Contents of summary

1. Introduction

The Tohoku District - off the Pacific Ocean Earthquake and the resulting tsunamis struck the Fukushima Dai-ichi and Fukushima Dai-ni Nuclear Power Stations (hereinafter, the "Fukushima NPSs") of Tokyo Electric Power Co. (TEPCO) at 14:46 on March 11, 2011 (all times herein are JST), followed by a nuclear accident unprecedented in both scale and timeframe.

The situation has become extremely trying for Japan, insofar as it has had to execute countermeasures for the nuclear accident whilst also dealing with the broader disaster caused by the earthquake and tsunamis.

This nuclear accident has turned out to be a major challenge for Japan, with numerous relevant domestic organizations working together to respond to the situation while also receiving support from many countries around the world. The fact that this accident has raised concerns around the world about the safety of nuclear power generation is a matter which Japan takes with the utmost seriousness and remorse. Above all, Japan sincerely regrets causing anxiety for people all over the world about the release of radioactive materials.

Currently, Japan is dealing with the issues and working towards settling the situation utilizing accumulated experience and knowledge. It is incumbent upon Japan to share correct and precise information with the world continually in terms of what happened at the Fukushima NPSs, including regarding how events progressed and how Japan has been working to settle the situation. Japan also recognizes a responsibility to share with the world the lessons it has learned from this process.

On the basis of the recognitions stated above, this report has been prepared as the report from Japan for the International Atomic Energy Agency (IAEA) Ministerial Conference on Nuclear Safety, which will convene in June 2011. The Government-TEPCO Integrated Response Office is engaged in working toward settling the situation from the accident under the supervision of Mr. Banri Kaieda, Minister of Economy, Trade and Industry, in conjunction with and joining forces with the Nuclear and Industrial Safety Agency and also with TEPCO. This report was prepared by the Government Nuclear Emergency Response Headquarters, taking into account the approach toward the restoration of stable control taken by the Government-TEPCO Integrated Response Office and hearing the views of outside experts. The work has been managed as a whole by Mr. Goshi Hosono, Special Advisor to the Prime Minister designated by Prime Minister Naoto Kan in his capacity as General Manager of the Government Nuclear Emergency Response Headquarters (GNER HQs).

This report is a preliminary accident report and represents a summary of the evaluation of the accident and the lessons learned to date based on the facts ascertained about the situation so far. In terms of its range, the summary is centered on technical matters related to nuclear safety and nuclear emergency preparedness and responses up to the present moment. Issues related to nuclear damage compensation, the wider societal effects, and so on are not covered.

In addition to preparing this report, the Government has established the “Investigation Committee on the Accidents at the Fukushima Nuclear Power Station of Tokyo Electric Power Company” (hereinafter the “Investigation Committee”) in order to provide an overall investigation of the utility of countermeasures being taken against the accident that has occurred at the Fukushima NPSs. Aspects stressed within this Investigation Committee are independence from Japan’s existing nuclear energy administration, openness to the public and the international community, and comprehensiveness in examining various issues related not only to technical elements but also to institutional aspects. These concepts are used as the basis for strictly investigating all activities undertaken so far, including activities by the Government in terms of countermeasures against the accident. The contents of this report will also be investigated by the Investigation Committee and the progress of the investigation activities will be released to the world.

Japan's basic policy is to release information about this accident with a high degree of transparency. In preparing this report under this policy, attention has been paid to providing as accurately as possible an exact description of the facts of the situation, together with an objective evaluation of countermeasures against the accident, clearly distinguishing between known and unknown matters. Factual descriptions are based on findings current as of May 31, 2011.

Japan intends to exert its full efforts to properly tackle the investigation and analysis of this accident and to continue to provide those outcomes to both to the IAEA and to the world as a whole.

2. Situation regarding Nuclear Safety Regulations and Other Regulatory Frameworks in Japan before the Accident

Safety regulations governing NPSs in Japan are mandated under the "Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors" and "The Electricity Business Act." The Nuclear and Industrial Safety Agency (NISA) within the Ministry of Economy, Trade and Industry is responsible for these regulations. The Nuclear Safety Commission (NSC), established under the Cabinet Office, has the role of supervising and auditing the safety regulation activities implemented by NISA and has the authority to make recommendations through the Prime Minister to the Minister of Economy, Trade and Industry to take necessary measures, as necessary. When the Minister of Economy, Trade and Industry issues a license for the establishment of an NPS, the Minister is required to seek in advance the NSC's views regarding safety issues.

The monitoring and measurement activities for preventing radiation damages and for evaluating radioactivity levels are carried out by related government bodies including the Ministry of Education, Culture, Sports, Science & Technology (MEXT) based on the related laws and regulations.

Responses to nuclear accidents in Japan are supposed to be carried out based on the Act on Special Measures Concerning Nuclear Emergency Preparedness, (hereinafter "ASMCNE"), which was established after the occurrence of a criticality accident in a JCO nuclear fuel fabrication facility in 1999. ASMCNE complements the Disaster Countermeasures Basic Law should a nuclear emergency occur. ASMCNE stipulates that the national and local governments, and the licensee, shall address a nuclear emergency by acting in close coordination with each other, that the Prime Minister shall declare a nuclear emergency situation in response to the occurrence of a nuclear emergency situation and give instructions to evacuate area(s) or to take shelter as appropriate, that the GNER HQs headed by the Prime Minister shall be established to respond to the situations, and so on.

Emergency environmental monitoring, which is one of the responses to be taken at the time of a nuclear disaster, shall be implemented by local governments and supported by MEXT.

3. Disaster Damage in Japan from the Tohoku District - off the Pacific Ocean Earthquake and Resulting Tsunamis

The Pacific coast area of eastern Japan was struck by the Tohoku District - off the Pacific Ocean Earthquake, which occurred at 14:46 on March 11, 2011. This earthquake occurred in an area where the Pacific plate sinks beneath the North American plate and the magnitude of this earthquake was 9.0, the largest in Japan's recorded history. The seismic source was at latitude 38.1 north, longitude 142.9 east and at a depth of 23.7km.

The crustal movement induced by this earthquake extended over a wide range, from the Tohoku District to the Kanto District. Afterwards, tsunamis struck the Tohoku District in a series of seven waves, resulting in the inundation of an area as large as 561km^2. As of the date that this report was issued, approximately 25,000 people are reported dead or missing.

In terms of the earthquake observed at the Fukushima NPSs, the acceleration response spectra of the earthquake movement observed on the basic board of reactor buildings exceeded the acceleration response spectra of the response acceleration to the standard seismic ground motion Ss for partial periodic bands at the Fukushima Dai-ichi NPS. As for the Fukushima Dai-ni NPS, the acceleration response spectra of the earthquake movement observed on the basic board of the reactor buildings was below the acceleration response spectra of the response acceleration to the standard seismic ground motion Ss. The earthquake damaged the external power supply.

Thus far, major damage to the reactor facilities which are important for safety functions has yet to be recognized. Further investigation is needed because the details of the situation remain unknown.

In terms of the damage to the external power supply at the Fukushima NPSs, a total of six external power supply sources had been connected to the Dai-ichi Power Station on the day the earthquake hit. However, all power supplied from these six lines stopped due to damage to the breakers, etc. and the collapse of the power transmission line tower due to the earthquake. Furthermore, at the Fukushima Dai-ni NPS, while a total of four external power supply sources had been connected as of the day of the earthquake, only one of them remained to supply electricity after the quake struck, as one line was under maintenance, one stopped due to the earthquake, and yet another also stopped. (After the completion of restoration works at 13:38 the following day, March 12, one power supply line was restored, resulting in two sources supplying the electricity thereafter.)

With respect to the strike of the tsunamis, the Fukushima Dai-ichi NPS was hit by the first enormous wave at 15:27 on March 11 (41 minutes after the earthquake), and the next enormous wave around 15:35, while the Fukushima Dai-ni NPS was hit by the first enormous wave at around 15:23 (37 minutes after the earthquake) and by the next enormous wave at around 15:35 (as stated in TEPCO's announcement). The license for the establishment of nuclear reactors at the Fukushima Dai-ichi NPS was based on the assumption that the maximum design basis tsunami height expected was 3.1m. The assessment in 2002 based on the "Tsunami Assessment Method for Nuclear Power Plants in Japan" proposed by the Japan Society of Civil Engineers (JSCE) indicated a maximum water level of 5.7m, and TEPCO raised the height of its Unit 6 seawater pump installation in response to that assessment. However, the inundation height due to the tsunami this time was 14 to 15m, and in all units, the seawater pump facilities for cooling auxiliary systems were submerged and stopped functioning. In addition to that, all the emergency diesel power generators and the distribution boards installed in the basements of the reactor buildings and turbine buildings except for Unit 6 were inundated and stopped functioning.

For the Fukushima Dai-ni NPS, the maximum design basis tsunami height was expected to be 3.1 to 3.7m. Further, the said assessment by JSCE in 2002 indicated a maximum water level of 5.1 to 5.2m. Because of the tsunamis, most of the seawater pump facilities for cooling auxiliary systems, except for some, were submerged and stopped functioning, and the emergency diesel power generators installed in the basement of the reactor buildings stopped.

Thus, the assumption of, and the preparedness for, the onslaught of enormous tsunamis were not sufficient.

4. Occurrence and Development of the Accident at the Fukushima Nuclear Power Stations

(1) Outline of the Fukushima Nuclear Power Stations

The Fukushima Dai-ichi NPS is located in the towns of Okuma and Futaba, which are in the county of Futaba in Fukushima Prefecture. This NPS consists of six Boiling Water Reactors (BWR) installed-- Units 1 to 6-- with a total generating capacity of 4,696MW.

The Fukushima Dai-ni NPS is located in the towns of Tomioka and Naraha of Futaba county in Fukushima Prefecture, and consists of 4 BWRs whose total generating capacity is 4,400MW.

(2) Status of safety assurance for the Fukushima NPSs

In facilities with nuclear reactors, the occurrence of failures must be prevented even if natural phenomenon, etc. should occur. However, assuming that failures may nevertheless happen, protective measures are provided to ensure safety even when the unusual situation of design basis event should happen. In addition, Japan started undertaking accident management measures in 1992, designed to minimize to the greatest possible extent the possibility of reaching a state of a severe accident should these protective measures not be enough and mitigate the effects even if the situation were to reach the state of a severe accident. Implementation of these accident management measures is not required by law under the safety regulations. The accident management measures are implemented by nuclear operators voluntarily, and the government requires them to make reports on their implementation.

The accident management measures at the Fukushima NPSs have been implemented for the following four functions: functions to shutdown the nuclear reactor, functions to inject water into the nuclear reactors and the PCVs, functions to remove heat from the PCVs, and functions to support the safety functions. For example, measures to maintain functions to inject water into the nuclear reactors include that the connection to the piping be secured for water injection functions to nuclear reactors through PCV cooling systems and that, as alternative water-injection equipment, the core spray system from the existing Make Up Water Condensate (MUWC) system and the fire extinguishing system be utilized.

(*Severe Accident: An event that significantly exceeds the design basis event, and a situation where appropriate cooling for the reactor core or control of reactivity is rendered inoperable by the postulated measures under the evaluation for safety design, resulting in serious damage to the reactor core.)

(**Accident Management: Measures taken to prevent an event leading to a severe accident, or to mitigate its influence in the event of a severe accident, by utilizing a) functions other than the anticipated primary ones under the safety margin and safety design included in the current design or b) newly installed equipment in preparation for a severe accident, etc.)

(3) Operating status of the Fukushima NPSs before the earthquake

In terms of the operating status at the Fukushima NPSs before the earthquake on March 11, Unit 1 was under operation at its rated electric power, Units 2 and 3 were under operation at their rated thermal power, and Units 4, 5 and 6 were under periodic inspection. Among these Units, Unit 4 was undergoing a major construction for renovations, with all the nuclear fuel in the RPV having already been transferred to the spent fuel pool. Moreover, 6,375 units of spent fuel were stored in the common spent fuel pool.

At the Fukushima Dai-ni NPS, all the nuclear reactors from Units 1 to 4 were under operation at their rated thermal power.

(4) The incidence and development of the accident at the Fukushima NPSs

At the Fukushima Dai-ichi NPS, Units 1 to 3 which were under operation automatically shut down at 14:46 on March 11. All six external power supply sources were lost because of the earthquake. This caused the emergency diesel power generators to start up. However, seawater pumps, emergency diesel generators and distribution boards were submerged because of the tsunami strike, and all emergency diesel power generators stopped except for one generator in Unit 6. For that reason, all AC power supplies were lost except at Unit 6. One emergency diesel power generator (an air-cooled type) and the distribution board escaped submersion and continued operation at Unit 6. In addition, since the seawater pumps were submerged by the tsunami, residual heat removal systems to release the residual heat inside the reactor to the seawater and the auxiliary cooling systems to release the heat of various equipment to the seawater lost their functions..

TEPCO's operators followed TEPCO's manuals for severe accidents and urgently attempted to secure power supplies in cooperation with the government, in order to recover various kinds of equipment within the safety systems while the core cooling equipment and the water-injection equipment, which had automatically started up, were operating. However, ultimately power supplies could not be secured.

Since the core cooling functions using AC power were lost in Units 1 to 3, core cooling functions not utilizing AC power were put into operation, or, alternately, attempts were made to put them into operation. These were operation of the isolation condenser*** in Unit 1, the operation of the reactor core isolation cooling system**** (RCIC) in Unit 2 and the operation of the RCIC and the high pressure injection system***** (HPCI) in Unit 3.

These core cooling systems that do not utilize AC power supplies stopped functioning thereafter, and were switched to alternative injections of freshwater or sea water by fire extinguishing lines, using fire engine pumps.

Concerning Units 1 to 3 of the Fukushima Dai-ichi NPS, as the situation where water injection to each RPV was impossible to continue for a certain period of time, the nuclear fuel in each reactor core was not covered by water but was exposed, leading to a core melt. Part of the melted fuel stayed at the bottom of the RPV.

A large amount of hydrogen was generated by chemical reactions between the zirconium of the fuel cladding tubes, etc. and water vapor. In addition, the fuel cladding tubes were damaged and radioactive materials therein were discharged into the RPV. Further, these hydrogen and radioactive materials were discharged into the PCV during the depressurization process of the RPV.

Injected water vaporizes after absorbing heat from the nuclear fuel in the RPV. Accordingly, the inner pressure rose in the RPVs which had lost their core cooling functions, and this water vapor leaked through the safety valves into the PCV. Due to this, the inner pressure within the PCVs in Units 1 to 3 rose gradually, with PCV wet well vent operations carried out a number of times, in which the gases in the PCVs are released from the gas phase area in the suppression chamber into the atmosphere, through the ventilation stack, for the purpose of preventing damage to the PCV caused by the pressure therein.

(***Isolation condenser: Equipment with the function of returning water condensed from water vapor in the RPV by natural circulation (that is, with no driving by pumps required) to cool the RPV, when the RPV is isolated due to the loss of external power supply, etc. (when reactor cooling cannot be done by the main condenser). An isolation condenser has a structure to cool the water vapor that was led into the heat transfer tube with the water stored in the condenser (body side).

(****Reactor core isolation cooling system (RCIC): A system that cools the reactor cores when reactors are isolated from feed water and condenser systems due to loss of external power, etc. Either the condensate storage tank or the pressure suppression pool water can be used as a water source. The driving system for the pump is a turbine which uses some of the steam in the reactors.)

(*****High pressure injection system (HPCI): One of the emergency core cooling systems that injects water, with the pump driven by providing the water vapor generated by the decay heat to the turbine.)

After the wet well venting of the PCVs, explosions presumably caused by hydrogen which had leaked from the PCV occurred in the upper area of the reactor buildings, ruining the operation floor in the reactor buildings of Units 1 and 3. As a result of these incidents, a lot of radioactive materials were discharged to the atmosphere. Following the ruination of the Unit 3 building, an explosion probably caused by hydrogen occurred in the reactor building of Unit 4, ruining its upper area. In Unit 4, all core fuels had been transferred to the spent fuel pool for periodic inspection before the earthquake. During this time, it seems that in Unit 2 a hydrogen explosion occurred and caused damage at a point presumed to be near the suppression chamber.

The most urgent task at the site, along with recovery of the power supply and the continuation of water injection to reactor vessels, was water injection to the spent fuel pools. In the spent fuel pool in each unit, the water level continued to drop on account of the evaporation of water caused by the heat of the spent fuel in the absence of the pool water cooling system, due to the loss of power supply. Water injection to the spent fuel pool was carried out by the Self-Defense Forces, the Fire and Disaster Management Agency and the National Police Agency, using helicopters and water cannon trucks. Concrete pump trucks were ultimately secured, which led to stable water injection using freshwater from nearby reservoirs after the initial seawater injection.

(5) Status of each Unit at the Fukushima NPSs

1) Fukushima Dai-ichi NPS Unit 1

· *Loss of power supply*

The reactor was scrammed by the earthquake that occurred at 14:46 on March 11. The external power supply was lost due to the earthquake and two emergency diesel generators started up. The two emergency diesel generators stopped functioning as a result of the tsunami at 15:37 on the same day and all AC power was lost.

· *Cooling of the reactor*

The emergency isolation condenser* (IC) automatically started up at 14:52 on March 11 and started cooling the reactor. Subsequently, the IC stopped functioning at 15:03 on the same day. According to the operation procedure document, the cooling speed is to be adjusted to 55 degrees Celsius/hour. The pressure in the reactor rose and fell three times afterwards, which indicates that the IC had been operated manually. According to TEPCO, fresh water injection from a fire extinguishing line started at 05:46 on March 12, using a fire engine pump, and 80,000 liters of water were injected by 14:53 on the same day, but they claim that it is unknown when water injection stopped. Seawater injection started at 19:04 by means of a fire extinguishing line. There was some confusion between the government and the main office of TEPCO in communications and in the chain of command on seawater injection, but seawater injection continued following the decision by the director of the Fukushima Dai-ichi NPS. Injection of freshwater resumed on March 25 with the injection of water stored in a pure water tank. For at least one hour after the earthquake, the water level in the reactor was not low enough to trigger an automatic start-up (L-L: 148cm below the bottom of the separator) of the High Pressure Coolant Injection system (HPCI), and there has been no record of a start-up.

· *Status of the reactor core*

Water injection seemed to have stopped for 14 hours and 9 minutes, after the total loss of AC power at 15:37 on March 11 until the start of freshwater injections at 5:46 on March 12. From the results of the evaluation by NISA (on the assumption that the HPCI was not operating), it seems that the fuel was exposed due to a drop in the water level around 17:00 on March 11, and that the core melt started afterwards. A considerable amount of melted fuel seems to have moved to and accumulated at the bottom of the RPV. There is a possibility that the bottom of the RPV was damaged and some of the fuel might have dropped and accumulated on the D/W floor (lower pedestal).

· *Hydrogen explosion*

Wet well venting of the PCV was carried out at 14:30 on March 12. Afterwards, a hydrogen explosion occurred in the reactor building at 15:36 on the same day. Zirconium appears to have reacted with water as the temperature rose in the RPV, generating hydrogen. It appears that the gas containing the hydrogen accumulating in the upper area of the reactor buildings due to leakage, etc. from the PCV triggered the hydrogen explosion. Injecting nitrogen into the PCV started on April 7.

· *Leakage of cooling water*

The cooling water that has been injected into the RPV appears to be leaking from the bottom of the RPV. The total amount of water injected into the RPV was approximately 13,700 metric tons (information from TEPCO; current as of May 31), and total amount of steam generated is estimated at 5,100 metric tons. Therefore the amount of leakage seems to be the difference between these two, approximately 8600 metric tons, minus the amount inside the RPV (approximately 350m^3).

2) Fukushima Dai-ichi NPS Unit 2

· *Loss of power supply*

The reactor was scrammed by the earthquake at 14:47 on March 11 and the external power supply was lost and two emergency diesel generators started up. The two emergency diesel generators were stopped by the tsunami and all AC power supply was lost at 15:41 on the same day.

· *Cooling of the reactor*

TEPCO started up the Reactor Core Isolation Cooling System (RCIC) manually around 14:50 on March 11. The RCIC automatically stopped because of the high water level in the reactor at around 14:51 on the same day. Afterwards, TEPCO manually started it up at 15:02 and it stopped again at 15:28 on the same day. TEPCO started it up again manually at 15:39 on the same day. The RCIC stopped at 13:25 on March 14. Seawater injection using a firefighting pump started at 19:54 on the same day.

· *Status of the reactor core*

Water injection appears to have stopped for 6 hours and 29 minutes, from 13:25 on March 14 when the RCIC stopped, until seawater injection resumed at 19:54 on the same day. According to the results of NISA's analysis, it seems that the fuel was exposed due to a drop in the water level at around 18:00 on March 14 and that the core started melting afterwards. A considerable part of melted fuel seems to have moved to and accumulated at the bottom of the RPV. There is a possibility that the bottom of the RPV was damaged and some of the fuel might have dropped and accumulated on the D/W floor (lower pedestal).

· *Explosion noise*

A PCV wet vent operation, which included that of small valves, was carried out from around 11:00 on March 13. Noise of an explosion occurred at around 6:00 on March 15 around the suppression chamber of the containment vessel. There is a possibility that the explosion occurred in the torus room, as the gas, including hydrogen, was generated by a reaction between the zirconium and water along with a temperature rise in the RPV, invading the suppression chamber by such means as the opening of the main steam safety relief valve.

· *Leakage of cooling water*

As of now, injected cooling water is thought to be leaking at the bottom of the RPV. The total amount of injected water to the RPV was approximately 21,000 metric tons (information by TEPCO; current as of May 31), and the total amount of steam generated is estimated at 7,900 metric tons. Therefore, the amount of leakage appears to be the difference between these two, approximately 13,100 metric tons minus the amount inside the RPV (approximately 500 m^3).

3) Fukushima Dai-ichi NPS Unit 3

· *Loss of Power supply*

The reactor was scrammed by the earthquake at 14:47 on March 11, and the external power supply was lost and two emergency diesel generators started up. The two emergency diesel generators were stopped by the tsunami and all AC power was lost at 15:41 on the same day.

· *Cooling of the reactor*

The Reactor Core Isolation Cooling System (RCIC) was manually started at 15:05 on March 11. It stopped automatically at 15:25 on the same day due to a rise in the reactor water level. It was started manually at 16:03 on the same day, and the RCIC stopped at 11:36 on March 12. The High Pressure Core Injection System (HPCI) automatically started due to the reactor low water level (L-2) at 12:35 on the same day, and the HPCI stopped at 2:42 on March 13. The reason for that appears to have been a drop in pressure in the reactor. Another probable cause could be water vapor outflow from the HPCI system.

· *Status of the reactor core*

The operation to inject water containing boric acid commenced using a fire extinguishing line at around 9:25 on March 13. However, the water could not be injected sufficiently due to the high pressure in the reactor, and the water level in the reactor lowered. As a result, water injection was halted for at least 6 hours and 43 minutes after the HPCI stopped at 02:42 on March 13 until water injection using the fire extinguishing line started at 09:25 on the same day. According to the results of NISA's analysis, the fuel appears to have been exposed due to a drop in the reactor water level at around 08:00 on March 13, with the core starting to melt afterwards. A considerable part of melted fuel seems to have moved to and accumulated at the bottom of the RPV. However, there is a possibility that the bottom part of the RPV was damaged and some of the fuel might have dropped and accumulated on the dry well floor (lower pedestal).

· *Hydrogen explosion*

A wet well vent operation of the PCV was carried out at 05:20 on March 14. A hydrogen explosion occurred at the reactor building at 11:01 on the same day. It seems that zirconium and water reacted along with a rise in temperature in the PCV, and that gas containing hydrogen by such means as leakage from the PCV accumulated in the upper area of the reactor buildings, triggering a hydrogen explosion.

· *Leakage of cooling water*

It is assumed at the moment that injected cooling water is leaking at the bottom of the RPV. The total amount of water injected into the RPV was approximately 20,700 metric tons (information by TEPCO; current as of May 31) and the total amount of steam is estimated to be approximately 8,300 metric tons. A substantial amount equivalent to the difference between these two, approximately 12,400 metric tons minus the amount in the RPV (approximately 500m^3), appears to have been leaked.

4) Fukushima Dai-ichi NPS Unit 4

· *Cooling of the spent fuel pool*

The reactor had been shut down for periodic inspection, with the nuclear fuel having been transferred to the spent fuel pool. External power supply was lost by the earthquake on March

11 and one emergency diesel generator started up. (The other one was under inspection and did not start up.) The emergency diesel generator stopped due to tsunami at 15:38 on the same day, and all AC power was lost. Both the cooling and feed water functions were thus lost. The spraying of water over the spent fuel pool started from March 20.

· *Explosion in the reactor building*

At around 6:00 on March 15, an explosion in the reactor building occurred, resulting in all the walls above the bottom of the operation floor and the walls on the west side and along the stairs collapsing. A fire broke out near the northwest corner on the 4^{th} floor of the reactor building at 09:38 on the same day. With regard to the explosion in the reactor building, an inflow of hydrogen from Unit 3 may be possible, as the exhaust pipe for venting the PCV joins the exhaust pipe from unit 4 before the exhaust stack. However, the cause of the explosion has not yet been determined.

5) Fukushima Dai-ichi NPS Unit 5

· *Securing a power supply*

This reactor had already been shut down for periodic inspection. Upon the loss of the external power supply due to the earthquake at 14:46 on March 11, two emergency diesel generators started up. However, the two emergency diesel generators stopped at 15:40 on the same day due to the tsunamis, causing all AC power to be lost. An alternate power supply was taken from the emergency diesel generator of Unit 6 on March 13, 2011.

· *Cooling of the reactor and the spent fuel pool*

Although an RPV pressure reduction operation was carried out at 06:06 on March 12, the reactor pressure slowly increased due to the effects of decay heat. The alternate power supply was taken from the emergency diesel generator of Unit 6 on March 13, and water injection into the reactor became possible, using the transfer pump for the condenser of Unit 5. Reduction of pressure through a safety relief valve had been carried out since 05:00 on March 14, and there was repeated replenishment of the water from the condensate storage tank to the reactor through the transfer pump in order to control the pressure and water level of the reactor. To carry out cooling by the residual heat removal system, a temporary seawater pump was installed and started up, and cooling of the reactor and of the spent fuel pool were carried out in turn by switching the system constitution for the Residual Heat Removal (RHR) system on March 19. As a result, the reactor reached cold shutdown status at 14:30 on March 20.

6) Fukushima Dai-ichi NPS Unit 6

· *Securing of power supply*

This reactor had already been shut down for periodic inspection. Three emergency diesel generators started up upon the loss of external power supply due to the earthquake at 14:46 on March 11. Two emergency diesel generators stopped running due to the tsunami at 15:40 on the same day, and the power supply was maintained by making use of the remaining emergency diesel generator.

· *Cooling of the reactor and the spent fuel pool*

Reactor pressure rose slowly due to the effect of decay heat. Water injection into the reactor became possible on March 13, using the transfer pump for the condenser with the emergency diesel generator. Reduction of the pressure by means of a safety relief valve has been carried out since March 14, with repeated replenishment of the water from the condensate storage tank to the reactor through the transfer pump, in order to control the pressure and the water level of the reactor. To carry out cooling through the residual heat removal system, a temporary seawater pump was installed and started up, and cooling of the reactor and the spent fuel pool was carried out in turn by switching the system constitution for the residual heat removal system on March 19. The reactor reached cold shutdown status at 19:27 on March 20.

7) Fukushima Dai-ni NPS

· *Overall*

Reactors from Units 1 to 4 at the Fukushima Dai-ni NPS which had been in operation were scrammed at 14:48 on March 11. A total of four external power supply lines had been connected to this NPS. One line was undergoing maintenance, another stopped due to the earthquake and yet another stopped one hour after the earthquake, which resulted in electric supply being provided by a single line. (Restoration work was completed at 13:38 on March 12, thereby making two lines available.) The RHR systems of Unit 1, Unit 2 and Unit 4, etc. were damaged upon the reactors being hit by the tsunami at around 15:34 on the same day.

· *Unit 1*

In terms of the reactor, cooling and water level maintenance were carried out by means of the reactor core isolation cooling system and the Make Up Water Condensate (MUWC) system.

However, the temperature of the suppression pool water exceeded 100 degrees Celsius because not all the heat could be removed. Cooling through dry well spraying started at 07:10 on March 12. Cooling of the suppression pool started with the operation of the RHR system by connecting a temporary cable from the functioning distribution board at 01:24 on March 14. The temperature of the suppression pool became lower than 100 degrees Celsius at 10:15 on the same day, and the reactor reached cold shutdown status at 17:00 on the same day.

· *Unit 2*

In terms of the reactor, cooling and water level maintenance were carried out by means of the reactor core isolation cooling system and the Make Up Water Condensate (MUWC) system. However, the temperature of the suppression pool water exceeded 100 degrees Celsius because not all the heat could be removed. Cooling through dry well spraying started at 07:11 on March 12. Cooling of the suppression pool started with the operation of the RHR system by connecting a temporary cable, just as happened at Unit 1, at 07:13 on March 14. The temperature of the suppression pool became lower than 100 degrees Celsius at 15:52 on the same day and the reactor reached cold shutdown status at 18:00 on the same day.

· *Unit 3*

The RHR system (A) and low pressure core spray system became unusable as a result of the tsunami. However, the RHR system (B) was not damaged and cooling by this system remained ongoing. Therefore the reactor reached cold shutdown status at 12:15 on March 12.

· *Unit 4*

In terms of the reactor, although cooling and water level maintenance were carried out by the RCIC and the MUWC system, the temperature of the suppression pool water exceeded 100 degrees Celsius because not all the heat could be removed. Cooling of the suppression pool started at 15:42 on March 14 with the operation of the RHR system. The temperature of the suppression pool became lower than 100 degrees Celsius and the reactor reached cold shutdown status at 07:15 on March 15.

(3) Status of the other NPSs

1) Higashidori NPS of Tohoku Electric Power Co.

The Higashidori NPS of Tohoku Electric Power Co. (one BWR) had been shut down for periodic inspection, and all fuels in the core had been transferred to the spent fuel pool. All three external power supply lines stopped due to the earthquake, and power was supplied by an emergency diesel generator.

2) Onagawa NPS of Tohoku Electric Power Co.

At the Onagawa NPS of Tohoku Electric Power Co. (BWR Units 1 to 3) Units 1 and 3 were under operation and Unit 2 was under reactor start-up operation before the earthquake on March 11. All 3 reactors were scrammed by the earthquake. Four of five external power supply lines stopped due to the earthquake, leaving one line remaining. Unit 1 suffered an on-site power loss and power was supplied by emergency diesel generators. Water injection into the reactor was carried out by the reactor core isolation cooling system, etc. and the reactor reached cold shutdown status at 0:57 on March 12. In Unit 2, the external power supply was maintained and the cooling function of the reactor was not affected. In Unit 3, although the external power supply was maintained, the auxiliary equipment cooling seawater pump stopped. After that, water was injected into the reactor by the RCIC, etc. and the reactor reached cold shutdown status at 1:17 on March 12.

3) Tokai Dai-ni NPS of Japan Atomic Power Company

Tokai Dai-ni NPS of the Japan Atomic Power Company (one BWR) was undergoing rated thermal power operation, and the reactor was automatically scrammed due to the earthquake at 14:48 on March 11. Although all three lines of external power supply stopped, three emergency diesel generators started up. One of those emergency diesel generators stopped due to the tsunami, but with the remaining two securing the power supply, the reactor reached cold shutdown status at 0:40 on March 15.

5. Response to the Nuclear Emergency

(1) Emergency response after the accident occurred

At the Fukushima Dai-ichi NPS, all AC power was lost due to the disaster of the earthquake and tsunamis. In accordance with Paragraph 1, Article 10 of the Special Law of Emergency Preparedness for Nuclear Disaster, TEPCO notified the government at 15:42 on March 11, 2011, the day on which the earthquake occurred, that all AC power had been lost in Units 1 to 5.

After that, TEPCO recognized that the injection of water via the emergency core cooling systems was impossible at Units 1 and 2 of the Fukushima Dai-ichi NPS and notified the government at 16:45 on the same day of a State of Nuclear Emergency in accordance with the Article 15 of the Special Law of Emergency Preparedness for Nuclear Disaster.

The Prime Minister declared a state of nuclear emergency at 19:03 on the same day and established the Nuclear Emergency Response Headquarters and the Local Nuclear Emergency Response Headquarters.

On March 15, the Integrated Headquarters for the Response to the Incident at the Fukushima Nuclear Power Stations (later renamed the Government–TEPCO Integrated Response Office on May 9) was established so that the government and the operator could work together in a concerted manner, decide to take necessary measures and promptly respond while sharing information on the state of the disasters at the nuclear facilities and on necessary measures

The Prime Minister, who serves as the Director-General of Nuclear Emergency Response Headquarters, determined the evacuation area and the in-house evacuation area according to the assessment of the possibility of discharging radioactive materials, and instructed Fukushima Prefecture and relevant cities, towns and villages to act in accordance with this determination. Responding to the status of accidents at the Fukushima Dai-ichi NPS, at 21:23, March 11, the evacuation area was set at the area within a 3km radius and the in-house evacuation area was a 3 to 10km radius from the Fukushima Dai-ichi NPS. Afterwards, according to the escalation of events, the evacuation area was expanded to a 20km radius at 18:25, March 12, and the in-house evacuation area was expanded to a 30km radius at around 11:00, March 15. Also, responding to the status of the accidents at the Fukushima Dai-ni NPS, the evacuation area within a 3km radius and the in-house evacuation area of a 3 to 10 km radius were set at the same time a nuclear emergency situation was declared at 7:45, March 12, with the evacuation area expanded to a 10 km radius at 17:39 on the same day. Then, the evacuation area was changed to a 8 km radius on April 21. Evacuation and stay-in-house instructions immediately after the accident were promptly implemented through a concerted effort by residents in the vicinity, local governments, the police and other relevant authorities.

The Prime Minister determined that evacuation areas within a 20km radius of Fukushima Dai-ichi NPS would be a “restricted area,” in accordance with the Basic Act on Disaster Control and instructed the mayors of cities and towns and the heads of villages and concerned local governments to prohibit access to the area on April 21.

The Local Nuclear Emergency Response Headquarters started its activities at an Off-Site Center as designated by the Basic Plan for Emergency Preparedness. However, it was moved to the Fukushima Prefectural Office in Fukushima City due to high-level radiation as the nuclear accident escalated, in addition to a communication blackout and a lack of fuel, food and other necessities caused by logistic congestion around the site.

The longer the accident lasted, the heavier the burden on residents in the vicinity of the NPS became. In particular, many of the residents who were instructed to stay within their houses were voluntarily evacuated and those who remained in the area found it increasingly difficult to sustain their livelihoods due to congestion in the distribution of goods and logistics problems. In response to this situation, the government launched support measures.

The primary functions of the Emergency Response Support System (ERSS), which monitors the status of reactors and forecasts the progress of the accident when a nuclear emergency occurs, could not be utilized because necessary information from the plants could not be obtained. In addition, the primary functions of the System for Prediction of Environmental Emergency Dose Information (SPEEDI), which conducts a quantitative forecast of variations of atmospheric concentrations of radioactive materials and air dose rates, could not be utilized because source term information could not be obtained. Although they were used in alternative ways, their operation processes and the disclosure of their results have remained as an issue.

(2) Implementation of environmental monitoring

In the Basic Plan for Emergency Preparedness, local governments are in charge of environmental monitoring when a nuclear emergency occurs. However, most of the monitoring posts became dysfunctional at first when the accident occurred. From March 16, it was decided that the Ministry of Education, Culture, Sports, Science and Technology (MEXT) would take charge of summarizing the environmental monitoring carried out by MEXT, local governments and cooperating U.S. organizations.

As for the land areas outside the premises of the NPS, MEXT measures the air dose rate, radioactive concentrations in the soil, and concentrations of radioactive materials in the air and takes environmental samples in cooperation with the Japan Atomic Energy Agency, Fukushima Prefecture, the Ministry of Defense, and electric companies. MEXT also carries out monitoring by aircraft in cooperation with the Ministry of Defense, TEPCO, the U.S. Department of Energy, etc. TEPCO carries out environmental monitoring at NPS sites and their vicinities, etc.

In terms of the sea areas near the NPS, MEXT, the Fisheries Agency, the Japan Agency for Marine-Earth Science and Technology, the Japan Atomic Energy Agency, TEPCO, and others cooperate with each other to carry out the monitoring of radioactive concentrations, etc. in the seawater and in the seabed, while the Japan Agency for Marine-Earth Science and Technology simulates the distribution and spread of radioactive concentrations.

The Nuclear Safety Commission evaluates and announces the results of these environmental monitoring efforts as they become available.

Environmental monitoring of the air, sea and soil of the premises and the surrounding areas of the Fukushima NPSs is conducted by TEPCO.

(3) Measures regarding agricultural products, drinking water, etc.

The Ministry of Health, Labour and Welfare decided that the "Indices relating to limits on food and drink ingestion" indicated by the Nuclear Safety Commission of Japan shall be adopted for the time being as provisional regulation values, and foods which exceed these levels shall not be supplied to the public for consumption, pursuant to the Food Sanitation Act. The Prime Minister, as the Director-General of Government Nuclear Emergency Response Headquarters, has instructed relevant municipalities to restrict shipments of foods that exceed the provisional regulation level.

As for tap water, the Ministry of Health, Labour and Welfare notified departments and agencies concerned in the local governments of the necessity to avoid drinking tap water if the radioactive concentration of tap water exceeds the level indicated by the Nuclear Safety Commission from March 19 onward, and released the monitoring results by the local governments concerned, as well.

(4) Measures for additional protected area

The environmental monitoring data have revealed that there were areas where radioactive materials were accumulated at high levels even outside of the 20 km radius. Therefore, the Prime Minister as Director-General of NERHQs instructed the heads of relevant local governments on April 22 that deliberate evacuation areas needed to be established for specific areas beyond the 20 km radius, and area between the 20 km and 30 km radius which had been set as in-house evacuation areas, excluding the areas within it qualifying as deliberate evacuation areas, was renamed an "evacuation-prepared area in case of emergency," since the residents there could possibly be instructed to stay in-house or evacuate in the case of future emergencies. In this way, residents inside the deliberate evacuation area were directed to evacuate in a planned manner, and residents inside of the area prepared for evacuation in case of emergency were directed to prepare for evacuation or for in-house evacuation in case of an emergency.

6. Discharge of Radioactive Materials to the Environment

(1) Amount of radioactive materials discharged to the atmosphere

On April 12, NISA and the Nuclear Safety Commission each announced the total discharged amount of radioactive materials to the atmosphere so far.

NISA estimated the total discharged amount from reactors at the Fukushima Dai-ichi NPSs according to the results analyzing reactor status, etc. by JNES and presumed that approximately $1.3\text{x } 10^{17}$ Bq of iodine-131 and approximately $6.1\text{x } 10^{15}$ Bq of cesium-137 were discharged. Subsequently, JNES re-analyzed the status of the reactors based on the report which NISA collected on May 16 from TEPCO on the plant data immediately after the accident occurred. Based on this analysis of reactor status and others by JNES, NISA estimated that the total discharged amount of iodine-131 and cesium-137 were approximately $1.6 \text{ x } 10^{17}$ Bq and $1.5 \text{ x } 10^{16}$ Bq, respectively. The Nuclear Safety Commission estimated the amount of certain nuclides discharged into the atmosphere (discharged between March 11 to April 5) with assistance from the Japan Atomic Energy Agency (JAEA) through back calculations, based on the data of environmental monitoring and air diffusion calculation; the estimations are $1.5 \text{ x } 10^{17}$ Bq for iodine-131 and $1.2 \text{ x } 10^{16}$ Bq for cesium-137. The discharged amount since early April has been declining and is about 10^{11} Bq/h to 10^{12} Bq/h in iodine-131 equivalent.

(2) Discharged amount of radioactive materials to seawater

Water containing radioactive materials diffused from the RPV leaked into the PCV at the Fukushima Dai-ichi NPS. Also, because of water injections into the reactors from the outside for cooling, some injected water leaked from the PCVs and accumulated in reactor buildings and turbine buildings. The management of contaminated water in reactor buildings and turbine buildings became a critical issue from the standpoint of workability in the buildings, and the management of contaminated water outside of the buildings became a critical issue from the standpoint of preventing the diffusion of radioactive materials into the environment.

On April 2, it was discovered that highly contaminated water with a radiation level of over 1000mSv/h had accumulated in the pit of power cables near the water intake of Unit 2 of the Fukushima Dai-ichi NPS and it was flowing into the seawater. Despite that, the outflow was halted by stopping work on April 6, and the total discharged amount of radioactive materials was assumed to be approximately 4.7×10^{15} Bq. As an emergency measure, it was decided that this highly contaminated water would be stored in tanks. However, as no tanks were available at the time, low-level radioactive water was discharged into the seawater from April 4 to April 10 in order to secure storage capacity for the contaminated water. The total amount of discharged radioactive materials was presumed to be approximately 1.5×10^{11} Bq.

7. Situation regarding radiation exposure

The government has changed the dose limit for personnel engaged in radiation work from 100mSv to 250mSv in light of the present situation of the accident in order to prevent escalation of the accident. This was decided based on the information that a 1990 recommendation by the International Commission on Radiological Protection provided for 500mSv as the dose limit to avoid deterministic effects that has been set for personnel engaged in emergency rescue work.

With regard to the activities by personnel engaged in radiation work in TEPCO, there was no alternative but for the chief workers to carry personal dosimeters and observe radioactivity for their entire work group unit, because a lot of personal dosimeters had been soaked by seawater, rendering them unusable. Afterwards, as personal dosimeters became available, all workers have been able to carry personal dosimeters since April 1.

The status of exposure doses of personnel engaged in radiation work is as follows. As of May 23, the total number of workers that had entered the area was 7,800, with an average exposure dose of 7.7mSv. Thirty of these workers had exposure doses above 100mSv. The internal exposure measurement of the radiation workers has been delayed and the exposure dose, including internal exposure of a certain number of workers, could exceed 250mSv in the future. On March 24, two workers stepped into accumulated water and their exposure doses have been estimated at less than 2 or 3Sv.

As for radiation exposure to residents in the vicinity, no cases of harm to health were found in 195,345 (the number as of May 31) residents who received screening in Fukushima Prefecture. All 1,080 children who went through thyroid gland exposure evaluation received results lower than the screening level.

The estimation and the evaluation of exposure doses of residents in the vicinity, etc. are planned to be carried out through the use of the results of environmental monitoring, in a prompt manner after the survey of evacuation routes and activities conducted mainly by Fukushima Prefecture, with the assistance of relevant ministries, agencies and the National Institute of Radiological Science, etc.

8. Cooperation with the International Community

Since the occurrence of this nuclear accident, experts have visited Japan from the United States, France, Russia, the Republic of Korea, China and the United Kingdom, exchanged views with relevant organizations in Japan, and given significant amounts of advice regarding stabilizing the nuclear reactors and the spent fuel pools, preventing the diffusion of radioactive materials, and implementing countermeasures against radioactive contaminated water. Japan has also received support from these countries and accepted materials necessary to undertake measures against the nuclear accident.

Experts from international organizations specializing in nuclear power such as the IAEA and the OECD Nuclear Energy Agency (OECD/NEA) visited Japan, providing advice and so on. Also, international organizations such as the IAEA, the World Health Organization (WHO), the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), and the International Commission on Radiological Protection (ICRP) have provided necessary information to the international community from their own technical standpoints.

9. Communication regarding the Accident

Initially after the occurrence of the accident, accurate and timely information was not sufficiently provided, typically demonstrated in delays in notifying local governments and municipalities, a situation which has been identified as a challenge in the field of communication regarding the accident. Transparency, accuracy and rapidity are important in domestic and international communication about accidents. The Japanese Government has utilized various levels and occasions such as press conferences at the Prime Minister’s Office as well as press conferences held jointly by relevant parties. While these have been improved as needed, in reflection of what and how information should be provided, efforts to improve communication must be ongoing.

Briefings on important issues regarding the accident have been provided at press conferences by the Chief Cabinet Secretary to explain to the citizens the status of the accident as well as the views of the Japanese Government. TEPCO as a nuclear operator and NISA as a regulatory authority have also held press conferences on the status, details and development of the accident. The NSC has provided important technical advice and explained the evaluation of environmental monitoring results and other matters at press conferences.

Joint press conferences with the participation of relevant organizations have been held since April 25 in order to share information in an integrated manner. The Special Advisor to the Prime Minister, NISA, MEXT, the Secretariat of the NSC, TEPCO and other relevant organizations have participated in these joint press conferences.

As for inquiries from the general public, NISA has opened a counseling hotline on the nuclear accident, etc., and MEXT has also opened a counseling hotline on the impact of radiation on health, etc. Experts in academia, including members of the Atomic Energy Society of Japan, have actively explained and provided information to citizens.

Regarding the provision of information to the international community, the Japanese Government reported the accident status to the IAEA promptly pursuant to the Convention on Early Notification of a Nuclear Accident, beginning with the first report on 16:45 on March 11, immediately after the accident occurred. The Japanese Government has also reported the provisional evaluations of the International Nuclear and Radiological Event Scale (INES) when the government made its announcement regarding each evaluation.

As for opportunities for communication with countries across the world including neighboring countries, briefings to diplomats in Tokyo and press conferences for the foreign media have been conducted.

Notification to other countries including neighboring countries about the deliberate discharge of accumulated water of low-level radioactivity to the sea on April 4 was not satisfactory. This is a matter of sincere regret and every effort has been made to ensure sufficient communication with the international community and to reinforce the notification system.

Provisional evaluations based on the INES have been as follows:

(1) The first report

A provisional evaluation of Level 3 was issued, based on the determination by NISA at 16:36 on March 11 that the emergency core cooling system for water injection had become unusable. This situation occurred because motor-operated pumps lost function due to all-around losses of power at Units 1 and 2 of the Fukushima Dai-ichi NPS.

(2) The second report

On March 12, the PCV venting of Unit 1 of the Fukushima Dai-ichi NPS was conducted, and an explosion at its reactor building occurred. Based on environmental monitoring, NISA confirmed the emission of radioactive iodine, cesium and other radioactive materials, and made an announcement on a provisional evaluation of Level 4, because NISA determined that over approximately 0.1% of the radioactive materials in the reactor core inventory had been emitted.

(3) The third report

On March 18, as some incidents causing fuel damage had been identified at Units 2 and 3 of the Fukushima Dai-ichi NPS, NISA announced a provisional evaluation of Level 5 because the release of several percentages of the radioactive materials in the core inventory was determined to have occurred, based on the information ascertained at that moment, including that of the status of Unit 1.

(4) The fourth report

On April 12, regarding the accumulated amount of the radioactive materials released in the atmosphere, NISA announced its estimates from analytical results of the reactor status, etc., while NSC announced its estimates from dust monitoring data. (Please refer to VI. 1.) The estimation by NISA was 370,000TBq of radioactivity in iodine equivalent, while the calculated value based on the estimate of NSC was 630,000TBq. Based on these results, NISA announced a provisional evaluation of Level 7 the same day. One month had passed between the third and fourth reports, and the provisional INES evaluation should have been made more promptly and appropriately.

10. Future Efforts to Settle the Situation regarding the Accident

Regarding the current status of the Fukushima Dai-ichi NPS, freshwater has been injected to the RPVs through feed water systems at Units 1, 2 and 3 and has been continuously cooling the fuel in the RPVs. This has helped the temperature around the RPVs stay around 100 to 120 degrees Celsius at the lower part of RPVs. Review and preparation for circulation cooling systems, including the process of transferring and treating accumulated water, have been underway. Although the RPV and PCV of Unit 1 have been pressurized to some extent, steam generated in some units such as Units 2 and 3 seems to have leaked from the RPV and PCV, which appears to have condensed to form accumulations of water found in many places, including the reactor buildings, and some steam seems to have been released into the atmosphere. To respond to this issue, the status has been checked by dust sampling in the upper part of the reactor buildings, and discussion and preparation for covering the reactor buildings has been underway.

Cold shutdown of Units 5 and 6 has been maintained using residual heat removal systems with temporary seawater pumps and their reactor pressure has been stable, ranging from 0.01 ~ 0.02 MPa (Gauge pressure).

Details of the current status of each unit are listed in the following chart.

(Megapascal: Unit of pressure 1MPa = 9.9 atmosphere. Gauge pressure is absolute pressure minus atmospheric pressure.)
TEPCO announced the “Roadmap towards Restoration from the Accident in Fukushima Daiichi Nuclear Power Station” on April 17, with the following 2 steps as targets: "Radiation dose in steady decline" as "Step 1" and "Release of radioactive materials is under control and radiation dose is being significantly held down" as "Step 2." The timeline for achieving targets is tentatively set as follows: "Step 1" is set at around 3 months and "Step 2" is set at around 3 to 6 months after achieving Step 1.

Subsequently, coolant leakage from the PCVs was found in Units 1 and 2. Since the same risk was found in Unit 3, TEPCO announced a revised roadmap on May 17. In the new roadmap, basically no changes were made to the schedule, but new efforts were added, including reviewing and improving cooling reactors, adding measures against tsunamis and aftershocks, and improving the work environment for workers.

In particular, in the review of the issues regarding the “Reactors,” the establishment of a “circulation cooling system” in which contaminated water accumulated in buildings (accumulated water), etc. is processed and reused for water injection into reactors, was prioritized for “cold shutdown” in Step 2.

The NERHQs also presented an approach toward settling the situation and that related to the evacuation area in the announcement, “Temporary approach policy for measures for nuclear sufferers,” of May 17.

11. Responses at Other Nuclear Power Stations

On March 30, NISA instructed all electric power companies and related organizations to implement emergency safety measures at all NPSs, in order to prevent the occurrence of nuclear disasters and core damage, etc. caused by tsunami-triggered total AC power loss, on the basis of the latest knowledge gained from the accident at the Fukushima NPSs. On May 6, NISA carried out on-site inspections at all NPSs (except the Onagawa NPS, Fukushima Dai-ichi and Fukushima Dai-ni NPS), and confirmed that emergency safety measures were appropriately implemented at these NPSs. On May 18, NISA received an implementation status report from the Onagawa NPS, where work to prepare against tsunamis was delayed after it was hit by the tsunamis. Regarding the Fukushima Dai-ni NPS, which achieved a stable condition after cold shutdown on April 21, NISA also instructed the NPS to implement emergency safety measures, and received an implementation status report from it on May 20. NISA confirmed that all the nuclear power stations in Japan have appropriately arranged measures against total AC power loss, etc. which are expected to be implemented immediately as emergency safety measures.

Based on the presumed causes of the accident and the additional knowledge gained from the accident, which are stated in this report, and the lessons learned from the accident, which are mentioned in Section 12, NISA and other relevant ministries are to improve and strengthen the emergency safety measures that have been put in place. NISA will strictly verify the implementation status of enhanced measures by the nuclear operators and promptly come up with mid- and long-term measures.

The Headquarters for Earthquake Research Promotion of MEXT has estimated that within the next 30 years there is an 87% percent chance of an imminent magnitude 8 earthquake in the Tokai region near the Hamaoka Nuclear Power Station of Chubu Electric Power Co., Inc. As this is accompanied by increasing concerns over the high possibility of a large-scale tsunami resulting from the envisioned earthquake, the government has placed its highest priority on public safety above all else, and, determining that the operation of all Units at the Hamaoka NPS should be halted until mid- to long-term countermeasures such as the construction of an embankment that can sufficiently withstand a tsunami resulting from the envisioned Tokai Earthquake are implemented, requested on May 6 that Chubu Electric Power Co., Inc., halt all reactors at the NPS. Chubu Electric Power Co., Inc. accepted this request and stopped operation of all the Units by May 14.

12. Lessons Learned from the Accident Thus Far

The Fukushima NPS accident has the following aspects: it was triggered by a natural disaster; it led to a severe accident with damage to nuclear fuel, Reactor Pressure Vessels and Primary Containment Vessels; and accidents involving multiple reactors arose at the same time. Moreover, as nearly three months have passed since the occurrence of the accident, a mid- to long-term initiative is needed to settle the situation imposing a large burden on society, such as a long-term evacuation of many residents in the vicinity, as well as having a major impact on industrial activities, including the farming and livestock industries in the related area. There are thus many aspects different from the accidents in the past at the Three Mile Island Nuclear Power Plant and the Chernobyl Nuclear Power Plant.

The accident is also characterized by the following aspects. Emergency response activities had to be performed in a situation where the earthquake and tsunami destroyed the social infrastructure such as electricity supply, communication and transportation systems across a wide area in the vicinity. The occurrence of aftershocks frequently impeded various accident response activities.

This accident led to a severe accident, shook the trust of the public, and warned those engaged in nuclear energy of their overconfidence in nuclear safety. It is therefore important to learn lessons thoroughly from this accident. The lessons are being presented classified into five categories at this moment, bearing in mind that the most important basic principle in securing nuclear safety is having defenses in depth.

Thus the lessons that have been learned to date are presented as classified in five categories. We consider it inevitable to carry out a fundamental review on nuclear safety measures in Japan based on these lessons. While some of them are specific to Japan, these specific lessons have been included regardless, from the standpoint of showing the overall structure of the lessons.

The lessons in category 1 are those learned based on the fact that this accident has been a severe accident, and from reviewing the sufficiency of preventive measures against a severe accident.

The lessons in category 2 are those learned from reviewing the adequacy of the responses to this severe accident.

The lessons in category 3 are those learned from reviewing the adequacy of the emergency responses to the nuclear disaster in this accident.

The lessons in category 4 are those learned from reviewing the robustness of the safety infrastructure established at nuclear power stations.

The lessons in category 5 are those learned from reviewing the thoroughness in safety culture while summing up all the lessons.

Lessons in category 1
Strengthen preventive measures against a severe accident

(1) Strengthen measures against earthquakes and tsunamis

The earthquake was an extremely massive one caused by plurally linked seismic centers. As a result, at the Fukushima Dai-ichi Nuclear Power Station, the acceleration response spectra of seismic ground motion observed on the base mat exceeded the acceleration response spectra of the design basis seismic ground motion in a part of the periodic band. Although damage to the external power supply was caused by the earthquake, no damage caused by the earthquake to systems, equipment or devices important for nuclear reactor safety at nuclear reactors has been confirmed. However, further investigation should be conducted as the details regarding this situation remain unknown.

The tsunamis which hit the Fukushima Dai-ichi Nuclear Power Station were 14-15m high, substantially exceeding the height assumed under the design of construction permit or the subsequent evaluation. The tsunamis severely damaged seawater pumps, etc., causing the failure to secure the emergency diesel power supply and reactor cooling function. The procedural manual did not assume flooding from a tsunami, but rather only stipulated measures against a backrush. The assumption on the frequency and height of tsunamis was insufficient, and therefore, measures against large-scale tsunamis were not prepared adequately.

From the viewpoint of design, the range of an active period for a capable fault which needs to be considered in the seismic design for a nuclear power plant is considered within 120,000-130,000 years (50,000 years in the old guideline). The recurrence of large-scale earthquakes is expected to be appropriately considered. Moreover, residual risks must be considered. Compared with the design against earthquake, the design against tsunamis has been performed based on tsunami folklore and indelible traces of tsunami, not on adequate consideration of the recurrence of large-scale earthquakes in relation to a safety goal to be attained.

Reflecting on the above issues, we will consider the handling of plurally linked seismic centers as well as the strengthening of the quake resistance of external power supplies. Regarding tsunamis, from the viewpoint of preventing a severe accident, we will assume appropriate frequency and adequate height of tsunamis in consideration of a sufficient recurrence period for attaining a safety goal. Then, we will perform a safety design of structures, etc. to prevent the impact of flooding of the site caused by tsunamis of adequately assumed heights, in consideration of the destructive power of tsunamis. While fully recognizing a possible risk caused by the flooding into buildings of tsunamis exceeding the ones assumed in design, we will take measures from the viewpoint of having defenses in depth, to sustain the important safety functions by considering flooded sites and the huge destructive power of run-up waves.

(2) Ensure power supplies

A major cause of this accident was the failure to secure the necessary power supply. This was caused by the facts that power supply sources were not diversified from the viewpoint of overcoming vulnerability related to failures derived from a common cause arising from an external event, and that the installed equipment such as a switchboard did not meet the specifications that could withstand a severe environment such as flooding. Moreover, it was caused by the facts that battery life was short compared with the time required for restoration of the AC power supply and that a time goal required for the recovery of the external power supply was not clear.

Reflecting on the above facts, Japan will secure a power supply at sites for a longer time set forth as a goal, even in severe circumstances of emergencies, through the diversification of power supply sources by preparing various emergency power supply sources such as air-cooled diesel generators, gas turbine generators, etc., deploying power-supply vehicles and so on, as well as equipping switchboards, etc. with high environmental tolerance and generators for battery charging, and so on.

(3) Ensure robust cooling functions of reactors and PCVs

In this accident, the final place for release of heat (the final heat sink) was lost due to the loss of function of the seawater pumps. Although the reactor cooling function of water injection was activated, core damage could not be prevented due to the drain of the water source for injection, the loss of power supplies, etc., and furthermore, the PCV cooling functions also failed to run well. Thereafter, difficulties remained in reducing the reactor pressure and, moreover, in injecting water after the pressure was reduced, because the water injection line into a reactor through the use of heavy machinery such as fire engines, etc. had not been developed as measures for accident management. In this manner, the loss of cooling functions of the reactors and PCVs aggravated the accident.

Reflecting on the above issues, Japan will secure robust alternative cooling functions for its reactors and PCVs by securing alternative final heat sinks for a durable time. This will be pursued through such means as diversifying alternative water injection functions, diversifying and increasing sources for injection water, and introducing air-cooling systems.

(4) Ensure robust cooling functions of spent fuel pools

In the accident, the loss of power supplies caused the failure to cool the spent fuel pools, requiring actions to prevent a severe accident due to the loss of cooling functions of the spent fuel pools concurrently with responses to the accident of the reactors. Until now, a risk of a major accident of a spent fuel pool had been deemed small compared with that of a core event and measures such as alternative means of water injection into spent fuel pools, etc. had not been considered.

Reflecting on the above issues, Japan will secure robust cooling measures by introducing alternative cooling functions such as a natural circulation cooling system or an air-cooling system, as well as alternative water injection functions, in order to maintain the cooling of spent fuel pools even in case of the loss of power supplies.

(5) Thorough accident management (AM) measures

The accident reached the level of a so-called “severe accident.” Accident management measures had been introduced to the Fukushima NPSs to minimize the possibilities of severe accidents and to mitigate consequences in the case of severe accidents. However, looking at the situation of the accident, although some portion of the measures functioned, such as the alternative water injection from the fire extinguishing water system to the reactor, the rest did not fulfill their roles within various responses, including ensuring the power supplies and the reactor cooling function, with the measures turning out to be inadequate. In addition, accident management measures are basically regarded as voluntary efforts by operators, not legal requirements, and so the development of these measures lacked strictness. Moreover, the guideline for accident management has not been reviewed since their development in 1992 and has not been strengthened or improved.

Reflecting on the above issues, we will change the accident management measures from voluntary safety efforts by operators to legal requirements, and develop accident management measures to prevent severe accidents, including a review of design requirements as well, by utilizing a probabilistic safety assessment approach.

(6) Response to issues concerning the siting with more than one reactor

The accident occurred at more than one reactor at the same time, and the resources needed for accident response had to be dispersed. Moreover, as two reactors shared the facilities, the physical distance between the reactors was small and so on. The development of an accident occurring at one reactor affected the emergency responses at nearby reactors.

Reflecting on the above issues, Japan will take measures to ensure that emergency operations at a reactor where an accident occurs can be conducted independently from operation at other reactors if one power station has more than one reactor. Also, Japan will assure the engineering independence of each reactor to prevent an accident at one reactor from affecting nearby reactors. In addition, Japan will promote the development of a structure that enables each unit to carry out accident responses independently, by choosing a responsible person for ensuring the nuclear safety of each unit.

(7) Consideration of NPS arrangement in basic designs

Response to the accident became difficult since the spent fuel storage pools were located at a higher part of the reactor buildings. In addition, contaminated water from the reactor buildings reached the turbine buildings, meaning that the spread of contaminated water to other buildings has not been prevented.

Reflecting on the above issues, Japan will promote the adequate placement of facilities and buildings at the stage of basic design of NPS arrangement, etc. in order to further ensure the conducting of robust cooling, etc. and prevent an expansion of impacts from the accident, in consideration of the occurrence of serious accidents. In this regard, as for existing facilities, additional response measures will be taken to add equivalent levels of functionality to them.

(8) Ensuring the water tightness of essential equipment facilities

One of the causes of the accidents is that the tsunami flooded many essential equipment facilities including the component cooling seawater pump facilities, the emergency diesel generators, the switchboards, etc., impairing power supply and making it difficult to ensure cooling systems.

Reflecting on the above issues, in terms of achieving the target safety level, Japan will ensure the important safety functions even in the case of tsunamis greater than ones expected by the design or floods hitting facilities located near rivers. In concrete terms, Japan will ensure the water-tightness of important equipment facilities by installing watertight doors in consideration of the destructive power of tsunamis and floods, blocking flooding routes such as pipes, and installing drain pumps, etc.

Lessons in Category 2
Enhancement of response measures against severe accidents

(9) Enhancement of measures to prevent hydrogen explosions

In the accident, an explosion probably caused by hydrogen occurred at the reactor building in Unit 1 at 15:36 on March 12, 2011, as well as at the reactor in Unit 3 at 11:01 on March 14. In addition, an explosion that was probably caused by hydrogen occurred at the reactor building in Unit 4 around 06:00 on March 15, 2011. Consecutive explosions occurred as effective measures could not be taken beginning from the first explosion. These hydrogen explosions aggravated the accident. A BWR inactivates a PCV and has a flammability control system in order to maintain the soundness of the PCV against design basis accidents. However, it was not assumed that an explosion in reactor buildings would be caused by hydrogen leakage, and as a matter of course, hydrogen measures for reactor buildings were not taken.

Reflecting on the above issues, we will enhance measures to prevent hydrogen explosions, such as by installing flammability control systems that would function in the event of a severe accident in reactor buildings, for the purpose of discharging or reducing hydrogen in the reactor buildings, in addition to measures to address hydrogen within the PCVs.

(10) Enhancement of containment venting system

In the accident, there were problems in the operability of the containment venting system. Also, as the function of removing released radioactive materials in the containment venting system was insufficient, the system was not effective as an accident management countermeasure. In addition, the independence of the vent line was insufficient and it may have had an adverse effect on other parts through connecting pipes, etc.

Reflecting on the above issues, we will enhance the containment venting system by improving its operability, ensuring its independence, and strengthening its function of removing released radioactive materials.

(11) Improvements to the accident response environment

In the accident, the radiation dosage increased in the main control room and operators could not enter the room temporarily, and the habitability in the main control room has decreased, as it still remains difficult to work in that room for an extended period. Moreover, at the on-site emergency station, which serves as a control tower for all emergency measures at the site, the accident response activities were affected by increases in the radiation dosage as well as by the worsening of the communication environment and lighting.

Reflecting on the above issues, we will enhance the accident response environment that enables continued accident response activities even in case of severe accidents through measures such as strengthening radiation shielding in the control rooms and the emergency centers, enhancing the exclusive ventilation and air conditioning systems on site, as well as strengthening related equipment, including communication and lightening systems, without use of AC power supply.

(12) Enhancement of the radiation exposure management system at the time of the accident

As these accidents occurred, although adequate radiation management became difficult as many of the personal dosimeters and dose reading devices became unusable due to their submergence in seawater, personnel engaged in radiation work had to work on site. In addition, measurements of concentration of radioactive materials in the air were delayed, and as a result the risk of internal exposure increased.

Reflecting on the above issues, we will enhance the radiation exposure management system at the time an accident occurs by storing the adequate amount of personal dosimeters and protection suits and gears for accidents, developing a system in which radioactive management personnel can be expanded at the time of the accident and improving the structures and equipment by which the radiation doses of radiation workers are measured promptly.

(13) Enhancement of training responding to severe accidents

Effective training to respond to accident restoration at nuclear power plants and adequately work and communicate with relevant organizations in the wake of severe accidents was not sufficiently implemented up to now. For example, it took time to establish communication between the emergency office inside the power station, the Nuclear Emergency Response Headquarters and the Local Headquarters and also to build a collaborative structure with the Self-Defense Forces, the Police, Fire Authorities and other organizations which played important roles in responding to the accident. Adequate training could have prevented these problems.

Reflecting on the above issues, we will enhance training to respond to severe accidents by promptly building a structure for responding to accident restoration, identifying situations within and outside power plants, facilitating the gathering of human resources needed for securing the safety of residents and collaborating effectively with relevant organizations.

(14) Enhancement of instrumentation to identify the status of the reactors and PCVs

Because the instrumentation of the reactors and PCVs did not function sufficiently during the severe accident, it was difficult to promptly and adequately obtain important information to identify how the accident was developing, such as the water levels and the pressure of reactors, and the sources and amounts of released radioactive materials.

In respond to the above issues, we will enhance the instrumentation of reactors and PCVs, etc. to enable them to function effectively even in the wake of severe accidents.

(15) Central control of emergency supplies and equipment and setting up rescue teams

Logistic support has been provided diligently by those responding to the accident and supporting affected people with supplies and equipment gathered mainly at J Village. However, because of the damage from the earthquake and tsunami in the surrounding areas shortly after the accident, we could not promptly or sufficiently mobilize rescue teams to help provide emergency supplies and equipment or support accident control activities. This is why the on-site accident response did not sufficiently function.

Reflecting on the above issues, we will introduce systems for centrally controlling emergency supplies and equipment and setting up rescue teams for operating such systems in order to provide emergency support smoothly even under harsh circumstances.

Lessons in Category 3
Enhancement of nuclear emergency responses

(16) Responses to combined emergencies of both large-scale natural disasters and prolonged nuclear accident

There was tremendous difficulty in communication and telecommunications, mobilizing human resources, and procuring supplies among other areas when addressing the nuclear accident that coincided with a massive natural disaster. As the nuclear accident has been prolonged, some measures such as the evacuation of residents, which was originally assumed to be a short-term measure, have been forced to be extended.

Reflecting on the above issues, we will prepare the structures and environments where appropriate communication tools and devices and channels to procure supplies and equipment will be ensured in the case of concurrent emergencies of both a massive natural disaster and a prolonged nuclear accident. Also, assuming a prolonged nuclear accident, we will enhance emergency response preparedness including effective mobilization plans to gather human resources in various fields who are involved with accident response and support for affected persons.

(17) Reinforcement of environmental monitoring

Currently, local governments are responsible for environmental monitoring in an emergency. However, appropriate environmental monitoring was not possible immediately after the accident because the equipment and facilities for environmental monitoring owned by local governments were damaged by the earthquake and tsunami and the relevant individuals had to evacuate from the Off-site Center Emergency Response Center. To bridge these gaps, MEXT has conducted environmental monitoring in cooperation with relevant organizations.

Reflecting on the above issues, the Government will develop a structure through which the Government will implement environmental monitoring in a reliable and well-planned manner during emergencies.

(18) Establishment of a clear division of labor between relevant central and local organizations

Communication between local and central offices, as well as with other organizations, was not achieved to a sufficient degree, due to the lack of communication tools immediately after the accident and also due to the fact that the roles and responsibilities of each side were not clearly defined. Specifically, responsibility and authority were not clearly defined in the relationship between the NERHQs Nuclear Emergency Response Headquarters and Local NERHQs Headquarters, between the Government and TEPCO, between the Head Office of TEPCO and the NPS on site, or among the relevant organizations in the Government. Especially, communication was not sufficient between the government and the main office of TEPCO as the accident initially began to unfold.

Reflecting on the above issues, we will review and define roles and responsibilities of relevant organizations including the NERHQs, clearly specify roles, responsibilities and tools for communication while also improving institutional mechanisms.

(19) Enhancement of communication relevant to the accident

Communication to residents in the surrounding area was difficult because communication tools were damaged by the large-scale earthquake. The subsequent information to residents in the surrounding area and local governments was not always provided in a timely manner. The impact of radioactive materials on health and the radiological protection guidelines of the ICRP, which are the most important information for residents in the surrounding area and others, were not sufficiently explained. Japan focused mainly on making accurate facts publicly available to its citizens and has not sufficiently presented future outlooks on risk factors, which sometimes gave rise to concerns about future prospects.

Reflecting on the above issues, we will reinforce the adequate provision of information on the accident status and response, along with appropriate explanations of the effects of radiation to the residents in the vicinity. Also, we will keep in mind having the future outlook on risk factors included in the information delivered while incidents are still ongoing.

(20) Enhancement of responses to assistance from other countries and communication to the international community

The Japanese Government could not appropriately respond to the assistance offered by countries around the world because no specific structure existed within the Government to link such assistance offered by other countries to domestic needs. Also, communication with the international community including prior notification to neighboring countries and areas on the discharge of water with low-level radioactivity to the sea was not always sufficient.

Reflecting on the above-mentioned issues, the Japanese Government will contribute to developing a global structure for effective responses by cooperating with the international community, for example, developing a list of supplies and equipment for effective responses to any accident, specifying contact points for each country in advance in case of an accident, enhancing the information sharing framework through improvements to the international notification system, and providing faster and more accurate information to enable the implementation of measures that are based upon scientific evidence.

(21) Adequate identification and forecasting of the effect of released radioactive materials

The System for Prediction of Environmental Emergency Dose Information (SPEEDI) could not make proper predictions on the effect of radioactive materials as originally designed, due to the lack of information on release sources. Nevertheless, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Nuclear and Industrial Safety Agency (NISA) and the Nuclear Safety Commission (NSC) Japan used SPEEDI to calculate the estimation with various assumptions for the internal examination of the situation. Even under such restricted conditions without adequate information on release sources, it should have been utilized as a reference of evacuation activities and other purposes by presuming diffusion trends of radioactive materials under certain assumptions, but it could not. Although the results generated by SPEEDI are now being disclosed, disclosure should have been conducted from the initial stage.

The Japanese Government will improve its instrumentation and facilities to ensure that release source information can be securely obtained. Also, it will develop a plan to effectively utilize SPEEDI and other systems to address various emergent cases and disclose the data and results from SPEEDI, etc. from the earliest stages of such cases.

(22) Clear definition of widespread evacuation areas and radiological protection guidelines in nuclear emergency

Immediately after the accident, an Evacuation Area and In-house Evacuation Area were established, and cooperation of residents in the vicinity, local governments, police and relevant organizations facilitated the fast implementation of evacuation and “stay-in-house” instruction. As the accident became prolonged, the residents had to be evacuated or stay within their houses for long periods. Subsequently, however, it was decided that guidelines of the ICRP and IAEA, which have not been used before the accident, would be used when establishing Deliberate Evacuation Area and Emergency Evacuation Prepared Area. The size of the protected area defined after the accident was considerably larger than a 8 to 10km radius from the NPS, which had been defined as the area where focused protection measures should be taken.

Based on the experiences gained from the accident, the Japanese Government will make much greater efforts to clearly define evacuation areas and guidelines for radiological protection in nuclear emergencies.

Lessons in Category 4
Reinforcement of safety infrastructure

(23) Reinforcement of safety regulatory bodies

Governmental organizations have different responsibilities for securing nuclear safety. For example, NISA of METI is responsible for safety regulation as a primary regulatory body, while the Nuclear Safety Commission of the Cabinet Office is responsible for regulation monitoring of the primary governmental body, and relevant local governments and ministries are in charge of emergency environmental monitoring. This is why it was not clear where the primary responsibility lies in ensuring citizens' safety in an emergency. Also, we cannot deny that the existing organizations and structures hindered the mobilization of capabilities in promptly responding to such a large-scale nuclear accident.

Reflecting on the above issues, the Japanese Government will separate NISA from METI and start to review implementing frameworks, including the NSC and relevant ministries, for the administration of nuclear safety regulations and for environmental monitoring.

(24) Establishment and reinforcement of legal structures, criteria and guidelines

Reflecting on this accident, various challenges have been identified regarding the establishment and reinforcement of legal structures on nuclear safety and nuclear emergency preparedness and response, and related criteria and guidelines. Also, based on the experiences of this nuclear accident, many issues will be identified as ones to be reflected in the standards and guidelines of the IAEA.

Therefore, the Japanese Government will review and improve the legal structures governing nuclear safety and nuclear emergency preparedness and response, along with related criteria and guidelines. During this process, it will reevaluate measures taken against age-related degradation of existing facilities, from the viewpoint of structural reliability as well as the necessity of responding to new knowledge and expertise, including progress in system concepts. Also, the Japanese Government will clarify technical requirements based on new laws and regulations or on new findings and knowledge for facilities that have already been approved and licensed-- in other words, it will clarify the status of retrofitting in the context of the legal and regulatory framework. The Japanese Government will make every effort to contribute to improving safety standards and guidelines of the IAEA by providing related data.

(25) Human resources for nuclear safety and nuclear emergency preparedness and responses

All the experts on severe accidents, nuclear safety, nuclear emergency preparedness and response, risk management and radiation medicine should get together to address such an accident by making use of the latest and best knowledge and experience. Also, it is extremely important to develop human resources in the fields of nuclear safety and nuclear emergency preparedness and response in order to ensure mid- and long-term efforts on nuclear safety as well as to bring restoration to the current accident.

Reflecting on the above-mentioned issues, the Japanese Government will enhance human resource development within the activities of nuclear operators and regulatory organizations along with focusing on nuclear safety education, nuclear emergency preparedness and response, crisis management and radiation medicine at educational organizations.

(26) Ensuring the independence and diversity of safety systems

Although multiplicity has been valued until now in order to ensure the reliability of safety systems, avoidance of common cause failures has not been carefully considered, and independence and diversity have not been sufficiently secured.

Therefore, the Japanese Government will ensure the independence and diversity of safety systems so that common cause failures can be adequately addressed and the reliability of safety functions can be further improved.

(27) Effective use of probabilistic safety assessment (PSA) in risk management

PSA has not always been effectively utilized in the overall reviewing processes or in risk reduction efforts at nuclear power plants. While a quantitative evaluation of risks of quite rare events such as a large-scale tsunami is difficult and may be associated with uncertainty even within PSA, Japan has not made sufficient efforts to improve the reliability of the assessments by explicitly identifying the uncertainty of these risks.

Considering knowledge and experiences regarding uncertainties, the Japanese Government will further actively and swiftly utilize PSA while developing improvements to safety measures, including effective accident management measures, based on PSA.

Lessons in Category 5
Thoroughly instill a safety culture

(28) Thoroughly instill a safety culture

All those involved with nuclear energy should be equipped with a safety culture. “Nuclear safety culture” is stated as, “A safety culture that governs the attitudes and behavior in relation to safety of all organizations and individuals concerned must be integrated in the management system” (IAEA, Fundamental Safety Principles, SF-1, 3.13). Learning this message and putting it into practice is the starting point, the duty and the responsibility of those who are involved with nuclear energy. Without a safety culture, there will be no continual improvement of nuclear safety.

Reflecting on the current accident, the nuclear operators whose organization and individuals have primary responsibility for securing safety should look at every item of knowledge and every finding and confirm whether or not they indicate a vulnerability of a plant. They should reflect as to whether they have been serious in introducing appropriate measures for improving safety, when they are not confident that risks concerning the public safety of the plant remain low.

Also, organizations or individuals involved in national nuclear regulations, as those who responsible for ensuring the nuclear safety of the public, should reflect whether they have been serious in addressing new knowledge in a responsive and prompt manner, not leaving any doubts in terms of safety.

Reflecting on this viewpoint, Japan will establish a safety culture by going back to the basics, namely that pursuing defenses in depth is essential for ensuring nuclear safety, by constantly learning professional knowledge on safety, and by maintaining an attitude of trying to identify weaknesses as well as room for improvement in the area of safety.

13. Conclusion

The nuclear accident that occurred at the Fukushima Nuclear Power Station (NPS) on March 11, 2011 was caused by an extremely massive earthquake and tsunami rarely seen in history and resulted in an unprecedented serious accident that extended over multiple reactors simultaneously. Japan is extending its utmost efforts to confront and overcome this difficult accident.

In particular, at the accident site, people engaged in the work have been making every effort under severe conditions to settle the situation. It is impossible to resolve the situation without these contributions. The Japanese Government is determined to make its utmost efforts to support the people engaged in this work.

We take very seriously the fact that the accident, triggered by a natural disaster of an earthquake and tsunamis, became a severe accident due to such causes as the losses of power and cooling functions, and that consistent preparation for severe accidents was insufficient. In light of the lessons learned from the accident, Japan has recognized that a fundamental revision of its nuclear safety preparedness and response is inevitable.

As a part of this effort, Japan will promote the "Plan to Enhance the Research on Nuclear Safety Infrastructure" while watching the status of the process of settling the situation. This plan is intended to promote, among other things, research to enhance preparedness and responses against severe accidents through international cooperation, and to work to lead the results achieved for the improvement of global nuclear safety.

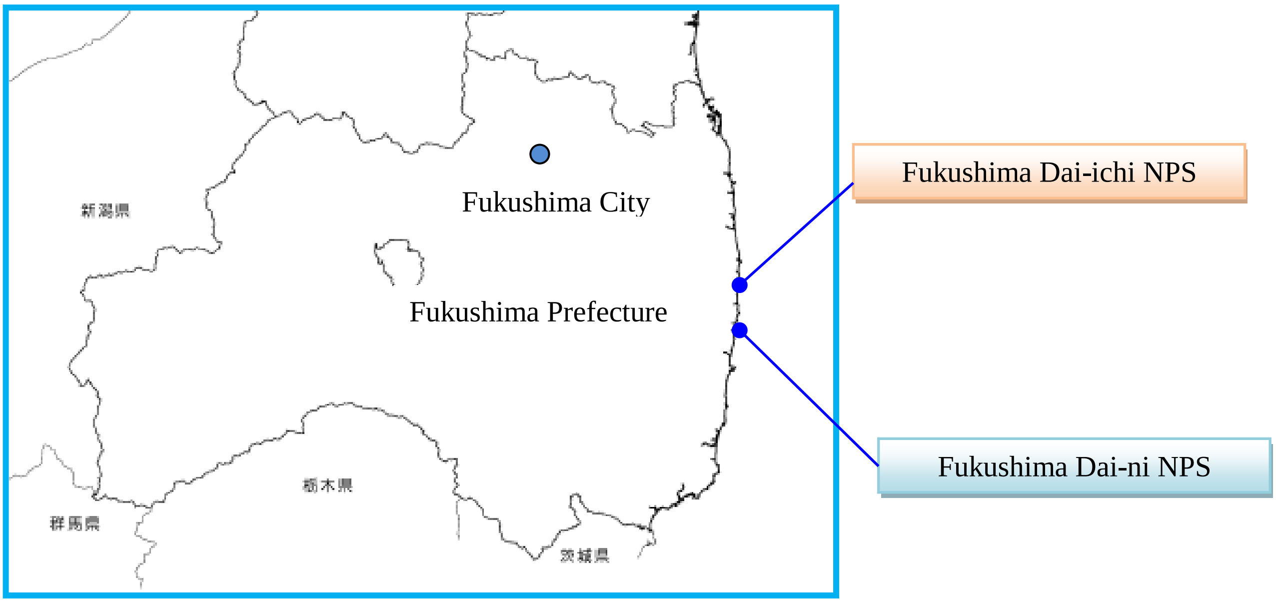
At the same time, it is necessary for Japan to conduct national discussions on the proper course for nuclear power generation while disclosing the actual costs of nuclear power generation, including the costs involved in ensuring safety.

Japan will update information on the accident and lessons learned from it in line with the future process of restoration of stable control and also further clarification of its investigations. Moreover, it will continue to provide such information and lessons learned to the International Atomic Energy Agency as well as to countries around the world.

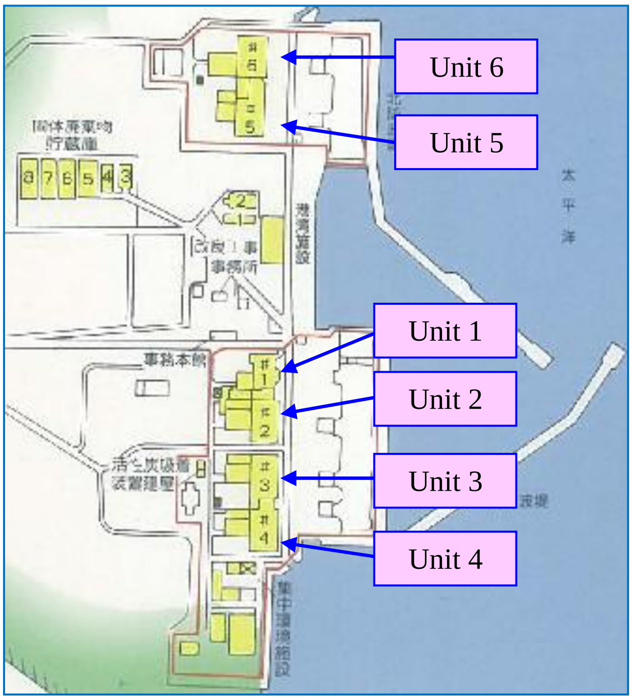
Moreover, we feel encouraged by the support towards restoration from the accident received from many countries around the world, to which we express our deepest gratitude, and we would sincerely appreciate continued support from the IAEA and countries around the world.

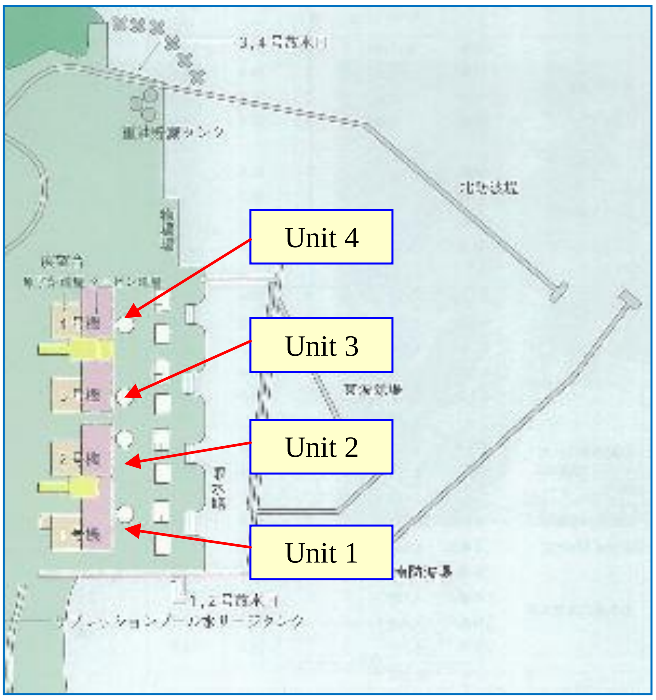
We are prepared to confront much difficulty towards restoration from the accident and also confident that we will be able to overcome this accident by uniting the wisdom and efforts of not only Japan but also the world.

Location of NPSs in the Tohoku District



Location of NPSs within Fukushima





Layouts of Fukushima Dai-ichi NPS and Fukushima Dai-ni NPS

Generation Facilities at the Fukushima Dai-ichi NPS

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Electric output (MWe)	460	784	784	784	784	1100
Commercial operation	1971/3	1974/7	1976/3	1978/10	1978/4	1979/10
Reactor model	BWR3	BWR4			BWR5	
PCV model	Mark-1					Mark-2
Number of fuel assemblies in the core	400	548	548	548	548	764

Generation Facilities at the Fukushima Dai-ni NPS

	Unit 1	Unit 2	Unit 3	Unit 4
Electric output (MWe)	1100	1100	1100	1100
Commercial operation	1982/4	1984/2	1985/6	1987/8
Reactor model	BWR5			
PCV model	Mark-2	Mark-2 Advance		
Number of fuel assemblies in the core	764	764	764	764

Status of Each Unit at the Fukushima Dai-ichi NPS (As of May 31)

Unit No.	Unit 1	Unit 2	Unit 3	Unit 5	Unit 6
Situation of water injection into reactor	Injecting fresh water via a water supply line. Flow rate of injected water : 6.0 m^3/h	Injecting fresh water via a fire extinguishing and water supply line. Flow rate of injected water: 7.0m^3/h(via the fire protection line), 5.0m^3/h(via the feedwater line)	Injecting fresh water via the water supply line. Flow rate of injected water : 13.5 m^3/h	Water injection is unnecessary as the cooling function of the reactor cores are in normal operation.	
Reactor water level	Fuel range A : Off scale Fuel range B : -1,600mm	Fuel range A : -1,500mm Fuel range B : -2,150mm	Fuel range A:-1,850mm Fuel range B:-1,950mm	Shut down range measure ment 2,164mm	Shut down range measure ment 1,904mm
Reactor pressure	0.555MPa g(A) 1.508MPa g(B)	-0.011MPa g (A) -0.016MPa g (B)	-0.132MPa g (A) -0.108MPa g (B)	0.023 MPa g	0.010 MPa g
Reactor water temperature	(Collection impossible due to low system flow rate)			83.0°C	24.6°C
Temperatures related to Reactor Pressure Vessel (RPV)	Feedwater nozzle temperature: 114.1°C Temperature at the bottom head of RPV: 96.8°C	Feedwater nozzle temperature: 111.5°C Temperature at the bottom head of RPV: 110.6°C	Feedwater nozzle temperature: 120.9°C Temperature at the bottom head of RPV: 123.2°C	(Monitoring water temperature in the reactors.)	
D/W Pressure, S/C Pressure	D/W: 0.1317 MPa abs S/C: 0.100 MPa abs	D/W: 0.030 MPa abs S/C: Off scale	D/W: 0.0999 Mpa abs S/C: 0.1855 MPa abs	-	
Status	We are working on ensuring the reliability of the cooling function by installing temporary emergency diesel generators and sea water pumps as well as receiving electricity from external power supplies at each plant.				