

For wind power generation, the ministry is conducting R&D on the establishment of wind turbine design technology that meets the conditions in Japan, as well as conducting a survey and demonstration project for the establishment of bottom-mounted offshore wind turbine technology. For geothermal power generation, research has been made to resolve issues such as high costs and risks. Technologies have been under development for the gathering of accurate data on underground thermal resources, evaluating and controlling geothermal resources for stable power supply, and realizing an environmentally friendly advanced power generation system. For biomass energy, the ministry is conducting R&D to increase the efficiency of a cellulosic ethanol production process while reducing its costs, and to introduce and disseminate next-generation biofuels, such as algal biomass, that are compatible with food production.

The Ministry of the Environment (MOE) is conducting R&D and verification studies on renewable energy technologies that afford carbon dioxide reductions. For example, regarding geothermal power generation, the ministry is engaged in developing and verifying a power generation system for high hot spring heat utilization and safety using a non-chlorofluocarbon agent (ammonia). For uses of biomass, the ministry is conducting R&D and verification for technology to realize the combustion of fuels with a high-ratio of biomass, included as fuel for thermal power generation plants, with the aim of reducing carbon dioxide emissions. For wind power generation, the ministry has installed and verified the operation of the Japan's first full-scale floating ocean wind power generation plant with a capacity of 2 MW.

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has implemented safety and environmental measures for power generation facilities, including floating facilities, to promote renewable marine energy such as that of wind, waves and currents.

The PWRI has been developing technology that utilizes renewable energy, such as biomass and resource recycling, that can lead to a low-carbon, low environmental load society.

The NILIM is conducting studies on sewerage disposal technology to reduce greenhouse gas emissions and collect energy and resources, as well as improving energy-saving housing

② R&D on a decentralized energy system

MEXT and national R&D institutes are promoting R&D on an energy conversion and storage system that uses fuel cells and batteries. The aim is to realize an innovative decentralized energy system.

The JST is developing technologies that are regarded as having a high potential for greenhouse gas reduction and that are not merely extensions of conventional technologies. Such technologies include those for superconducting systems and electric storage devices. They are to be developed within a competitive environment. In addition, MEXT has been cooperating with METI to promote

comprehensive R&D from the stage of basic research to commercialization for next-generation storage batteries with much higher performance than those in current use.

NIMS is conducting R&D on the creation of new materials for superconducting power transmission and high-performance power generation and storage that will contribute to the development of a microgrid[1] society that combines small-scale decentralized power generation and networks.

METI is conducting the technological development and demonstration of batteries and fuel cells. For batteries, the ministry is conducting technological development for the performance enhancement and cost reduction of large renewable energy or lithium-ion batteries for next-generation vehicles, such as plug-in hybrids or fully electric cars. R&D on fuel cells for domestic use and other fixed uses, and on vehicle fuel cells, has focused on lowering costs while increasing durability and reliability. Anticipating the launch of fuel-cell vehicles into the market in December 2014, the ministry had installed about 80 hydrogen stations, mainly in four major cities, as of FY 2015.

Towards the construction of smart communities, technology demonstrations have been conducted to examine the potential of realizing negawatt trade in Japan in order to contribute to demand response[2]. Demand response controls power supply and demand towards saving power and reducing peak demand. METI is also supporting the development of energy systems for locally produced and consumed renewable energy, such as the residual heat of factories and sewers and photovoltaic power (for project planning and energy system building). In this way, METI is promoting energy efficiency and the use of renewable energy.

The MOE is implementing a verification project for a low-carbon energy system in which renewable energy sources are used at their maximum and automatically supply and consume electricity when the power supply is suspended from the grid at the time of a disaster.

③ Efficiency and low-carbonization of key energy sources

(i) Clean Coal Technology

METI has promoted the development and commercialization of thermal power generation systems, including the Integrated Coal Gasification Combined Cycle (IGCC) and the Integrated Coal Gasification Fuel-Cell Combined Cycle (IGFC), for highly efficient power generation with reduced carbon dioxide emissions. METI has simultaneously developed clean coal technologies, including advanced ultra-supercritical pressure (A-USC) thermal power generation to improve heat efficiency by a boiler-turbine system which withstands high temperatures and high pressures. R&D for carbon dioxide capture and storage has also been conducted.

(ii) Material technology innovation applicable to key energy

The JST has selected technological fields, such as ultra heat-resident materials and high quality recyclable steel, in which to promote the R&D on innovative technology within a competitive environment. The targeted technologies are aimed at developments that have a high potential for greenhouse gas reductions and that are not merely extensions of conventional technologies.

NIMS is promoting R&D on technological innovations in materials. These include the development of high-strength, heat-resistant steel geared to thermal or nuclear power plants and the improvement of

1 This is a system of mutual provision of electricity that combines small-scale decentralized power generation, power sources and network
2 These are efforts to use ICT in order to change energy consumption patterns based on the energy supply.

damage evaluation technologies for nuclear reactor materials.

(iii) Carbon Dioxide Capture and Storage (CCS)

Aiming at the practical use of Carbon Dioxide Capture and Storage (CCS), METI is advancing R&D for the demonstration of an integrated system designed to separate and capture carbon dioxide from large carbon dioxide sources and store it underground at depths of more than 1,000 m, as well as developing technology to drastically reduce costs and improve safety. METI and MOE have jointly conducted geological investigations, including elastic wave explorations, to determine areas suitable for CCS in Japan. MOE has examined the environmental impact of separating carbon dioxide from gases emitted at coal-fired power plants, and potential technologies and systems for transporting the collected carbon dioxide by ship and injecting it into the ocean floor for storage.

(iv) Innovative petroleum refinery technologies

In response to the demand for heavier crude oil[1] and lighter petroleum products[2] and in response to global warming, METI has developed innovative oil refining technologies to extract all possible petroleum products and petrochemical raw materials from residual oil generated in the course of refining heavy crude oil using petroleomics technology for molecular-level structural analysis and reaction modeling.

(v) High-efficiency gas turbine

In response to the increasing need for LNG thermal power generation, METI has conducted R&D on technology for raising the gas combustion temperature at LNG thermal power stations to 1700 degrees Celsius, in order to improve power generation efficiency while reducing fuel costs and carbon dioxide emissions.

(vi) Carbon dioxide storage as blue carbon

PARI is promoting research that includes onsite surveys in coastal areas and experiments aimed at quantitatively measuring the atmosphere/seawater gas exchange rate and the carbon flow between the seawater and benthic ecosystems (benthic flora, fauna and sediments). The aim is to establish a method for measuring blue carbon[3], which has potential for both domestic and international applications.

④ R&D on nuclear energy power and fusion

R&D toward decommissioning, decontamination and other efforts for recovery from nuclear hazards have been made according to the Acceleration Plan of Reactor Decommissioning R&D for Fukushima Daiichi NPS, TEPCO and other policies. R&D and human resource development have been promoted to support the infrastructure and safety of nuclear power generation.

Development and international collaboration with the U.S.A., France, and elsewhere, and domestic R&D have been promoted for fast reactors, pursuant to the Basic Energy Plan. Regarding the prototype Monju fast-breeder reactor, the project implementation system has been reorganized. However, in response to a November 13, 2015, recommendation by the Nuclear Regulation Authority (NRA) about

1 The share of heavy crude oil is increased
2 The share of light petroleum products such as gasoline, light heating oil becomes is higher than that of heavy petroleum products such as heavy heating oil in domestic demand
3 This is carbon isolated and stored in oceans and coastal ecosystems.

the operator of Monju, MEXT organized the Special Committee on the Management of Monju, under its minister, and started discussion on the issues. The government continues to make necessary efforts for R&D on fusion energy, which is expected to be an essential future energy source, global nuclear cooperation and other aspects of nuclear research.

(i) Securing and developing human resources in the nuclear field

There is the need to foster and secure a wide range of skilled human resources, in order to support the nuclear technology, ensure greater safety, and secure the safety of nuclear facilities and the smooth decommissioning of reactors in older nuclear power plants.

MEXT is conducting inter-organizational activities to develop human resources in an effective, efficient, strategic manner, in collaboration with the relevant sectors of industry, academia and government, based on the Global Nuclear-HRD Initiative (GN-HRD). The Initiative supports the fostering of human resources that are needed for nuclear safety and risk management in light of the lessons learned from the accident at the TEPCO Fukushima Daiichi Nuclear Power Station. For the study and examination of policies for human resource development in nuclear technological fields in view of the current situation and issues, in April 2015, the Nuclear Human Resource Development Working Group was organized under the Nuclear Science and Technology Committee, the Subdivision on R&D Planning and Evaluation, the Council for Science and Technology.

METI also has been supporting human resource development using funds provided by the Expenses for Commissioning Human Resource Development toward Improving Nuclear Safety, in order to educate field engineers involved in nuclear facility maintenance and in the nuclear safety industry. This undertaking is expected to contribute to the decommissioning of the TEPCO Fukushima Daiichi Nuclear Power Station and to the safety control of other existing nuclear power stations.

(ii) Basic and fundamental R&D for nuclear science

The JAEA is conducting basic and fundamental research on nuclear engineering, reactor engineering, irradiation materials science, partitioning and transmutation technology, radiochemistry, computational science, advanced nuclear science and related areas.

R&D has been promoted for improved safety and the diversified application of high-temperature gas-cooled reactors, with high potential for widespread industrial use in power generation and hydrogen production in addition to the inherent safety.

MEXT has launched strategic programs that address political requirements for the Center of World Intelligence Project for Nuclear S&T and Human Resource Development to reinforce basic and generic research. MEXT has been establishing strategic programs that address policy needs clearly and has been promoting research at universities and other research institutions under competitive research environments.

METI conducts R&D under the Safety Enhancement for LWRs Program -R&D Program for Plant Safety Enhancement to enhance safety measures at commercial power-generation reactors. This is based on what has been learned since the accident at the TEPCO Fukushima Daiichi Nuclear Power Station.

(iii) Fast-Breeder Reactor (FBR) cycle technologies

Fast-breeder reactors (FBRs) enable the effective use of resources, given their potential contribution to

reducing the volume and hazard potential of high-level radioactive waste by recycling minor actinide contained in spent fuel as fuel and by significantly boosting the efficiency of uranium resource utilization through the production of more fuel than is consumed while generating electricity. The Basic Energy Plan calls for international cooperation with the U.S.A. and France, and other countries while promoting domestic R&D.

The Basic Energy Plan defines Monju as an international R&D center for reducing the volume and hazard potential of radioactive waste and requires detailed studies on issues to be solved towards producing outcomes under the Monju R&D Plan launched by MEXT.

In response to inadequate equipment maintenance at Monju, the JAEA started intensive reforms. These were extended to the maintenance and management system and the quality assurance system. The JAEA submitted a report to the NRA in December 2014 as part of its reforms. MEXT organized the Monju Reorganization Headquarters, under the Vice Minister, and held meetings regularly to improve the maintenance system of Monju and to secure operational safety. The headquarters guided and managed the progress of improvements done by the JAEA. MEXT is dispatching the Monju Reorganization Director (deputy director general equivalent position) to the site and has supervised the reform of the system. However, in November 2015, the NRA recommended that an operator capable of ensuring safe reactor operation and reliable power output be found as a replacement for the JAEA. In December 2015, the Special Committee on the Management of Monju, whose members are experts, was organized under the Minister of MEXT and started discussions. Regarding the Experimental Fast Reactor Joyo, the recovery from damage caused by the failure to separate the specimen portion from the Material Testing Rig with Temperature Control-2 (MARICO-2) was completed in June 2015.

To realize very safe fast-reactor systems, METI has been conducting projects toward the establishment of the international safety design guidelines under the international cooperation framework of the Generation-IV International Forum (GIF). METI also has advanced R&D for the establishment of verification technology for fast reactors by means of Japan-French cooperation and other international cooperation frameworks. Fast reactors are expected to contribute to reductions in toxicity and in the volume of radioactive waste.

Monju (Turuga, Fukui Prefecture)

Source: JAEA

In October 2015, at a meeting between French Prime Minister Manuel Valls and Japanese Prime Minister Shinzo Abe, the two countries held discussions on further strengthening their cooperation in the development of Generation IV fast reactors, including the ASTRID project, and on finding a way of using both Monju and Joyo.

(iv) Fusion energy

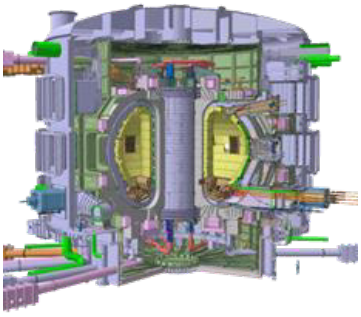
Fusion energy is expected to be the prime energy source in the future, because fuel resources abound, no greenhouse gases are emitted during power generation and small amounts of fuel can generation

power on a large scale. It could completely solve energy and global environmental problems. With regard to the application of fusion energy, three types of reactor have been the subject of advanced R&D and have produced world-class results in fusion: 1) the Tokamak reactor (JAEA, High-Performance Fusion Experiment System: JT-60SA[1]), 2) a helical reactor (National Institute for Fusion Science (NIFS) and the Large Helical Device (LHD)) and 3) a laser fusion reactor (Institute of Laser Engineering, Osaka University, GEKKO-XII Laser).

Based on international agreements, Japan has also been taking part in the International Thermonuclear Experimental Reactor (ITER) Project[2], which demonstrates the scientific and technological feasibility of fusion energy through the construction and operation of an experimental reactor. Japan, in partnership with Europe, is also advancing fusion R&D in Rokkasho Village (Aomori Prefecture) and Naka City (Ibaraki Prefecture) under Broader Approach (BA) activities that complement and support the ITER Project.

International Fusion Energy Research Center (Rokkasho Village, Aomori Prefecture)

Source: JAEA



ITER (International Thermonuclear Experimental Reactor)

Source: JAEA / ITER Organization

(v) Disseminating radiation application

At the Takasaki Ion Accelerators for Advanced Radiation Application (TIARA) of the JAEA Takasaki Advanced Radiation Research Institute, new materials are being produced and technologies for directing radiation towards semiconductors are being developed.

(vi) Disposal of radioactive waste from research facilities

The JAEA is making efforts to establish site criteria and procedures for disposal facilities in accordance with the Basic Policy Concerning the Implementation of Land Disposal (decided in December 2008 by ministers of MEXT and METI) and the General Plan for Implementation of Land Disposal (approved in November 2009; revision approved in March 2014). The aim is to facilitate the disposal of waste from research facilities.

1 In August 2008, operation of the JT-60 break-even test facility was suspended. The facility was subsequently dismantled for repair and is now being reassembled as the JT-60SA.

2 This project is for demonstrating the scientific and technological feasibility of fusion energy through the construction and operation of an experimental fusion reactor based on a seven-party international agreement (Japan, EURATOM, the U.S.A., Russia, China, South Korea and India) on the application of fusion energy, which is expected to completely solve energy and environmental problems.

R&D that addresses the need to reduce the volume and hazard potential of high-level radioactive waste is a critical national policy issue. Using an accelerator, basic study has been made on nuclear transmutation and group separation technologies.

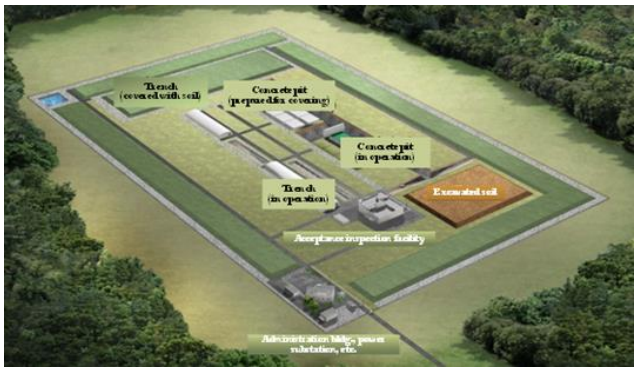


Image of a disposal facility

Source: JAEA

(vii) Efforts for assuring trust and coexistence with communities

MEXT is conducting public hearings for residents living in the vicinity of the Fast-Breeder Reactor (FBR) Monju to answer any questions they might have, or to allay any concerns with regard to the lessons learned from the accident at the TEPCO Fukushima Daiichi Nuclear Power Station. In addition, MEXT has been supporting projects to deepen the understanding of the facilities among people nationwide and in regions where those facilities are located, towards the sustainable development of the region and education on nuclear power and other energy sources.

(viii) International nuclear energy cooperation

For R&D on highly sustainable nuclear systems, Japan is collaborating in various fields with the United States, France and other countries that are advanced in the use of atomic energy. This collaboration falls under frameworks such as the GIF.

MEXT has been leading the way in the peaceful use of nuclear energy and in nuclear non-proliferation by contributing to projects implemented by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency under the Organisation for Economic Co-operation and Development (OECD/NEA). Also as part of MEXT's contributions to the Forum for Nuclear Cooperation in Asia (FNCA), most of whose members are Asian countries, MEXT has been helping FNCA member countries to develop infrastructure and human resources that facilitate the use of radiation and research nuclear reactors. In collaboration with industry, academia and government, the Japan Nuclear Human Resource Development Network has been accepting trainees from overseas.

(2) Increasing the efficiency of energy utilization and introducing smart devices

Towards increased energy utilization efficiency, R&D on high-efficiency energy use has been promoted. Such R&D focuses on the following: 1) much more efficient use of fossil resources in the manufacturing sector, and 2) carbon emissions reductions and energy conservation in the consumer sector (domestic use, business use) and in the transport sector. The consumer and transport sectors together account for approximately half of the final energy consumption in Japan. The government is also promoting R&D for further energy conserved ICT which is indispensable for innovations in energy supply, energy use and infrastructure.

① More efficient use of fossil resources in manufacturing

The JST has selected technological fields, such as biotechnology, in which to promote R&D on

innovative technologies within a competitive environment. The targeted technologies are aimed at developments that have a high potential for greenhouse gas reduction and that are not merely extensions of conventional technologies. In addition, in collaboration with METI, MEXT has been promoting R&D on technologies for synthesizing next-generation chemicals.

RIKEN has been conducting leading studies on the cyclic use of carbon, that has been consumed in petrochemical products, through interdisciplinary studies on plant science, microorganism science and biochemical and synthetic organic chemistry. Another RIKEN endeavor is R&D on the establishment of innovative bioprocesses towards the discovery of new materials derived from biomass.

NIMS is conducting R&D on materials such as photocatalysts that can render hazardous materials in water, air and soil harmless.

METI is making efforts to diversify chemical raw materials, innovate manufacturing processes, promote innovation by applying advanced chemical technology and advanced chemical manufacturing processes, and improve the common evaluation criteria for chemical materials to promote R&D for Green and Sustainable Chemistry that contributes to the realization of a sustainable society in which humans live in harmony with nature. By applying technologies for producing chemical products from inedible biomass and other materials and technologies for printing, the ministry is also developing technologies for electrical devices (electronic paper, large-area sensors) that afford greater energy savings and efficiency than conventional ones and is developing methods for evaluating materials for lithium-ion cells and for evaluating organic EL, in order to accelerate materials development. By applying technologies for producing chemical products from inedible biomass and other materials and technologies for printing, the ministry is also developing technologies for electrical devices (electronic paper, large-area sensors) that afford greater energy savings and efficiency than conventional ones and is developing methods for evaluating materials for lithium-ion cells and for evaluating organic EL, in order to accelerate materials development.

In steel manufacturing, the ministry is developing innovative carbon dioxide reduction technologies, including a technology to partially substitute hydrogen for coke as a reductant in steel manufacturing and to separate and capture carbon dioxide from blast furnace gas toward further improving the utilization efficiency of fossil fuels.

The ministry also has been promoting the development of empirical studies on basic technologies for the high-efficiency production of high value-added products (e.g., vaccines, functional foods) from genetically modified plants, thereby promoting the commercialization of safe, high-efficiency material production technologies that make the most of plant biological functions.

② Low-carbon emissions and energy savings in the consumer and transport sectors

As was proven by the 2013 Nobel Prize awarded for the invention of the blue light-emitting diode, R&D on next-generation semiconductors is a field in which Japan leads the world. Such R&D can be applied to power electronics and can greatly reduce power losses during transmission. MEXT, METI and the Cabinet Office have been promoting R&D on technologies for accelerating of commercial use of next-generation semiconductors.

The JST has selected fields of technologies such as innovative energy-saving devices and the like in which to promote R&D on innovative technologies within a competitive environment. The targeted

technologies are aimed at developments that have a high potential for greenhouse gas reduction and that are not merely extensions of conventional technologies. In addition, MEXT has been collaborating with METI to promote R&D on technologies for next-generation chemical synthesis processes that do not require fossil resources.

RIKEN has been conducting R&D on technologies for devices that realize radical lower power consumption and great improvement of energy conversion efficiency, with creating new materials science that enables innovation in electricity consumption under completely novel concepts.

NIMS is developing long-lasting, functionally stable, low-cost fuel cells that will help to improve the efficiency of energy use in industry and homes, both of which consume large amounts of energy at present. The institute is conducting R&D towards technical breakthroughs in magnets for motors, wide-gap semiconductors and LED lighting systems, which are already used for various purposes. The institute is also conducting R&D on innovative materials technologies for lightweight materials for aircrafts, which promise to contribute to energy savings.

The Japan Aerospace Exploration Agency (JAXA) has been conducting R&D on lowering the fuel consumption and environmental load of airplanes. JAXA intends to accelerate R&D in this area because it is directly related to international competitiveness. JAXA intends to make the aeronautics industry a super-growth industry that rates on par with the automobile industry. For instance, R&D will address technologies for making engines lighter and more efficient, and technologies for reducing noise from the airplane body, while taking into account the potential R&D trend for next-generation airplanes and beyond. While maintaining and improving wind tunnels and other large-scale experimental facilities, JAXA will transfer innovative aeronautic technologies to other industries wherever feasible.

METI launched the R&D of Innovative Utilization Technology of Wasted Heat Energy project in FY 2013, towards reducing and utilizing waste heat energy that has been emitted to the environment through inefficiency usage. Through the advancement and practical application of fundamental technologies, including those for heat insulation and for the storage and transformation of heat energy, the use of heat pumps and the development of thermal management technologies that combine the aforementioned technologies, the ministry has been working to save energy and to reduce carbon dioxide emissions.

The New Energy and Industrial Technology Development Organization (NEDO) implemented the Strategic Energy-Saving Innovative Technology Program through open public invitations for proposals that focused on key technologies listed in the Strategy for Energy Efficiency Technologies 2011 (formulated in March 2011; partially revised in May 2014), in consideration of the fact that energy-saving technology encompasses many fields and widely applied.

With the aim of further reducing carbon dioxide emissions in international marine transportation, MLIT is making integrated efforts to support R&D on innovative energy-saving technologies for ships and to forge an international framework for regulating carbon dioxide emissions from ships. The developed technology is expected to be deployed around the world.

In addition, the ministry is promoting technological development that contributes to the further improvement of environmental performance by railways, such as the development of battery trains that charge their own batteries when they stop at stations in electrified sections, and that run by discharging electricity from their batteries in unelectrified sections.

With the aim of greatly reducing carbon dioxide emissions from ships, the National Maritime Research Institute (NMRI) is conducting research on basic technologies that afford great reductions in environmental impact by facilitating the implementation of common-sense environmental regulations aimed at zero emissions. The Building Research Institute (BRI) is developing effective evaluation methods for energy conservation performance based on the clarified energy consumption structure in the housing and construction industries, and is conducting R&D on the preparation of technical data for the dissemination of advanced energy-efficient houses.

③ Improving information and communications technology

MIC has conducted R&D on the practical application of optical transmission technology capable of meeting the expected rapid increase in network traffic to one terabyte per second.

NICT is promoting R&D on an all-optical network that combines ultrahigh speed with low power consumption over the entire network, while also responding to exponential increases in communications traffic and power consumption. This is being realized by utilizing information and ICTs. The NICT, in collaboration with industry, academia and other government organizations, is promoting R&D on basic technologies for a next-generation network to supersede the Internet by 2020.

METI has been conducting R&D on technologies for achieving faster and more energy-saving servers, computers and next-generation automobiles, including those for 10-nm semiconductor micro-fabrication and manufacturing, ultra-low power consumption of semiconductors using new materials and structures, new information processing that consumes electricity only when data processing is required, organic EL sheet display, integration of next-generation semiconductor devices and optical electronics combining optical and electronic circuits. It has also developed basic policies ensuring standardization, generalization, reliability and safety for applying innovative devices in diverse areas.

(3) Greening of social infrastructure

Japan is making efforts to innovate resource recycling technologies, to create substitute materials for rare earth elements[1] and to implement other projects for the creation of environmentally advanced cities. The data obtained by Earth observations, forecasts and integration analysis make up an important social and public base for promoting green innovation. Japan is working to drastically improve technologies related to obtaining such data and is promoting the use of data such as that gained by Earth observations in various fields.

① Efforts to create substitute materials for existing rare resources

To overcome the constraints imposed by the scarcity of certain elements, such as the rare earths and rare metals that are necessary for next-generation cars and wind power generation, MEXT and METI have, since FY2007, been conducting mutual R&D to reduce the use of these materials and to find substitutes for them.

To overcome Japan's resource constraints and improve its industrial competitiveness, MEXT is promoting the Elements Strategy Initiative (research funding type) in order to find completely new materials that eliminate the need for scarce elements.

1 Rare earth elements, consisting of 17 metallic elements in the periodic table

METI has launched the Rare Metal Substitute and Energy-Saving Materials Development Project to investigate the supply and demand for rare metals and the trends in technological development. METI also has been supporting the development of technologies for substituting or reducing the use of rare metals. Such technologies are indispensable for the manufacture of energy-saving products by the private sector. In collaboration with MEXT, METI has been developing the Magnetic Material Technology for High-Efficiency Motors of Next-Generation Automobiles since FY 2012. The project promotes the development of materials that are more magnetic than conventional ones, without using rare earths such as dysprosium, whose global distribution of which are highly uneven.

The ministry is also promoting the development of technologies capable of producing substances that were previously difficult to synthesize, significantly improving the production efficiency of useful materials, reducing energy consumption in material production, vastly reducing environmental loads and dramatically improving the development efficiency of lightweight, high-performance materials through genetic design and recombinant technologies based on large-scale genome information.

In September 2012, in a joint council meeting, the Industrial Structure Council and the Central Environment Council complied an interim report on appropriate measures to ensure the economic feasibility of recycling rare metals. The measures include securing quantities of collected used products and improving recycling efficiency. Based on the interim report, METI and MOE provided subsidies and other assistance for demonstration projects and R&D by private businesses, which will contribute to the efficient and economical collection and recycling of used products.

② Promotion of responses to climate change and to large-scale natural disasters

(i) Promotion of Earth observations

Regarding Earth observations, the GEO Strategic Plan 2016-2025: Implementing GEOSS, which is the framework that succeeds the Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan, was endorsed at the Ministerial Summit of the Group on Earth Observations (GEO) in 2015. Japan is promoting Earth observations by means of satellite, land and ocean observation to contribute to the GEO Strategic Plan 2016-2025.

The MOE, the JAXA and the National Institute for Environmental Studies (NIES) have jointly developed the Greenhouse Gases Observing Satellite "IBUKI" (GOSAT). They are using the obtained data to contribute to the development of climate change-related science, and they are obtaining and analyzing data in order to contribute to policies that address climate change, aiming at a low-carbon society.

To promote satellite observations of the earth, JAXA has been operating the Global Change Observation Mission - Water "SHIZUKU" (GCOM-W) and the Advanced Land Observing Satellite-2 "DAICHI-2" (ALOS-2), and has been conducting R&D for the Global Change Observation Mission - Climate (GCOM-C) and for other satellites (See Chapter 3, Section 1, Paragraph 3 (1).)

MEXT is promoting research and observation in various fields related to the Antarctic and Arctic, where it is possible to accurately measure global environmental changes. The Antarctic Research Programs have been administered by the Headquarters for the Japanese Antarctic Research Expedition (Chief of the headquarters: the minister of MEXT), in cooperation with other ministries and research institutions, including the National Institute of Polar Research (NIPR). They are collaborating with

other nations on research and observation in the Antarctica. "Exploring Global Warming from Antarctica" was the main research topic based on the 8th Six-Year Antarctic Research Program (FY2010 - FY2015). Regarding the Arctic, the Headquarters for Ocean Policy at the Prime Minister's Office decided Japan's Arctic Policy on October 16, 2015. The Arctic Challenge for Sustainability Project (ArCS) started in FY 2015. Under the project, climate change in the Arctic and the impacts of such change on the global environment have been comprehensively studied to forecast such change and impacts with high accuracy and to clarify the socioeconomic effects of such impacts. The project aims to provide stakeholders with the obtained information so that they can make appropriate decisions and address issues. To this end, international joint research has been promoted, a center for international research has been developed and the fostering of young researchers has been promoted. Under the Subdivision on Ocean Development of CST, MEXT established the Arctic Research Strategy Committee, which studies the direction of study on the Arctic.

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been making the most of its cutting-edge technologies. Such technologies are used for the oceanographic research vessel MIRAI drift buoys, mooring buoys and other advanced observation devices, and for a four-dimensional data assimilation system. Using such technologies, JAMSTEC has been conducting ocean observations in the Pacific Ocean, the Indian Ocean and the Southern Ocean.

The Japan Meteorological Agency (JMA) has been observing greenhouse gasses in the atmosphere at three sites in Japan and at the Showa Station in Antarctica. In addition, the JMA is observing greenhouse gasses in seawater and in the atmosphere near seawater by using an ocean weather observation ship, and in the atmosphere at high elevations in the northwest Pacific Ocean by using an aircraft. These data and other observed global warming related data and their analyses are made available to the public. The JMA has also been observing the ozone layer and ultraviolet rays in the atmosphere at four sites in Japan and at the Showa Station in Antarctica.

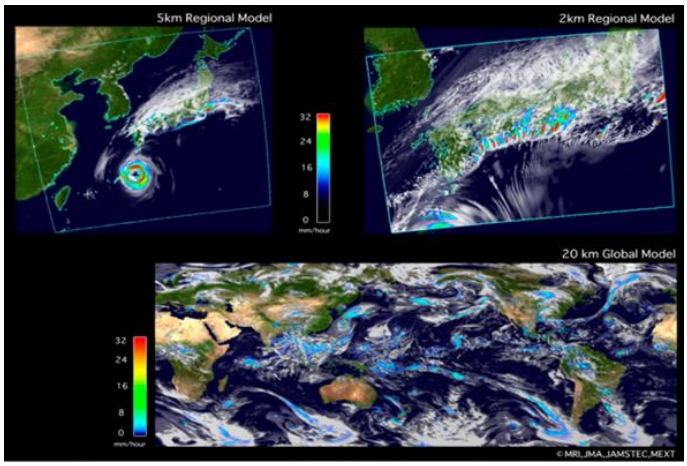
In addition, the JMA is collecting observation data on the above items from ships, Argo Floats and satellites and by using other means, and has been analyzing such data. These results have been published in a report called The State of the Ocean Climate, which provides information on current conditions and the prospects for changes in oceanic fluctuations related to global warming.

With international cooperation, the Geospatial Information Authority (GSI) of Japan is promoting earth observation and the Earth Map, which is fundamental geospatial information to be used for various purposes, such as measures against global warming and technologies for data development using earth observation satellite data.

(ii) Promotion of climate change prediction study

MEXT has been working to generate the basic data that are necessary for advances in climate change projection and for the management of risks derived from climate change, such as typhoons of much greater scale than ever. Using the MEXT Earth Simulator and other supercomputers that rank among the best in the world for computational capacity, MEXT has been conducting R&D in close collaboration with other projects. The R&D focuses on 1) projecting and diagnosing the global environmental changes that are expected to occur in the immediate future (a few years or decades), 2) projecting long-term climate change in relation to greenhouse gas emissions scenarios, 3) developing the probabilistic

projection methods for global climate change and 4) developing accurate impact assessment methods. With these research results, MEXT is contributing to the Intergovernmental Panel on Climate Change (IPCC). MEXT is also implementing a basic study aimed at understanding the mechanisms of environmental change and the projection of these changes by using the Earth Simulator, which has a high computational capacity. MEXT also is conducting R&D on technologies for increasing simulation speed and accuracy, and for using the simulation technology to project global environmental changes.



An example of a typhoon simulation

Source: Meteorological Research Institute, JMA

The Meteorological Research Institute (MRI) is conducting near-future projections of climate change in the next ten years and a long-term projection based on IPCC emissions scenarios. Furthermore, the MRI is conducting a spatially detailed regional warming projection (See Part 2, Chapter 3, Section 1, 3, (1).)

(iii) Promotion of data integration and analysis

MEXT has been extending and advancing the Data Integration and Analysis System (DIAS). DIAS integrates and analyzes Earth Observation data, climate change and socioeconomic data gleaned from Earth Observation satellites and from land and ocean observations. Integrated and analyzed results are to be provided to policymakers and scientists in water resource, agricultural produce and fishery resource management. Furthermore, using DIAS as a core information platform, MEXT has been building a research network of universities and research institutions that work on climate change and other global issues. In this way, MEXT is comprehensively promoting world-leading research and human resource development.

For the creation, under the World Data System (WDS), of a scientific data platform that will be the largest in the world and that is being promoted by the International Council for Science (ICSU[1]), the NICT has been selected to host this endeavor's International Program Office. NICT is building a network with the Science Council of Japan (SCJ) and related domestic and international research institutions. By gathering scientific papers and their reference data on Earth observation, the NICT is developing a global-scale science data platform that allows the stored data to be analyzed and is conducting R&D for reference relation analysis among reference data of different papers and for active use of science big data using a cloud system.

(iv) Promotion of a society adapted to climate change

To enable local governments to adapt to the effects of climate change, which will vary by region,

1 The International Council for Science (ICSU): This non-governmental, non-profit, global academic organization was established in 1931. Its mission is to strengthen international activities in the applied science and other science for the benefit of society.

MEXT is conducting research on the following technologies in collaboration with local governments: 1) the highly reliable forecasting of climate change effects in the near future, 2) the high-resolution down-scaling of forecast data, 3) impact assessment of climate change and 4) assessment of the effectiveness of measures to address issues related to climate change. The results of this research will be available as scientific knowledge for regions when they examine responses to climate change. In addition, symposiums were held to foster a better understanding of climate change adaptation. The general public has been invited to attend the symposiums.

MAFF has advanced research and other study on greenhouse gas emissions reductions and absorption improvement technologies. These include study on the following: the mechanism of greenhouse gas generation and absorption, greenhouse gas mitigation technologies, absorption improvement technologies for forests and farm soil, technologies for the creation of new-generation forestry seedling in a short period and new technologies for wood use.

As part of the development of a production technology system that aims at the creation of low-input, recycling-based agriculture, the ministry has also advanced the establishment of chemical fertilizer and pesticide reduction technologies. These include organic resource recycling and microbial utilization, a fertilization system that achieves high nutrient use efficiency, a management system for the effective use of nutrients accumulated in the soil, and the development of an insect pest control system that effectively uses biological control.

For climate change adaptation technology in agriculture, forestry and fishery, the ministry has developed a high-precision yield and quality prediction model and other means to assess the impact of climate change on agricultural and marine products. They also promoted the development of a production stabilization technology that can cope with global warming. In addition, the ministry has promoted the development of plant varieties that are resistant to high temperature and drought by making the most of genome information.

Through the Comprehensive Research on Climate Change Impact Assessment and Adaptation Policies (S-14), an Environment Research and Technology Development Fund program, MOF is promoting research that contributes to the planning of the following: 1) the development of basic quantitative materials to be used for assessing the effectiveness and efficiency of mitigation/adaptation measures, and 2) climate change countermeasures for risk management.

(v) Town development in harmony with nature

The MRI is addressing the development of real-time observation and monitoring technology for the detection of unusual meteorological phenomena, such as intense localized downpours (known in Japanese as "guerrilla rain"), by means of dual polarization radar, phased array radar and global positioning system (GPS). The MRI is also advancing the development of a numerical prediction model with high enough resolution to display intense localized downpours, in order to improve the accuracy of weather information and thereby to help reduce damage from local meteorological phenomena.

The PWRI has been developing technologies that contribute to the realization of the following: a sustainable society where people live in harmony with nature, the preservation and restoration of the natural environment and sound water circulation, and food production infrastructure development in Hokkaido that increases the food supply capacity. In addition, the PWRI has been developing

technologies for the use of low-carbon blended cements and for the use, in embankments, of surplus soils that are generated by construction but that certain heavy metals.

2 Reforming the Systems for the Promotion of Green Innovation

Japan is advancing regulatory, institutional and other reforms of various systems, in order to promote green innovation and to promptly and effectively lead innovation for sustainable growth in Japan and for the resolution of global issues.

To help resolve the environmental problems related to ICT utilization, MIC has been publishing recommendations through the Environment and Climate Change Study Group 5 (ITU-T SG5[1]) of the International Telecommunication Union. Published recommendations include L. 1300: *Best practices for green data centers*, L. 1410: *Methodology for environmental life cycle assessments of information and communication technology goods, networks and services* and *L. 1200: Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment.* In addition, based on a summary of the international standardization of best practices and other aspects of environmental sustainability for cities-a summary that was produced by the Focus Group on Smart Sustainable Cities (FG-SSC), which was established under Study Group 5--the Ministry of Internal Affairs and Communications (MIC), has been working on standardization that is necessary for the expansion of the environmental impact assessment model to cover areas that are the scale of cities. The MIC is promoting the energy-saving renovation and new construction of data centers in Japan, towards reductions in power consumption and carbon dioxide emissions.

Aiming to reform the social system in order to create a new society that can adapt to climate change, MEXT is doing the following: developing fundamental technologies, such as for the effective use of biomass and heat; conducting field experiments in which such fundamental technologies are used in various combinations in a social system; and promoting the social implementation of such technologies.

1 International Telecommunication Union Telecommunication Standardization Sector Study Group 5

■ Table 2-2-6 / Major policies for the promotion of green innovation (FY 2015)

Ministry	Implemented by	Project
MIC	MIC	R&D on next-generation optical network technologies that support the distribution of big data
MEXT	MEXT	Initiative for Strategic Adaptation to Climate Change
		University-originated Green Innovation Creation Program
		Program for Risk Information on Climate Change
		Japanese Antarctic Research Program
		Elements Strategy Initiative
		Grants for area-locating electric power stations
		Grants for promoting the development of power supply regions
		Grants for radiation application and for research and experimentation on basic nuclear energy technologies
		Grants for nuclear fuel cycle-related promotion coordination, etc.
		Commissioning expenses for nuclear system R&D (nuclear system R&D project)
		R&D on next-generation Energies for Tohoku Recovery Project
		The Arctic Challenge for Sustainability Project
		Center of World Intelligence Project for Nuclear S&T and Human Resource Development
	NIMS	The promotion of R&D on materials that address the needs of society
	JST	Advanced Low Carbon Technology Research and Development Program
MAFF	MAFF	R&D for Production Sites Improvement
		Projects for Accelerating the Introduction of Next-Generation Greenhouse Horticulture
METI	METI	R&D on Advanced Aerodynamic Design
		Expenses of the Carbon Dioxide Reduction Technology Demonstration Project
		Commissioning Expenses for the Dissemination and Promotion Program of Global Warming Countermeasure Technologies
		Subsidy for the introduction of clean energy automobiles, etc.
		Expenses for the Development of Carbon Capture and Storage Safety Assessment Technologies Project
		Commissioning expenses for infrastructure development projects such as green contribution certification systems
		Project for the international standardization and dissemination of energy-savings, etc.
		Carbon dioxide storage potential investigative project
		Carbon capture technology commercialization project
		Demonstration project for security assessment of smart grids
		International collaborative research project on innovative energy technologies
		Project for the international standardization and dissemination of energy savings

METI	Agency for Natural Resources and Energy (ANRE)	Grants for the development of practical use of element technology for ultra-supercritical pressure thermal power generation
		Commissioning expenses for projects to streamline international energy utilization, etc.
		Development of advanced processing technologies for heavy oil, etc.
		Subsidies for Supporting Operators Streamlining Energy Use
		Subsidies for Accelerated Support of Renewable Energy Heat Utilization
		Subsidies for an Integrated Coal Gasification Fuel Cell Combined Cycle Demonstration Project
		Subsidies for a High-Efficiency Gas Turbine Technology Demonstration Project
		Subsidies for Supporting Operators Streamlining Energy Use (for Private Corporations) (for Natural Gas)
		Subsidies for housing and building innovative energy-saving technology introduction project
		Subsidies for the Specific Equipment Introduction Promotion Project for Streamlining Energy Use
MLIT	MLIT	Breakthrough by Dynamic Approach in Sewage High Technology Project (B-DASH project)
		Comprehensive measures for the strategic promotion of the marine industry
	JMA	Development of the HIMAWARI geostationary meteorological satellite
MOE	MOE	The Environment Research and Technology Development Fund
		Contributions to the Institute for Global Environmental Strategies
		Technology development and verification project to induce strengthening of the measures for carbon dioxide reduction.
		Floating Offshore Wind Turbine Demonstration Project
		Waste Energy Introduction and Low-Carbon Promotion Project
		Project for the practical application of technologies for tidal current power generation
		Total environmental study promotion cost (competitive funds) (for the general account)
		MRV-related technology advancement for promoting a bilateral credit system (JCM)
	NRA	Radiation survey and research expenses
		Detailed Soundness Survey of Light Water Reactor Materials and Fuels
		Costs for commissioning the project for advancing lifetime-extension evaluation technology
		Costs for commissioning of survey and research on geological structures at nuclear facilities
		Costs for commissioning surveys on the level of radioactivity
		Costs for commissioning surveys on a comprehensive radiation assessment of the marine environment
		Costs of surveying the effects of the nuclear power plant accident
	NIES	Satellite Observation Cost

Section 3 Promotion of Life Innovation

To promote life science, four key issues have been set out in the 4th Science and Technology Basic Plan, with MEXT and the agencies concerned addressing them.

The health care and medical R&D projects that have been conducted by MEXT, MHLW and METI until FY 2014 were taken over by Japan Agency for Medical Research and Development in FY 2015 (See Chapter 2, Section 2, Paragraph 1.)

1 Promotion of Measures to Address Critical Issues

(1) Development of innovative disease-prevention methods

① Realizing next-generation medicines

Through AMED, MEXT is promoting the Tohoku Medical Megabank Project, which is a long-term genome cohort study on areas affected by the GEJE. The project, which intends to promote long-term epidemiological research (genomic cohort research), including that on genomic information, is being implemented for regional medical information sharing. MEXT promotes this project in close collaboration with the regional medical information network supported by MIC and MHLW. The project intends to restore community medical systems in the affected regions and to attain next-generation medical care, such as personalized prevention. Through AMED, MEXT is also implementing the Tailor-made Medical Treatment with the Biobank Japan Program (the 3rd term). The program has been identifying and verifying genes associated with diseases that may significantly affect national health and the side effects of medications for individual patients, utilizing the world's largest biobank of patient DNA, biological samples and clinical information collected from cooperating medical institutions. Also, the program has been searching for genes that cause rare or intractable diseases and has been promoting the comprehensive study of diagnosis and treatment using genome information. In conjunction with this project, RIKEN is also conducting research to find the causes of diseases.

② Efforts to clarify environmental risks to children

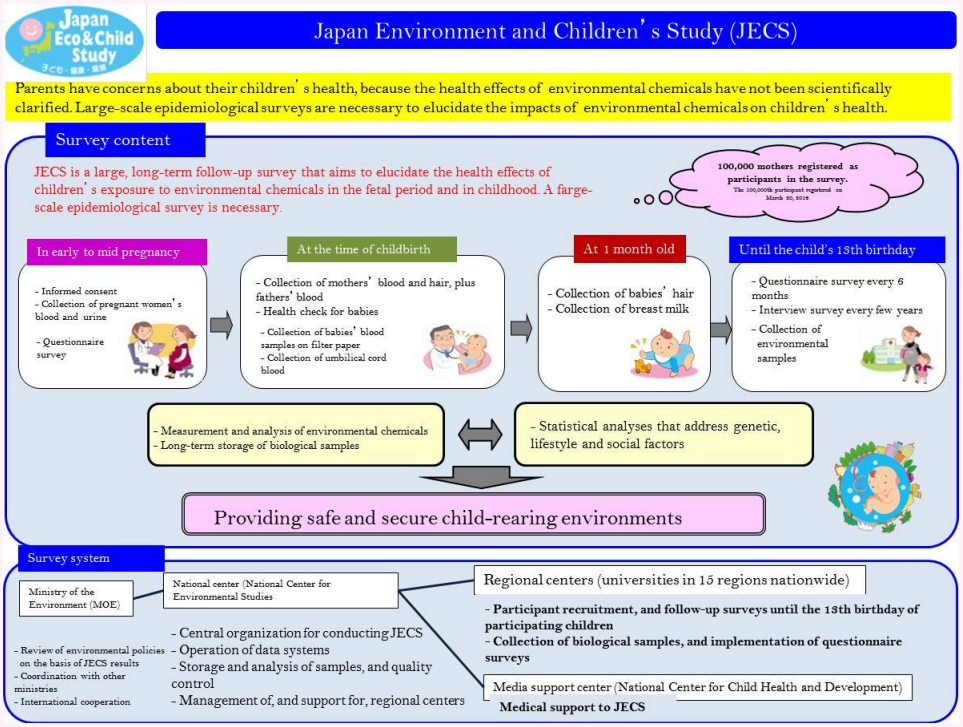
Recently, the possibility of increased environmental risks to children has become apparent.

In FY 2010, MOE started a large-scale, long-term cohort study, the Japan Environment and Children's Study (JECS), by enrolling 100,000 pairs of parents/ children in a study to clarify the influences of environmental chemical agents on children's health (Figure 2-2-7). In this study, survey subjects (pregnant women) were publicly recruited over a 3-year period from the end of January 2011. Blood, umbilical blood, breast milk and other biological samples of the subjects were taken, preserved and analyzed. Follow-up studies will be conducted using questionnaires, until the children reach 13 years of age.

Under JECS, the National Institute for Environmental Studies (NIES) serves as the core center and the National Center for Child Health and Development (NCCHD) serves as the medical support center. NIES develops research plans and analyzes biological samples. The NCCHD provides medical support. Concurrently, unit centers, which are publicly recruited and designated universities from 15 districts throughout Japan, have been conducting follow-up studies. Based on the results of this study, the MOE

will re-examine environmental policies.

■ Figure 2-2-7 / Japan Environment and Children's Study (JECS)



Source: MOE

Based on the knowledge to be gained from this study and through the improved management of hazardous chemical substances, the MOE intends to secure the health and safety of children, as well as to ensure a safe child-rearing environment. The MOE expects that the bank of 100,000 pairs of biological samples and data will contribute to the maintenance of Japan's international competitiveness in basic research, as a shared infrastructure for medical- and health-related studies.

③ Efforts to Overcome Emerging and Reemerging Infectious Diseases

Through AMED, MEXT is implementing the Japan Initiative for Global Research Network on Infectious Diseases (J-GRID). The 9 research centers in 9 countries throughout Asia and Africa have been collaborating with the relevant organizations of their countries on epidemiological research that addresses the pathogens of infectious diseases widely suffered by the people of the country, in order to promote the basic study of diagnostic/ therapeutic medications and to develop new technologies that contribute to infection control and prevention, and to diagnosis and treatment.

MHLW is also conducting research into cell culture-based vaccines and intranasal vaccines, so that simpler and more effective vaccines can quickly be provided to people to contain novel flu pandemics. With particular concern for preventive inoculations that are an important means to fight infectious diseases, MHLW is researching the evaluation of medical safety and economic efficiency, helping the vaccination administration. MHLW is working on the development of proper diagnostic techniques, treatment strategies and preventive methods that facilitate the necessary administrative responses. In the

field of novel influenza, MHLW is also conducting research into cell culture-based vaccines and intranasal vaccines, so that simpler and more effective vaccines can quickly be provided to people to contain novel flu pandemics.

④ Efforts to Overcome Mental and Neurological Disorders

In June 2013, CST of MEXT drafted its first recommendations for the basic concept and method of promoting a long-term study on brain science. Based on the recommendations, MEXT launched the Strategic Research Program for Brain Sciences (SRPBS), which aims at brain science that contributes to society. The program includes R&D aiming at the support for independence and permanent cure of mental and neurological disorders using Brain Machine Interface (BMI) technology and R&D to clarify the pathogenic mechanisms of mental and neurological disorders, and to develop early diagnosis, treatment and preventive methods. In June 2013, the Brain Science Committee founded under the Subdivision on Science and the Subdivision on R&D Planning and Evaluation of CST examined the basic concept of the Brain Mapping by Integrated Neurotechnologies for Disease Studies. Based on this examination, MEXT launched Brain Mapping by Integrated Neurotechnologies for Disease Studies (Brain/MINDS) in FY 2014.

At RIKEN and the JST, under the Strategic Basic Research Program, research into brain science is also being promoted in the fields of molecular structures, nerve cells, neural networks and other areas.

(2) Development of novel and early diagnostic technology

Aiming at the early application of these technologies, through AMED, MHLW is implementing the Practical Research for Innovative Cancer Control project based on the Comprehensive 10-Year Strategy for Cancer Research. The project aims for the early detection of disorders, mainly refractory cancers, and is promoting R&D for the practical application of innovative diagnostic methods using new biological indicators.

Through AMED, METI is implementing the Project for R&D on Equipment and Systems to Realize Future Medicine, in order to develop devices, including one for diagnosing cancer metastasis by using an atomized contrast agent to make metastasized cancer cells more detectable.

(3) Achieving safe and effective therapies

① Promotion of the scientific research of cell generation, differentiation and regeneration

Research into cell generation, differentiation and regeneration seeks to clarify the mechanism whereby a single cell differentiates into various tissues and organs to form and maintain the body. Aiming at the early realization of regenerative medicine and drug development using stem cells, including iPS cells, the agencies concerned are promoting research in cooperation with each other.

Based on the Comprehensive Strategy on Science, Technology and Innovation 2014 and the Healthcare Policy, MEXT is promoting the world's first implementation of regenerative medicine and innovative drug development using iPS cells and related materials, in order to achieve the goal set under the Road Map on iPS Cell Research, a road map that was set by the Stem Cell and Regenerative Medicine Strategy Task Force under the Life Science Committee of the Research Planning and Evaluation Subdivision, CST, in November 2015. To this end, AMED is forming the Research Center Network for the Realization of

Regenerative Medicine to construct a nationwide framework by enriching core center functions and improving networking. In addition, with the Highway Program for Realization of Regenerative Medicine of AMED, MEXT is continuously supporting the study of regenerative medicine in cooperation with MHLW and METI. In collaboration with MHLW, research is being conducted into diseases and drug discovery using patient-derived iPS cells under the Program for Intractable Diseases Research Utilizing Disease-specific iPS Cells. MEXT is implementing basic research under the Advanced Research & Development Programs of AMED, and similar research is being conducted at RIKEN. The relevant agencies are working in unison to secure the necessary research funds by improving research systems, and to establish and manage intellectual property.

MHLW continuously supports endeavors that have moved from the nonclinical phase to the clinical phase. MHLW is also promoting research on basic technologies that will contribute to the search and selection of candidate compounds for medicines using human iPS cells.

MHLW is seeking to establish a base of technology for safe and effective regenerative medicine that uses human cells, such as iPS cells, to promote research into tumorigenicity, rejection and other areas, which are hurdles for the early clinical application of regenerative medicine.

Through AMED, METI is implementing the Project for R&D on Equipment and Systems to Realize Future Medicine and is conducting R&D on systems which include one that will create body tissues by using 3D printing technology to stack cells. In addition, under the Project Focused on Developing Key Evaluation Technology, Aiming at Industrialization in the Field of Regenerative Medicine, the ministry clarified the safety evaluation items specific to each regenerative medicine product and developed a reasonable evaluation method. And METI is promoting the development of basic technologies for the stable mass production of high-quality stem cells, such as iPS cells, that will be needed for regenerative medicine.

② Promotion of innovative cancer research

In Japan, one in two people will develop cancer. One in three people die from the disease (about 370,000 persons/year as of FY 2014.) Cancer remains a serious problem for life and health. Therefore, aiming at joint efforts by patients and society, the government has promoted studies on cancer with a permanent cure and prevention in mind and on living with cancer. These efforts are based on the Comprehensive 10-Year Strategy for Cancer Control (decided by the Ministers of MEXT, MHLW and METI on March 31, 2014), the Cancer-fighting Basic Act (Act No.98 of 2006) and the Basic Plan to Promote Cancer Control Programs (Cabinet decision in June 2012).

Through AMED, MEXT launched the Next-generation Cancer Research Strategy in cooperation with MHLW and METI. Under this program, MEXT carefully selects innovative basic research with promising results, towards establishing next-generation cancer medicines. MEXT is promoting the development of potential seeds for new compounds that are useful for innovative diagnoses and drugs.

MHLW is continuing prior strategic cancer research and is promoting the development of innovative therapies that can restrict and eradicate cancer stem cells, and that mainly target refractory cancers. Cancer vaccine therapies are rapidly advancing as a fourth type of therapy, following surgical operations, radiation therapies and chemotherapies. Therefore, MHLW is promoting high-quality, non-clinical trials and international-level, doctor-centered clinical trials for drug development, mainly for refractory and/or

orphan cancers, by taking advantage of Japan's rich history of such studies. These studies include those on cancer vaccine therapies, molecular target drugs (such as antibody drugs), nucleic acid medicines and cancer peptide vaccines. MHLW is also promoting research into palliative care for cancer patients and their families. This includes methods for effective cancer pain evaluation, advanced information communication and palliative care quality assessment. The goal is to improve treatments for physical pain, cancer-specific pain, depression and anxiety, psychological and mental pain, and social distress, including work and financial problems.

Through AMED, METI is implementing the Project for R&D on Equipment and Systems to Realize Future Medicine to develop devices such as a high-precision radiotherapy apparatus that applies a technology for irradiating organs that move during breathing, and a device for diagnosing cancer metastasis that uses an atomized contrast agent to make metastasized cancer cells detectable.

③ Promotion of drug discovery research

In the Platform Project for Supporting in Drug Discovery and Life Science Researches, through AMED, MEXT supports the commercialization of drugs using technology bases for protein structure and functional analysis, improved through the Protein-3000 Project and the Target Protein Research Program, and promotes upgrading of technology bases.

RIKEN is also promoting the advancement of structural prediction technology, etc. using protein production technology, structure and function analysis technology and computational science.

Under its Development of technology for measuring miRNAs in serum program, METI has accumulated large amounts of clinical information and biobank specimens. Using these, METI aims to achieve the following: the early discovery of markers for 13 cancers, including breast and bowel cancer, and for dementia; the practical use of less invasive and highly sensitive diagnosis system technology.

④ Promotion of genomic science research

Through AMED, MEXT supports life science researchers in their highly advanced epigenomic and transcript analysis that use a genome/epigenome analysis technology base developed in research programs that include Innovative Cell Biology by Innovative Technology (Cell Innovation), which is under the Platform Project for Supporting in Drug Discovery and Life Science Researches; and MEXT enhances related technologies and facilities.

⑤ Promotion of R&D for radiation therapy equipment

The National Institute of Radiological Sciences (NIRS) is promoting research on heavy-ion cancer therapy, which is expected to be a breakthrough therapy for refractory cancers. Efforts will be made to disseminate its use domestically and internationally. Based on R&D performed by the NIRS, heavy-ion cancer therapy facilities were installed in Hyogo, Gunma, Saga and Kanagawa prefectures for medical treatment.

⑥ Promotion of study on dynamic biological systems science

MEXT launched the Platform for Dynamic Approaches to Living Systems project under the Platform Project for Supporting in Drug Discovery and Life Science Researches in January 2013, in accordance with the *How to Promote Dynamic Biological Systems Science* (The Working Group of the Life Science Committee CST's Subdivision on R&D Planning and Evaluation, on July 19, 2011) to establish research centers for the progress

of this scientific field. RIKEN and Osaka University are proactively implementing state-of-the-art technology for the measurement, quantification and modeling of life phenomena and for the reproduction of cell functions. The JST also intends to create basic technologies in its Strategic Basic Research Programs. MEXT consolidates these R&D programs.

⑦ Other efforts for safe and effective treatments

To provide safer treatments for patients, through AMED, MHLW is promoting the development of test drugs appropriately selected for patients who require drug administration and the development of non-invasive/minimal invasive medical equipment utilizing nanotechnology.

⑧ Innovations in biomedical structural and synthesis technology

Through AMED, MEXT has been conducting the Basic Science and Platform Technology Program for Innovative Biological Medicine to assist in developing innovative basic technologies in universities for producing Japanese next-generation, innovative biomedical drugs.

To develop medicines with high healing effects and minimal side effects, METI has been establishing basic production technology for next-generation antibody drugs that meet international standards, as well as developing innovative drug discovery processes.

⑨ Promotion of the practical application of research results achieved at universities and other institutions

For the purpose of promoting the practical application of research results achieved at universities and other institutions as a result of industry-academia coordination on medical innovations, MEXT is promoting, through AMED, Industry-Academia Collaborative R&D Programs in medicine.

(4) Improving quality of life (QOL) for the elderly, the disabled and medical patients

For the purpose of clinical applications and life support, MIC, MEXT and MHLW are working to develop BMIs that can decode information in the brain in non-invasive or minimally invasive ways, to treat, recover and complement physical functions.

In support of disabled people's independence and participation in society, MHLW has been implementing the Project for Development and Promotion of Equipment to Support Independence of Persons with Disabilities. They seek to develop convenient support apparatuses that can be used easily by disabled people, as per their needs.

METI is promoting a project to provide support to private business operators who are engaged in R&D on welfare apparatuses. To facilitate the development and practical application of robot care devices in needed areas, METI has been implementing the Project to Promote the Development and Introduction of Robotic Devices for Nursing Care since FY 2013. This is an area of focus for future research. The ministry is supporting R&D on robotics technology development by private businesses that address the needs of the elderly and care service personnel.

2 System Reform for Life Innovation Promotion

(1) Improving systems to translate medical R&D to the practical application

To contribute to the realization of a society where citizens stay healthy and live longer, medical R&D that will contribute to the provision of world-leading medical cares and to the generation of industrial activities for the realization of such a society will be promoted in a planned, comprehensive manner. To this end, efforts are being made under the leadership of the Headquarters for Healthcare Policy, and based on the Healthcare Policy and the Plan for Promotion of Medical Research and Development.

AMED was founded in April 2015 for the purposes of supporting medical R&D and improving the R&D environment. Medical R&D budgets, which used to be spread across ministries, are now consolidated under AMED. Based on the Plan for Promotion of Medical Research and Development, AMED provides seamless research support from the stage of basic research to practical applications.

(2) Developing a foundation to support drug discovery and medical technology

To improve drug development and medical technology support bases that link high-quality basic research results with the commercialization of innovative drugs, through AMED, MEXT is involved in projects to allow industries and universities to share information: 1. developing technological bases, for example, a world-class level radiation facility, a compound library facility and protein production and bioinformatics technology facility, 2. upgrading current technological bases and 3. promoting a Platform for Drug Discovery, Informatics and Structural Life Science project.

(3) Improving systems for conducting translational research and clinical studies/trials

For the Translational Research Network Program, which was initiated in FY 2012, MEXT is promoting further transitional research, in cooperation with MHLW and METI, by improving translational research support centers and by networking these centers so as to strengthen their ability to nurture seeds, and MEXT is establishing permanent centers. Since FY 2014, the projects under the Improvement of the Clinical Research Quality Assurance System program of MHLW and related projects have been integrated and unified. Since FY 2015, AMED has been working on the integrated project and establishing a system for putting basic research outcomes to practical use.

For the production of innovative Japanese medical drugs and devices, since FY 2012, MHLW has been conducting clinical research in accordance with international standards (ICH-GCP) and has been promoting the C Project for the Improvement of the Clinical Research Quality Assurance System and other measures to provide support for all hospitals from core hospitals. In addition, to promote the high-quality clinical research and clinical trials that are required for the development of innovative Japan-made drugs and medical equipment, a system to approve hospitals that play a central role in international-standard clinical research and doctor-centered clinical trials as clinical research core hospitals was outlined in April 2015 in the Medical Treatment Act (Act No. 205, 1948). MHLW supported the development of doctor-centered trials in Iwate, Miyagi and Fukushima prefectures in a 5-year plan from FY 2011 to FY 2015. Such development makes use of the innovative medical equipment industry in the Tohoku region to vitalize the regional economy by promoting business location and creating jobs.

The Pharmaceuticals and Medical Devices Agency (PMDA) started the pharmaceutical affairs

consultations on R&D strategy in 2011 to commercialize academic ventures' excellent seeds. Since October 2013, consultations have been provided at the Kansai Branch of the PDMA.

In cooperation with MHLW and through AMED, METI is preparing a guideline to clarify items for evaluating the technological and biological stability of medical equipment towards future commercialization, in order to promote the development of medical equipment.

(4) Improving biological resources

Under the National BioResource Project, through AMED, MEXT is improving the system so that biological resources, including animals and plants that may become the base of life science and that may be strategically important for the country, can be collected, preserved and distributed in a systematic manner.

METI is actively implementing the development of biological genetic resources in Asia by executing bilateral agreements with each Asian country under the Convention on Biological Diversity (CBD) and by forming a multilateral collaboration system (the Asia Consortium) for the conservation and sustainable use of microbial resources.

(5) Promoting the integration of life science databases

MEXT founded the National Bioscience Database Center (NBDC) at the JST in FY 2011 and started the Life Science Database Integrated Project to promote R&D required for integrating the life science databases owned by various research institutions. In addition, MEXT, MHLW, MAFF and METI had established a joint portal site to disseminate their policies concerning the integration of the life science database and the achievements in life science by the four ministries. Since FY 2013, a steering committee has been established for implementing security and operation guidelines regarding human data.

The ministries hold symposiums to discuss database integration-related issues every year.

(6) Issues in the development of systems for life science research

① Efforts for the proper implementation of animal trials

The Act on Welfare and Management of Animals (Act No. 105 of 1973) stipulates that animal trials be conducted in accordance with the 3Rs (Replacement, Reduction and Refinement).

Based on this act, the Standards Relating to the Care and Management of Laboratory Animals and Relief of Pain (Standards for Care and Keeping) (Public Notice of MOE, No. 88 of 2006) was enacted for animal experiments.

Based on these guidelines, MEXT, MHLW and MAFF have implemented similar basic guidelines[1] for research institutes that fall under their jurisdictions, in order to ensure proper care for animal trials.

MOE provided a leaflet covering guidelines to promote the proper feeding and care of experimental animals, which was then circulated for dissemination.

② Approaches to bioethical issues

1 Basic Guideline for Animal Trials at Research Institutes (Public Notice of MEXT, No. 71 of 2006); Basic Guideline for Animal Trials at Research Institutes Under Jurisdiction of MHLW (Public Notice by the Director of Welfare and Science, MHLW, 2006); and Basic Guideline for Animal Trials at Research Institutes Under Jurisdiction of MAFF (Public Notice of by the Secretary-General of Secretariat of Agriculture, Forestry and Fisheries Research Council, MAFF, 2006).

Today's rapidly advancing life science is beneficial to people, but raises ethical questions which may threaten human dignity and rights. The relevant ministries and agencies have formulated the necessary regulations.

For medical research involving human subjects, proper implementation has been planned based on the Ethical Guidelines for Medical and Health Research Involving Human Subjects (Public Notice of MEXT and MHLW, No. 3 of 2014), which was enacted by combining the Ethical Guidelines for Epidemiological Research and Ethical Guidelines for Clinical Studies.

For research using human cloning techniques and human embryonic stem (ES) cells, the ministries concerned have taken appropriate measures based on the Act on Regulation of Human Cloning Techniques (Act No. 146 of 2000) and the Guidelines on the Derivation of Human Embryonic Stem Cells (Public Notice of MEXT and MHLW, No. 2 of 2014).

③ Securing safety in life science

Recombinant DNA technology can result in new combinations of genes that do not exist in nature. The Act on the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms (Act No. 97 of 2003) provides regulations necessary for ensuring biodiversity.

■ Table 2-2-8 / Major policies for the promotion of life innovation (FY 2015)

Ministry	Implemented by	Project
MEXT	MEXT	Human Frontier Science Program
	AMED	Subsidies for Medical Research and Development
MHLW	MHLW	Health and Labour Sciences Research Grants
		Specific Disease Treatment Research Grants
		Project for Improvement of the Clinical Research Quality Assurance System
		Innovative Drug, Medical Equipment, Regenerative Medical Product Commercialization Promotion Project
		Project for Securing Safety in Clinical Research on Unapproved Drugs
	Radiation Effects Research Foundation	Subsidies for the Radiation Effects Research Foundation
	Prefectural governments	Cost for Commissioning Toxic Gas Disability Person Investigation
METI	METI	Project to Promote the Development and Introduction of Robotic Devices for Nursing Care
		Project focused on developing key technology for discovering and manufacturing drugs for next-generation treatment and diagnosis
		Project for Fundamental Technological Development: Evaluating the Industrialization Potential of Regenerative Medicines
		Project for R&D on medical equipment and for a future medical care system
		Medical-engineering collaboration business promotion project
MOE	MOE	Planning and Survey for the Japan Environment and Children's Study (JECS)
	NIES	Japan Environment and Children's Study (JECS)

Section 4 System Reform toward the Promotion of Science, Technology and Innovation

1 Strategic System Reform toward the Promotion of Science, Technology and Innovation

(1) Strengthening industry-academia-government "knowledge" networks

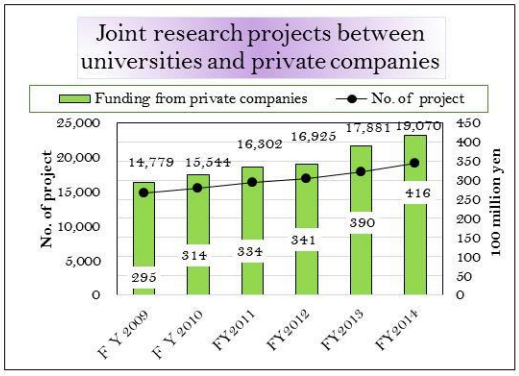
Innovation drives Japan's economic growth. To link the high-quality research results of universities and public institutions with innovations, it is necessary to strengthen industry-academia-government "knowledge" networks.

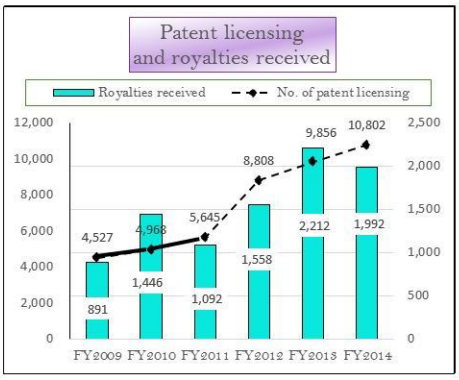
① Current status of domestic and international industry-academia collaborative activities

(i) Status of industry-academia-government collaboration at universities

Since April 2004, when national universities were reorganized as independent administrative agencies, cooperative industry-academic-government activities have been increasing. In FY 2014, the number of collaborative research activities between universities and private corporations was 19,070 (a 6.6% increase over the previous year) and the amount received for joint research from private corporations was about 41.6 billion yen (a 6.6% increase over the previous year). In contrast to FY 2009, the number of the cooperative research activities increased by approximately 20%. In addition, the number of patent licensing reached 10,802 (Figure 2-2-9).

■ Figure 2-2-9 / Transition in achievements of joint research at universities





Research funding from private companies

(million yen)

	FY2011	FY2012	FY2013	FY2014
National Universities	26,522	27,312	30,557	33,108
Public Universities	1,637	1,555	1,783	1,911
Private Universities	5,274	5,281	6,682	6,584
Total	33,433	34,148	39,022	41,603

Patent licensing royalties

(million yen)

	FY2011	FY2012	FY2013	FY2014
National Universities	855	1,101	1,823	1,526
Public Universities	39	45	73	72
Prvate Universities	167	411	316	394
Total	1,061	1,557	2,212	1,992

Notes: 1. Subjects: national, public and private universities
2. The term "Universities" indicates universities, junior colleges, technical colleges and inter-university research institutes.
3. The number of patent licenses denotes the number of patents that have been licensed or transferred (including patents pending)
4. A broken line is used for FY 2012, because that was the year when countries began to use the counting method stipulated in the Patent Cooperation Treaty (PTC).
5. "Total" and "total of intermediate total of national, public and private universities" amount may not match because values of less than 1 million yen are rounded.

Source: Implementation Status of Industry-Academia-Government Collaborations at Universities (2014), MEXT (as of December 25, 2015)

(ii) Activities of the Technology Licensing Organization (TLO)

As of March 31, 2016, 37 TLOs had been approved by MEXT and METI under the Act on the Promotion of Technology Transfer from Universities to Private Business Operators (Act No. 52 of 1998).In FY 2014, the number of patent licenses reached 3,577.

② Effort to expand industry-academia-government collaboration

(i) Development of industry-academia-government collaboration systems at universities

MEXT supports open innovation at universities by creating an environment in which universities can make autonomous, sustainable efforts for industry-academia-government collaborative activities through interactive workshops (places for creating new ideas through dialog in different fields and industries). To appropriately address the diverse risks (e.g., conflicts of interest, the prevention of technology leaks) that accompany improvements in industrial-academic collaboration, MEXT has been supporting the creation and expansion of a system for managing the risks involved in the collaborative activities industry, university and government through its Model Projects for Industry-University-Government Risk Management.

The Japan Patent Office (JPO) has sent university network IP advisors (university intellectual property management experts) to wide-area networks configured by multiple universities, through the National Center for Industrial Property Information and Training (INPIT), in order to develop university IP management systems and enhance IP management capabilities in accordance with the development of industry-academia-government collaboration.

MIC is promoting cooperative industry-academia-government R&D and holding demonstration tests using the New Generation Network Testbed (JGN-X[1]) that has been developed and managed by NICT (See Chapter 3, Section 1, Paragraph 2 (2).)

Through the Industry-Academia Collaborative Support Project for Accelerating Business Deployment, MAFF has allocated coordinators (experts in agriculture, forestry and fisheries and in the food industry) around the country to collect research seeds and to support matching and research planning.

(ii) Enhancement of R&D through industry-academia-government collaboration

The JST is conducting the following programs: 1) the Adaptable & Seamless Technology Transfer Program through Target-Driven R&D (A-STEP), which seamlessly covers the exploration of prospective technological seeds developed at universities and public research institutes and their practical application in industry, 2) the Strategic Promotion of Innovative R&D (S-Innovation), which supports R&D carried out under themes selected from excellent research outputs in academia and aims to create technological foundations of new industries, 3) Collaborative Research Based on Industrial Demand, which supports basic research in academia that could resolve technical challenges commonly seen in industry and 4) the Next-Generation Technology Transfer Program (NexTEP) to support private corporations that are working on the large-scale practical application of university research outputs, whose application involves development risks.

③ Promoting the development of industry-academia-government networks

To promote the development of industry-academia-government networks, it is essential to foster an awareness that is shared by industry and academia. The national government is bringing relevant people together throughout the country and attempting to match them up through forums with open lectures and seminars. To share information, universities are disclosing their achievements by means of workshops, the publication of journals and annual reports, the presentation of research papers at conferences and in academic journals, and patent disclosures.

(i) The 13th Award of Winners Contributing to Industry-Academia-Government Collaboration (Linking Innovation Award) (FY 2015)

To promote industry-academia-government collaboration, 14 such collaborations were given this award by the Prime Minister and other ministers for their contributions to this effort (Table 2-2-10).

(ii) Innovation Japan 2016 - University Trade Fair & Business Matching Event (August 27 - 28, 2015)

MEXT and METI, in cooperation with the JST and NEDO, held the Innovation Japan 2016 - University Trade Fair & Business Matching Event, which was Japan's largest matching forum, with people gathering from universities, public research institutions and private corporations.

1 Japan Gigabit Network–eXtreme

■ Table 2-2-10 / Award winners for contributions to industry-academia-government collaboration

Award	Project	Winner
Prime Minister's Award	Development and standardization of safety verification technologies for "life support robots"	Hirohisa HIRUKAWA, Director of the Robot Innovation Research Center, the National Institute of Advanced Industrial Science and Technology (AIST) Kohtaro OHBA, Deputy Director of the Robot Innovation Research Center, AIST Tatsuo FUJIKAWA, Director, Robot Project Promotion Dept., Japan Automobile Research Institute Yoji YAMADA, Professor, Mechanical Science and Engineering, Graduate School of Engineering, Nagoya University
Minister of State for Science and Technology Policy Award	The entry by local businesses into the aircraft industry based on carbon fiber composite materials developed by a public research organization	Industrial Technology Center of Fukui Prefecture Mitsuya Co., Ltd. Shindo Co., Ltd.
Minister of State for Science and Technology Policy Award	Development of a GaN power semiconductor on a Si board for energy savings	Takashi EGAWA, Professor, Graduate School of Engineering, Nagoya Institute of Technology Akira OHTSUKA, President, DOWA Electronics Materials Co., Ltd.
Minister of Internal Affairs and Communications Award	Promotion of research on resilient ICT and efforts to implement the research result in society through research consortium activities in which industry, academia and the government collaborate	Yoshiaki NEMOTO, Secretary-General of the Association for Disaster-Resilient ICT; Director General of Resilient ICT Research Center, the National Institute of Information and Communications Technology (NIC
Minister of Education, Culture, Sports and Science Award	Development and dissemination of a 4-dimensional gated spot-scanning proton beam therapy system in real-time tumor tracking	Fumito Nakamura, Executive General Manager of Radiation Oncology Systems Division at Hitachi, Ltd. Kazuo Hiramoto, Corporate Chief Engineer, Research and Development Group, Hitachi, Ltd. Hiroki SHIRATO, Professor, Hokkaido University Graduate School of Medicine Kikuo UMEGAKI, Professor, Hokkaido University Faculty of Engineering Hirohiko TSUJII, Fellow, National Institute of Radiological Sciences
Minister of Education, Culture, Sports and Science Award	Development of a stem cell substrate that will be a foundation for regenerative medicine	Kiyotoshi SEKIGUCHI, Professor, Institute for Protein Research, Osaka University Shunji HATTORI, Director, Nippi Research Institute of Biomatrix, Nippi Inc. Masato NAKAGAEA, Lecturer, Center for iPS Cell Research and Application, Kyoto University
Minister of Health, Labour and Welfare (MHLW) Award	Development of the Dentapac Kokoro portable equipment package for home-visit dental treatment	Japan Dental Association Japanese Association for Dental Science Japan Dental Trade Association

Award	Project	Winner
Minister of Agriculture, Forestry and Fisheries (MAFF) Award	A case in which the abandonment of arable land was reversed by the cultivation of the Manten Kirari variety of Tartary buckwheat and its "sextiary industrialization"	Manten Kirari Cultivation Group, Hokkaido Agricultural Research Center, National Agriculture and Food Research Organization (NARO) Junzo SERIZAWA, President, Kobayashi Shokuhin Ltd. Akihiko HARADA, President, Shinmon Co., Ltd.
Minister of Economy, Trade and Industry Award	Development of a 3-dimensional vision sensor for industrial robots	Gang, Professor, Ritsumeikan University; CEO, 3D Media Co., Ltd. Tomohiro NAKAMICHI, Director of R&D Dept., 3D Media Co., Ltd.
Minister of Economy, Trade and Industry Award	Development of techniques for screening cancer in digestive organs by using gene expression analysis of blood	Hiroshi TANNO, CEO, Kubix Co., Ltd. Shuichi KANEKO, Professor, Graduate School of Medical Sciences, Kanazawa University
Minister of Land, Infrastructure, Transport and Tourism Award	The world's first large-scale recycling of large amounts of waste from a mega-disaster	Fujio MATSUZAKI, then-Counselor, Environment and Community Affairs Dept., Miyagi Prefectural Government Kotaro TAKEMURA, Visiting Professor, School of Engineering, Tohoku University Masatoshi SASKI, then-Director of the Special Purpose Joint Venture for Disaster Waste Disposal in the Ishinomaki Area
Minister of Environment Award	Dramatic carbon emissions reductions for data centers and the cooperative development of a technique for using waste heat in offices	Kou MIYAKE, President and CEO, President, NTT Data Intellilink Corp. Atsushi OUCHI, CEO, Takasago Thermal Engineering Co., Ltd. Morito MATSUOKA, Professor, Cybermedia Center, Osaka University Masayuki MURATA, Professor, Graduate School of Information Science and Technology, Osaka University Norihiro HAGITA, Director, Social Media Research Center, Advanced Telecommunications Research Institute International
Keidanren (Japan Business Federation) Chairman Award	Development of Muscle Suit®, a powered exoskeleton	Takashi FUJIMOTO, then President and CEO, Innophys Co., Ltd. Isao KIKUCHI, President & CEO, Kikuchi Seiksakusho Co., Ltd. Hiroshi KOBAYASHI, Professor, Faculty of Engineering Division I, Department of Mechanical Engineering, Tokyo University of Science
President's Award, SCJ	Development of a shortwave and longwave UV LED	Hiroshi AMANO, Professor, Graduate School of Engineering, Nagoya University Toshihiko KAI, President and CEO, Nikkiso Co., Ltd.

(iii) Agribusiness Creation Fair (November 18 - 20, 2015)

In cooperation with the relevant ministries and institutions, MAFF holds the Agribusiness Creation Fair every year. The objective is to exhibit technology seeds from private corporations, universities, public experimental research institutions and independent administrative institutions, and to promote collaboration with institutions which are in need of technology. In FY 2015, the exhibition was held next to an exhibition hall in which private corporations were promoting the industrial use of their new technologies. At the fair, 148 institutions from throughout Japan exhibited their seeds and about 35,000 people attended.

(2) Developing platforms for industry-academia-government collaboration

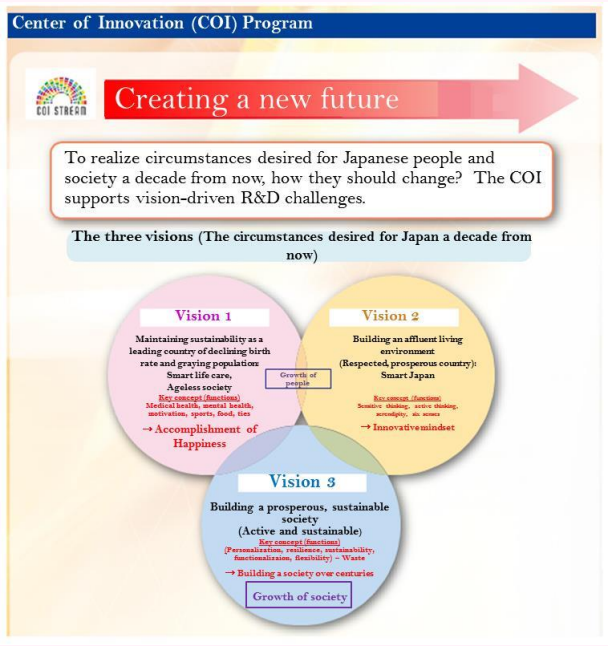
To promote STI promptly and effectively, it is necessary to develop forums for industry-academia-government cooperation.

① Developing centers for the creation of cutting-edge innovation

Since 2013 MEXT has been implementing the Radical Innovation and Entrepreneurship Program (COI STREAM).

COI STREAM has set visions with the aim of realizing a desirable society and way of life within 10 years. They identify innovative challenges to fulfill the visions. Universities and businesses make utmost efforts, particularly businesses, to take the lead in the practical application of research results. The goal is to build a large-scale R&D center that is world competitive and where concentrated R&D is conducted by universities and businesses seeking the commercialization of research results (Figure 2-2-11).

■ Figure 2-2-11 / Visions of COI



Source: Created by MEXT and JST

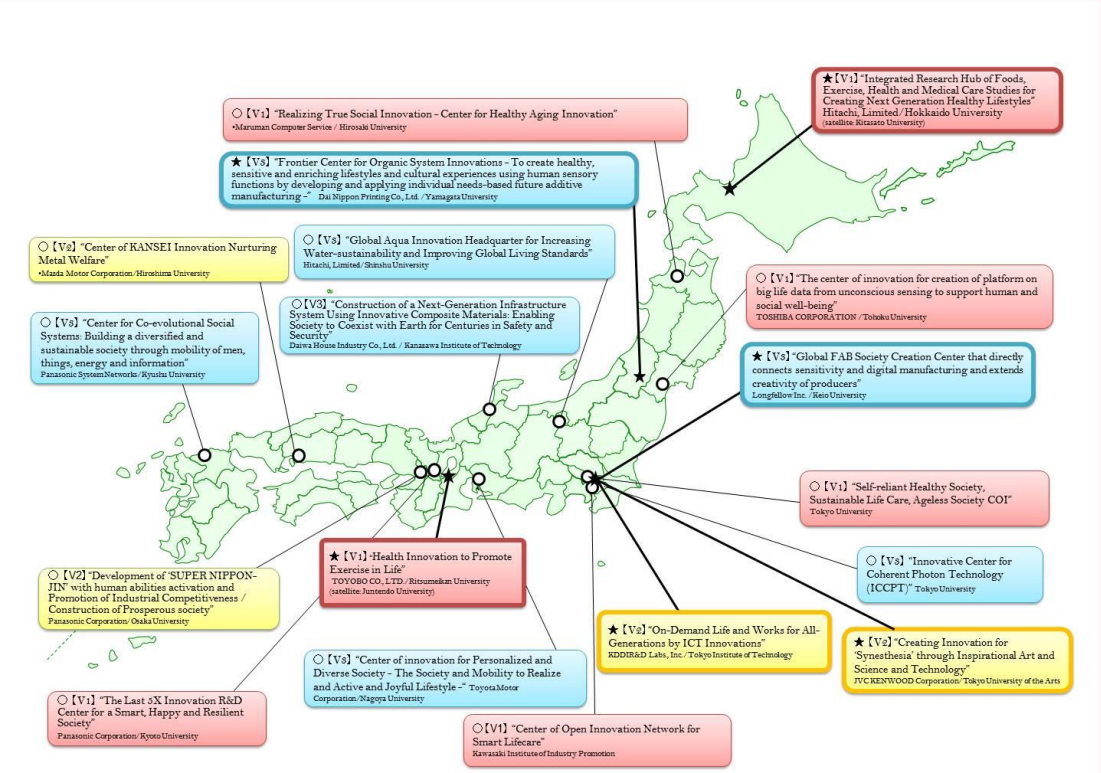
In FY 2013, 12 sites were selected for designation as COI sites where industry and academia would collaborate on cutting-edge research and 14 sites were selected as candidate COI sites for the examination of technology concepts and element technologies geared to solving R&D challenges.

In FY 2015, R&D was conducted at 18 COI sites, including at 6 sites that had been upgraded from trial COI sites to COI sites (Figure 2-2-12).

② Formation of a world-leading R&D and demonstration base for R&D projects of local origin

Since FY 2015, MEXT has been implementing the World-leading Locally Originated R&D and Demonstration Base (Research Complex) Promotion Program, towards the creation of world-class

■ Figure 2-2-12 / COI sites



Source: Created by MEXT and JST

innovations. The program aims to assist local industries, universities, governments and financial institutions, which are united under a common vision, in their efforts to achieve regional revitalization through commercialization of the results of advanced and collaborative R&D by researchers in different fields in Japan and abroad. The ministry has been working towards the development and improvement of research complexes that serve as bases for the promotion of comprehensive innovation, where human resource development can be achieved comprehensively. In FY 2015, the ministry selected one base for the full-fledged implementation of the program and three other bases for feasibility studies.

③ Developing open innovation centers

(i) Tsukuba Science City

Tsukuba Science City has been developed as a center of R&D and education of the highest level in Japan, away from the congestion of Tokyo. The city has more than 300 research institutes, including 32 national experimental research and education institutes, and has been promoting many governmental plans, such as those for research exchanges and the functional improvement of international research exchanges.

The city has been aiming to organize a world-class nanotechnology research center at which three core institutes (NIMS, AIST and Tsukuba University) serve as the major force. In June 2009, the Tsukuba Innovation Arena Nanotechnology (TIA-nano) was launched as a base for industry-academia-government collaboration. In April 2012, the High-Energy Accelerator Research Organization (KEK),

which possesses the Photon Factory synchrotron, became the fourth core institute to join the TIA. TIA-nano is promoting the formation of the center to make the most of increased core research domains and core infrastructure. Based on the TIA-nano 2015-2019 plan formulated in March 2015, TIA-nano has been developing a system for promoting the formation of "open platforms" that bring together people, knowledge and technologies and has been bolstering the management of that system. Towards expanding the number of participating businesses, TIA-nano publicized itself by holding the TIA-nano Open Symposium in September 2015. In December 2015, TIA-nano announced that the University of Tokyo would be joining the central organizations of TIA-nano and started examinations for collaborative research themes done by the five central organizations, with the aim of forming a world-class base for innovation.

Aiming to foster next-generation human resources in the field of nanotechnology and to create new industries that will lead Japan in the future, the TIA graduate school collaboration project held the Summer Open Festival in 2015 at the TIA Collaboration Building. It attracted 334 young researchers, including undergraduate students, graduate students and business researchers from throughout Japan.

Under the Nanotech CUPAL[1] human resource development project, which has been implemented to facilitate career enhancement and mobility improvements for young researchers in nanotechnology, practical training courses have been held that provide young researchers with opportunities to learn fundamental and elemental technologies for R&D. Course participants totaled 158 in FY2015.

The National Institute of Advanced Industrial Science and Technology has been exploring technological seeds and promoting R&D projects while capturing the various technological needs of industry and society. Specifically, AIST is promoting the activities of TIA-nano, an open innovation hub. AIST has participated in 22 technology research associations as part of an undertaking to form a co-creation platform and has carried out 20 large-scale external funding projects (as of January 2016).

(ii) Kansai Science City

Kansai Science City is promoting the construction of towns that will play a role as bases for developing the world's culture, science and research and the nation's economy. As of the end of FY 2015, it had about 120 facilities at which various research activities were under way.

④ Organizing a co-creation platform under which industry and universities interact through discussions

The JST is implementing a program known as Collaborative Research Based on Industrial Demand. This program aims to organize a co-creation platform where dialogs between industries and universities take place so that universities can identify and engage in basic research on technical issues faced by industries and also that solutions to such issues can be accelerated.

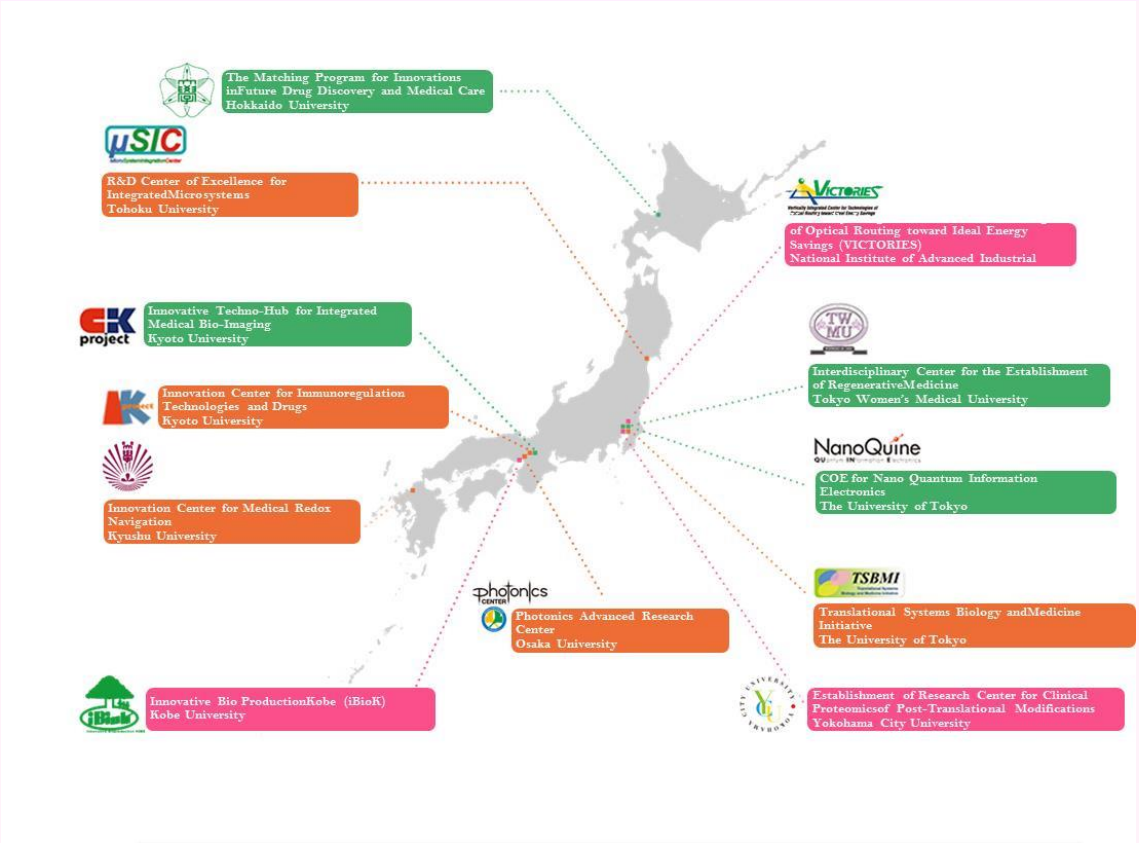
MAFF arranges for coordinators to promote industry-academia co-creative collaboration and hosts local matching forums to support the diffusion of local R&D and technology, so that the people involved in the process, from R&D to its diffusion and industrialization, can work collaboratively toward the same goal.

1 Nanotech Career-up Alliance

⑤ Creation of Innovation Centers for Advanced Interdisciplinary Research Areas

MEXT is promoting the Creation of Innovation Centers for Advanced Interdisciplinary Research Areas to support institutions that form bases for R&D, from the first stages to future commercialization under industry-academia collaboration for advanced interdisciplinary research areas. This is considered important for innovation creation; 12 projects at 10 institutions have been supported as of FY 2015 (Figure 2-2-13).

■ Figure 2-2-13 / List of projects being implemented under the Creation of Innovation Centers for Advanced Interdisciplinary Research Areas



Source: Created by MEXT

2 Construction of a New System for Science, Technology and Innovation

(1) Environmental improvement to support industrialization

To create new industries and jobs to vitalize the economy, it is essential to activate start-up businesses that utilize the results of advanced S&T.

However, the number of university-launched venture companies decreased to 65 companies in 2014 compared with 252 per year in the peak years of 2004 and 2005. Some university-launched venture companies encountered business issues, such as securing sales channels. Therefore, MEXT has been improving the environment for start-ups of high-quality university-launched venture businesses that can identify true market needs and grow into global businesses.

① Support for university-launched venture companies

The JST has launched the Program for Creating Start-ups from Advanced Research and Technology (START). Under this program, universities and independent administrative agencies conduct R&D towards commercializing technologies that are high risk but have great potential by using the commercialization know-how of private-sector experts such as venture capitalists. Under this program, projects for selecting and fostering technological seeds are implemented.

This program adds new projects for developing technologies and demonstrating the feasibility of their commercialization, including robotics technologies. The Enhancing Development of Global Entrepreneurs (EDGE) program, launched in FY 2014 provides the most advanced human resource development for young researchers and graduate students who are learning skills such as entrepreneurship, start-up know-how and idea creation methods in collaboration with private sectors and overseas institutes including venture capitals and manufacturers.

In addition, the Support Program of Capital Contribution to Early-Stage Companies (SUCCESS) invests in the foundation and capital increases of venture companies that utilize R&D outcomes of the JST, or offers labor and technical support whereby early-stage venture companies can promote the commercialization of R&D results through their business activities.

② Support for R&D-type ventures

MIC has been implementing the Challenge Program for ICT Innovation Creation since FY 2014. The program invites venture capitalists to support business projects by serving as experts, and it uses the connoisseur capabilities, management know-how and project development abilities of these experts to provide support during the business model verification phase, so that SMEs can start new businesses that have innovative technological seeds and ideas as a result of R&D.

RIKEN has established a preferential treatment system for patent licensing to promote the quick diffusion and industrialization of achievements. Under this system, RIKEN gives preferential treatment to businesses that they recognize as promising.

In addition, under the Program for promotion of private-sector commercialization research and in consideration of market needs and costs, NARO has been utilizing various resources, ubiquitous in rural areas, to promote the R&D of private corporations that is in the commercialization stage, toward the "sextiary industrialization" of rural areas.

③ Support by the Small Business Innovation Research System (SBIR system)

Under the small business innovation research (SBIR[1]) system, subsidies and commissions have been granted (special subsidies) to provide small and mid-sized businesses with assistance for R&D on new technologies. Several industrialization support measures, including the provision of patent fee reductions and low-interest loans by the Japan Finance Corp., have also been taken. In FY 2015, seven ministries (MIC, MEXT, MHLW, MAFF, METI, MLIT and MOE) designated 102 special subsidies in all and earmarked about 45.5 billion yen as expenditures for small and mid-sized enterprises.

1 Small Business Innovation Research: The agencies concerned jointly and comprehensively support R&D and its commercialization for small and mid-sized enterprises that use new technologies.

(2) Regulations and systems for accelerating innovation

Although regulations and systems have been established for the promotion of safe, smooth R&D, these could potentially impede innovation due to excessive strictness. The Japanese government has been promoting a system called National Strategic Special Zones. The system is positioned as a breakthrough point for regulator and system reforms under the Japan Revitalization Strategy. In addition, the conventional Comprehensive Special Zone System and other special zone systems are expected to be increased. These systems are expected to accelerate innovation.

① Efforts for National Strategic Districts

The Japanese government designated 10 areas as National Strategic Special Zones.

From January to July 2015, investigative commissions for Special Zones for Near-Future Technologies were convened six times. Through interview surveys on remote medical care, remote education, autonomous driving and autonomous flying, the commissions decided on several important regulatory reform items and published them in the *Japan Revitalization Strategy, Revised Edition (2015)*. The government presented a plan for revising the National Strategic Economic Zone Act--a plan that included the measure "Exceptions to face-to-face drug guidance by pharmacists in favor of guidance by TV phones" during the ordinary Diet session of 2016. The government has been further promoting the reform of regulations and systems.

In Semboku City, Akita Prefecture, a flight demonstration for a small unmanned airplane was done. In Kanagawa Prefecture and Sendai City, Miyagi Prefecture, demonstration tests for full-fledged autonomous driving were conducted. The government has been conducting efforts to promote innovations, mainly of near-future technologies.

② Efforts for the Comprehensive Special Zone System

The government has selected 7 areas to designate as International Strategic Zones, in order to form industrial and functional clusters that will drive Japan's economic growth. It has also selected 41 areas as Comprehensive Special Zones for Local Revitalization to strengthen regions through local vitalization in which the use of local resources is maximized, and it has comprehensively support the selected areas through preferential measures on regulations and support measures regarding taxation and financing.

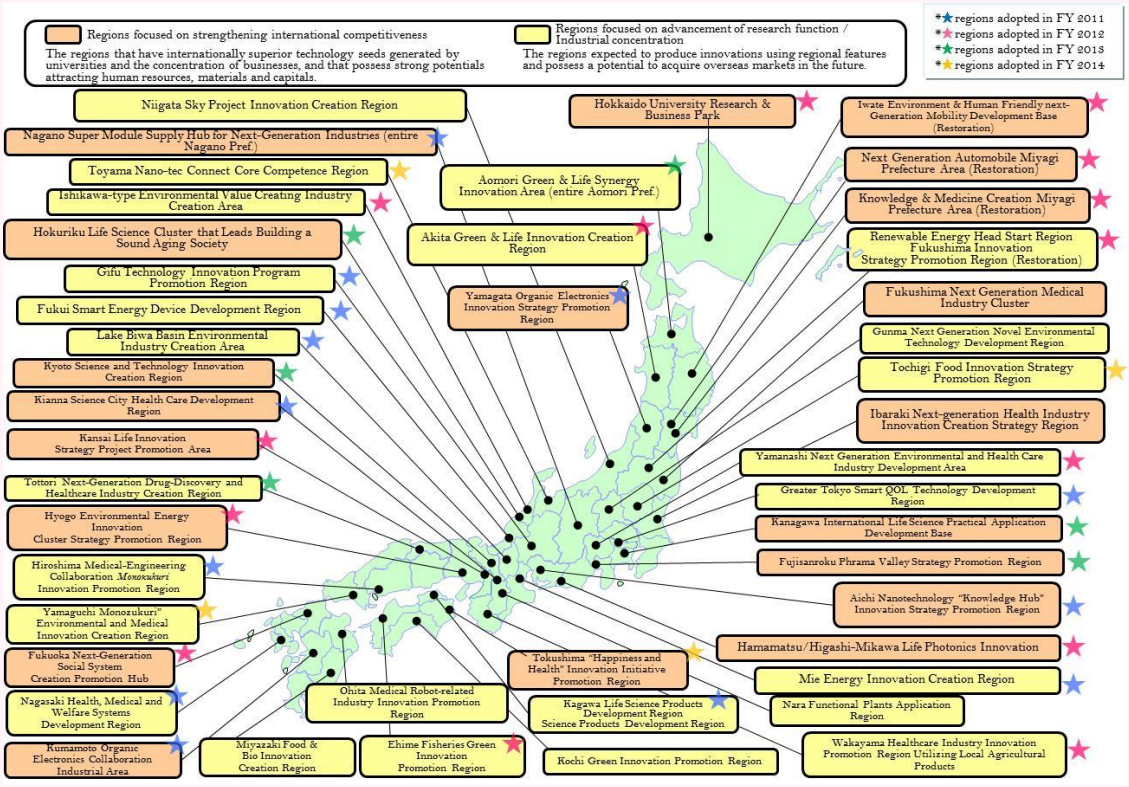
(3) Development of a regional innovation system

To promote efforts to solve various issues at the local level and to vitalize local areas using S&T, it is important to utilize the advantages, diversity, uniqueness and originality that each area possesses.

With the aim of regional innovation, MEXT, METI, MAFF and MIC have been designating certain regions as Innovation Strategy Promotion Regions. These regions are those in which original concepts have arisen through partnerships or other cooperation between local governments, university research institutes, other research institutes, businesses and financial institutions. MEXT, METI, MAFF and MIC have mobilized policies to establish support systems that target these regions and that provide continuous support, from initial research to commercialization.

The above-mentioned four ministries and the Reconstruction Agency select GEJE-afflicted areas separately from the selected regions described above for designation as GEJE Recovery Support-type Regional Innovation Strategy Promoting Regions, and support the industries, universities and

■ Figure 2-2-14 / Regions in which Innovation Promotion Strategies have been supported: List of regions selected in FY 2015



As of FY 2015, 17 regions had been designated as Regions Focused on International Competitiveness, 24 regions had been designated as Regions Focused on Advancement of Research Function/Industrial Concentration and 4 regions had been designated as GEJE Recovery Support-type of Regional Innovation Strategy Promoting Regions, for a total of 45 regions selected.

Source: MEXT

governments in these regions in achieving proactive and outstanding ideas in the regions, in order to create regional innovations based on regional strengths and features.

As of FY 2015, 41 regions had been selected: 17 Regions Focused on International Competitiveness, in which local universities have internationally competitive technological seeds, internationally competitive businesses have gathered, and there is a strong potential to attract labor, goods and money from abroad; and 24 Regions Focused on Advancement of Research Function/Industrial Concentration, which are expected to create innovations based on local features and which have the potential to capture overseas markets in future (Figure 2-2-14).

Based on a decision by the Minister of State for Science and Technology Policy on 22 July 2015, the Cabinet Office discussed how to achieve collaboration among ministries and agencies. The Science and Technology Innovation Promotion Task Force for Regional Revitalization was established under the minister in order to discuss information sharing and use.

The first meeting of this task force was on July 31, 2015. Five meetings had been held as of January 15, 2016. Cases were introduced from industry, academia and government on wide areas, including the food industry, the crafts industry, agriculture, renewable energy, intellectual property and post-earthquake reconstruction. Active discussions were held on the various topics, including the directions of their efforts.

MEXT has been providing support for the development of intellectual property and human resources. Regarding the GEJE Recovery Support-type of Regional Innovation Strategy Promoting Regions, MEXT has been supporting efforts intended to construct mechanisms for sustainable and developmental innovations.

Under the Matching Planner Program, matching planners connect seeds from universities to the needs of regional businesses throughout Japan. These planners support the universities and businesses from cooperative research to the commercialization of the seeds, and provide solutions to businesses that need them. The program supports the regional innovations in science and technology. Even though the innovations are for niche markets, they have added value and competitiveness.

For the promotion of local industries through ICT R&D under the Strategic Information and Communications Research and Development Promotion Program, MIC is promoting industry-academia collaborative research on ICT that will contribute to the creation of new local industries, promote local industries and vitalize local society.

Under the program for the promotion of science and technology research on agriculture, forestry and fishery and food, MAFF has set research topics that could lead to local vitalization using ideas and solutions to issues faced by manufacturers, in order to promote cooperative industry-academia-university R&D led by prefectural experimental research institutions and local universities. It specifically supports research on local innovation strategies. In addition, MAFF has allocated industry-academia-university collaborative coordinators nationwide who are experts on agriculture, forestry and fishery and on food industries, to promote R&D in local industries through support for the preparation of research planning.

METI supports the discovery of business seeds by providing places for matching and technological development that may lead to new business by SMEs and small-scale enterprises using technological seeds developed by universities through the R&D Project for Discovering and Using Seeds, in order to facilitate licensing agreements between SMEs or small-scale enterprises and universities.

The AIST has designated the Tsukuba Center, the Fukushima Renewable Energy Institute, the Rinkai-Fukutoshin Center and seven other local centers throughout Japan as research centers whose purpose is to engage in world-leading research related to local circumstances and to transfer the results to local industry. The revitalization of regional industries has been promoted through the concerted efforts of the AIST at these ten research platforms around Japan, which work in collaboration to support regional core businesses, well-established businesses, SMEs, universities, and public testing and research organizations, by providing technological assistance, conducting collaborative research and receiving human resources from these organizations.

(4) Promoting an intellectual property strategy and an international standardization strategy

With the progress of economic globalization, the importance of various intellectual activities that are sources of economic growth has been increasing. To enhance the competitiveness of Japanese industries and improve the lives of the citizens, it has become important for Japan to create advanced technologies and rich culture, and to link these to the creation and expansion of businesses. The Intellectual Property Strategy serves as the foundation for such activities.

The Intellectual Property Strategy Headquarters launched the IP Promotion Plan 2015 in June 2015

for the creation and protection of intellectual property. The plan calls for the promotion of intellectual property use in regional areas, the active use of conflict-resolution systems for intellectual property and the introduction of a system for new employee inventions and for the comprehensive reinforcement of business secrets protection. To promote the IP strategy according to the plan, the Intellectual Property Strategy Headquarters has been leading the activities under the Intellectual Property Strategy in collaboration with ministries and agencies concerned.

① Efforts towards the promotion of strategic standardization

The Japan Revitalization Strategy, 2015 Revision and the IP Promotion Plan 2015 call for the promotion and acceleration of strategic standardization.

Based on the public-private standardization strategy (formulated in May 2014) and in close collaboration with the public and private sectors, METI has been promoting policies for the promotion of strategic standardization that may lead to the strengthening of a system for developing public-private collaboration, the formation of world-class certification infrastructure, cooperation with Asian nations, the creation of new markets and the strengthening of industrial competitiveness.

By utilizing the New Market Creation Standardization System, which was established based on the above strategy, the ministry decided on the standardization of 9 items that had been proposed by well-established businesses and SMEs at the Japanese Industrial Standards Committee, in stages (May 2015, December 2015 and January 2016). METI established and launched the Partnership System for Supporting Utilization of Standardization in November 2015. Under this system, local authorities and business promotion organizations, local financial institutions, universities and public research institutions (partner organizations), and the Japanese Standards Association work in collaboration and provide information and advice to local businesses on their utilization of standardization strategies.

In the ministry's efforts to realize a world-leading system for the granting of certifications, METI established a facility for certifying large power conditioners and large batteries, under its Project to Develop Global Certification Infrastructure. The purpose was to provide Japanese businesses with a foundation for certification and a test facility the results from which would be internationally acknowledged. The business fields selected for this project were those that were thought to be important for the overseas expansion and development of Japanese industry. The ministry held the ACCSQ-METI conference in Manila, Philippines, in April 2015 and exchanged information and opinions with the participants on the standardization activities in fields in which Japan and the participating countries are interested. The ministry and the Singapore Office of the International Organization for Standardization (ISO) held a workshop to promote activities for international standardization by Japan and the ASEAN countries. In August 2015, the ISO certified a method for evaluating a technology for bonding metal and resin, which had been developed by a Japanese manufacturer. The certified method became an international standard.

MIC has promoted standardization activities in the ITU[1] and related forums mainly for the prioritized areas of smart grids, digital signage[2] and next-generation browsers, in line with the report of the Telecommunications Council Standardization Policies in Telecommunication (July 2012).

1 International Telecommunication Union
2 In this system, information is delivered by using electronic displays that are connected to networks. The displays are in various places, including outdoors and in shops, public spaces and public transportation systems.

Water supply has been included as a specific strategic field for international standardization, so MLIT and MHLW are promoting its strategic international standardization under the IP Promotion Plan to ensure that Japanese corporations launching water supply and sewerage system businesses in the global market can achieve high competitiveness. Currently, these two ministries are actively participating in the Asset Management Area (ISO/TC224WG6& ISO/PC251) and the Crisis Management Area (ISO/T224WG7) to lay out policies for ISO International Standards.

The establishment of the Project Committee on Wastewater Reuse for Irrigation (ISO/PC282) was led by MLIT. This was the first water-related ISO committee in which Japan served as the secretariat.

② Review of IP systems and improvement of IP-related systems

In response to changes in the world innovation environment, the relevant authorities are promoting the following approaches towards the development and implementation of international standardization strategies, the review of IP systems and the improvement of IP-related systems.

(i) JPO

a) Promotion of the Global IP Initiative

Amidst growing economic globalization and open innovation, the JPO is promoting the Global IP Initiative (laid out by the JPO in July 2011) to incrementally improve global IP infrastructure, so that Japanese companies can smoothly engage in business internationally. Currently, the JPO is implementing the "patent prosecution highway (PPH)" with 30 nations (as of February 2016). This will allow patent applicants whose patents have been deemed patentable to apply for early examination in other countries. As a new effort to contribute to international cooperation in patent examination, the JPO and the U.S. Patent and Trademark Office (PTO) initiated the JP-US Collaborative Search Pilot Program on August 1, 2015. Under this program, the patent examiners in Japan and the U.S.A. conduct independent searches on advanced technology applications and share the search results and opinions before forwarding the examination results to the patent office of each country.

b) Provision of patent information

To respond to the increasingly sophisticated and diversified user needs for patent information, INPIT started a patent information provision service called Patent Information Platform (J-PlatPat), which provides patent information through the Internet, in March 2015.

The JPO started the System for Searching and Translating Documents from Chinese and Korean, which aids investigations on the burgeoning patent documents of China and South Korea (started in January 2015), and the Foreign Patent Information Service (FOPISER), which provides patent information of ASEAN and other countries (started in August 2015).

c) Acceleration of the examination system

To meet the need among patent applicants for expedited patent rights acquisition, the JPO is implementing an accelerated examination system that applies under certain conditions. Additionally, they have, since August 2011, been implementing the Accelerated Examination and Accelerated Appeal Examination to Support Recovery from Earthquake Disasters, in order to speed the examination of patent applications from people and business facilities affected by the GEJE, so as to allow them to apply intellectual property towards restoration.

The Act for Special Measures Promotion of Research and Development Businesses etc. by Specified Multinational Enterprises (Act for Promotion of Japan as an Asian Business Center) (Act No. 55 of 2012) was enacted to promote activities that will attract R&D bases and supervisory bases of global enterprises to Japan. In November 2012, the patents applied as the results of R&D projects approved under the Act were, on a trial basis, included in the subject of the acceleration of the patent examination system.

d) Collective examination for IP portfolio supporting business activities

In recent years, along with the globalization of business activities and the diversification of business structure, the intellectual property strategies of businesses have been changing to those that originate from their business. The JPO studied a new examination system to meet the needs of patent applications in response to the Global IP Initiative. In April 2013, the JPO started a new initiative, collective examination for IP portfolio supporting business activities, under which it examines applications and grants rights interdisciplinarily according to the timing of the applicant's business development, in order to support applications for comprehensive intellectual property. The new initiative applies to groups of intellectual rights (i.e., patents, design rights and trademarks) that are associated with domestic and overseas projects.

e) Information services concerning licensable patents and research tools

To expedite the use of IP, the JPO provides information on licensable patents and research tool patents in the form of a database through INPIT.

f) Complete revision of the Examination Guidelines for Patent and Utility Model

Based on the basic policy approved by the Working Group on the Patent Examination Standards of the Industrial Structure Council, JPO has examined the *Examination Guidelines for Patent and Utility Model in Japan* and the *Examination Handbook for Patent and Utility Model in Japan*, and has completely revised them. In October 2015, JOP published and started using the *Examination Guidelines for Patent and Utility Model in Japan* and the *Examination Handbook for Patent and Utility Model in Japan*, revised in September 2015.

g) Compilation and publication of the Handbook for PCT International Search and Preliminary Examination in the Japan Patent Office

The *Handbook for PCT International Search and Preliminary Examination in the Japan Patent Office*, in which business procedures and evaluation criteria for PCT application are explained comprehensively and in detail, was newly compiled and published. The new handbook has been used for international searches in PCT applications and preliminary examinations since October 2015.

h) Implementation and the publication of a survey on technology trends

There are calls for coordination between R&D strategies and intellectual property strategies, to facilitate the utilization of patent information on R&D. Therefore, the JPO has comprehensively analyzed technology trends by analyzing patent application trends in light of R&D trends and market trends. It has published the results.

(ii) Developing and securing human resources

The JPO has been collaborating with INPIT in spreading knowledge about intellectual property, as well as in providing support to senior high schools and colleges of technology that utilize intellectual property in practical education for human resources development.

(iii) JST

The JST is making efforts that range from the discovery of high-quality research achievements through support for patent acquisition and onward to industrialization. Specifically, the agency is giving full support to the utilization of intellectual property through the Promotion of the Use of Intellectual Property. This includes supporting the strategic acquisition of foreign patents by universities through use of their research results, collecting and packaging some patent rights scattered across some universities for more efficient use and offering patent information to universities free of charge through the Internet (J-STORE).