Feature 1 Recovery and Reconstruction from the Great East Japan Earthquake through Science and Technology

Recovery and reconstruction from the Great East Japan Earthquake is still ongoing.

In this special feature, we summarize the current situation of the recovery and reconstruction from the Great East Japan Earthquake (GEJE) and the efforts of the Japanese government; we also introduce the process of tackling the challenges of the recovery and reconstruction through science and technology, in accordance with the basic guidelines for reconstruction[1] pursuant to "the Basic Act on Reconstruction in Response to the Great East Japan Earthquake" (the Act No. 76 of 2011).

1 Current Situation of Recovery and Reconstruction from the Great East Japan Earthquake and the Efforts of the Japanese Government

(1) Support for Disaster Victims

The number of evacuees in afflicted regions was approximately 470,000[2] immediately after the earthquake, but that number has decreased to 310,000[3] (as of April 4, 2013), 110,000[4] of whom have moved into temporary housing (as of April 1, 2013).

As for supporting disaster victims, activities including mental care and other types of care have been given to the victims, and progress is being made in the improvement of infrastructure and in improving cooperation among those working to provide medical treatment and nursing so as to provide both comprehensive care and general care in a community setting. Progress has also been made in supporting the enhancement of infrastructure including reconstruction and housing preparation (Refer to Feature 1-1 (2) (3) (4)).

(2) Regional Development

With respect to the recovery of infrastructure, utilities such as electricity and gas had been mostly recovered by the middle of FY 2011. The temporary recovery of public infrastructure including traffic networks and waterworks had also been nearly completed [The restoration rate of directly controlled national highways in Iwate, Miyagi, and Fukushima (hereinafter referred to as "three afflicted prefectures") was 97%, and the railway restoration rate was 88%, as of the end of December 2012.] Recovery and reconstruction have progressed to a full-fledged phase.

As of the end of March 2013, Iwate Prefecture had completed the disposal of 49% of disaster waste, and Miyagi Prefecture had completed 65%. These prefectures improved their disposal systems, and furthermore, wide-area disposal will enable them to complete disposal of the remaining disaster waste by the end of March 2014. On the other hand, Fukushima Prefecture has completed disposal of 40% of its disaster waste excluding the "region with contaminated waste control" that is directly controlled by the Japanese government. However, it is expected to be rather difficult to complete disposal of some portion of the remaining waste by the end of March 2014, but Fukushima has been making every effort to accelerate the disposal process.

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1 "The Basic Guidelines for Reconstruction in Response to the Great East Japan Earthquake" (determined by the Reconstruction Headquarters in Response to the Great East Japan Earthquake on July 29, 2011)

2 A total of six prefectures: Aomori, Iwate, Miyagi, Fukushima, Ibaraki, and Tochigi (As of March 14, 2011).

3 The total number of people residing in shelters (public halls, schools), inns/hotels, residences (including public/temporary/private housing and hospitals), and others (relative's/acquaintance's housing) throughout Japan.

4 A total of seven prefectures: Iwate, Miyagi, Fukushima, Ibaraki, Tochigi, Chiba, and Nagano.

As for house reconstruction and transferring residential areas to higher-elevation land areas, and in regard to a program established to promote collective relocation for disaster prevention, the legal procedures which were preconditions for starting the program were completed in 325 out of 328 districts (as of the end of March 2013) that were required to conduct surface improvements as based on a residence reconstruction roadmap, and the program has sequentially begun. The three afflicted prefectures announced that they need approximately 24,000 reconstructed houses, 248 of which have completed preparation as of the end of March 2013. These activities should progress promptly so that disaster victims can return to their normal daily lives.

In addition, regarding medical facilities, approximately 90% (166 hospitals) of the hospitals which had had limited hospitalization, or which had had no capability for the admission of patients immediately after the disaster, have recovered in all three of the afflicted prefectures. As for school facilities, approximately 81% (1,876 schools) of the schools which had applied for disaster recovery project funding for their school facilities have completed their recovery as of the end of November 2012.

(3) Industry and Employment

1) Industry

As for the mining and manufacturing industry, according to the estimated production value of plants in tsunami inundated regions[1] (59 plants), their production has almost recovered from 99% reduction it had faced in May 2011 (as compared with the numbers in May 2010). With respect to financial support, approximately 240,000 loans have been provided (5.3 trillion yen in total), and approximately 95,000 cases have been guaranteed (2.1 trillion yen in total) as of April 5, 2013.

As for agriculture, tsunami afflicted farmland was approximately 21,480 ha[2], and 38% of the afflicted farmland (approximately 8,190 ha, as of the end of January 2013), was ready to resume farming; however, restarting farming on the land damaged by salt water remains a problem.

As for fishery activity off the coast of Fukushima Prefecture, all coastal and trawl-net fishing is no longer conducted, except for experimental fishing[3] targeted only at particular fish species in particular areas of the sea (as of the end of May 2013)[4]. Furthermore, approximately 36% of all afflicted fishing ports had recovered their functions by extending the unloading of quays to their full length (115 of 319 fishing ports, as of the end of March 2013), and the main fish markets of the three afflicted prefectures have recovered 71% of their pre-disaster catch (from January to March 2013, in comparison with the same period before the disaster[5]).

As for tourism, the total number of people staying at accommodations mainly used by tourists decreased by 18.5% in the three afflicted prefectures (from October to December 2012, as compared with the same quarter of 2012).

Measures have been taken to solve the situations facing these industries, such as promoting the large compartmentalization of farmland, resuming the business of fish processing facilities and of small and medium enterprises through financial support, and supporting business rehabilitation against the burden

1 Tsunami afflicted regions of the following six prefectures: Aomori, Iwate, Miyagi, Fukushima, Ibaraki, and Chiba.
2 Tsunami afflicted farmland of the following six prefectures: Aomori, Iwate, Miyagi, Fukushima, Ibaraki, and Chiba.
3 Conducted to acquire basic data concerning the restart of fisheries off the coast of Fukushima Prefecture, by experimental small-scale fishing, sales, and investigation into appraisals at the destination of fish species in order to secure safety.
4 When radioactive cesium exceeding the reference value is detected in products caught from the sea, prefectures will request fishermen not to ship them or to catch the same kind of marine products, and the fishermen refrained from the fishing and shipment of contaminated fish to meet this request.
5 Comparison of the total amount of fish caught in January and February 2011, and March 2010 [“The Great East Japan Earthquake Influence on Marine Products and the Response to It” (May 20, 2013, released by the Fisheries Agency)].

of having to pay off old loans while taking out new one, a problem faced by many small and medium enterprises.

2) Employment

With regard to the employment situation of the three afflicted prefectures, although the effective job offer ratio had decreased to 0.45 in April 2011, the ratio has exceeded 1.0 as of March 2013. The ratio is still high in the coastal areas, however, and the number of employees has yet not reached pre-earthquake levels due to both depopulation and delays in recovery and reconstruction. Employment mismatches[1] have also occurred.

In response to these issues, the government is promoting the support of employment that is integrated with industrial policy, careful vocational counseling at public employment agencies, and other employment support, including vocational training.

(4) Reconstruction from the Nuclear Power Disaster

As for the status of evacuees, the number of evacuees throughout Fukushima Prefecture was approximately 154,000 as of May 10, 2013. Approximately 84,000 of whom were evacuated from areas under evacuation orders[2], and approximately 22,000 of whom were from areas where the orders had already been lifted (formerly areas prepared for emergency evacuation[3]).

As for systematic efforts regarding the reconstruction and revival of Fukushima, an Act[4] to reassure the disaster victims and to help them realize the stabilization of their daily lives has been formulated, and life supports with the special consideration of their children has been provided.

As for the compensation of nuclear damages, the Dispute Reconciliation Committee for Nuclear Damage Compensation[5] has arranged a settlement of compensation damages, and the committee has also sequentially formulated guidelines indicating which items can be regularly categorized as damage and which items shall receive compensation, as well as the extent of the compensation. In addition, since the Nuclear Damages Dispute Resolution Center[6] has received complaints about its response to the Tokyo Electric Power Company (hereinafter referred to as "TEPCO"), in March 2013, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has corresponded with TEPCO through a formal written request for a more sincere response.

As for measures taken to reduce the damage on health by radiation, support for educating citizens, including residents in Fukushima Prefecture, about the effects of radiation have been conducted in order to dispel uncertainty about radiation. Measures have also been conducted in order to prevent the distribution of food which contains radioactive substances that exceed the standard value, with dose evaluation research being done by the National Institute of Radiological Sciences, and measurements

1 The situation that occurs when a job applicant does not meet the requirements for employment, including the occupational category, type of industry, or qualifications necessary to apply for the job offer.

2 In accordance with decision made by the Nuclear Emergency Response Headquarters on December 26, 2011, caution zones within a 20-kilometer radius of the Fukushima Daiichi Nuclear Power Station and planned evacuation zones over 20 kilometers away from the plant are being rearranged (as of May 10, 2013). Newly designated areas are organized into the following three categories: "areas preparing for the cancellation of evacuation orders" where annual accumulated radiation doses were confirmed to have been 20 millisieverts (mSv) or less, "restricted areas for residence" where annual accumulated radiation doses may exceed 20 mSv, and the continuation of evacuations is required to reduce the irradiation doses of residents, and "areas which have difficulties in return" where annual accumulated radiation doses may not be lower than 20 mSv even after six years have passed since the time of the accident.

3 Areas mainly within a 20-30 kilometer radius of the TEPCO Fukushima Daiichi Nuclear Power Station, except for the planned evacuation zones.

4 "Act on the Promotion of Measures regarding Life Support for Disaster Victims to Protect and Support the Lives of Residents, Including Children Afflicted by the TEPCO Nuclear Accident" (the Act No. 48 of June 27, 2012)

5 Created by MEXT based on "Act on Compensation for Nuclear Damage" (the Act No. 147 of 1961)

6 Arranging settlement between victims and TEPCO.

being conducted with whole-body counters done by the Japan Atomic Energy Agency (JAEA). Furthermore, a wide range of radiation monitoring focusing on Fukushima Prefecture has been conducted according to the "Comprehensive Monitoring Plan" (revised on April 1, 2013, the Monitoring Coordination Meeting), and relevant organizations have cooperated with each other to conduct radiation monitoring of land, sea, schools, agricultural soil, food, and waterworks. The concentration of radioactive substances in soil, water, air, and food is analyzed and the results are published on their website. The results of air dosage measurement rates at monitoring posts are published on the website in real time. Various relevant organizations have carried out these measurements together.

As for decontamination, based on the Act[1] and basic guidelines of this Act, the Japanese government has carried out decontamination in cooperation with local governments in order to promptly reduce the effects of environmental pollution on human health and on living environments that is caused by accident-originated radioactive substances. In addition, in regard to contaminated waste, waste with concentrations exceeding 8,000 Bq/kg, including sewage sludge and ash from incineration facilities requires special processing and storage as designated waste[2].

With regard to securing the safety of the TEPCO Fukushima Daiichi Nuclear Power Station, and in response to the emergency that occurred after the accident, the government and TEPCO have achieved their goal[3] to stabilize the plant by cold shutdown and by remarkably suppressing radioactive substances. In addition, they have also made efforts toward decommissioning based on the "Medium-to-long-term roadmap toward the abolition of Units 1-4 of the TEPCO Fukushima Daiichi Nuclear Power Station." On April 5, 2013, water leaked from an underground water storage tank and the outer radiation concentration of the tank increased; however, the cause of the leakage has not been identified (as of the end of April 2013), and efforts to decrease the concentration continue.

Regarding the response to financial damages caused by harmful rumors and misinformation, which have had negative influences on agriculture, forestry, fisheries and tourism, the Japanese government has provided accurate information, both domestically and internationally, about the inspection results regarding radioactive substances and has promoted support of reconstruction and tourism, and risk communication in order to increase consumers' understanding. Furthermore, Fukushima Prefecture has taken measures including voluntary inspections, such as the inspection of all rice bags, which are stricter than the requirements issued in the guidelines formulated by the Nuclear Emergency Response Headquarters.

As for the issues of industry and employment throughout Fukushima Prefecture, research and development sites utilizing renewable energy and medical and healthcare devices are being improved to promptly carry out the reconstruction of Fukushima Prefecture which has suffered significant damage as a result of the nuclear disaster.

(5) Efforts for Recovery and Reconstruction with the Comprehensive Strategy of Science, Technology and Innovation

Reconstruction from the GEJE is the top-priority issue in Japan, and we intend to embody measures

1 "Act concerning special measures to deal with contamination of the environment by radioactive substances emitted by the Nuclear Power Plant accidents caused by the Tohoku-Pacific Ocean Earthquake that occurred on March 11, 2011" (the Act No. 110 of 2011)

2 "Regulations of the Act concerning special measures to deal with the contamination of the environment by radioactive substances emitted by the Nuclear Power Plant accidents caused by the Tohoku-Pacific Ocean Earthquake that occurred on March 11, 2011" (December 14, 2011, MOE)

3 Step 2 was completed on December 16, 2011.

along the direction of policies for creating a "new Tohoku region," while also accelerating reconstruction.

In the comprehensive strategy of science, technology and innovation (decided by the cabinet on June 7, 2013), it has been decided to maximize the use of science, technology and innovation and to effectively and efficiently promote activities during reconstruction of the afflicted regions, so that the afflicted regions can become "regions with fresh innovations and possibilities."

The strategy lists the following five matters as those requiring particular attention for "early reconstruction and revival from the Great East Japan Earthquake" and they are "issues that need to be tackled through the use of science, technology and innovation."

1) Protection of residents' health from the effects caused by the disaster, and the realization of a society in which children and the elderly are in good spirits
2) Construction of a disaster-resistant energy system
3) Development of new business models in regional industry
4) Construction of disaster-resistant, next-generation infrastructure
5) Reduction and elimination of the effects caused by radioactive substances.

When tackling these issues, in order to accelerate reconstruction and revival, prompt solutions to these issues need to be achieved in a short period of time so as to accelerate the reconstruction and revival of the afflicted regions while outcomes from challenges to be tackled in the mid-and-long-term shall be utilized sequentially. Furthermore, the strategy articulates the goal that the afflicted regions will proactively inform people in Japan and overseas about these results and that the practical nature of those results will be a shining example the other countries throughout the world can follow.

2 Examples of Efforts toward Recovery and Reconstruction through Science and Technology

Although the practical use of S&T is limited in helping the recovery and reconstruction of the afflicted regions mentioned in the preceding paragraph, some efforts have accelerated recovery and reconstruction.

Among the various efforts taken, we will discuss examples of efforts toward the recovery and reconstruction through S&T as made by the national government, the local governments, universities, and relevant organizations, including various enterprises, as follows.

(1) Efforts for disaster-resistant regional development

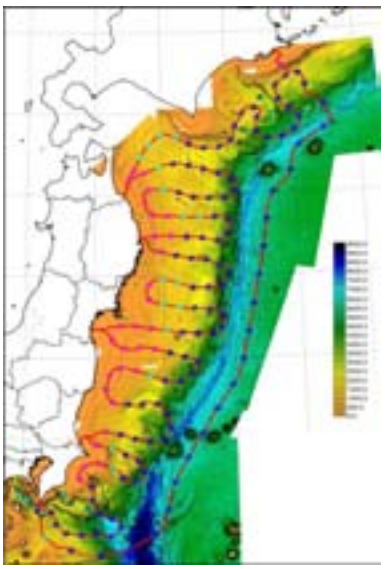
1) Improvement of the Japan Trench underwater earthquake and tsunami observation network

As part of MEXT, the National Research Institute for Earth Science and Disaster Prevention (NIED) acts as a public assistance administrator that promotes improvement of the underwater earthquake and tsunami observation network, a system that is equipped with seismometers and water pressure meters along the Japan Trench in the Tohoku region. It is noted for its practicality in terms of being able to quickly submit earthquake warnings and to its ability to more accurately issue tsunami warnings.

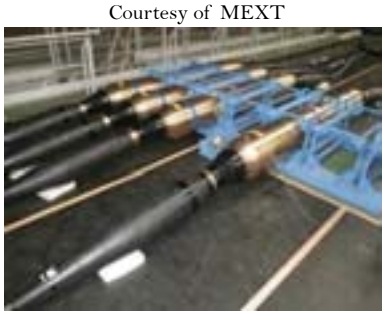
Large scale ocean-trench earthquakes have occurred continuously off the coast of the Tohoku region (along the Japan Trench). Although strong quakes and high tsunamis may continuously occur in the future, specific details about earthquakes are not known. In addition, the current tsunami warning system has limited accuracy because it estimates the height of tsunamis, primarily by the use of seismometers located on land.

Therefore, assigning the National Research Institute for Earth Science and Disaster Prevention (NIED) as its public assistance administrator, since FY 2011, MEXT has promoted the improvement of the underwater earthquake and tsunami observation network system, which is equipped with seismometers and water pressure meters, and which is located along the Japan Trench where strong aftershocks and induced earthquakes may occur in the future. In FY 2012, previous investigations into cable routes and the production of sea area observation devices and submarine cables were conducted. It is determined to install these observation devices in all locations by FY 2014, and to begin their full-scale operation in FY 2015.

In the case of an earthquake occurring off the coast near the Japan Trench, the observation network would enable us to detect earthquake motions up to 20 or 30 seconds earlier, and to detect



Outline of the underwater earthquake and tsunami observation network which is to be improved.
Courtesy of MEXT



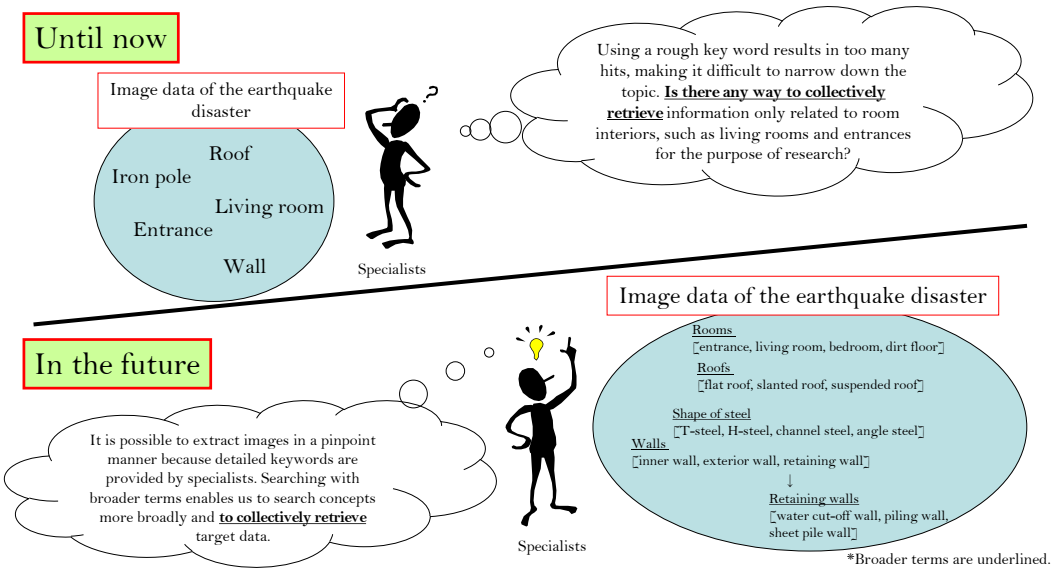
Seabed observation cable network (Seismometers and water pressure meters)
Courtesy of MEXT

tsunami occurrences up to 20 minutes earlier, than the previously relied upon conventional network[1].

Thus, by utilizing this data gathered by the emergent earthquake warning system and the tsunami warning system, in the future, it will be possible to provide local governments and residents with appropriate and prompt disaster information that can be used for evacuations. Contributions to the formulation of a disaster prevention plan by the local governments, is expected to result from utilizing such data for the future prediction (long-term evaluation) of earthquakes and tsunamis occurring in the same sea areas.

2) Promotion of the practical use of data on the Great East Japan Earthquake by collecting and organizing such data

The Japan Science and Technology Agency (JST) has systematically organized scattered multimedia data relating to the GEJE and has prepared the data into forms that can be used by specialists, in cooperation with Tohoku University and others, in order to develop a new information distribution model that connects various useful information for reconstruction from the earthquake disaster and for disaster prevention and mitigation.



Conceptual diagram of information arrangement
Courtesy of JST

While the National Diet Library, Tohoku University, and the International Research Institute of Disaster Science have collected all memories, records, examples, and knowledge about the earthquake disaster and as the amount of the information becomes exponentially larger, it is getting harder to extract useful information for disaster prevention and mitigation.

Consequently, since April of 2013, JST systematically has organized[2] scattered multimedia data such as images and videos relating to the GEJE, and has begun preparing the data into forms that can be used

1 Detection of earthquakes with a seismometer near the seismic center enables us to announce prompt reports from the Earthquake Early Warning System. Early detection of tsunamis using a water pressure meter enables us to precisely update tsunami warnings.

2 Applying keywords and classifications from the viewpoint of specialists to provide information including text, images, and videos, whose data styles are made up of various classes or categories, and, then, connecting that information with various scientific and technical information to make it possible to obtain better information more easily and efficiently.

by specialists in cooperation with Tohoku University and others. In the future, the goal shall be to aim at developing a new information distribution model[1] that improves the link between a variety of information which is useful for reconstruction from the earthquake disaster and for disaster prevention and mitigation.

These efforts are expected to accelerate research and development by researchers, both inside and outside of Japan, and to contribute to reconstruction from the earthquake disaster and to future disaster prevention and mitigation.

3) Efforts for the acceleration of relocations to higher ground

Miyagi Prefecture and Iwate Prefecture, with technical cooperation from the Agency for Cultural Affairs, the National Institutes for Cultural Heritage, Tohoku University, and Iwate University, have introduced digital devices developed by enterprises to promptly implement a process (an actual measurement of remains) needed to determine whether or not historical cultural property might be buried at the potential locations for relocation.

It is necessary to promptly implement the relocation of people to higher ground in regions where tsunami disasters occurred in order to reduce tsunami damage in the future. However, because most of the candidate locations for relocation are "locations requiring survey" as designated under the Cultural Properties Protection Law, research into whether there is historic cultural property buried in these locations is required before they can be selected for relocation.

A scene of survey with an automatic tracking type measuring device
Courtesy of the Agency for Cultural Affairs

Miyagi Prefecture and Iwate Prefecture have introduced digital devices[2] to accelerate the measuring process of surveying remains.

As a result, research time is reduced in comparison to the previously used conventional methods. Miyagi Prefecture has introduced digital measuring devices that enable one person to perform the work of three people. In Iwate Prefecture, the introduction of digital photographic measuring devices and the creation of recording systems have presumably improved efficiency at six to ten times that of the conventional method, and the introduction of three-dimensional laser scanners has presumably improved the efficiency of tumulus measurements up to 70 times that of the conventional method.

Prompt relocation resulting from the acceleration of research is expected to contribute to disaster mitigation.

1 The model has a scheme in which specialists and information creators (providers) in various classes share and use the information provided to them, then, the utilization history is fed back to the creators (providers). The scheme is considered to innovatively promote the utilization of information.
2 In cooperation with the Agency for Cultural Affairs, the National Institutes for Cultural Heritage, Tohoku University, and Iwate University.

(2) Efforts for the regeneration of daily lives and economic activities in regions

1) Implementation of empirical research toward labor savings and a high quality cultivation using facility horticulture

The Ministry of Agriculture, Forestry and Fisheries (MAFF) has determined the National Institute of Vegetable and Tea Science, part of the National Agriculture and Food Research Organization (NARO), as a general research institution for the implementation of empirical research combining particular technology of protected cultivation, with obtaining participation of research institutions in Incorporated Administrative Agency, public experimental research institutions, universities, enterprises, and diffusion support organizations, to diffuse of cultivation in facility horticulture which saves labor and raise the quality in salt-damaged regions by tsunami.

MAFF has implemented the "Scheme to Revitalize Agriculture and Fisheries in Disaster Area through Deploying Highly Advanced Technology[1]" to promptly reconstruct the afflicted regions and to rehabilitate the regions as new food-production areas. Empirical research toward labor savings and a high quality cultivation using facility horticulture is one of the primary efforts of the program.

Tubes for heating and cooling the base of strawberry plants
Courtesy of NARO

Watari County in Miyagi Prefecture was once the best strawberry production area in the Tohoku region. However, tsunami damage resulting from the GEJE caused the destruction of most production facilities, including the strawberry production facilities, and damage caused by high salt contents in underground water have made the lands unsuitable for production. Not only are solutions needed to help the afflicted regions promptly return to normal production, but also to enhance technology that will improve the system of production and contribute to the growth of these regions.

A tank with a rainwater utilization system

Therefore, a solar powered facility horticultural for research was built in Yamamotocho, Watari County, and used to implement empirical research[2] combining particular technology, such as a technique capable of controlling efflorescence while saving energy, including a technique that controls temperatures at the base of strawberry plants, a technique that has an advanced environmental control system which maximizes production efficiency, and a technique that has a rainwater utilization system which is independent of underground water.

Introduction of the production system is expected to establish a technical system that improves the quality and efficiency of the cultivation of strawberries and tomatoes whose production are to be resumed as one of the steps toward the recovery of the afflicted regions; in fact, the system aims to double the previous earning rates. It was decided to verify the effects improved by the introduction of the technology in regard to future production and corporation management, and to deploy the developed

1 Implementation of this program is expected to combine and optimize many advanced technologies accumulated by industry-university-government, and substantiate the technologies in afflicted regions for the promotion of their diffusion and practical application.

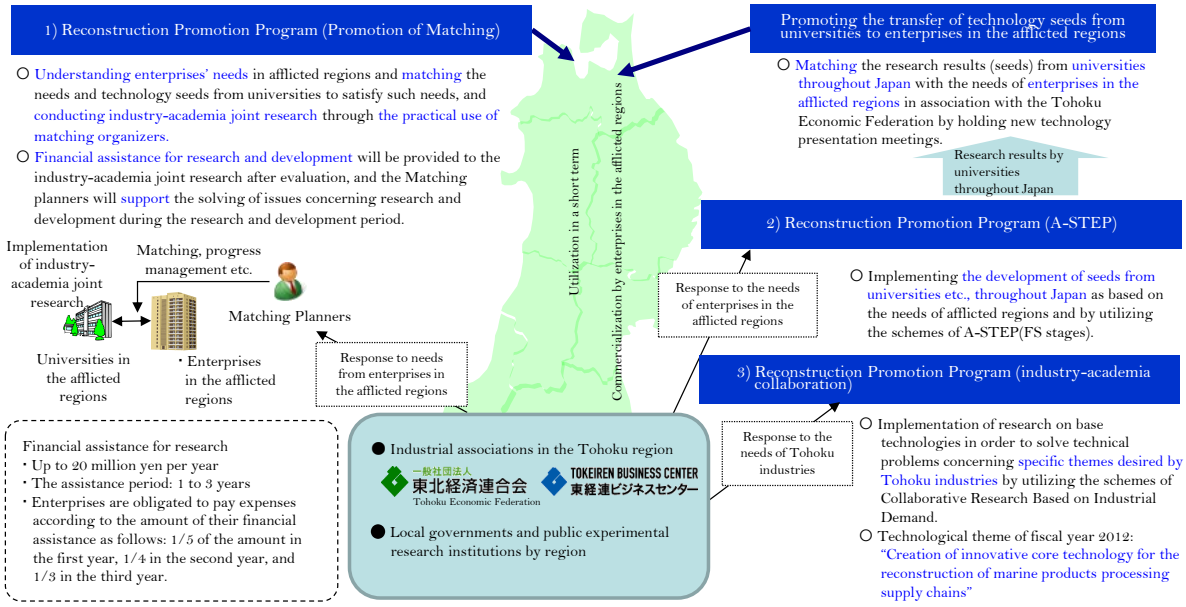
2 The National Institute of Vegetable and Tea Science in NARO became a general research institution for the implementation of empirical research at 23 organizations in total, obtaining the participation of research institutions including the Incorporated Administrative Agency, public experimental research institutions, universities, research institutions consisting of enterprises, and diffusion-support organizations.

production system to other afflicted regions by informing them of the results.

Diffusion of the use of facility horticulture technology that is highly profitable and capable of being implemented on the salt-damaged farmland of the afflicted regions is expected to contribute to the resumption of production in these regions as soon as possible.

2) Promotion of matching the needs of enterprises in the afflicted regions with the technology seeds of universities

JST has implemented the Reconstruction Promotion Program in cooperation with industrial associations and local governments in the Tohoku region in order to put technology seeds of universities into practical application in the enterprises of the afflicted regions.



Outline of the Reconstruction Promotion Program

Courtesy of JST

Technology originated from universities is expected to be utilized for the industrialization of enterprises and used to reconstruct the economies of the afflicted regions.

JST established offices in Sendai, Morioka, and Koriyama, and assigned Matching Planners[1] to every office and it has implemented the Reconstruction Promotion Program supporting the discovery of the needs of enterprises, matching those needs with the technological seeds of universities, and promoting collaborative research in cooperation with industrial associations[2] and local governments in the Tohoku region.[3]

The technological seeds of universities and the needs of enterprises are matched regarding 162 issues (in FY 2012) of the program. The commercialization of industrial cutters with high corrosion

1 Technical experts who support industry-university collaboration and technology transfer.
2 Tohoku Economic Federation, etc.
3 The breakdown of total 517 issues adopted in FY 2012 follow: 162 issues for the promotion of transferring technical seeds from universities to enterprises in the afflicted regions (promotion of matching), 345 issues for the development of seeds from universities, etc. throughout Japan as based on the needs of the afflicted regions (A-STEP), 10 issues for the fundamental research to solve technical problems in specific themes that the industrial sectors in Tohoku are seeking for region (industry-academia collaboration).

resistance[1], the kind used in circumstances where corrosion and rust are generated during food/marine product processing, has been implemented in collaboration between local enterprises and the Institute for Materials Research at Tohoku University. The development of functional foods, including supplements and new cosmetic products having a high moisturizing effect, has also been advanced as part of the collaboration among other local enterprises, the Ichinoseki National College of Technology, and the Iwate Industrial Research Institute.

Through similar efforts, the technology seeds from universities are expected to contribute to the reconstruction of the afflicted regions by increasing cases in which those seeds are put to practical application at enterprises in the afflicted regions.

3) Surveys and research of a marine ecosystems and technological developments toward the creation of new industry (Tohoku Ecosystem-Associated Marine Sciences)

MEXT has implemented surveys and research, as well as technological developments, to recover the marine ecosystems of fishing grounds and to create new industries using resources from the sea around Tohoku region, designating Tohoku University as a representative organization, and designating research institutions of universities throughout Japan, local fishery cooperative associations, and enterprises as participatory/cooperative organizations.

In the Pacific coast area around the Tohoku region, large quantities of disaster waste were accumulated, seaweed beds were lost, sand and mud accumulated on rocks, the marine ecosystem changed dramatically, and fishing grounds suffered, all as a result of the damage caused by the GEJE and the tsunami that followed.

Rubble accumulated on a submarine valley
Provided by MEXT

MEXT gathered researchers throughout Japan mainly from organizations including Tohoku University that had implemented surveys and research off the Pacific coast of the Tohoku region before the earthquake disaster. They conducted research and development to understand mechanisms of change in the marine ecosystem by conducting surveys and research for the marine ecosystem, and also to create a new industry by cooperating with local enterprises[2].

The research in the past revealed that the number of young shellfishes and larvae of sea urchins and abalones was reduced by 70% in Otsuchi Bay and Onagawa Bay, and that 60-70% of species in tidelands was lost. The obtained scientific knowledge has been provided to local areas, so they can utilize it for planning local fisheries and begin to recover the marine ecosystems of their fishing grounds.

A tank for on-land culture of large algae
Courtesy of MEXT

In addition, technological developments toward the creation of new industries has advanced, including the implementation of land-based

1 The strength of the cutter is increased by the knowledge of cobalt alloy research at the Institute for Materials Research of Tohoku University and by an electron beam lamination shaping method.

2 They are implemented by designating Tohoku University as a representative organization, and by designating the Atmosphere and Ocean Research Institute, the University of Tokyo, and Japan Agency for Marine-Earth Science and Technology (JAMSTEC) as deputy representative organizations, and research institutions of universities throughout Japan, local fishery cooperative associations, and enterprises as participate/cooperative organizations.

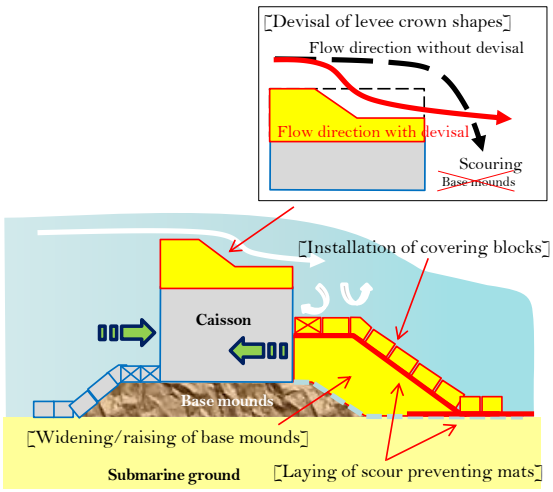
technology for the cultivation of wakame seaweed that would be unaffected by tsunamis, and the development of new materials containing functional components from unutilized seaweed. In the future, this technology will be transferred to enterprises for the creation of new industries using resources from the sea around the Tohoku region.

These efforts are expected to contribute to the reconstruction of the fisheries located in the coastal areas of afflicted regions.

4) Efforts for the Reduction of Tsunami Damage by Using Breakwaters

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT), based on scientific knowledge obtained through surveys conducted by the Port and Airport Research Institute and other institutes to understand the causes of breakwater collapse, has implemented the recovery work of repairing breakwaters in the afflicted regions, formulating guidelines for the necessary level of tsunami resistance to be used in the design of breakwaters.

The coastal areas around the Tohoku region suffered damage including breakwater collapse as a result of the tsunami caused by the 2011 off the Pacific coast of Tohoku Earthquake. The surveys[1] conducted by the Port and Airport Research Institute and other institutes revealed that the main causes of this damage were the slippage of caisson due to the tremendous power of waves caused by the tsunami, and the scouring of the ground located behind the breakwaters due to the overflow of water resulting from the tsunami.



Outline of tenacious breakwater structure
Courtesy of MLIT

Therefore, based on scientific knowledge obtained by the surveys, MLIT has made progress in establishing "Guidelines for Tsunami Resistance in the Design of Breakwaters." In addition, MLIT has decided to implement breakwater recovery work by March 2016, including 1) the devisal of levee crown shapes to control overflow by forming structures that demonstrates tenacious effects against disaster mitigation without collapsing when impacted by a tsunami exceeding the expected scale used in their design, as well as 2) the reinforcement of land located behind the breakwaters, in order to prevent the slippage of caisson and the scouring of land behind the breakwaters.

MLIT aims at developing disaster-resistant harbors which will protect the towns and industries of the afflicted regions by combining tangible measures, such as breakwater development, with intangible measures, such as evacuation planning.

1 On the same surveys, it was revealed that breakwater demonstrated a certain effect for disaster mitigation, for example, breakwater at the mouth of Kamaishi Bay reduced the height of the tsunami by 40% and the maximum run-up height by 50%, and delayed the arrival of the tsunami to urban areas by six minutes, resulting in the reduction of human/material damage in urban areas.

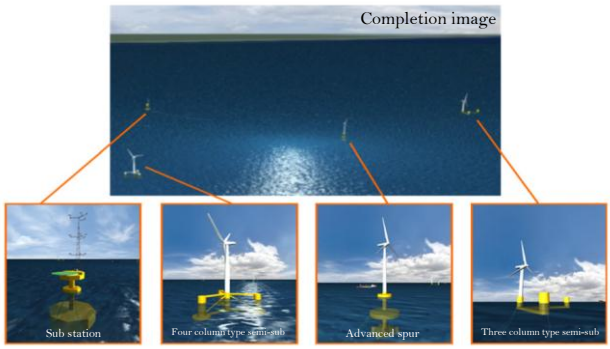
5) Efforts for the establishment of floating wind farms

METI has implemented a verification process or a floating wind-power generation system off the coast of Fukushima Prefecture and has designated a consortium consisting of 11 enterprises and universities as implementing organizations that will establish the floating wind power generation technology and derive measures for its coexisting with fisheries.

Japan has decided to promote the implementation of renewable energy as much as possible[1] Furthermore, in Fukushima Prefecture, the creation of jobs derived from the enhancement of research and development bases, and issuing invitations to related industries, is regarded as one of the important projects of the Fukushima Prefecture reconstruction plan.

METI has established power generation technology with floating wind-power generation[2] stations and has demonstrated their safety, reliability, and economic efficiency, designating a consortium consisting of 11 enterprises and universities as implementing organizations. Since March 2012, METI has also implemented the verification of a floating wind power generation system off the coast of Fukushima Prefecture to derive measures for coexisting with fisheries[3].

In the future, Japan is expected to realize the full-fledged establishment of wind farms, to set up a wind power generation base, and to contribute to the regeneration of industries in Fukushima Prefecture.



Images of floating wind farm
Courtesy of the Fukushima Offshore Wind Consortium

6) Efforts to realize next-generation medical care (Tohoku Medical Mega-Bank Project)

MEXT has implemented large-scale genome cohort research in cooperation with the Ministry of Health, Labour and Welfare (MHLW) and with the Ministry of Internal Affairs and Communications (MIC), designating both Tohoku University and Iwate Medical University as implementing organizations, to eliminate the health anxiety of people living in the afflicted regions and to realize next-generation medical care in the Tohoku region.

In the Tohoku region, where medical institutions suffered from serious damages caused by the GEJE, it is necessary to develop a mechanism for establishing a medical care system and health care system in

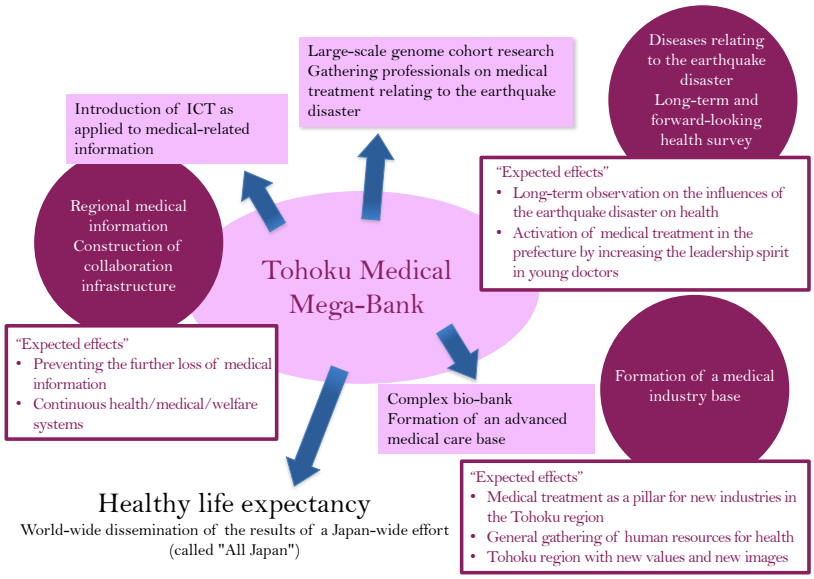
1 In Prime Minister Abe's administrative policy speech at the 183rd Session of the National Diet on February 28, 2013, he announced that he would advance the introduction of energy savings and renewable energy to the maximum.

2 While Japan is a marine nation possessing the sixth largest exclusive economic zone in the world and having greater potential at sea in comparison with on land, Japan has fewer sea areas with shallow water depths than other countries do. Floating wind power generation is suitable for the coast off of Fukushima Prefecture.

3 A verification introducing wind power generation system comprised of an apparatus generating 2,000kW and two apparatuses generating 7,000 kW per apparatus is planned by a consortium consisting of 11 enterprises and universities.

which the lives and the overall health of disaster victims is protected, allowing them to live in peace.

MEXT has promoted the Tohoku Medical Mega-Bank Project in cooperation with MHLW and MIC, designating Tohoku University and Iwate Medical University as implementing organizations.



Expectations from the results of the Tohoku Medical Mega-Bank Project
Courtesy of Tohoku University and the Tohoku Medical Mega-Bank Organization

In this project, health surveys will be conducted while obtaining the consent of residents living in the afflicted regions, and a biobank will be constructed by accumulating collected health information and biological samples. Research and development for the creation of next-generation medical care according to individual genome information, including the accurate diagnosis and prevention of diseases as well as a reduction in side effects of medicine, will be conducted by research and development utilizing the biobank, and by an analysis of the relationship between the earthquake disaster and diseases.

A scene of a health survey
Courtesy of Tohoku University and Tohoku Medical MegaBank Organization

Various systems for the implementation of actual measures were enhanced in FY 2012, including the opening of "regional support centers" which serve as bases for health survey activities in the afflicted regions. Full-scale health surveys were begun in FY 2013, and there is a plan to implement large-scale genome cohort research[1] utilizing results from these surveys.

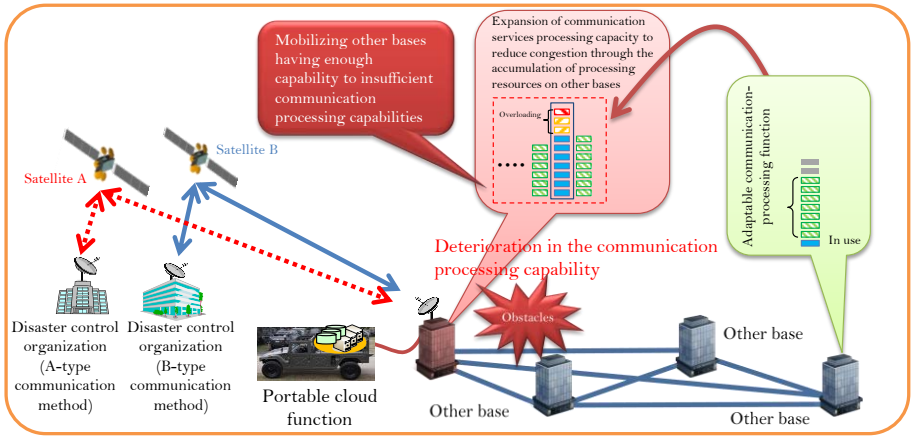
There is also an ongoing expectation to form a biobank serving as the foundation of personalized medical care in the Tohoku region and to promote cutting-edge analysis research thereafter, which will contribute to the elimination of the health anxieties affecting the residents of the afflicted regions. This will be done as a result of doctors' activities in regard to the health surveys and by sharing the results of

1 Genes and environmental factors relating to diseases and to medicinal effects are identified by collecting the biological samples, health information, and medical examination information of cooperators by properly obtaining the consent of prefectural residents and by an analysis of the health information and medical examination information combined together with the genome information from biological samples. Consequently, the influences of human genes on diseases are clarified.

those surveys in close cooperation with local governments and related organizations. In the future, this is expected to create new industries, including drug-discovery.

7) Implementation of research and development concerning communication infrastructure technology in the case of a disaster

MIC has implemented R&D and an evaluation of the verification of communication infrastructure technology in the Tohoku region, designating each university and enterprises as an implementing organization, and improving the disaster resistance abilities of the entire information communications system of Japan, and of the Tohoku region, especially.



Conceptual diagram of communication infrastructure technology in case of disaster
Courtesy of MIC

In the GEJE, large-scale congestion occurred due to a concentration of communications whose volume was 50 times that of the normal volume, resulting in a great deal of obstacles affecting the protection of important communications and the recovery work of the afflicted regions.

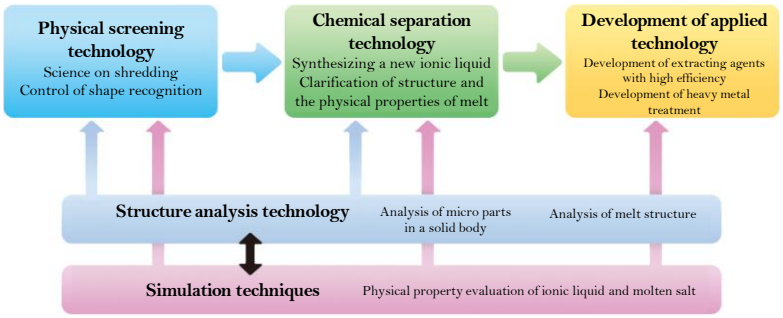
In response to such cases, since FY 2012, MIC has started R&D and has begun the evaluation of the verification of communication infrastructure technology in the Tohoku region, where seismic activity remains active, even after the earthquake disaster; thus, there are strong needs for disaster resistant communication. Specifically, it is supposed to establish a technology of portable ICT units that are capable of urgent transportation to afflicted regions and that are capable of operating with multiple connections. In addition, technology is being developed to accommodate communication processing capabilities during the occurrence of large-scale communication congestion. This will be accomplished through networks ensuring the cooperation of bases in areas having a surplus capacity and of bases in areas suffering from a capacity shortage.

These efforts are being implemented to improve the disaster resistance of the entire Japanese information communication system, especially that of the Tohoku region, and to promote the construction of a disaster-resistant information communication network that is integrated with urban development, and which the people can reliably use. In addition, the creation of associated demands and employment are also expected.

8) Formation of a base for research and development on nanotechnology conducted through industry-university-government collaboration

MEXT has implemented the development of advanced material utilizing world-class, cutting-edge technology to drive the development of material industry in the Tohoku region, designating Tohoku University as an implementing organization.

Since FY 2012, MEXT has started the program entitled "Tohoku Innovative Materials Technology Initiations for Reconstruction" to drive the development of the material industry in the Tohoku region, designating Tohoku University[1] as an implementing organization. In nanotechnology and materials fields, where universities and manufacturers in the Tohoku region have advantages, the program is supposed to form a base for the research and development of nanotechnology at Tohoku University by means of an industry-university-government collaboration in order to develop leading-edge materials.



Conceptual diagram of research (research and development concerning rare element extraction technology)
Courtesy of Tohoku University

Specifically, Tohoku University is supposed to cooperate widely with universities and enterprises in the Tohoku region, in order to implement the research and development of technology that can contribute to improvements in the combustion efficiency of automobiles, technology that can dramatically reduce energy loss in power transmission and motors, and technology by which rare elements are extracted from urban mines. It is also supposed to implement the creation of innovative technology seeds and act as their bridge to practical applications.

These efforts are expected to contribute to industrial clusters and to the creation of new industries and employment, which will vitalize industries in the Tohoku region.

(3) Efforts for recovery from the nuclear power disaster

1) Efforts for the development and broad deployment of highly sensitive, high-speed devices for inspecting the radioactivity of food in order to secure food safety

JST publicly invited applications for research and development themes on inspection equipment for measuring radioactive concentrations in food. A development team including enterprises has conducted the research and development of broadly deployed inspection equipment, and Fukushima Prefecture has promptly conducted the inspection of all rice bags produced in the prefecture by using this equipment.

1 The university maintains the world's top level in a materials science field.

The measurement of radioactive concentrations in food is necessary in all of the regions afflicted by radioactive substances. MHLW has defined reference values[1] for each food group (commonly eaten foods, foods for babies, milk, and drinking water), and periodic inspections have been conducted[2] based on these values.

Measuring and analyzing device
Courtesy of JST

As for marine products that are commonly eaten, the scope of the application was changed[3] based on the inspection results regarding shipment restrictions[4] and self-restraint, which were implemented after the accident. However, the operations of all coastal fisheries and trawl net fisheries located off the coast of Fukushima Prefecture were voluntarily restrained after the accident, and even then, only experimental operations involving specific areas of the sea and specific fish species have been implemented, but a return to normal operations are in view. In addition, Fukushima Prefecture has voluntarily conducted the inspection of all rice bags and of all beef in order to eliminate anxiety about food consumption and the financial damages caused by harmful rumors and misinformation.

As for rice, JST has promoted the development of equipment to measure the radioactivity of food under the "Development Program of Equipment and Technology for Advanced Measurement and Analysis (in radiation measurement areas)." With regard to measurements on the radioactive concentrations in rice, the development team, including universities and enterprises, has developed measuring and analyzing devices[5] with high-speed and high sensitivity. These devices are capable of inspecting up to 250 rice bags per hour with the rice remaining inside the bag (30kg). The developed device accounts for approximately half of all inspection devices used in the inspection of all rice bags produced in Fukushima Prefecture, and it has contributed to the acceleration of the inspections (as of the end of April 2013).

Furthermore, the verification of the applications of this equipment to farm products other than rice, including apples and wheat, is being verified under a demonstration project began in FY 2012. It is expected to contribute to the implementation of inspections that correspond to on-site needs by continuously progressing the improvement of inspection equipment based on the needs for the inspection of commonly eaten foods.

In addition, in order to visually and intelligibly display radioactive substances at various sites, development teams including the Japan Aerospace Exploration Agency (JAXA), universities, and enterprises, are developing a gamma ray visualization device (Compton camera)[6] through the above-mentioned development program. Since the device has high sensitivity and high resolution, and is

1 A new reference value of radioactive substances in food, established by MHLW and enforced since April 1, 2012.
2 The inspection planning, and concept of designating items and areas under a shipment restriction and releasing the restriction. (Nuclear Emergency Response Headquarters, March 19, 2013)
3 Fisheries Agency website: http://www.jfa.maff.go.jp/j/kakou/hyouzi/kisei_kekka.html
4 When the spread of contamination is recognized, such as with the same marine products exceeding standard values in several places off the coast of a certain prefecture, the general manager of the Nuclear Emergency Response Headquarters (the Prime Minister) will instruct the prefectural governor to restrict shipments.
5 After automatically measuring the radioactive concentrations of rice remaining enclosed in bags, rice bags whose radioactive concentration is under the standard value are labeled with a QR code of the measurement result, and then distributed to markets. Consumers can confirm the radioactive concentrations of purchased rice through the Internet.
6 The camera is capable of measuring an incoming direction of radial rays and their energy (wavelength) at the same time and in real time. It is also capable of identifying substances emitting gamma rays, such as radioactive cesium-137 (Cs-137) and radioactive iodine (I-131).

capable of the prompt visualization of radioactive substances in comparison with conventional methods, by loading the device on unmanned helicopters and taking measurements from the sky, it is expected to easily comprehend decontamination results.

2) Implementation of decontamination utilizing new technology

The Cabinet Office conducted various demonstration projects including the establishment of effective decontamination methods and issued an invitation for public applications for promising decontamination technology, designating JAEA as an implementing organization. The Ministry of the Environment (MOE) has continuously invited public applications for promising decontamination technology and then implemented the verification afterward.

Decontamination is important work that is necessary to reduce the influences of environmental pollution caused by radioactive substances on human health and on the environment.

As one of the efforts to ensure the implementation of decontamination, the Cabinet Office conducted a decontamination model verification project[1] and a decontamination technology demonstration project[2] in FY 2011, designating JAEA as an implementing organization. Efficient methods and procedures for decontamination and measures to suppress the amount of retrieved material were verified and confirmed by the decontamination model verification project. Available data toward future full-scale decontamination implementation was obtained and prepared. In addition, a high decontamination effect was recognized even on a road surface which had revealed no decontamination effects when measured using the conventional method by using ultrahigh pressure water technology from the decontamination technology demonstration project. Also, it was verified that sprayed water was absorbed and collected, and was capable of reuse after removing radioactive substances.

MOE has continuously invited public applications for promising decontamination technology, and it implemented the verification afterward in FY 2012. In addition, the above-mentioned ultrahigh pressure water technology has already been utilized on decontamination spots, and it effectively worked to reduce the concentration of radioactive substances adhered on paved surface by 90% where pollution with comparatively high concentration rates was observed.

A scene of decontamination
Courtesy of JAEA

Before decontamination After decontamination

*Decontamination was implemented with ultrahigh pressure water technology on a road surface which had revealed no decontamination effects when measured by the conventional method. Radioactive substances in gaps between blocks were removed.

Courtesy of JAEA

1 Designating areas with high levels of radiation, where the annual additional dose irradiation exceeded 20mSv, as its main targets, efficient and effective decontamination methods concerning measures for soil decontamination, and a strategy for security concerning radiation and the protection of workers were established.

2 Evaluating the effectiveness (economic efficiency and safety) of new, promising decontamination technology which is considered to be practicable, by adopting the technology through invitations for public applications, and conducting demonstrations.

3) Efforts toward reducing the volume of contaminated waste

MOE designated the Japan Sewage Works Agency and enterprises as implementing organizations, and started the volume reduction of sewage sludge, which is designated waste in Fukushima Prefecture, by introducing drying technology that was jointly developed by the implementing organizations.

Some contaminated waste whose radioactive substance concentration exceeds 8,000 Bq/kg requires special processing and storage as designated waste. The designated waste was collected in areas where designated waste was generated, however, processing of the waste was impossible and storage capacity has reached the limit. Problems including sludge putrefaction due to long-term storage have also occurred.

Drying apparatus
Courtesy of MOE

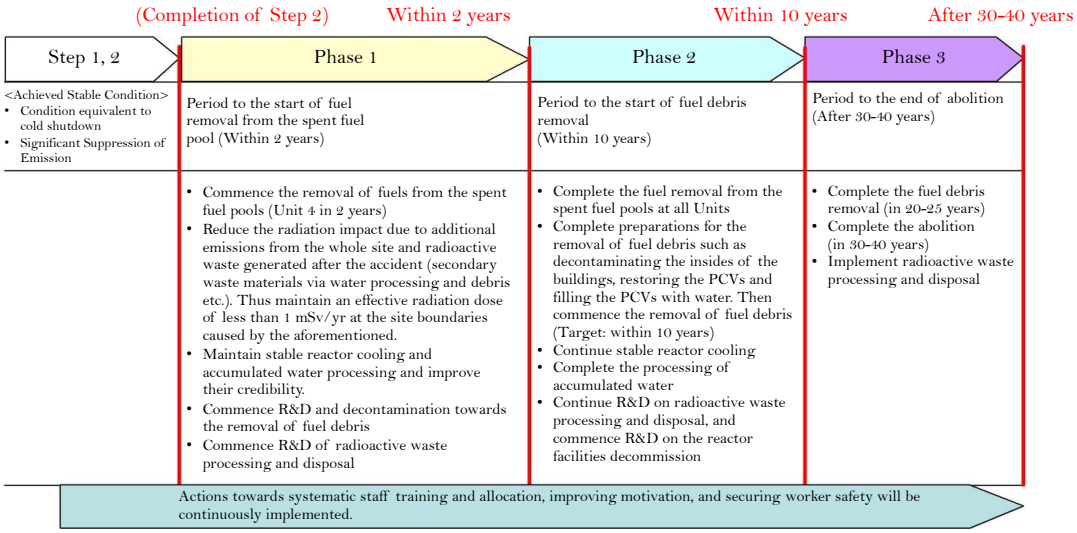
Therefore, since January 2012, at a terminal treatment plant in Horikawacho, Fukushima City, MOE has implemented a verification project that installs a drying system to a facility that prevents the external leakage of radioactive substances, designating Japan Sewage Works Agency as an implementing organization. It is supposed to reduce the volume of sewage sludge by approximately 80% while considering safety and preventing putrefaction in the verification project. The volume reduction of sewage sludge has started in April 2013.

It is a goal to mitigate the financial burdens of local governments that store designated waste by promoting the volume reduction of waste utilizing knowledge about the safety of treatment technology that were obtained during the demonstration in order to prevent the leakage of radioactive substances.

4) Efforts for the stabilization and decommissioning of the TEPCO Fukushima Daiichi Nuclear Power Station

The Japanese government and TEPCO have made efforts for the stabilization and decommissioning of the TEPCO Fukushima Daiichi Nuclear Power Station, based on "medium-to-long-term roadmap towards the abolition of Units 1-4 of the TEPCO Fukushima Daiichi Nuclear Power Station." As for the inspection of the interiors of reactor buildings, robots developed by universities and enterprises were improved based on feedback from the disaster sites and then deployed to those sites.

(i) A road toward decommissioning

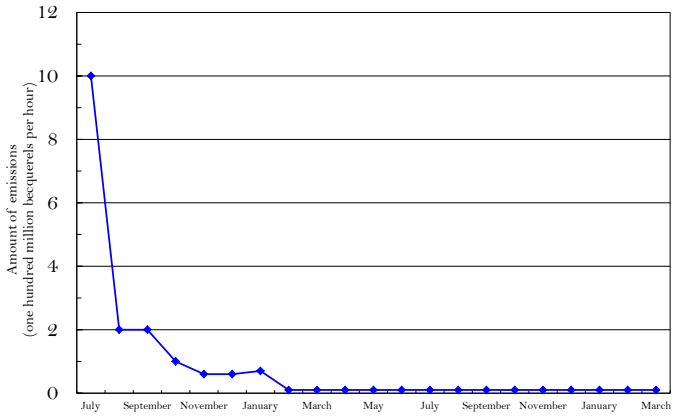


Summary of Medium-to-Long-Term Roadmap
Courtesy of TEPCO

Since the accident, the emission amount of radioactive substances from the reactor building has decreased, and one of the goals set in the first term, achieving an "effective dose of less than 1 mSv per year within property boundaries," was accomplished in March 2013. Efforts to accomplish the other goals are ongoing.

As for starting the extraction of fuel from a spent fuel pool within two years after the completion of Step 2, which was a primary goal of the first term, efforts are being made to reach the Unit 4 related milestones more quickly by accelerating the starting time of the extraction by one month (November 2013) and by achieving the completion time of the extraction by one year (around the end of 2014).

It is a goal to complete abolition after 30-40 years by making continuous efforts toward decommissioning as outlined in the roadmap.



Amount of radioactive substance (cesium) emissions from Units 1 to 3 of the Fukushima Daiichi Nuclear Power Station per hour (from July 2011 to March 2013)
Courtesy of TEPCO

(ii) Utilization of Robots on Disaster Sites

Domestic and foreign remote control robots work well in taking measurements of radiation doses in the reactor building after much trial and error. Japanese robots have been utilized, and their capabilities have improved as a result of the feedback given from the disaster sites. One example of this is the robot, Quince, which was developed by collaboration between universities and enterprises.

Quince is capable of climbing stairs, and was invested in a field environment inspection of the second floor and other parts of the reactor building in which circumstances were unclear. It contributed to subsequent work by grasping clear images and measuring radiation doses in the reactor building and by providing information for making a decision as to whether or not people can enter the building.

Quince
Courtesy of TEPCO

On the other hand, inspection of the torus room under the reactor building, whose access stairs are narrow, was implemented with a smaller Survey Runner. Distribution of radiation doses in the torus room and the conditions of the room were grasped by clear images. Inspection with four-leg walking robots was started afterward in the places where crawler type robots, including Quince, had had difficulty reaching.

Survey Runner
Courtesy of TEPCO

In addition, the subsidized projects adopted by METI include various activities for further development: 1) a remote decontamination robot that can collect secondary waste from inside the reactor buildings, and 2) a remote survey device which can survey the conditions of the containment vessels located inside a reactor, even when high levels of radiation are present.

As for the development and verification of the remote control equipment/device utilized on disaster sites, METI is planning the establishment of a base in Fukushima Prefecture, and further progress of research and development is expected.