Report to the Foreign Academies from Science Council of Japan on the Fukushima Daiichi Nuclear Power Plant Accident

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Great East Japan Earthquake Taskforce
Science Council of Japan
http://www.scj.go.jp/en/index.html

Preamble

In the wake of the massive earthquake (magnitude 9.0) that occurred off the coast of Miyagi Prefecture on March 11, 2011 and the subsequent major tsunami and accident at the Fukushima Daiichi (No. 1) Nuclear Power Plant of Tokyo Electric Power Co., Ltd. (TEPCO) resulted in a discharge of radioactive materials and evacuation of residents living near the nuclear power plant. Science Council of Japan (SCJ) has received messages of sympathy and encouragement and offers of cooperation from academies in countries and regions around the world. We would like to express our heartfelt thanks for your warm messages of concern and comfort.

The SCJ recognizes that the leakage of radiation from the nuclear power plant may be a great concern of the people living not only in Japan but also abroad, and so we wanted to report to academies around the world on the progress of the situation at as early an opportunity as possible. We must confess honestly, however, that for some time even we did not have adequate information to enable us to do this. At present, the measurement and the influence on health evaluation about the radiation poisoning of the air, ocean and soil are done on a large scale by the government agency, and the result came regularly to be made public. The accident at the nuclear power plant itself, unfortunately, still has not been resolved. What is needed now, however, is to devise measures from a medium- and long-term perspective, based on the information that we have at present. The SCJ has prepared a provisional summary, based on what we know at this stage, of the current situation and the issues to be resolved going forward. In presenting this report to academies in countries and areas around the world, the SCJ hopes that they will continue to provide their cooperation and support in the future.

Unless otherwise noted, the data in this report were obtained from the Nuclear and Industrial Safety Agency (NISA) of the Ministry of Economy, Trade and Industry, the Ministry of Education, Culture, Sports, Science & Technology, the Nuclear Safety Commission (NSC) of the Cabinet Office, TEPCO, and the International Atomic Energy Agency (IAEA).

I What Happened

1. Background to the accident

1) Status of Fukushima Daiichi Nuclear Power Plant immediately prior to the earthquake

Of the six reactors at the TEPCO Fukushima Daiichi Nuclear Power Plant, Units 1, 2 and 3 were in operation at the time of the earthquake. Units 4, 5 and 6 had been shut down for regular maintenance. A certain number of spent fuel rods from each of these six reactors were being stored in spent fuel pools built in the each reactor housing. In Unit 4 only, all of the fuel in the reactor core had been transferred to the spent fuel pool in order to conduct regular maintenance. As a result, there were no fuel rods in the rector core. On the other hand, the number of fuel rods from Unit 4 that were in the spent fuel pool was greater than the number at the other reactors.

2) Status of the nuclear power plant after the earthquake and legally mandated steps

At 2:46 p. m. on March 11, 2011, a massive earthquake with a magnitude of 9.0 occurred off the coast of Miyagi Prefecture. The nuclear reactors and turbines of Units 1, 2 and 3 stopped automatically. The steel towers on the plant grounds collapsed as a result of the earthquake, preventing Units 1 through 6 from receiving external power. The emergency diesel generators started up automatically. However, as a result of the major tsunami that hit the Fukushima Daiichi Nuclear Power Plant approximately an hour later, at 3:41 p. m., all of the emergency diesel generators at Units 1 through 4 failed and stopped operating, and subsequently the diesel oil tanks were washed away. As a result of this situation, all AC power was lost, and operation continued on battery power only. As this is a situation which must be reported under Article 10 of the Nuclear Disaster Special Measures Law, TEPCO reported the situation to the national and local governments. The tsunami had flooded not only the pumps but also the turbine building, making it impossible to use the pumps, and there was no power in the central control room as well, making all operations difficult. When the batteries were exhausted and cooling became impossible, TEPCO judged that all cooling functions had been lost, and at 4:36 p. m. TEPCO reported the occurrence of a nuclear power emergency situation to the national and local governments in accordance with Article 15 of the Nuclear Disaster Special Measures Law. In response, the government announced a nuclear power emergency situation at 7:03 p. m. on March 11. From that point on, the flow of information to the media came almost exclusively from only three sources: the Prime Minister's residence, TEPCO and NISA.

With regard to cooling operations for the reactors at this point, water vapor inside the reactor at Unit 1 was cooled using the emergency condensers, and water was supplied to Unit 2 and Unit 3 using the steam-driven Reactor Core Isolation Cooling system. Meanwhile, the loss of cooling function at the spent fuel pools in Units 1 through 4 continued.

Although the site of Units 5 and 6 had also been damaged by the tsunami, one diesel generator continued to function. As a result, Units 5 and 6 achieved cold shutdown on March 20 as a result of the cooling operation.

3) Behavior of units as a result of the loss of power

As a result of the total loss of AC power, the ordinary route of released heat to the sea water was cut off. As the batteries had also been exhausted and emergency pumping of water and cooling were unstable, adequate cooling could not be conducted and the fuel rods were exposed to air. The temperature of the fuel rods rose rapidly, and the zirconium in the zirconium alloy fuel cladding tubes reacted with the water, producing large quantities of hydrogen. As a result, early in the morning on March 12, the pressure in the containment vessel of Unit 1 began to rise due to the leakage of hydrogen, etc., and at the same time the emergency condenser stopped operating at 4:00 a. m. Accordingly, after the reactor vessel was vented at 10:17 a. m., a hydrogen explosion occurred inside the building housing the nuclear reactor at 3:36 p. m., blowing the building apart. In order to continue the cooling operation, the fire service system was used to pump in seawater at 8:20 p. m.

At Unit 2, the Reactor Core Isolation Cooling system was functioning, but it was not stable, and the reactor core was exposed. At 11:00 a. m. on March 13, the containment vessel was vented. At 11:30 a. m. on the following day, March 14, the Reactor Core Isolation Cooling system stopped functioning. Although workers began pumping in seawater at 4:34 p. m., the fuel was exposed to air for an extended period of time. Venting was initiated at 12:02 a. m. on March 15, and at 6:10 a. m. an abnormal noise was heard near the pressure suppression chamber and the pressure dropped, and it is presumed that there was a full-fledged release of the radioactive materials inside the containment vessel. This was subsequently confirmed by measurements of radiation in the atmosphere that were made public.

At Unit 3, cooling was conducted using the Reactor Core Isolation Cooling system, and at 1:00 p. m. on March 12 cooling water was pumped in using a high-pressure coolant injection system. However, at 5:10 a. m. on the following day, March 13, the high-pressure coolant injection system stopped operating, and it became impossible to start up the Reactor Core Isolation Cooling system as well. The pressure in the reactor vessel rose sharply, and at 8:41 a. m. the reactor vessel was vented, and seawater was pumped in at 1:12 p. m. At 11:01 a. m. on March 14, a hydrogen explosion occurred inside the Unit 3 reactor building as well, destroying the building. This is presumed to have been caused by the rise in the water temperature in the spent fuel pool, causing the water level to drop and exposing the fuel rods to air, producing hydrogen.

At Unit 4 as well, the loss of cooling function at the spent fuel pool caused the temperature of the water in the pool to rise, causing the water level to drop and producing hydrogen, and as a result an explosion occurred at 6:14 a. m. on March 15, destroying that building as well.

Unit 5 and Unit 6, which had been undergoing regular inspection, had lost external power as a result of the earthquake, but a single diesel generator remained in operation and conducted emergency cooling. As a result, cold shutdown was achieved for both of these reactors on March 20. Subsequently, on March 21 and 22, external power was restored. Although cooling function at the spent fuel pools had been lost temporarily, it was subsequently restored, and at present the cooling function is operating and a sound status is being maintained.

4) Pumping of water into the spent fuel pools, restoration of external power and treatment of high-level liquid waste

In Units 1 through 4, in addition to cooling of the reactor cores, the fuel rods at the spent fuel pools which were emitting heat due to decay heat also needed to be cooled. However, as the cooling water circulating pumps were no longer functioning, the temperature of the water in the spent fuel pools in Units 3 and 4 rose and the water level dropped, giving rise to concern that the fuel rods would be exposed to air. Accordingly, on March 17, the Tokyo Fire Department, Self Defense Force etc. began spraying and discharging seawater into the spent fuel pools in Unit 3 and 4. Subsequently, the discharge of water, etc. using concrete pumping vehicles continued, and the work crews gradually shifted from the use of seawater to the use of freshwater. Beginning on March 20, external power was restored, but this was mainly for the lights only, and freshwater discharge and pumping continued.

As a result of the discharge and pumping of water into the reactor cores and spent fuel pools, water containing large quantities of radioactive materials flowed out into the ground beneath the turbine buildings and other areas. Particularly at Unit 2, the damage to the containment vessel on March 15 resulted in the release of radioactive materials, creating highly radioactive water. In order to resolve the accident, the highly radioactive water in the turbine building must be removed and the cooling system equipment must be inspected and repaired, and continuous circulating water must be restored to the reactors and the spent fuel pools. However, it will not be possible to proceed with inspection and repairs until the highly radioactive water that has collected in the turbine building is removed. On April 2, it was discovered that highly radioactive water was flowing into the ocean from a crack in the outlet at Unit 2. In order to stop the leak of highly radioactive water and transfer it to the centralized waste treatment facility, on April 4 the low-concentration contaminated water that had been in the centralized waste treatment facility was discharged into the ocean. The transfer of the highly radioactive water will take a considerable amount of time, but the pumping of water into the reactors and spent fuel pools must be continued during this process, making this a difficult task.

Since April 6, nitrogen has been pumped into the containment vessel of Unit 1 in order to prevent a hydrogen explosion. TEPCO plans to pump nitrogen into Unit 2 and 3 as well.

2. Changes in radiation levels in areas around Fukushima Daiichi Nuclear Power Plant and current status

Due to the release of radioactive materials as a result of the accident at the Fukushima Daiichi Nuclear Power Plant, the radiation dose rate in air in various locations near the plant has increased. There was a particularly significant increase accompanying what is assumed to have been the release of radioactive materials at the time of the abnormal noise heard near the pressure suppression chamber of Unit 2 on March 15. The atmospheric concentration and soil deposition quantity of radioactive materials released into the atmosphere will differ depending on the wind direction, rainfall and other conditions at the time of the release. On March 15, there was a southeast wind, and as this was accompanied by rainfall as well, locations northwest of the plant were exposed to a high dose of radiation. After the highest values were measured from March 15 to March 17, however, the levels have decreased over time except a temporary high values measured on March 21, as shown in the attached figure 1.

The release of radioactive materials has continued, but the quantities are relatively small. Even if types of radiation that have a short half-life, such as iodine-131 (which has a half-life of approximately eight days), are deposited, they are thought to break down relatively quickly, leading to a decrease in radiation dose.

In its provisional assessment of the accident based on the International Nuclear and Radiological Event Scale (INES), made at 12:30 a. m. on March 12, NISA assessed the accident at Level 3 for Units 1 through 3 based on the standard for "Impact on radiological barriers and control". In the early evening on that same day however, as the radiation level inside the nuclear power plant had risen, it made a provisional assessment of Level 4 for Unit 1. An assessment was conducted again on March 18, and a provisional assessment of Level 5 was made for Units 1 through 3 due to the high probability of damage to the nuclear fuel rods. A provisional assessment of Level 4 was made for Unit 4. On April 12, based on a preliminary estimate of the total amount of radioactive materials released into the atmosphere from Units 1 through 3, the provisional estimate was raised to Level 7. NISA estimated that the total amount of radioactive materials released into the atmosphere was approximately 10% of the quantity released at the time of the Chernobyl accident in 1986.

3. Estimates of radioactivity

1) Amount of radioactive materials inside reactor core

NISA estimated the amount of radioactive materials in the reactor core immediately after the reactor shut down as follows. Iodine-131; approximately 1.3 million terabecquerels (1.3×10^{18} Bq) for Unit 1, 2 million terabecquerels (2.0×10^{18} Bq) for Unit 2, and 2 million terabecquerels (2.0×10^{18} Bq) for Unit 3. Cesium-137; approximately 130,000 - 370,000 terabecquerels ($1.3 - 3.7 \times 10^{17}$ Bq) for Unit 1 and 220,000 - 500,000 terabecquerels ($2.2 - 5.0 \times 10^{17}$ Bq) each for Unit 2 and 3.

Cabinet office estimated the total amount of Iodine-131and Cesium-137 in Unit 1, 2 and 3 as 6.1 million terabecquerels (6.1×10^{18} Bq) and 710,000 terabecquerels (7.1×10^{17} Bq), respectively.

2) Amount of radioactive materials in spent fuel pools

No estimates of the radioactive materials in the spent fuel pools have been released. According to Professor Shunichi Tanaka, however, as some time has passed, the quantity of iodine-131 can be disregarded in the case of Units 1 through 3, and the quantity in the spent fuel pool at Unit 4 is 11,000 terabecquerels (1.1×10^{16} Bq). The amount of cesium-137 is 350,000 terabecquerels (3.5×10^{17} Bq) at Unit 1, 470,000 terabecquerels (4.7×10^{17} Bq) each at Unit 2 and 3, and 1 million terabecquerels (1.0×10^{18} Bq) at Unit 4.

3) Amount of radioactive materials discharged into the atmosphere

According to back calculation estimates made by the Nuclear Safety Commission using the System for Prediction of Environmental Emergency Dose Information (SPEEDI) of the Nuclear Safety Commission of Japan (a cabinet office), the amount of radiation released into the atmosphere from March 11 to April 5 is 130,000 terabecquerels (1.3×10^{17} Bq) of iodine-131 and 6,100 terabecquerels (6.1×10^{16} Bq) of cesium-137.

SPEEDI was designed to quickly predict the concentration in air, dose etc. of radioactive materials in the surrounding environment when a large quantity of radioactive materials is released from a nuclear power plant or other facility, based on data on the emission source and taking into account the topography and measurements of wind and rainfall at that time. The results of SPEEDI are published in http://www.nsc.go.jp/mext_speedi /index.html

4) Amount of radioactive materials discharged into the ocean

On April 21, TEPCO measured the flow quantity and discharge water concentration near the outlet screen of Unit 2, from which water that included highly concentrated radioactive materials had been discharged into the ocean. The total amount of radioactive materials discharged into the ocean was estimated as follows: 2,800 terabecquerels (2.8×10^{15} Bq) of iodine-131, 940 terabecquerels (9.4×10^{14} Bq) of cesium-134 and 940 terabecquerels (9.4×10^{14} Bq) of cesium-137, making a total of 4,700 terabecquerels (4.7×10^{15} Bq). Assuming that there are no other major discharge routes, the amount discharged into the ocean is presumed to be close to this value.

4. Evacuation of residents

On the evening of March 11, the evacuation of residents from areas within 3 kilometers of the plant was ordered by the Prime Minister out of concern regarding the possible leakage of radiation from the Fukushima Daiichi Nuclear Power Plant. Residents living in the area of 3 to 10 kilometers around the plant were also ordered to stay indoor. On the following day, March 12, the radiation dose in the area around the plant increased, and the evacuation zone was increased to 10 kilometers around the plant, and shortly thereafter to 20 kilometers. On March 15, residents living in the area 20 to 30 kilometers around the plant were instructed to stay indoors. Approximately 140,000 people live within a 30-kilometer radius of the plant, and of these approximately 87,000 live within 20 kilometers of the plant.

On April 10, judging from changes over time in the radiation dose rate in air at various locations and calculations made using SPEEDI, the Nuclear Safety Commission indicated that there were areas northwest of the plant in which the integrated dose rate exceed 20 millisievert per year and the NSC presented measures to deal with the situation to the government. Based on the recommendations of the NSC, the government held discussions with the affected communities, and on April 22 the area 20 kilometers around the Fukushima Daiichi Nuclear Power Plant was declared a "Caution Zone" to which entry was prohibited. In addition, the instruction to remain indoors was lifted for the area 20 to 30 kilometers around the plant and the area northwest from the Caution Zone outside 20 kilometers of the plant was designated a "Planned Evacuation Zone." Also, "Emergency Evacuation Preparation Zones " are designated in the areas within the zone 20 to 30 kilometers around the plant (Figure 2).

Evacuation measures were needed to protect the health of residents, and as a result of their establishment, physical radiation damage (deterministic effect) has not been confirmed in residents, and it is expected that no such damage will be confirmed in the future as well. On the other hand, many of the residents who evacuated under emergency conditions taking nothing with them, and who moved to places that had had virtually no time to prepare to receive them, continue to live under difficult conditions.

5. Radiation contamination of food and water and damage from harmful rumors

On March 15, a temporary increase in the radiation level in the air was observed even in Tokyo, some 200 kilometers to the south-southeast from Fukushima. This led to concerns regarding increased radioactive fallout and resulting pollution of crops. Accordingly, on March 17, the Ministry of Health, Labor and Welfare established provisional standards for radiation in food in accordance with the Food Sanitation Law. For radioactive iodine (the representative nuclide is iodine-131 in the mixed isotopes), the standards were 300 Bq/kg for drinking water and milk, 2,000 Bq/kg for vegetables and so on.

Based on these standards, measurements were initiated in various prefectures. As a result, from March 19 through 21, radioactive iodine exceeding the standards was detected in vegetables, milk and water in Fukushima Prefecture, Ibaraki Prefecture and other areas. On March 21, the government instructed that the level should not exceed 100 Bq/kg for drinking water given to infants. The government also restricted shipment of certain vegetables and milk produced in Fukushima, Ibaraki, Tochigi and Gunma Prefectures.

On March 22 and 26, radioactive iodine was detected by TEPCO in seawater near the nuclear power plant, and on March 29 radioactive iodine was also detected by the Ministry of Education, Culture, Sports, Science & Technology, off the coast 16 kilometers south of the plant. In addition, on April 4, radioactive iodine was detected in small fish off the coast of Ibaraki

Prefecture. In response, the Ministry of Health, Labor and Welfare established standards for radioactive iodine in fish and shellfish (which had not been established previously), setting them to the same level as the standards that had already been established for vegetables. On April 9, radioactive cesium was detected in small fish off the coast of Fukushima Prefecture, and on April 20 restrictions were placed on the shipment and ingestion of small fish caught off the coast of Fukushima Prefecture.

With regard to the water supply, as of April 12, the level of iodine-131 in all of the water supply corporations in Fukushima, Ibaraki, Chiba, Tokyo and Tochigi Prefectures was well below the standard for infants of 100 Bq/kg. However, the village of Iitate in Fukushima Prefecture decided on its own to establish and publicize intake restrictions for infants.

With regard to contamination of vegetables and water, the situation has improved along with the decrease in radioactive fallout. In terms of seawater, contamination has been detected in some small fish, but only sporadic cases have been observed as of May 2.

In this way, the safety of the water supply and the vegetables making their way to market has been protected due to the establishment of strict regulations and the implementation of inspections. The problem that remains to be resolved is that of harmful rumors. When contamination exceeding the standards has been discovered in the crops from a certain region, the government has placed restrictions on the shipment of that crop from the entire prefecture. The government explained that the main reason for imposing shipment restrictions over such a wide area is that the labeling of the originating location of agricultural crops is done by prefecture, but another objective was to prevent the spread of harmful rumors. At present, the scope of shipment restrictions has been scaled back from the prefecture level to the regional level. Ultimately, however, sales of vegetables, fish and shellfish from Fukushima, Ibaraki, Tochigi, Chiba and other prefectures have decreased substantially. Each prefecture implemented its own measure for harmful rumor, and governors of these prefectures have made requests to the national government to take counter plans of the damages.

6. Worker exposure

The operation to remove the highly radioactive water that had collected inside the turbine buildings began on March 24. On that day, two workers were suspected of having been exposed to radiation from the contaminated water, and they were briefly hospitalized for examination. However, there was no decrease in lymphocytes and no skin burns, redness or other symptoms, and the exposure dose was estimated by National Institute of Radiological Sciences to be less than 2 to 6 sievert. Including these two workers, no radiation damage has been confirmed so far in any of the workers engaged in nuclear power plant recovery efforts, which are being managed based on the establishment of a reference exposure value of 250 millisievert per year (5 millisievert per three months for women).

7. Future predictions

At present, continuous pumping of water into the nuclear reactors and spent fuel pools at the TEPCO Fukushima Daiichi Nuclear Power Plant is being continued, and the status of reactor cooling is recognized as having been generally stabilized. If cooling is continued in an appropriate manner, it will be possible to stabilize the nuclear reactors, and the likelihood of a release of large amounts of radioactive materials is expected to gradually decrease. The highest priority is continuing the cooling operations, using multiple cooling methods and other efforts to maintain the stable status of the nuclear reactors. At the same time, however, it is also important to ensure that the water that has become contaminated by radioactive materials does not leak out into the environment. In addition, while adequately considering the risk of aftershocks and the like, a long-term stable cooling system must be built and measures must be implemented to seal in the radioactive materials.

On April 17, TEPCO released a "Roadmap toward Resolution from the Accident at the Fukushima Daiichi Nuclear Power Station." In the future objectives and prospects indicated in the Roadmap, Step 1, to be implemented over a period of approximately three months, lists the targets of radiation dose is in steady decline — in other words, nuclear reactors and spent fuel pools are being cooled in a stable manner and contaminated water is contained and radioactive materials are being prevented from scattering into the air or soil. In Step 2, to be implemented over a period of approximately three to six months following Step 1, the targets are release of radioactive materials is controlled so radiation dose is prevented to a large degree — in other words, nuclear reactors achieve cold shutdown and spent fuel pools are cooled with greater stability, and overall quantity of contaminated water is reduced and covers are placed over reactor buildings, and decontamination and monitoring of returning resident's homes are conducted to ensure radiation dose in evacuation zone, etc. decreases sufficiently.

The targets for the medium-term issues to be resolved subsequently are corrosion fracture of nuclear reactor structural members caused by salts is prevented, fuel rods are removed from spent fuel pools, full-fledged water treatment facilities for standing water are provided, containers in the nuclear reactor buildings are provided and contaminated soil is immobilized to prevent radioactive materials from being released into the air and soil and safety of the environment in evacuation zones, etc. is confirmed on an ongoing basis.

The risks anticipated by TEPCO in implementing these measures are as follows:

(1) That cooling will cause the water vapor in the containment vessel to condense, increasing the hydrogen concentration and resulting in a hydrogen explosion.
(2) That the process of sealing damaged sections will take a long time.
(3) That further aftershocks, lightning during the summer months etc. will cause a (partial) loss of system power.
(4) That the process of filling with water will increase the amount of water flowing into the turbine buildings.
(5) That work in locations with high levels of radiation will take a long time.
(6) That it will be impossible to restore the normal cooling lines due to

damage to the buildings.

(7) That there will be a delay in providing water treatment facilities or they will not operate properly.

(8) That a large-scale reduction in radiation dose levels which is a precondition for beginning construction work will be delayed

(9) That the covers may be damaged in the event of a major typhoon

A scientific study will be needed in order to conduct a technical assessment and risk assessment of these measures and determine their validity, etc. Science Council Japan decided to tackle these matters immediately.

II What We Did

From a legal standpoint, the SCJ is the government agency consisting of Japanese scientist which is originally given the authority acting independently from government control. The SCJ charged with providing advice and recommendations relating to government and society. It should cooperate with scientists around the world to contribute to academic advancement. Although it is a government agency, however, it is not in the position to directly deal with accidents such as this one. The organization for the handling of this accident is as follows. The owner of the Fukushima Daiichi Nuclear Power Plant, Tokyo Electric Power Co., Ltd., a private sector company, deals directly with the accident; the Nuclear and Industrial Safety Agency (NISA) of the Ministry of Economy, Trade and Industry, the national government agency with jurisdictional authority, provides guidance; and the prime minister's official residence (meaning the staff under the direct control of the prime minister) give instructions to these two entities. Under this organization, almost no information regarding the accident was provided to the SCJ, and it was not possible for the SCJ to independently gather information, other than that which could be obtained through newspapers, television and other media sources. In the first few days after the earthquake, tsunami and nuclear power plant accident, we could only watch, holding our breath and with an aching heart, as the status of the accident changed rapidly and the scale of the damage gradually became clearer.

On March 18, the SCJ issued emergency recommendations to the government agencies responsible for accident response and providing information. These recommendations included:

(1) Gather the knowledge of researchers involved in the area of nuclear power in order to resolve the accident

(2) Release information on the discharge of radiation to areas outside the plant

In addition, the SCJ established a Great East Japan Earthquake Task Force to expeditiously work to deal with the earthquake and tsunami disaster and nuclear power plant accident. The Task Force has already submitted six emergency recommendations to the government (appended as references). These emergency recommendations constitute proposals to the national and local governments regarding the response to these multiple disasters unprecedented in modern Japanese history, of an earthquake, tsunami and nuclear power plant accident. They involve rescue of disaster victims and reconstruction of affected areas, and efforts to deal with the nuclear power plant disaster and to rescue and care for evacuees. The Task Force has made the following recommendations regarding the nuclear power plant disaster.

(1) With regard to the nuclear power plant accident and the spread of radioactive materials, the government should respond to the concerns and doubts of the general public by deepening their understanding of the situation and establishing a basis for appropriate action, and should work to gain the trust and understanding of the international community.

(2) In providing information and explanations to society regarding the accident, etc., the government should create an organization in which appropriate specialists and scientists provide supplementary explanations.

(3) With regard to environmental monitoring of radioactive materials and evaluation of the data obtained through monitoring, an integrated and ongoing organization should be set up as quickly as possible, with the

participation of overseas specialists and specialized institutions in this organization, in an effort to provide reliable scientific information both at home and abroad.

(The above are from the 1st recommendation, submitted March 25)

(4) With regard to environmental monitoring, the ground surface pollution, the concentration of radiation in air, the ground level radiation dose rate and the residents' radiation exposure dose should be measured at approximately 15,000 points (each point within an area of several hundred square meters) within a 30-kilometer radius of the nuclear power plant accident site. For this purpose, a cooperative organization for universities and other institutions should be established and measurements should be initiated as soon as possible.

(The above is from the 2nd recommendation, submitted April 4)

(5) Living situations, employment and children's education should be secured for residents who have evacuated the area to avoid the danger of radioactive materials, and accurate information should be communicated to residents regarding the accident, response efforts and future prospects.

(6) It should be the government's responsibility to quickly provide compensation to victims for contamination of crops, livestock etc. from radioactive materials and related damage that may be sustained, based on the premise that claims for compensation will be made to TEPCO. In addition, adequate information should be provided regarding the contamination, and codes of practice should be presented to farmers.

(7) The safety of workers at the site who are working to deal with the accident under harsh conditions should be secured.

(8) A full inspection of currently operating nuclear power plants should be conducted to ensure their safety.

(9) A system should be established for the safe treatment of radioactive wastes.

(10) In order to resolve the nuclear power plant accident, all scientists in Japan should be mobilized and overseas cooperation and assistance should be requested as well in order to deal with the accident, and a

schedule should be presented for the process from preventing radiation leakage through cold shutdown of the reactor cores and leading up through decommissioning of the reactors. In addition, tireless efforts should be made to provide adequate information in a timely manner.

(The above are from the 3rd recommendation, submitted April 5)

(11) With regard to the specific handling of the nuclear power plant accident, a joint response team made up of the government, power companies, specialists and so on should be set up to promote efforts to utilize robotics technologies on an ongoing basis, based on cooperation with the academic community.

(The above is from the 5th recommendation, submitted April 13)

For some of these recommendations, the government has already taken comparable steps, and the objectives have been partially achieved. While pursuing these recommendation activities, the SCJ, as a group made up of scientists, has also worked to gather and analyze information. The SCJ has also requested the disclosure of data by the Nuclear Safety Commission, the government agency responsible for checking the safety of nuclear power use, but this has not been obtained. As the status of the nuclear power plant at which the accident occurred is not yet stable, it is extremely difficult to accurately determine the state of the nuclear reactors. Moreover, while it is possible to make a rough estimate of the total amount of fuel present inside the nuclear reactors and in the spent fuel pools and the degree of damage sustained by this fuel and so on, as well as the total amount of radiation in the contaminated water that has been discharged into the ocean, unfortunately we have still not been able to obtain data that would enable us to determine these values accurately. The SCJ collects the data and analyzes them continuously to investigate the whole issues of the accident from scientific point of view. We strengthen our activities and make public the accurate information to the world.

III What We Should Do

1. Steps toward resolving nuclear power plant accidents and full disclosure

The leakage of radiation from the nuclear power plant (Units 1 through 4) at which the accident occurred has not yet been terminated. At the request of the government, TEPCO, which is working at the site, has released a roadmap (April 17) toward the resolution of the accident. According to this roadmap, approximately three months will be required to complete the step at which the release of radioactive materials is decreased, and approximately three to six months will be required to complete the next step, leading to cold shutdown for the nuclear fuel rods. At present, the major problem is how to bring the nuclear power plant to the state of cold shutdown. There are concerns regarding the aftershocks occurring in the wake of, or earthquakes triggered by, the major earthquake of March 11 that may occur during these two steps, and we must also be aware of the danger of tsunamis that may occur as a result of such earthquakes.

The most imperative thing right now is to restore or rebuild a system capable of continuously and properly cooling the nuclear fuel rods in the reactor core and the spent fuel pools, and to create a situation in which these nuclear fuel rods can be brought to cold shutdown. Moreover, the power needed to operate this cooling system must be thoroughly protected against anticipated aftershocks and triggered earthquakes and the tsunamis that may occur as a result.

The workers engaged in the recovery effort must continue to conduct operations under appropriate radiation control so as to prevent radiation damage (deterministic effect) from occurring.

With regard to future efforts in accordance with the aforementioned roadmap, many factors are still present that make the effort to resolve the accident an extremely tenuous situation. The accident has had wide-ranging effects internationally, including not only the dispersal of radioactive materials in the air but also dumping of radioactive water in the ocean, and the government has an international responsibility to do everything it can to resolve the accident. The SCJ will lend its full support to the government's efforts, and furthermore will work to get a complete picture of the accident and determine its causes. Based on the recognition that it is the international duty of the academic community in Japan to assess the impact of radioactive materials on the environment and health, the SCJ resolves to fulfill its responsibilities and, with the support and cooperation of academies in other countries, will actively work to provide information.

2. Steps toward reconstruction of evacuation zones and environs

On April 22, the government established "Caution Zones" in accordance with the Nuclear Disaster Special Measures Law for the areas within a 20-kilometer radius of the nuclear power plant at which the accident occurred. Departure of residents from Caution Zones is compulsory, and entry is restricted. Ten municipalities that are home to residents in 27,000 households have been designated Caution Zones. In the areas around these Caution Zones, Planned Evaluation Zones and Emergency Evacuation Preparation Zones have been established, and approximately 140,000 residents will need to be evacuated. Cultivation of rice in these zones in 2011 is prohibited.

The residents who are evacuated will either move as a group to another area (either within the prefecture or in another prefecture) or will relocate individually by relying on their own connections. The duration of the evacuation will depend on the progress in bringing closure to the nuclear power plant accident. The national and prefectural governments must secure places for residents to evacuate to, as well as working to secure living situations, employment and children's education in those locations. Compensation for damage sustained as a result of evacuation must be provided in a timely manner. At the government's request, TEPCO is making preparations to provide temporary lump-sum payments for this purpose.

Predicting when residents will be able to return is a precondition for the reconstruction of evacuated areas. In this regard, the government and TEPCO must take the responsibility for presenting a schedule for the resolution of the nuclear power plant disaster (from cold shutdown through decommissioning), and scientific studies of the safety of the evacuated areas must be conducted. In such cases, the intensity distribution for radiation must be verified at various levels, including in the air, on the surface of the ground, at a shallow depth, at a rather deep depth, in groundwater, and in the ocean. This must be done in order to confirm the safety of not only the living situation of residents returning to evacuated areas but also the conditions for continuation of the agriculture and fishing industries that are major industries in the region, and the safety of crops and food from fishery resources. After safety has been confirmed in this manner, new urban planning for the time after the nuclear power plant has been decommissioned should be formulated, as a reconstruction plan that is based on the wishes and needs of the residents.

Moreover, throughout this process, steps must be taken to control the residents' exposure to radiation and ensure that no absolutely no radiation damage (deterministic effect) occurs, and to reduce the risk of developing cancer in the future to the level of "as low as reasonably achievable (ALARA)."

The Science Council of Japan positively and timely proposes our opinion to the government and to the municipality for rebuilding the life of shelter resident, and for revival of the safety of evacuation area region and the surrounding area. And we establish the system to advance continued activities until these problems are solved.

3. Recommendation actions for reconstruction in Japan

The Great East Japan Earthquake and tsunami and the accident at the Fukushima Daiichi Nuclear Power Plant constitute a major ordeal for Japan. As the Prime Minister said, in order to overcome this ordeal, we need to implement not merely "restoration" in which we return to the way things were before but "reconstruction" in which we create something better than what was there before. In this light, the SCJ has established two committees to study Japan's reconstruction (April 8). One is a committee to study the "grand design" for reconstruction of the stricken region. This committee will reassess the position of the Tohoku Region (the stricken region) in the

Japanese archipelago and pursue discussions with the goal of creating a new model for the 21st century, in terms of disaster prevention, the environment, industry, land use, urban structure and residence organization.

The other committee is one set up to study options with regard to energy policy. This committee will center on the role of nuclear power generation in order to discuss various options from a science and technology-based perspective, including further intensification and development of nuclear power generation, eliminating our dependence on nuclear power generation within a certain period of time, or immediately abandoning nuclear power generation, with the objective of contributing to the public debate regarding energy policy.

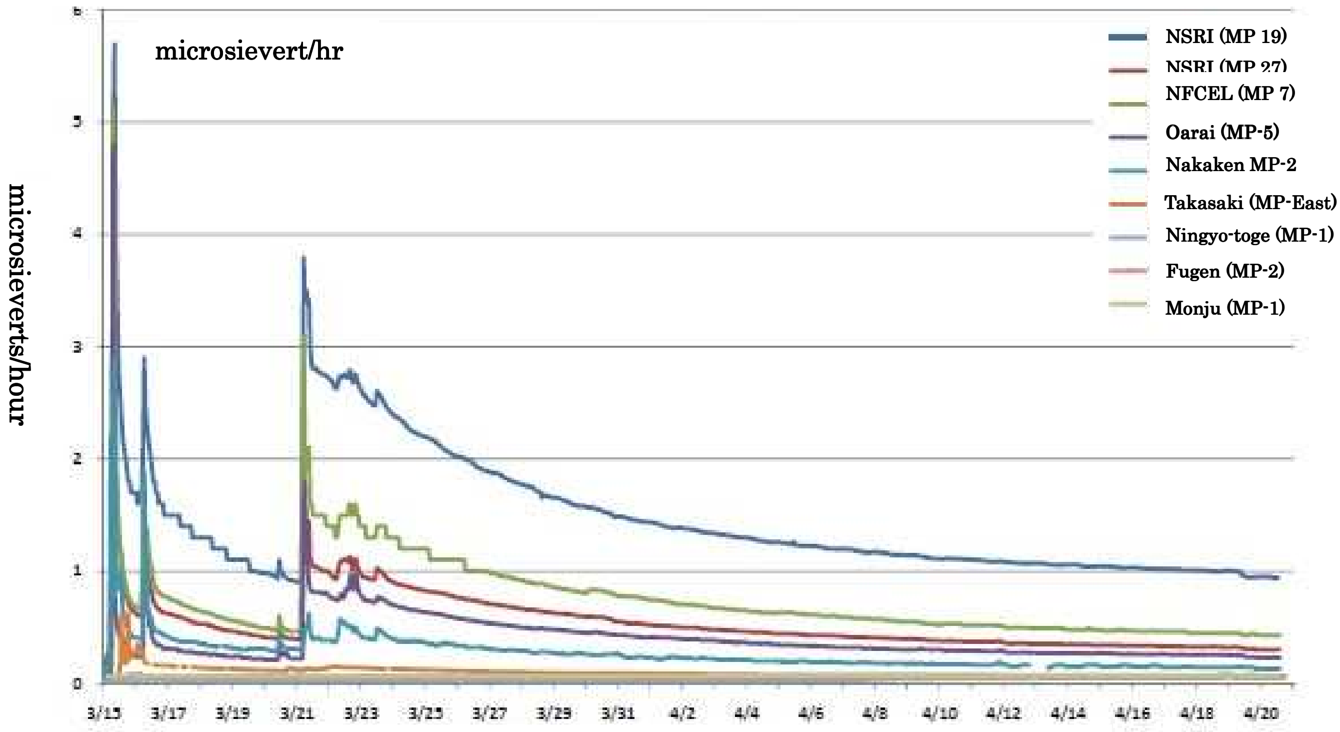
These two committees will offer important and essential points for discussion in the drafting of government policy, debate in the Diet, and public debate regarding Japan's reconstruction. This debate is urgently needed, and plans call for interim recommendations to be compiled within two months of the establishment of the committees.

Closing

The SCJ determines to advance activities with our best efforts as a representative of the scientist community in Japan for recovering Japan from the Great East Japan Earthquake. Especially, it is Japan government global responsibility to overcome the Fukushima Daiichi Nuclear Power Plant accident as soon as possible. We should do our best for the execution of these issues, and we hereafter want to ask all academies in countries and regions around the world to support and cooperate with us. In addition, this nuclear accident seriously asks us the ideal way of the science related to safety in the world. The SCJ should verify our past activities related to this matter. And we also consider that we have to wrestle with this difficult problem together with the academies in the world.

Reference data

Figure 1. The amount of radioactive materials as observed at each environment monitoring post (representative locations) of the Japan Atomic Energy Agency (March 15 to April 20)

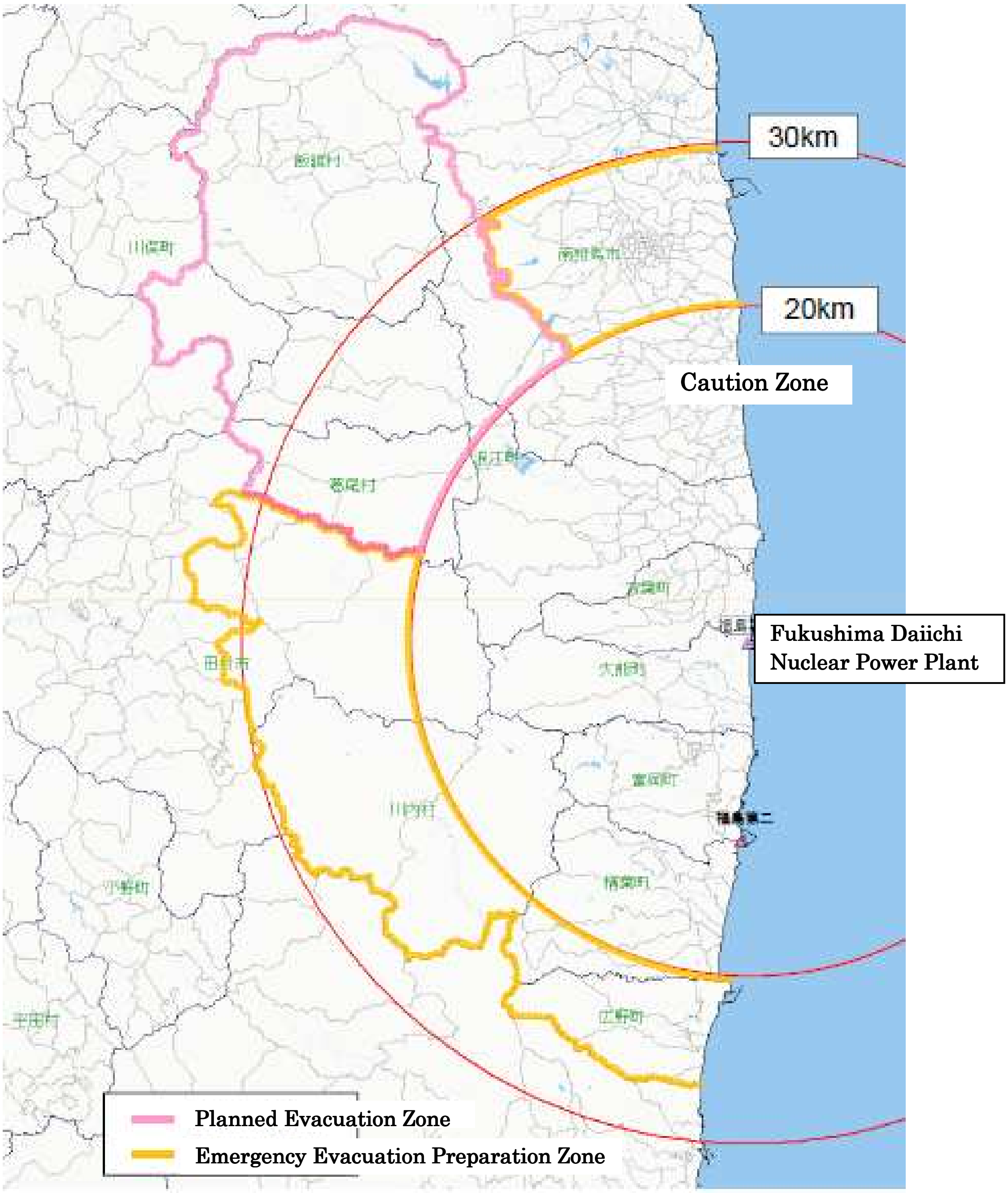


Note: 1 microgray/hr is taken as equal to 1 microsievert/hr

NSRI: Nuclear Science Research Institute

NFCEL: Nuclear Fuel Cycle Engineering Laboratories

Figure 2. Evacuation zone around Fukushima Daiichi Atomic Power Plant as of May 2, 2011



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Tateo Arimoto	Member of the SCJ

Note

Section One; Humanities and Social Sciences

Section Two; Life Sciences

Section Three; Physical Sciences and Engineering

List of the Attached Documents

1. March 18, 2011: Emergency Meeting of the Science Council of Japan: Emergency report on "What can we do now?"

2. March 18, 2011: Statement of the Executive Committee of Science Council of Japan: Disaster in Northeast Japan and Nuclear Emergency

3. March 25, 2011: The first urgent proposal for the Great East Japan Earthquake

4. April 4, 2011: Regarding the necessity of the investigation of radiation levels after the accident of the Fukushima Daiichi Nuclear Power Plant

5. April 5, 2011: For the relief of victims of the Great East Japan Earthquake and the recovery of the disaster-stricken areas

6. April 5, 2011: Urgent proposal related to measures for earthquake disaster waste and prevention of environmental impact

7. April 13, 2011: Utilization of robot technology for the accident of the Fukushima Daiichi Nuclear Power Plant

8. Supplementary explanatory document for the fifth urgent proposal

9. April 15, 2011: Perspective of gender equality with regard to relief, support, and restoration