

## Chapter 2 Realization of Sustainable Growth and Societal Development into the Future

### Section 1 Realization of Recovery and Restoration from the Earthquake Disaster

Numerous efforts to resolve the various issues listed in Basic Guidelines for Reconstruction in response to the Great East Japan Earthquake (determined by Reconstruction Headquarters in response to the Great East Japan Earthquake on July 29, 2011) showing the policy for recovery and restoration from the GEJE, to rebuild promptly victim's lives and realize a secure and safe society are being undertaken by making full use of STI including creation of new industries, development of decontamination and improvement of disaster information systems with the most advanced technology calling upon the wisdom of industry-academic-government.

#### 1 Promotion of Measures to Accomplish the Important Issues

##### (1) Reconstruction and revival of industries in the disaster areas

The industries in the disaster areas suffered significant damage by the earthquake, tsunami and diffusion of radioactive material. Thereafter, the various problems exposed by the earthquake disaster are being resolved by making full use of S&T towards realizing the vigorous revival with prompt reconstruction of the base of economic and industrial activities, while the advanced R&D taking advantage of strength and characteristics of each area is being pursued in the field of research leading to creation of a new growing industry and employment which are expected to help the reconstruction in the disaster areas.

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

MEXT has established the "Tohoku Marine Science Center" as network system for reconstruction support by universities or research institutes in collaboration with local governments or ministries concerned and is conducting survey research on reconstruction of the marine ecology offshore Tohoku in the Pacific, suffered from tsunami, and technology development leading to creation of a new industry. The obtained results have started to be used for the formulation of local fishery projects and building of fish farms. The Ministry is also promoting the "Tohoku Medical Megabank" project conducting the cohort study of local residents in close cooperation with construction of a regional medical information center with support of MIC and the Ministry of Health, Labour and Welfare (MHLW), in order to contribute to the reconstruction of the medical services for the disaster areas and to provide early next-generation medical care such as individualized medicine for the disaster areas. The Ministry is also promoting the "Tohoku Innovative Materials Technology Initiatives for Reconstruction" with the aim to drive the development of material industry in Tohoku area by forming nanotechnology research and development center through industry-academia-government cooperation and developing cutting-edge

materials using the world leading technologies in the nanotechnology and material fields in which universities and industries in Tohoku are strong.

The Ministry of Agriculture, Forestry and Fisheries (MAFF) is conducting large-scale experimental study for the farming industry - farming village type of model areas located in Miyagi Prefecture, the fishery industry - fishing village type of model areas located in Iwate Prefecture, making full use of advanced technology in the field of agriculture, forestry and fisheries, in order to accelerate reconstruction and revival of agriculture, forestry and fishing as key industries and farming or fishing villages in the disaster areas and to develop a new growing agriculture, forestry or fishing industry. The Ministry has also started to make efforts to analyze the effects of technology introduction and diffuse and promote research results. In concrete terms, the Ministry is conducting experimental studies on technology for cost reduction of land use type agriculture in disaster-affected paddies, precise environmental control technology for horticultural facilities, mechanization of seaweed harvesting and others in collaboration with farmers.

The Ministry of Economy, Trade and Industry (METI) is assisting demonstrations or performance evaluations of the practical technology, conducted jointly by testing and research institutes established by companies, universities or local governments in the disaster areas, as promotion efforts of commercializing superior practical technology meeting the needs in the disaster areas. The ministry is also taking measures to promote R&D in industry-academia-government collaboration in the growing fields such as medical, information and communications, and renewable energy and to create new industries or employment. In particular, the Ministry is assisting the development and demonstration of medical equipment in collaboration with Monodzukuri companies and medical institutions, as efforts leading to activation of local industries in Fukushima Prefecture, and the improvement project of medical industry base centering on Fukushima Medical University through Recovery Fund concerning Nuclear Emergency Preparedness in Fukushima established for restoration from the nuclear hazards. For the efforts to assist the business deployment leading to reconstruction of the disaster areas in Tohoku and reconstruction of Japan, the Ministry has implemented improvement and development of the base of study and system development for which companies and bodies concerned form the best consortium in an IT integration field<sup>1</sup> and provided a subsidy.

In addition, for the efforts to expand the introduction of renewable energies, METI has implemented the development of R&D centers for renewable energies through industry-academia-government cooperation, an experimental project designed to commercialize world's top class floating offshore wind power plant, assistance of the construction of a smart community focused on the use of renewable energies for building disaster-resistant communities and others.

## (2) Recovery and revival of social infrastructures

In the disaster areas a lot of civil engineering or building structures were destroyed or washed away, social infrastructures were blocked due to the earthquake, tsunami and liquefaction, and so enormous damage was caused. The technical advice for recovery of bridges and banks which suffered from the tsunami, or R&D for functional recovery of lifelines and improvement in seismic capacity of structures is

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<sup>1</sup> There is huge potential for creation of a new business in the event of an industrial structural change by integration of IT in this field, where Japan has the advantage in elemental technologies (for example, energy, medical and health, agriculture, robot, or car and transportation).

being provided in the light of such damage. Additionally, measures are being taken to strengthen disaster-resistance of the information and communications facilities, and to carry out R&D of Information and Communications Technology (ICT) for understanding the situations in a disaster area.

In case of the GEJE, intensive use of telephones or widespread and great damage of communication facilities made it impossible to secure the communication means necessary in disaster. In light of the lessons learned from such communication failure, MIC is conducting R&D and empirical experiments of “technology to reinforce communication processing capacity urgently in time of disaster” and “satellite communication network which autonomously works” in order to eliminate tight communication when a natural disaster such as a large-scale wind and flood damage and the like occurs and implement secure information transmission. The ministry is also conducting R&D of the network robot technology which realizes sensitive operation with information gathering and situation analysis via networks towards practical application in the disaster response field. In MIC and NICT, furthermore, R&D of the airborne synthetic aperture radar, Polarimetric and Interferometric Synthetic Aperture Radar System 2 (Pi-SAR2), which can flexibly and as needed observe land surface situations in the event of disaster whatever the weather, and the electromagnetic wave sensing technology which can make a non-destructive diagnosis of structural health of buildings if there is possibility of damage by earthquakes is being conducted.

MEXT is conducting investigation and research for maintaining and recovering city functions with a view to reviewing the margin of safety ratio against building collapse following the vibration test results etc. in the “Special Project for Reducing Vulnerability in Urban Mega Earthquake Disasters”.

National Research Institute for Earth Science and Disaster Prevention (NIED) is conducting a large seismic motion experiment using 3-D Full-Scale Earthquake Testing Facility (E-Defense) for the purpose of analysis of destructing process of urban structures such as buildings and lifeline facilities by seismic motions, development of effective disaster mitigation technology, and maintenance and sustainable utilization of city functions in a time of disaster.(refer to Part 2, Chapter 3, Section 1 (1))

In addition, National Institute for Materials Science (NIMS) is comprehensively promoting the efforts to develop materials which will contribute to the toughening of Japan aimed at disaster prevention and competitiveness enhancement by fully mobilizing scientific and technological capacities in the materials field where Japan excels with the aim to promote the prolongation and enhance earthquake resistance of the social infrastructure which poses a big social threat because of the age progression.

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is conducting technology development which will contribute to the improvement in precision for evaluating the resistance to seismic force of buildings based on the implementation of seismic observations of buildings and organization as well as analysis of their records in order to secure safety of buildings against major earthquakes including subduction earthquakes and others.

National Institute for Land and Infrastructure Management (NILIM), on its part, is conducting the review on the validation of technical standards based on understanding and analysis of the disaster situations, including preparation of guidelines showing the standard method for prompt and appropriate tsunami flooding simulation, development of methods to allow a quick estimation of the damage of rivers and roads after the occurrence of a large-scale earthquake, development of liquefaction countermeasure technology of residential lands and of tool to analyze its effects and influences, establishment of method and criteria for evaluating earthquake-proof safety of nonstructural components of buildings among other measures in order to assist to design recovery and reconstruction

plans for the disaster areas.

Public Works Research Institute (PWRI) is conducting a research on the behavior and resistance characteristics of bridges which are affected by tsunami and a research on the sophistication of liquefaction determination method in order to urgently deal with the damage caused by the tsunami and liquefaction which occurred as a result of Tohoku-Pacific Ocean Earthquake.

### (3) Realization of safety living in the disaster areas

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

In and around the aftershock area of “Off the Pacific coast of Tohoku Earthquake,” the greater seismic activities have been occurring and it is likely that great aftershock or induced seismicity will occur in the future, so that destructive shaking and major tidal wave may be generated. Taking into account this prediction, efforts to expand and enforce the survey and observation of earthquake and tsunami is being undertaken for the purpose of understanding their generation mechanism and providing prompt and accurate information on them. In addition, a disaster information providing system developed in the aim of collecting, preparing and transmitting the information useful for disaster response, recovery and reconstruction, has been set in the disaster areas. Furthermore, surveillance and monitoring technology for lifesaving has been developed and measures to mitigate damage from fires caused by earthquake have been considered.

In FY 2011, MEXT started the “Ocean Bottom Seismic and Tsunami Network Planning along the Japan Trench” which helps to convey quick and accurate disaster information based on direct detection of earthquakes and tsunamis off the Pacific Coast of Tohoku Region. In FY 2012, the Ministry manufactured necessary equipment with a view to starting full-scale operation in FY 2015 (Figure 2-2-1).

In the “Research on Earthquake and Tsunami off the Pacific Coast of Tohoku, in order to help understand a seismogenic mechanism, the Ministry conducted observation of the crustal structure and activity as well as history study of the past earthquakes and tsunamis along northern Sanriku and Boso offings. Furthermore, in the “Sophistication of Technology to Observe Seafloor Crustal Movements,” the ministry laid out many observation points in and around the marine areas offshore Miyagi Prefecture to conduct research and development for the sophistication of technology to observe seafloor crustal movements which will contribute to clarify fixation of the plate boundary. Furthermore, the ministry has conducted seismic activity or crustal structure research around the hypocentral region of the Off the Pacific coast of Tohoku Earthquake in partnership with researchers of institutes including universities, with support of Grant-in-Aid for Scientific Research.

NIED is collecting, preparing and providing information useful for disaster response, recovery and reconstruction in the disaster areas - including disaster information on seismic motion or landslides, evacuation from earthquake-affected areas or capacity of evacuation centers - on a website “All 311 Great East Japan Earthquake Cooperative Information Platform” utilizing each type of map and geospatial information, launched in collaboration with various bodies and individuals (Although the operation of this website was terminated in July of 2012, the website remains available for viewing archives).

Fire and Disaster Management Agency (FDMA) is conducting the development of surveillance and monitoring technology with an unmanned helicopter for rapid finding and saving survivors in tsunami-hit sites, traverse technology applicable to fire-fighting in rubble- or water-covered areas, and



rescue technology and is currently in the process of developing a prototype.

In preparation for interrelated massive earthquakes, the agency is also conducting the studies on prediction of strong ground motion of petrochemical complex, on preventive measures against and estimation of petroleum tank damage caused by the tsunami, in order to establish the technical standards for tsunami countermeasures and the petroleum tank damage estimation system, and makes calculation of space variation due to long-period ground motion and cutoff cycle by empirical prediction method. Furthermore, the agency is conducting the studies on fire-prevention and fire-fighting measures for extinguishing blazes at rubble or scrap metal deposit after the earthquake and is also in the process of summarizing points to bear in mind for fire-fighting activity to extinguish fires occurring at provisional storage sites and waste collection sites and of clarifying the thermal ignition behavior such as corroded tatami mats mixed in rubble.



Rubble fire at Natori City

Courtesy of National research Institute of Fire and Disaster

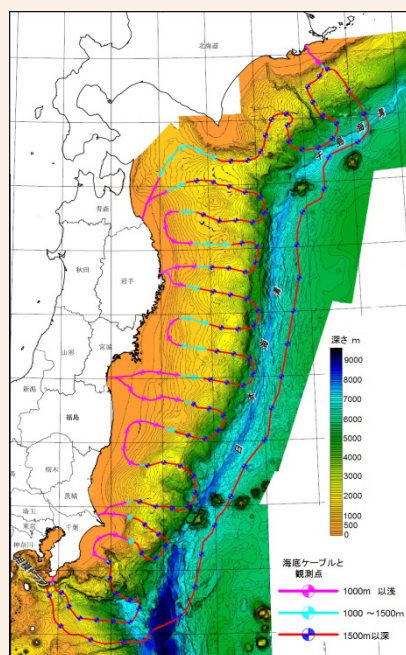
Furthermore, the agency is collecting information on fires that broke out during the GEJE and conducting the studies on preventive technology and fire-prevention measures by capturing the characteristics of fires depending on the presence or absence of tsunami damage based on survey analysis of fire or fire spreading causes. In addition, the agency is conducting the study to clarify risk factors in fire-fighting activities by fire experiments of solar power system whose utilization is predicted to be promoted in the future and to elaborate a policy of safe fire-fighting.



Fire exposure experiment of a solar cell module

Courtesy of National research Institute of Fire and Disaster

Figure 2-2-1/ Outline of Ocean Bottom Seismic and Tsunami Network Planning along the Japan Trench



Source: Created by MEXT

## 2) Response to accident at TEPCO Fukushima NPS

### (i) Implementation of radiation monitoring

With respect to the radiation monitoring as a result of the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company, Incorporated (hereinafter referred to as “TEPCO”), relevant ministries, Fukushima Prefecture and others are conducting measurements of air dose rate at the monitoring posts etc, analysis of radioactive substances contained in the soil by type of nucleus, analysis of radioactive substances contained in the water and soil of rivers and seas and monitoring of radioactive substances contained in food and tap water in line with the “Comprehensive Monitoring Strategy” (adopted by the Monitoring Coordination Meeting in August of 2011 and revised in March and April of 2012, and in April of 2013) (Figure 2-2-2). As a result of the review of atomic energy regulation after the accident at the TEPCO Fukushima Daiichi Nuclear Power Station, the Nuclear Regulatory Authority which came into being on September 19, 2012 as the governing body of radiation monitoring summarizes the information on the monitoring performed by bodies concerned and publishes the summarization on the website<sup>1</sup>.

MEXT has conducted the emergency monitoring with a monitoring car or a ship, as well as the aerial monitoring in the land and marine areas around TEPCO Fukushima Daiichi Nuclear Power Station immediately after the accident at Fukushima Daiichi Nuclear Power Station. In FY 2012, the Ministry has brought together the distribution condition of radionuclides such as gamma-emitting radionuclides (radiocesium etc), plutonium, strontium and others, and published the travel surveys conducted in cooperation with local governments.

In addition, the ministry conducted aerial monitoring throughout the country including Hokkaido and

<sup>1</sup> <http://www.nsr.go.jp/activity/monitoring>

Western Japan as well as within and outside of 80km from TEPCO Fukushima Daiichi Nuclear Power Station in order to check the air dose rates and deposition condition of radiocesium in these areas (Figure 2-2-3). With respect to coastal areas, concentration measurements of radioactive materials contained in sea water, seafloor beds and marine life were conducted off the coasts of Fukushima Prefecture, Miyagi Prefecture, Ibaraki Prefecture and others under the cooperation among relevant ministries and local governments in line with the “2012 Marine Area Monitoring Procedure” formulated on March 30, 2012. Furthermore, the air dose rates are measured by the real-time dose measurement system set up in Fukushima Prefecture, the portable monitoring posts set up in the whole Fukushima Prefecture and the neighboring prefectures and by the fixed monitoring posts set up in all prefectures throughout the country for strengthening the nationwide radiation survey system and these measurements are displayed on the website on a real-time basis (Figure 2-2-4).

Figure 2-2-2/ Monitoring implementation system of each ministry in accordance with the Comprehensive Monitoring Strategy

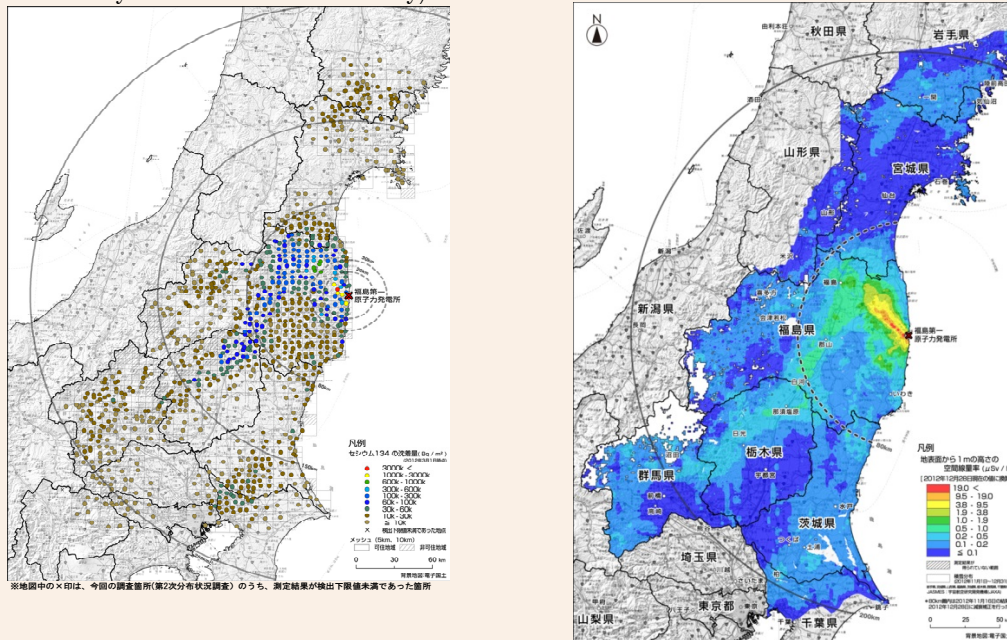
Main monitoring in accordance with the Comprehensive Monitoring Strategy (modified on April 1, 2018)		* Monitoring implementation system of each ministry in accordance with the Comprehensive Monitoring Strategy
<p><b>Monitoring of the environment in general throughout Japan</b> (Nuclear Regulation Authority, relevant prefectural authorities)</p> <ul style="list-style-type: none"> <li>- Real-time publication of measurement results of air dose rate at monitoring posts in each prefecture</li> <li>- 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</li> <li>- Aerial monitoring in the area of a relatively-high level of deposition amount of radioactive substances in the prefectures adjacent to Fukushima Prefecture</li> </ul>	<p><b>Monitoring of seaports, airports, parks, sewage etc.</b> (MLIT, Fukushima Prefecture, local authorities and others)</p> <ul style="list-style-type: none"> <li>- Concentration measurement of radioactive substances in sewage sludge</li> <li>- Measurement of air dose rate at seaports, airports, urban parks etc.</li> </ul>	
<p><b>Monitoring of the environment in general throughout Fukushima Prefecture</b> (Nuclear Regulation Authority, Nuclear Emergency Response Headquarters, Fukushima Prefecture, TEPCO and others)</p> <ul style="list-style-type: none"> <li>- 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.</li> <li>- Continuous measurement of air dose rate, airborne dust etc. around the NPP</li> <li>- 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</li> <li>- Periodical aerial monitoring within 80 km of the NPP</li> <li>- Detailed monitoring of the evacuation order areas</li> </ul>	<p><b>Monitoring of waste in water environment, natural parks etc.</b> (MOE, Fukushima Prefecture, municipalities, TEPCO and others)</p> <ul style="list-style-type: none"> <li>- Concentration measurement of radioactive substances and measurement of air dose rate in water, sediment and environment samples from rivers, lakes, marshes, water sources, ground waters and coasts in Fukushima Prefecture and neighboring prefectures</li> <li>- Analysis of concentration measurement of radioactive substance in wild plants and animals</li> <li>- Concentration measurement of radioactive substances in influent water from refuse incineration plants and measurement of air dose rate on the boundary zones according to the Act on Special Measures in relation to Measures for Environmental Pollution by Radioactive Materials</li> </ul>	
<p><b>Monitoring in marine areas</b> (Nuclear Regulation Authority, MLIT, MAFF, Japan Coast Guard, MOE, Fukushima Prefecture, TEPCO and others)</p> <ul style="list-style-type: none"> <li>- 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</li> </ul>	<p><b>Monitoring of farm soil, forests and pasture</b> (MAFF, Forestry Agency, relevant prefectural authorities Prefecture)</p> <ul style="list-style-type: none"> <li>- Understanding of alteration in concentration of radioactive substances and clarification of the transfer characteristics in Fukushima Prefecture and neighboring prefectures</li> <li>- Concentration measurement of radioactive substances in forest soil, branches, leaves, bark, forests wood and others in test areas in Fukushima Prefecture</li> <li>- Concentration measurement of radioactive substances in pasture by prefectures</li> <li>- Concentration measurement of radioactive substances in reservoirs in Fukushima Prefecture.</li> </ul>	
<p><b>Monitoring of schools and nursery centers</b> (Nuclear Regulation Authority MEXT, MHLW and Fukushima Prefecture)</p> <ul style="list-style-type: none"> <li>- 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</li> <li>- Concentration measurement of radioactive substances in water in outdoor pools</li> <li>- Check of radioactive substances concentration in school lunches</li> </ul>	<p><b>Monitoring of foods</b> (MHLW, MAFF, Fisheries Agency, Fukushima Prefecture and relevant prefectural authorities)</p> <ul style="list-style-type: none"> <li>- Concentration measurement of radioactive substances in foods</li> <li>- Measurement of actual exposure dose due to ingestion of contaminated foods</li> </ul>	
	<p><b>Monitoring of tap water</b> (MHLW, Nuclear Emergency Response Headquarters and relevant prefectural authorities)</p> <ul style="list-style-type: none"> <li>- 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</li> </ul>	
<p>* The results of each monitoring as shown above are collectively published via the portal site set up on the Nuclear Regulation Authority website.</p>		

Source: Created by Nuclear Regulation Authority



Figure 2-2-3/ Distribution Map of Radiation Dose and others

Nuclide analysis result of Cesium 134 (result of the secondary distribution condition survey)

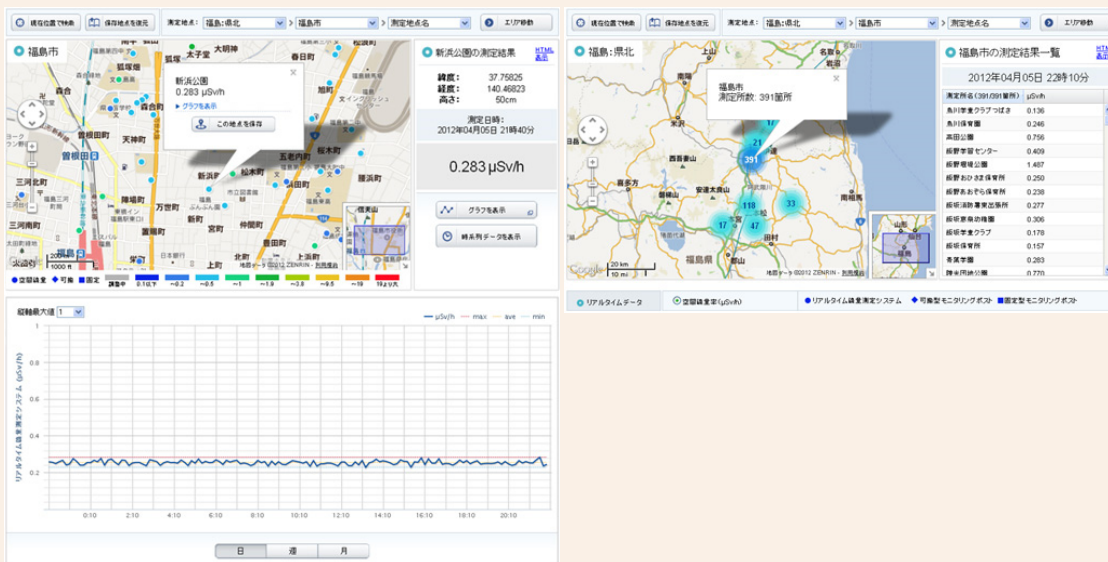


\* (left) Cesium 134 soil concentration map

\* (right) Air dose rate 1m above the ground across the eastern Japan, reflecting the measurement result of the 4th aerial monitoring  
Source: Created by MEXT

Figure 2-2-4/ Real-time Display System

\* The system is under management of the Nuclear Regulation Authority as from April 2013



Source: Created by Nuclear Regulation Authority

Ministry of Health, Labour and Welfare (MHLW) reviewed the indicators of radioactive materials in



tap water in light of the monitoring results of radioactive materials in tap water and the trend of reviewing the reference value for foods. The ministry established a new management target value (a total of 10Bq/kg of cesium-134 and 137), which is applied since April 1, 2012. The monitoring results do not show any case where the management target value has been exceeded and no intake restriction has been implemented.

MAFF conducted surveys on the distribution condition of radioactive materials in the farmland soil same as last year to advance efforts for farming including farmland decontamination. The Ministry also conducted surveys on the radiocesium concentration and its cumulative dose of soil, fallen leaves, leaves and trunks of trees and others by parts in the three areas of Fukushima Prefecture and published the results by bringing together the distribution conditions of radiocesium in the forest.

National Institute for Land and Infrastructure Management (NILIM) is conducting the behavior research of radioactive substances in sewerage treatment plants in Fukushima Prefecture as emergency measures after the earthquake, and is now accumulating knowledge of appropriate disposal of sewage sludge containing radioactive substances.

(ii) Efforts toward decontamination

Bodies concerned are working together to recover the environment contaminated by the radioactive substances released due to the accident at TEPCO Fukushima Daiichi Nuclear Power Station.

The Cabinet Office and Ministry of the Environment (MOE) conducted a decontamination empirical model project for the caution zones in Fukushima Prefecture, the zones defined in 12 municipalities designated as the planned evacuation zones to obtain knowledge necessary for the effective decontamination. They are also publicly calling for contribution to discovery superior technologies available in the field of decontamination efficiency, removal reduction etc., and conducting demonstration tests of the decontamination technology in terms of decontamination effects, economic efficiency and safety check.

Japan Atomic Energy Agency (JAEA) is conducting research and development for decontamination in order to recover the environment contaminated by the radioactive substances released due to the accident at TEPCO Fukushima Daiichi Nuclear Power Station.

MAFF does not only develop decontamination technology aimed at an effective and efficient decontamination of forests and farmland, but also demonstrates the decontamination technologies of farm land and forestry so far developed to establish them as methods applicable in the respective places and publishes their results swiftly.

The National Institute of Advanced Industrial Science and Technology (AIST) developed the absorbent by nanoparticulation of an inorganic compound called Prussian blue and studied its application to decontamination technology for plant incineration ash, soil and agricultural water contaminated by radioactive cesium, and furthermore conducted a demonstration test by building a demonstration plant for the decontamination of incineration ash in Kawauchi village in Fukushima Prefecture in collaboration with an engineering company.

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

The Ministry of Economy, Trade and Industry (METI) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT), in their efforts toward decommissioning of TEPCO Fukushima Daiichi Nuclear Power Stations 1 to 4, conducted research and development necessary for fuel extraction from the spent fuel pools, fuel debris extraction from the interior of the reactors, radioactive waste disposal and others in collaboration with the bodies concerned based on the “R&D program toward the decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company, Incorporated” formulated in December, 2011.

(iv) Regarding compensation for nuclear damages

Since the accident at TEPCO Fukushima Daiichi and Daini Nuclear Power Stations, a number of residents have been forced to live in evacuation shelters or to give up business activities including manufacturing and sales. It is essential that victims such as these receive compensation promptly, fairly and appropriately to enable them to get their safe and secure lives back as quickly as possible.

MEXT sequentially formulates guidelines to determine the scope of nuclear damage that could be sorted into categories in the Dispute Reconciliation Committee for Nuclear Damage Compensation established according to the “Act on Compensation for Nuclear Damages” (Law No. 147 of 1961) and formulated Interim Guidelines in August, 2011<sup>1</sup>, Supplement to the Interim Guidelines in December<sup>2</sup> and Second Supplement to the Interim Guidelines in March, 2012<sup>3</sup>. Subsequently, since shipment restrictions were placed on new items and areas as a result of the establishment of new reference values for radioactive materials in food and of provisional tolerance values for agriculture and forestry products, Third Supplement<sup>4</sup> to the Interim Guidelines which add types which are subject to damage due to harmful rumors was formulated on January 30, 2013 in addition to the items and areas indicated in Interim Guidelines. Furthermore, the “Nuclear Damage Compensation Dispute Resolution Center” established in August of 2011 is strengthening measures such as improvements in business operations and increase in personnel for speeding up and improving efficiency of reconciliation of disputes. In July, 2012, the branch offices (Fukushima City, Aizuwakamatsu City, Iwaki City, and Minamisoma City) of Fukushima Office (Koriyama City) were opened, while in August, the office in Tokyo was expanded.

The Government, having recognized the need that TEPCO take every possible measure for prompt and appropriate compensation for damage, authorized the “Comprehensive Special Business Plan” on management rationalization (authorized on May 9, 2012 and authorized a change on February 4, 2013) and is providing assistance through the Nuclear Damage Compensation Facilitation Corporation to TEPCO for smoothly carrying out compensation.

## 2 System Reform for Restoration and Recovery from Earthquake Disaster

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

<sup>1</sup> Interim Guidelines on Determination of the Scope of Nuclear Damage Resulting from the Accident at TEPCO Fukushima Nuclear Power Station 1 & 2

<sup>2</sup> Supplement to the Interim Guidelines on Determination of the Scope of Nuclear Damage Resulting from the Accident at TEPCO Fukushima Nuclear Power Stations 1 & 2 (damage associated with voluntary evacuation)

<sup>3</sup> Second Supplement to the Interim Guidelines on Determination of the Scope of Nuclear Damage Resulting from the Accident at TEPCO Fukushima Nuclear Power Stations (damage associated with the re-definition of the evacuation areas by the Government)

<sup>4</sup> Third Supplement to the Interim Guidelines on Determination of the Scope of Nuclear Damage Resulting from the Accident at TEPCO Fukushima Nuclear Power Stations (damage associated with bad rumors to agriculture, fishery and food industry)

In particular, Japan is improving R&D bases through collaboration between industry, academy and government as efforts to create new industries to contribute to the restoration of the disaster areas.

Table 2-2-5/ Main measures for promotion of realization of restoration and recovery from earthquake disaster (FY 2012)

Ministry	Research organization	Subject
Ministry of Internal Affairs and Communications (MIC)	MIC	R&D on Information and Communication Technology Infrastructure in a Disaster
		R&D on Network Robot Technology Contributing to Disaster Response
		High Resolution Airborne Synthetic Aperture Radar to be Mounted on Small Aircraft
	National Institute of Information and Communications Technology (NICT)	R&D of Electromagnetic Wave Sensing Infrastructure Technology R&D for Fundamental Network Technologies
MIC (Fire and Disaster Management Agency (FDMA))	National Research Institute of Fire and Disaster (NRIFD)	R&D on Technology for Ensuring Fire-Fighting Safety
		Research on the Safety Improvement of Oil Tanks When Earthquake and Tsunami Occur and Fire-Fighting Technology of Sediment Fire
		Securing of Security against Diversifying Fires
	MEXT	Tohoku Innovative Materials Technology Initiatives for Reconstruction Formation Program of Tohoku Marine Science Center
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	National Research Institute for Earth Science and Disaster Prevention (NIED)	Improvement of Ocean Bottom Seismic and Tsunami Network Planning along the Japan Trench
	Japan Science and Technology Agency (JST)	Matching Promotion
	Japan Aerospace Exploration Agency (JAXA)	Advanced Land Observing Satellite-2 (ALOS-2)
	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Building of Observation and Monitoring Systems for Earthquakes and Tsunamis
Ministry of Agriculture, Forestry and Fisheries (MAFF)	MAFF	Research Program on Innovative Technologies for Animal Breeding, Reproduction, and Vaccine Development
		Advanced Technology Deployment Project for the Revitalization of Food Production Area
		Radioactive Materials Removal and Reduction Technology for Forests and Farmland
		Technology Validation and Development Project for the Prevention of Diffusion of Radioactive Substances in Forests
		Decontamination Demonstration Project in Forests
		Emergency Research for the Establishment of Measures to Reduce Transition of Radioactive Substances to Agricultural Products According to Field Environment
		Emergency Research for the Elucidation of Contamination Source and Contamination Route of Fish Contaminated by High Concentration Cesium

Ministry of Economy, Trade and Industry (METI)	METI	Innovation Site Location Promotion Project
	National Institute of Advanced Industrial Science and Technology (AIST)	Implementation of Emergency Geological Survey and Research
		Radioactive Cesium Decontamination Using Prussian Blue Particles
Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	MLIT	Development of Breakwater Structure which is not easily Broken by Tsunami
	MLIT, National Institute for Land and Infrastructure Management (NILIM)	Development of Performance Based Seismic Design Technology in light of Earthquake Characteristics such as Subduction Earthquakes and others
	National Institute for Land and Infrastructure Management (NILIM)	Study on Assessment Method and Reference on Earthquake-proof Safety of Nonstructural Members
		Study on Technology to instantly Predict Large-Scale and Wide-Area Earthquake Damage
		Study on Low-Cost Liquefaction Countermeasure Study in Urban Area
		Study on Tsunami Inundation Prediction System to Improve Disaster Countermeasures
	Public Works Research Institute (PWRI)	Sewage Sludge Contamination Mechanism by Radioactive substances and Research on Response Guidelines
Meteorological Research Institute, JMA	Development of Technology for Composite Measures for Rivers and Banks against Large-Scale Earthquake and Tsunami	
	Research on Prediction Accuracy Improvement for Earthquake Early Warning	
Ministry of the Environment (MOE)	MOE	Upgrade of Tsunami Forecast Information and Enhancement of Tsunami Prevention System
		Decontamination Demonstration Project in Considerably High Dose Area

## Section 2 Promotion of Green Innovation

It is necessary for Japan to strongly promote green innovation in order to address the following two issues - securement of stable energy supply and response to climate change - faced by Japan as well as the international community. Therefore, with the aim of building of the stable energy supply-demand structure from a long-term view 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 is to positively promote to expand and spread such technologies or systems at home and abroad to realize sustainable growth in Japan. In order to accomplish the objective as shown above, Japan sets up the following three important issues - 1) realizing of stable energy supply and a low-carbon society, 2) increasing and smartening of energy utilization efficiency, and 3) greening of social infrastructures - and is promoting R&D to resolve these issues.

### 1 Promotion of Measures to Accomplish Important Issues

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

In order to realize stable energy supply and a low-carbon society, the R&D for innovative technology aiming at accelerating of spread of renewable energy and for innovation of the dispersion energy system



is being promoted in a manner consistent with stability, economy and sustainability of energy supply all over Japan. In addition, measures for promotion of biomass utilization have been taken according to the “Basic Plan for the Promotion of Biomass Utilization” (decided by the Cabinet in December 2010) prescribing the basic policies and objectives of Japan.

#### 1) R&D for renewable energy technology

MEXT is promoting R&D towards drastic improvement of conventional technology for renewable energy such as solar power generation or biomass utilization. In particular in the field of plant science and advanced environmental materials, the ministry is promoting R&D aiming at construction of “Green Network of Excellence” which comprehensively supports studies at the highest global standards and human resource development (HRD) in the relevant field with research target, facilities and personnel shared among the leading universities in Japan under strategic cooperation between them.

In addition, in order to realize the restoration of the affected areas following the GEJE and innovative research and development for renewable energies, the Ministry is not only establishing a research and development base on super-efficient solar cells in Fukushima Prefecture, but also is implementing the “Tohoku Recovery Next-generation Energy Research and Development Project” which promotes research and development on renewable energy technology under the cooperation among community, industry and research institutes including universities in affected areas.

In the “Development of Environmental Technology Using Nanotechnology,” the Ministry has also established a research center for fundamental R&D to develop the technical seeds of solar power generation and others, to support HRD for advanced environment technology.

JST has set up the fields of solar cell and solar energy utilization system, biotechnology and others to promote R&D for innovative technology (game changing technology) with enormous potential for greenhouse gas reduction from a mid- and long-term standpoint and based on such new scientific and technological knowledge as is not an extension of conventional technology under a competitive environment.

The National Institute for Materials Science (NIMS) is creating new materials useful to boost the efficiency of next-generation solar cells essential to the diffusion of renewable energy utilization.

MAFF has not only assisted the efforts to overcome the problems which have become apparent as a result of the demonstration experiments hitherto conducted to establish production bases of domestic biofuels in local areas, but also the efforts to establish the technology for biofuel production and utilization based on collection and transport of soft cellulosic resources such as rice straw compatible with food or feed supply, and to spread biofuels on a full-scale.

The Ministry is also focusing on the research and development of technology to produce biofuels from plants, woods and microalgae.

METI is implementing R&D for cost reduction and efficiency increasing of the renewable energy-related technology including solar power generation, wind power generation, biomass utilization and power generation utilizing ocean energy. For solar power generation, for example, the Ministry is conducting R&D of innovative technology such as quantum dot solar cell. For wind power generation, the ministry is conducting R&D for establishment of wind turbine design technology applicable to the external condition in Japan, and the survey and demonstration project for establishment of bottom-mounted offshore wind turbine technology. For biomass energy, the ministry is conducting R&D

for efficiency increasing and cost reduction of cellulosic ethanol production process, for introduction and spread of next-generation biofuel compatible with food production, such as algal biomass.

MOE is conducting R&D and empirical study on renewable energy technology which is necessary and possible to be put into practical use early. For geothermal power generation, for example, the ministry is conducting the development and demonstration of hot spring power generation system using hot spring water, the empirical study on a geothermal reservoir management system for coexistence between hot springs and geothermal power, and the technology development for reducing the cost of slant drilling. For biomass utilization, the Ministry is conducting R&D for cost reduction and efficiency increasing of ethanol production from cellulosic biomass. For wind power generation, the ministry is conducting the development of small- and medium-size wind turbine system with wind-lens technology, and promoting the demonstration project for setting and running Japan's first full-scale floating offshore wind turbine.

The Public Works Research Institute (PWRI) is implementing the technology development contributing to realization of a low-carbon society with environmental impact reduction, which utilizes renewable energy such as biomass energy and recycled resources.

The National Institute for Land and Infrastructure Management (NILIM) is conducting the study on infrastructures including sewage treatment facilities and low carbon houses. The institute is also conducting the survey and examination of enhancement method of water power generation utilizing existing dams throughout the country, in order to contribute to the stable power supply in the future in light of experience obtained from the power shortage caused by the GEJE.

## 2) R&D of a dispersion energy system

MEXT and independent administrative institutions concerned are promoting R&D for realizing the energy conversion and storage system using fuel cells and batteries with the aim of innovation of a dispersion energy system.

JST has set the research fields of superconducting system, battery device and others to promote R&D for innovative technology (game changing technology) with enormous potential for greenhouse gas reduction and based on such new scientific and technological knowledge as is not an extension of conventional technology under a competitive environment, in order to continuously and steadily advance the greenhouse gas reduction from a mid- and long-term standpoint.

The National Institute for Materials Science (NIMS) is conducting R&D for creation of new materials for superconducting power transmission or high-performance power generation and storage which contribute to realization of a microgrid<sup>1</sup> society with a combination of small-scale dispersion power generation and networking.

METI is conducting the technology development and demonstration of batteries and fuel cells. For the batteries, in particular, the Ministry is conducting the technology development for performance enhancement and cost reduction of a large-size battery for the system necessary to introduce and expand renewable energy or the lithium-ion battery for next-generation vehicles such as electric cars, plug-in hybrid cars. For the fuel cells, the ministry is conducting the technology development for cost reduction and durability-reliability enhancement, and the technology development and demonstration for a hydrogen station for introduction of fuel cell cars.

<sup>1</sup> A system of mutual provision of electricity with a combination of small-scale dispersion power generation, power supply and networking

On the other hand, the four areas - Yokohama City, Toyota City, Kansai Science City (Keihanna) and Kitakyushu City - are conducting a large-scale demonstration aiming at construction of a smart community with participation of local residents, local governments and private companies since FY 2011. For the purpose of utilizing technology and ideas complementing that demonstration, the eight areas throughout the country are conducting demonstration for solving technological and systematic problems towards construction of a smart community to promote the development of smart grid-related technology. MEXT is also promoting R&D for enhancement of energy management technology.

As for the smart grid, MIC is conducting research and development on communication platform technology for remote-controlling various appliances in a building with high precision and high reliability to realize an optimal energy management on a local level and is also promoting its international standardization (refer to Part 2, Chapter 3, Section 1, 2, (2)).

MOE is conducting the development of an energy interchange system on direct current among areas for the purpose of construction of a self-sustained dispersion energy system and the development and demonstration of a grid system which adjusts supply-demand balance with a combination of a small-size water power generator and a heat pump for demand load regulation.

### 3) Efficiency and low-carbonization of key energy source

#### (i) Clean Coal Technology

Although it has greater supply stability than petroleum and others, coal as key energy source has more carbon dioxide emissions per unit energy than other fossil fuels in the process of burning, so it is necessary to develop a technology for environmental impact reduction. Taking into account the environmental necessity, METI has developed the Clean Coal Technology based on R&D for realization of low carbon thermal power generation with a combination of Integrated Coal Gasification Combined Cycle (IGCC), Integrated Coal Gasification Fuel Cell Combined Cycle (IGFC) which can generate electricity with high efficiency in restraint of carbon dioxide emissions and Carbon Dioxide Capture and Storage (CCS), and development of a boiler-turbine system which can stand high temperature and high pressure, Advanced Ultra-Super Critical (A-USC) for improving thermal efficiency.

#### (ii) Material technology innovation applicable to key energy

The National Institute for Materials Science (NIMS) is promoting R&D for material technology innovation including development of the high-strength and heat-resistant steel applicable to thermal power plants or nuclear power plants, and improvement of the damage evaluation technology for nuclear reactor materials.

#### (iii) Carbon Dioxide Capture and Storage (CCS)

With the aim of practical use and diffusion of CCS, METI is advancing R&D for demonstration of the integrated system from separation and capture of carbon dioxide from a large carbon dioxide source to a carbon dioxide storage in the ground (at depths in excess of 1,000 m below surface), and for substantial cost reduction and safety improvement of the system.

## (iv) Innovative petroleum refinery technology

In response to heavy crude oil<sup>1</sup> trend, light petroleum products trend<sup>2</sup> and global warming, METI is advancing development of technology to obtain value-added petrochemical raw material from heavy oil and the innovative petroleum refinery technology to make efficient use of residues remained after petroleum production in oil refineries to promote sophistication of oil refineries.

## (v) High-efficiency gas turbine

METI has been developing and demonstrating a technology on high-efficiency gas turbine to promptly respond to demand for replacement of aged LNG thermal power plants, carbon dioxide emissions reduction and energy conservation measures and conducting demonstration experiments. The Ministry conducted a comprehensive test including design, manufacturing and validation of its compressors, cooling blades and others for reliability improvement in FY 2012.

## (vi) Carbon dioxide storage in blue carbon

The Port and Airport Research Institute (PARI) is promoting a research including conduction of on-site surveys in coastal areas and experiments aimed at quantitatively measuring the gas exchange speed between the atmosphere and seawater and the carbon flow and others between the seawater and benthic ecosystem (benthic flora and fauna, and sediments) with a view to establishing the measurement method of blue carbon (carbon captured by the oceans and coastal ecosystems) which can be widely applicable in and out of Japan.

## 4) R&amp;D for nuclear energy power and fusion

Regarding nuclear energy power, the government is poised to discuss revision of the energy policy including the nuclear energy taking into account the accident at TEPCO Fukushima Daiichi Nuclear Power Station.

In FY 2012, the government continued to address R&D and nuclear Human Resource Development (HRD) for atomic energy bases and safety with a particular emphasis on the efforts to recover from the nuclear power disaster. For the fast breeder reactor cycle technologies, the government also continued to focus on the further improvement of safety and maintenance of the facilities in anticipation of the discussions about reviewing the energy policy including the nuclear energy. For R&D of the fusion expected as essential future energy source, the global nuclear cooperation and others, the government has successively made necessary efforts.

## (i) Securing and developing of nuclear human resources

MEXT and METI are implementing the “Nuclear Human Resource Development Program” supporting the nuclear education in universities or technical colleges to foster superior human resources to serve as a basis of the safety of nuclear power. MEXT is also supporting the inter-organ activities to develop human resources in an effective, efficient and strategic manner in collaboration with relevant bodies of industry, academia and government based on the “Global Nuclear-HRD Initiative (GN-HRD),” and, in FY 2012, continued to focus on the development of human resources who engage in nuclear

<sup>1</sup> A phenomenon where the rate of heavy crude oil is increased

<sup>2</sup> A phenomenon where the rate of light petroleum products such as gasoline, light heating oil becomes higher than that of heavy petroleum products such as heavy heating oil in domestic demand



safety and risk management in light of the accident at TEPCO Fukushima Daiichi Nuclear Power Station.

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

The Basic and fundamental R&D for nuclear science aiming at reinforcement of technology bases for utilization of nuclear energy, contribution to safety improvement and creation of new knowledge and technology is important in supporting utilization and development of nuclear energy.

The Japan Atomic Energy Agency (JAEA) is conducting the basic and fundamental R&D for nuclear data, reactor engineering, irradiation material science, actinide science, radiochemistry, environmental science, radiation protection, computational science, partitioning-transmutation technology, advanced nuclear science and others.

For the purpose of enriching and enhancing the basic and fundamental R&D, MEXT is promoting the research in universities under a competitive environment on the strategic program set to clarify the policy needs according to the “Initiatives for Atomic Energy Basic and Generic Strategic Research.”

(iii) Fast Breeder Reactor (FBR) cycle technologies

Because FBR can tremendously improve the efficiency in utilizing uranium resources by producing more fuel than consumed in the process of power generation, the FBR cycle technologies holds the possibility of contribution to long-term stable energy supply and to reduction of potential harm of high-level radioactive waste by reusing minor actinide contained in spent fuel as fuel. Although the FBR cycle technologies is placed as key technologies for national security in the 4th Basic Plan, Japan is to decide on the implementation of R&D in anticipation of the direction of energy policy and nuclear energy policy in Japan.

In May 2010, the FBR “Monju” restarted a test run about 14 years and 5 months after the sodium-leak accident, and completed the first phase of the test in July 2010. The restoration of the accident in which parts of the In-Vessel Transfer Machine (IVTM) fell down in August 2010 was completed in August, 2012. Currently, further safety measures are being taken and efforts to improve safety are focused on in light of experience obtained from the accident at TEPCO Fukushima Daiichi Nuclear Power Station. In the meantime, in October, 2012, the Monju Research Plan Working Group was set up under the Council for Science and Technology, Research Planning and Evaluation Subcommittee and Nuclear Science and Technology Committee and research plan is being reviewed for promoting research in an effective and efficient manner considering the past development history.

Incidentally, defective equipment maintenance was found in Japan Atomic Energy Agency (JAEA) in November, 2012 and in response to this, the Nuclear Regulation Authority issued order to the agency to take necessary measures for maintenance in accordance with the “Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors” in May, 2013. In consideration of the importance of the order, MEXT ordered Japan Atomic Energy Agency to complete the inspection of uninspected equipment and the revision of maintenance plan as soon as possible, to secure complete safety, and to develop mechanisms and systems for recurrence prevention among other measures.

R&D for practical application of the FBR cycle technologies was limited to the minimum required such as study, obtaining of data as well as maintenance of facilities aimed at the building of safety design requirements for the sodium-cooled FBR in an international framework (the Generation-IV Nuclear