(Provisional translation)

Basis for Discussing the Revision of the "Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1-4"

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Secretariat of the Council for the Decommissioning of
TEPCO's Fukushima Daiichi Nuclear Power Station

1. Introduction

After the accident at the TEPCO's Fukushima Daiichi nuclear power station, TEPCO and the government prepared a roadmap and pursued efforts to put an end to the aftermath of the accident as early as possible based on the Roadmap.

It was decided at the 28th meeting of the Nuclear Emergency Response Headquarters on February 8, 2013 to establish "the Council for the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station" chaired by Minister Motegi of METI. It aims to reinforce the R&D management towards fuel debris removal and to enhance the further collaboration between on-site work and government-led R&D program The first meeting of the Council for the Decommissioning was held on March 7, 2013, at which discussions were made on such matters as the possibilities of speeding up the fuel debris removal and Minister Motegi, the chair of the Council, directed to complete a "revised" roadmap by the end of June 2013. In response to these developments, the Roadmap will be revised.

2. Basic Principles for Addressing the Mid-and-long-Term Issues

【Principle 1】 Systematically tackle the issues while placing top priority on the safety of local citizens and workers.

【Principle 2】 Move forward while maintaining transparent communications with local and national citizens to gain their understanding and respect.

【Principle 3】 Continually update this roadmap in consideration of the on-site situation and the latest R&D results etc.

【Principle 4】 Harmonize the individual efforts of the government and TEPCO to achieve our goal.

The government and TEPCO will take the appropriate measures taking into consideration the importance of implementing the Roadmap and based on the above-mentioned basic principles. In addition, the government and TEPCO will review and revise the plan regularly and take measures to ensure transparency such as announcement of the status of mid- and long-term efforts.

3. Approach to Ensuring Safety in Relation to the Implementation of Mid-and-Long-Term Efforts

Taking into consideration the importance of ensuring safety in implementing efforts towards the decommissioning of Units 1 to 4 of TEPCO's Fukushima Daiichi Nuclear Power Station, efforts to improve equipment safety, work safety and radioactive safety will be continued.

3-1.Ensuring Safety in Implementing Efforts towards the Decommissioning of Units 1 to 4 as Specified Reactor Facilities

(1) Shift to a New Safety Management System in Response to the Designation of Units 1 to 4 as Specified Reactor Facilities

On November 7, 2012, the Nuclear Regulation Authority designated the reactor facilities of the Fukushima Daiichi nuclear power station as "Specified Reactor Facilities" and presented a "List of the Matters to Be Addressed" to TEPCO, with the objective of reducing the risks in and optimizing the facilities as a whole and ensuring safety in and around the power station site.

In response to this, TEPCO prepared an "Implementation Plan" based on the "List of the Matters to Be Addressed" and submitted it to the Nuclear Regulation Authority on December 7, 2012. Currently, the Implementation Plan is being examined.

(2) Basic Concept of Efforts to Ensure Safety

The Fukushima Daiichi nuclear power station, whose facilities have been designated as Specified Reactor Facilities, is different from other nuclear power stations in that speedy and efficient implementation of the measures necessary to reduce the risks in and optimize the facilities as a whole is needed. TEPCO proposes specific measures to address the matters on the "List of the Matters to Be Addressed" in the Implementation Plan. In addition, TEPCO reviews and revises the Implementation Plan in a flexible manner so that the necessary measures can be implemented in a timely and effective manner taking into consideration the status of the progress of the on-site work.

In addition, it is specified as the strategic goal to minimize the impacts of radioactive substances from the Specified Reactor Facilities on the areas outside the power station site and to restore the areas to the level before the accident through implementing the specific measures etc. presented in the Implementation Plan in a speedy manner. The following tactical goals for ensuring safety are established in order to attain the strategic goal:

(1)To complete the decommissioning as early as possible while maintaining the stability of the plant

(2)To ensure safety in the areas outside the power station site (to reduce the impacts of exposure of the general public)

(3)To ensure safety within the power station site (to reduce the impacts of exposure of the workers)

In addition, the response actions based on the “Nuclear Operator Emergency Action Plans" for Fukushima Daiichi Nuclear Power Stations” that has been developed will be taken in the case where an emergency occurs despite the above-mentioned efforts.

3-2. Specific Efforts for Ensuring Safety

(1) Equipment Safety – Continuous Efforts towards Improving the Reliability of Equipment -

① Measures Based on the “Implementation Plan related to Countermeasures for Improving Reliability”

TEPCO will continuously take measures to ensure that present equipment can withstand long-term use based on the “Implementation Plan related to Countermeasures for Improving Reliability” established in May 2012. Examples of such measures include A) Switching to injection of water that uses condensate storage tanks as the water source, B) replacing the resident water transfer lines with polyethylene pipes, C) considering and establishing maintenance policies for tanks and other water treatment equipment and D) changing power sources for the important loads such as spent fuel pools to better ones.

In addition, measures necessary to further improve the reliability of equipment shall be considered continuously, and planned and implemented in a speedy manner taking into consideration the situation at the power station and other factors.

② Recent Troubles and the Response Measures

With regard to the spent fuel pool cooling equipment that has stopped operating on March 18, 2013 as a result of a fault in the power supply system (the power supply panel for the temporary power source for Units 3 and 4), the implementation of the response measure was completed by the end of March 2013. In addition, the deadline for completion of implementation of the measures to prevent similar faults on similar power supply equipment (the power supply panel for the common pool power source) will be hastened to the end of July 2013 from the end of September 2013.

In addition, TEPCO set up an “Emergency Response Measures Headquarters for Reliability Improvement in the Fukushima Daiichi Nuclear Power Station” in April 2013 after a water leakage incident from a basement water storage tank of the power station, in order to speedily implement reliability improvement measures relating to equipment and operation management for maintaining and enhancing the stability of the plant.

(2) Work Safety – Safety and Radiation Control for Workers -

In addition to measures to ensure general work safety of workers, “measures to reduce workloads through the use of more appropriate personal protective equipment, measures to reduce dose levels through decontamination etc. and measures utilizing remote technologies such as robots” will be taken in order to maintain the dose levels in the areas workers enter and the dose of workers due to exposure below the dose limit values and reduce the dose of workers in each operation.

(3) Reducing the Impacts on the Surrounding Environments – Reducing and Controlling Radiation Dose Levels at the Boundaries of the Power Station Site -

Currently, the nuclear fuels in the reactors are being cooled in a stable condition and radioactive material release from the reactor buildings is kept at a low level. As a result, the current annual radiation exposure at the site boundaries is assessed, in general, lower than the values observed at the time of completion of Step 2[1]. The maximum current annual radiation exposure is 0.03 mSv/year. In addition, the effective dose at the site boundaries due to additional radioactive release from the power station as a whole, and radiation from the rubble generated

[1] December 2011

after the accident and stored on the site and the secondary waste generated as a result of treatment of contaminated water (such as used cesium adsorption towers and sludge; hereinafter referred to as “secondary waste from water treatment”) were reduced to less than 1 mSv/year at the end of FY 2012 as planned.

On the other hand, the maximum of the dose levels at the site boundaries due to the effect of the contaminated water that has accumulated in the basement water storage tank and is being transferred after the water leakage from the water tank in April 2013 is assessed at 7.8 mSv/year, which is higher than the target value. Therefore, the dose levels at the site boundaries due to the accumulated water will be lowered as soon as possible through contaminated water purification using equipment capable of removing multiple nuclides.

With regard to liquid wastes, the necessary evaluations regarding the matters listed below will be made and measures based on the results of the evaluations will be implemented, and discharges of liquid wastes to the ocean will not be made lightly.

① Fundamental measures to prevent inflows of groundwater into reactor buildings etc. which can cause water level rises (ground water inflow control)

② Measures to ensure stable operation including measures relating to improving decontamination capabilities of contaminated water treatment facilities and to the use of an alternative facility in the event of a failure (strengthening of contaminated water treatment systems)

③ Measures to establish additional land facilities for contaminated water management (plan for constructing additional tanks)

Discharges into the sea must not be performed without the approval of the relevant ministries.

3-3. Preparations for the Development of New Standards and Regulatory Response Actions

To implement the steps for the decommissioning such as fuel debris removal, it is important to develop the judgment criteria and the necessary standards in a timely manner and speedily take regulatory response measures that are based on such judgment criteria and standards.

It is important for TEPCO to present as early as possible their opinions as an operator and data in support of them. Based on the fastest schedule towards the commencement of fuel debris removal, the schedule for the development of the above-mentioned standards and the submission of the application forms to the regulatory authorities will be considered, developed and presented.

4. Specific Mid- and Long-term Measures

4-1. Phases of the Way towards the Decommissioning that are Defined in the Mid-and-Long-Term Roadmap

【Phase 1】From the completion of Step2[2] to the commencement of the removal of fuel from the spent fuel pool for the first unit (Phase 1 is to be completed within 2 years after completion of Step 2)

- This is the intensive preparation phase for the decommissioning in which preparations for the commencement of the removal of fuel from the spent fuel pools will be made, the research and development activities necessary for fuel debris removal will be carried out and on-site investigations will be started.

【Phase 2】From the completion of Phase 1 to the commencement of the fuel debris removal for the first unit (Phase 2 is to be completed within 10 years after completion of Step 2.)

- In Phase 2, many R&D activities and primary containment vessel repair operations towards the fuel debris removal will start in earnest.
- Phase 2 is subdivided into Phase 2 (early), Phase 2 (mid) and Phase 2 (late) so that the progress of Phase 2 can be assessed more easily.

【Phase 3】From the completion of Phase 2 to the completion of the decommissioning (Phase 3 is to be completed within 30 to 40 years after completion of Step 2.)

- This is the phase in which the fuel debris removal and the succeeding activities up to the completion of the decommissioning will be carried out.

Currently, activities of Phase 1 are being carried out. Phase 2 will be started in half a year. Activities of Phases 2 and 3 entail many technological challenges, and it is necessary to carry out each of the steps in stages. For this reason, “holding points” (HPs) were established which were defined as important junctures at which decisions must be made regarding the transition to the next step including decisions as to whether it is necessary to conduct additional R&D activities and whether the step or its operations should be revised.

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[2] Step 2 is one of the stages established toward putting an end to the aftermath of the accident at the Fukushima Daiichi nuclear power station. The aim of Step 2 is to bring about a “state in which releases of radioactive substances are controlled and radioactive dose levels have been lowered significantly.”

4-2. Unit-specific Concrete Plans for the Removal of Fuel from the Spent Fuel Pool and the Fuel Debris Removal and the Associated Holding Points

In this review, the differences between the units regarding the current situation were analyzed in detail and the possibilities of hastening milestones of the schedule were evaluated. For the fuel removal from the spent fuel pool and the fuel debris removal for each of the units, multiple plans were developed and the points in time at which plan selection is likely to be made or plans are likely to be revised or modified were defined and clearly indicated as HPs.

(1) Unit 1

Because the upper part of the reactor building for Unit 1 had been damaged by a hydrogen explosion, a reactor building cover was installed in October 2011 to prevent airborne radioactive substances from diffusing. After that, the rates of generation of radioactive substances were reduced by continued stabilization cooling of the reactor. Removal of the building cover and the rubble in the upper part of the operating floor are planned.

【Plan ①】This is the plan for the case where the reactor building cover can be modified. In this plan, fuel handling equipment for fuel removal will be installed on the operating floor and then fuel removal will be carried out. Fuel debris will be removed after removing the reactor building cover and installing a full-scale container.

(Target Schedule)

- Commencement of fuel removal(first half of FY2017)
- Commencement of fuel debris removal(first half of FY2022)

【Plan ②】 This is the plan for the case where the reactor building cover cannot be modified. In this plan, fuel removal will be carried out after installing an upper container equipped with the functions necessary for fuel removal. Then, fuel debris removal will be carried out after modifying the upper container to equip it with the functions necessary for fuel debris removal.

(Target Schedule)

- Commencement of fuel removal(second half of FY2017)
- Commencement of fuel debris removal(first half of FY2020)

【Plan ③】This is the plan for the case where neither Plan ① nor Plan ② is viable in view of the result of the evaluation of seismic safety of the reactor building, the status of development of the container design conditions or the feasibility of the reactor building cover modification.

(Target Schedule)

- Commencement of fuel removal(second half of FY2017)
- Commencement of fuel debris removal(second half of FY2022)

<HP for selecting the plan to adopt (Plan ①, Plan ② or Plan ③)>

(HP1-1)Selection of the fuel removal plan and fuel debris removal plan (first half of FY 2014)

The fuel removal plan and fuel debris removal plan will be selected taking into consideration the result of the evaluation of seismic safety of the existing reactor building, the feasibility of the reactor building cover modification and the status of the development of the conditions necessary for designing the upper and full-scale containers.

<HP for determining when to commence fuel debris removal>

(HP1-2)Determination of the fuel debris removal method

Techniques and equipment for fuel debris removal will be developed to allow the fuel debris removal equipment for Unit 1 to be installed, and the decision as to which removal method to use will be made by the end of the second half of FY 2020 for Plan ①, by the end of the first half of FY 2019 for Plan ② and by the end of the second half of FY 2020 for Plan ③.

(2) Unit 2

The reactor building for Unit 2 has not suffered any hydrogen explosion damage, but the dose level in the building is very high. An investigation to confirm the state of contamination of the operating floor is planned.

【Plan ①】This is the plan for the case where the decontamination of the operating floor and the restoration of the existing fuel handling equipment is feasible. In this plan, the existing fuel handling equipment will be restored after lowering the dose level on the operating floor by decontamination and shielding. Fuel debris will be removed by installing fuel debris removal equipment in the existing reactor building.

(Target Schedule)

- Commencement of fuel removal(second half of FY2017)
- Commencement of fuel debris removal(first half of FY2020)

【Plan ②】This is the plan for the case where the decontamination of the operating floor or the restoration of the existing fuel handling equipment is not feasible. In this plan, fuel removal will be carried out after installing an upper container equipped with the functions necessary for fuel removal.

(Target Schedule)

- Commencement of fuel removal(first half of FY2020)
- Commencement of fuel debris removal(first half of FY2021)

【Plan ③】This is the plan for the case where neither Plan ① nor Plan ② is viable in view of the result of the evaluation of seismic safety of the reactor building, the feasibility of restoration of the existing fuel handling equipment or the decontamination of the operating floor.

(Target Schedule)

- Commencement of fuel removal(first half of FY2023)
- Commencement of fuel debris removal(first half of FY2024)

<HP for selecting the plan to adopt (Plan ①, Plan ② or Plan ③)>

(HP2-1)Selection of the fuel removal plan and fuel debris removal plan (first half of FY 2014)

The fuel removal plan and fuel debris removal plan will be selected taking into consideration the result of the evaluation of seismic safety of the existing reactor building, the feasibility of restoration of the existing fuel handling equipment, the state of contamination of the operating floor as investigated and the status of the development of the design conditions for the upper and full-scale containers.

<HP for determining when to commence fuel debris removal>

(HP2-2)Determination of the fuel debris removal method

Techniques and equipment for fuel debris removal will be developed to allow the fuel debris removal equipment for Unit 2 to be installed, and the decision as to which removal method to use will be made by the end of the first half of FY 2018 for Plan ①, by the end of the first half of FY 2018 for Plan ② and by the end of the first half of FY 2021 for Plan ③.

(3) Unit 3

In the upper part of the operating floor of the reactor building for Unit 3, rubble has piled up in an intricate manner. In addition, the dose level on the operating floor is very high. Currently, the rubble in the upper part of the operating floor is being removed. Installation of fuel handling equipment and a cover for fuel removal is planned.

【Plan ①】This is the plan for the case where the cover for fuel removal can be modified. In the case, the fuel in the spent fuel pool is removed using the fuel handling equipment installed on the cover for fuel removal. Then, the cover will be modified and fuel debris removal will be carried out.

(Target Schedule)

- Commencement of fuel removal(first half of FY2015)
- Commencement of fuel debris removal(second half of FY2021)

【Plan ②】This is the plan for the case where the modification of the cover for fuel removal in Plan ① is not feasible in terms of earthquake resistance and workability.

(Target Schedule)

- Commencement of fuel removal(first half of FY2015)
- Commencement of fuel debris removal(second half of FY2023)

<HP for selecting the plan to adopt (Plan ① or Plan ②)>

(HP3-1)Selection of the fuel debris removal plan (first half of FY 2015)

The fuel debris removal plan will be selected taking into consideration the result of the evaluation of the feasibility, in terms of seismic safety and workability, of the modification of the cover for fuel removal.

<HP for determining when to commence fuel debris removal>

(HP3-2)Determination of the fuel debris removal method

Techniques and equipment for fuel debris removal will be developed to allow the fuel debris removal equipment for Unit 3 to be installed, and the decision as to which removal method to use will be made by the end of the second half of FY 2019 for Plan ① and by the end of the second half of FY 2019 for Plan ②.

(4) Unit 4

The removal of rubble in the upper part of the operating floor of the reactor building for Unit 4 was completed in December 2012. Currently, the cover for fuel removal is being installed. Installation of fuel handling equipment for fuel removal in the cover for fuel removal is planned.

Fuel removal from the spent fuel pool was originally scheduled to commence within 2 years after completion of Step 2 (which is December 2011), but the target was brought forward to November 2013 by shortening the durations of processes and introducing parallel operation.

It is expected that fuel removal can entail risks such as the risk of efficiency reductions due to work environment-related factors and the risk of equipment failures and troubles, but the result of the new fuel removal conducted as a preliminary step showed that there was no deformation or corrosion that may affect fuel handling, and it was confirmed that the possibility of a delay from the assumed schedule was small. In addition, the fuel removal period will be shortened from the original plan's "about 2 years" to "about 1 year" to complete fuel removal around the end of 2014 by introducing parallel operation using 2 onsite casks.

(Target Schedule)

- Commencement of fuel removal (November 2013)
- Completion of fuel removal (around the end of 2014)

(5) Common equipment and common matters

① Common equipment and common matters relating to the removal of fuel from the spent fuel pools

(a) Common pool and temporary dry cask storage

In principle, fuel removed from the spent fuel pools will be transferred to the common pool located in the power station and stored in the common pool in a stable manner. The risks that arise in relation to the fuel removal and the countermeasures for them will be clearly indicated.

The normal spent fuel that has been in the common pool since before the accident will be transferred to a newly constructed temporary dry cask storage. The temporary dry cask storage was brought into operation in April 2013 to meet the need to temporarily store the 9 dry storage casks that had been stored in the cask storage building damaged by the tsunami. Because transferring all fuel being stored in the spent fuel pools for Units

1 to 4 to the common pool will overflow the temporary dry cask storage, additional temporary dry cask storages will be constructed. In addition, efforts will be made to ensure that dry casks will be acquired without problem.

(b)Onsite casks/fuel debris containers

With regard to the transfer of normal spent fuel from the spent fuel pools to the common pool, use of the existing onsite casks will be considered. For units with a work area with a high dose level, fuel handling equipment and onsite casks that can be operated remotely will be newly constructed.

The damaged fuel will be put into onsite casks (and transported) that have been built in such a way that airborne radioactive substances will be prevented from diffusing according to the type of damage.

For Unit 4, two casks that have been used for transport within the Fukushima Daiichi nuclear power station will be used.

(c) Handling of the removed fuel

The fuel removed from the spent fuel pools will be stored in the common pool for the time being. In parallel with this, discussions will be made towards long-term soundness evaluation and disposal taking into consideration the effects of the sea water.

② Common equipment and common matters relating to preparations for the removal of fuel debris

The location and properties of the fuel debris, the locations of the damaged parts of the primary containment vessels and pressure vessels, and other details are not known, but it is considered that, like TMI-2[3], the approach of removing the fuel debris with it submerged in water is the safest approach from the standpoint of minimizing exposure of workers.

Therefore, preparations for fuel debris removal that are listed below ((a) to (k)) will be made in stages on the premise that submersion approach-based work steps will be designed and implemented and taking into consideration the progress status of R&D and on-site work.

[3] Unit 2 of the Three Mile Island nuclear power station of the United States

The specific fuel debris removal method to use will be clearly indicated. In addition, the risks that arise in relation to the fuel debris removal will be clearly indicated for each stage of fuel debris removal, together with the countermeasures for them.

(a) Reducing dose levels in the reactor buildings

<Basic Policy> Human access to the spaces inside the reactor buildings is still difficult because of the high dose levels and rubble, dust, etc. that have been scattered in them. Therefore, investigations of the spaces inside the reactor buildings will be conducted to estimate and assess the states of contamination in them and identify the decontamination technologies that can be applied. In addition, decontamination equipment that can be remotely operated will be developed and the spaces will be decontaminated to make them accessible.

【Target Schedule】

First half of FY2014: Completion of decontamination etc. to allow the lower part of the primary containment vessel of Unit 2, which has been selected as the first unit, to be investigated

First half of FY2015: Completion of decontamination etc. to allow the upper part of the primary containment vessel of Unit 2, which has been selected as the first unit, to be investigated

Second half of FY2019: Completion of the operations to lower the dose levels inside the reactor buildings

(b)Investigations and Repair for filling the primary containment vessels with water

<Basic Policy> Because it is considered that the approach of removing the fuel debris with it submerged in water is the safest approach from the standpoint of minimizing exposure of workers, investigation and repair (stopping leakages) equipment for the primary containment vessels will be developed and investigations and repair for filling the primary containment vessels with water will be performed. In addition, methods of removing the fuel debris without filling the primary containment vessels with water will be studied as alternative methods.

【Target Schedule】

Second half of FY2016: Determination of the repair (stopping leakages) method for the lower part of the primary containment vessel of Unit 2, which has been selected as the first unit (HP DE-1)

First half of FY2017: Commencement of the repair (stopping leakages) of the lower part of the primary containment vessels

First half of FY2018: Determination of the repair (stopping leakages) method for the upper part of the primary containment vessels (HP DE-3)

(c) Investigations of the inside of the primary containment vessels

<Basic Policy> Because the removal of the fuel debris requires the pinpointing of the locations of the fuel debris pieces, equipment to investigate the states of the inside of the primary containment vessels will be developed and the necessary information such as the locations, distributions and shapes of the fuel debris pieces will be obtained.

【Target Schedule】

Second half of FY2016: Determination of the method of investigating the inside of the primary containment vessels (HP DE-2)

Second half of FY2016: Commencement of investigations of the inside of the primary containment vessels

(d) Investigations of the inside of the reactor pressure vessels

<Basic Policy> Fuel debris removal requires the development of investigation technologies to allow the states of the inside of the reactor pressure vessels (the states of the fuel debris pieces, the states of the damage inside the reactors and the states of equipment contamination) to be grasped. Therefore, such technologies will be developed.

【Target Schedule】

Second half of FY2018: Determination of the method of investigating the inside of the reactor pressure vessels (HP DE-4)

Second half of FY2019: Commencement of investigations of the inside of the reactor pressure vessels

(e) Development of fuel debris removal technologies

<Basic Policy> The preconditions for fuel debris removal will be identified, and fuel debris removal technologies and equipment, including technologies to open the reactors and remove structures housed in the reactors, will be developed.

【Target Schedule】

First half of FY2018: Determination of the method of removing the fuel debris and the structures housed in the reactors (part of HP DE-5)

First half of FY2020: Commencement of the removal of the fuel debris of the first unit (in the case of the fastest plan)

(f) Packing, transfer and storage of fuel debris

<Basic Policy> Basically, the experiences of TMI-2 can be used as a source of reference for the packing, transfer and storage of fuel debris. However, it is expected that the fuel debris generated by the accident at the Fukushima Daiichi nuclear power station is higher in dose level and heating value. Therefore, the states of the inside of the reactors will be investigated first. Then, technologies for the packaging, transfer and storage of fuel debris will be developed based on the result of the investigation.

【Target Schedule】

Second half of FY2019: Completion of the development of the fuel debris container and the completion of the preparations (part of HP DE-5)

First half of FY2020: Commencement of the packing, transfer and storage of the fuel debris removed from the first unit (in the case of the fastest plan)

(g) Evaluation of integrity of reactor pressure vessel and containment vessel

<Basic policy> Since there are concerns that the structural materials of the reactor pressure vessel and containment vessel, into which seawater was poured, may corrode and that the strength of the structure (pedestal) supporting the reactor

pressure vessel may drop due to high temperatures after the accident, data such as on the expected corrosion speed of each unit of equipment and the strength of the materials will be gathered to evaluate the integrity of the structures until fuel debris is taken out.

[Target schedule]

Second half of FY2015	Re-evaluation of integrity and life extension effect, taking into account the condition of the plant until it is submerged
Second half of FY2016	Determining method of repairing the lower part of the reactor containment vessel (HPDE-1) (written again)

(h) Management of criticality of fuel debris

<Basic policy> Sub-criticality will be evaluated and monitoring techniques will be developed because it is necessary to prevent re-criticality even in case the shape of the fuel debris or the quantity of the water, which is poured during the process of extracting the fuel debris, changes.

[Target schedule]

Second half of FY2019	Development of fuel debris criticality management technology
First half of FY2020	Start of taking out fuel debris from the first unit (in the case of the fastest plan (written again))

(i) Grasping internal conditions of reactor by using advanced accident growth analysis technology

<Basic policy> Physical observation such as by using a camera is impossible for time being, and the result that can be obtained from accident progression analysis technology, which is expected as a means to estimate and grasp the internal conditions of the reactor, is still uncertain. To reduce this uncertainty, severe accident analysis codes (MAAP and SAMPSON) will be advanced by analyzing information that can be obtained from actual work at the site.

[Target schedule]

First half of FY2013	Addition and improvement of models of MAAP and SAMPSON
Second half of FY2013	Evaluation of internal conditions of the reactor by using revised version of MAAP and SAMPSON on which improvements until the first half of 2013 are reflected
Second half of FY2016	Start of examining the internal conditions of containment vessel

(j) Understanding the characteristics of and preparation for processing/disposing of fuel debris

<Basic policy> The characteristics of fuel debris generated as a result of the Fukushima Daiichi Nuclear Power Station accident will be grasped through analysis tests using simulated fuel debris, TMI-2 fuel debris, and others. In addition, a study on processing technology will be moved ahead toward processing and disposal of fuel debris after it has been taken out.

[Target schedule]

Second half of FY2015	Summarizing characteristic data of simulated fuel debris
First half of FY2016	Getting up speed of development of fuel debris extraction technique and system
First half of FY2016	Start of making a plan toward grasping characteristics, using actual fuel debris sample
Second half of FY2017	Start of operating radioactive substances/analysis research facility
Second half of FY2019	Start of reflecting characteristics data of actual debris sample on research and development toward processing and disposal of fuel debris
Phase 3	Determining method of processing and disposing of fuel debris (HP DE-6)

(k) Accounting for and control of nuclear material in fuel debris

<Basic policy> Based on safeguards agreements with the Japan and International Atomic Energy Agency (IAEA), accountancy for and control of the nuclear fuel materials and declaration of the accountancy report are required. Because an ordinary means of accountancy and control which uses fuel aggregate as one unit cannot be applied to fuel debris, a technique that can reasonably execute accountancy and control in a transparent manner will be created before the fuel debris will be removed and stored in the future.

[Target schedule]

Second half of FY2013	Carry out the applicability evaluation of technique for measuring nuclear materials in fuel debris
First half of FY2014	Start of development of technique for measuring nuclear materials in fuel debris and accountancy and control technique
Second half of FY2019	Start of operation of instrument that measures nuclear materials in fuel debris and completion of creating methodology for accountancy and control of fuel debris

[Holding points]

The concept of the above holding points is summarized as follows:

HP DE-1: Whether to start repair work (stopping leakages) of the lower part of the reactor containment vessel will be decided when development of a device for repairing (stopping leakages) the lower part of the containment vessel and constructing a system that takes water from the lower part of the vessel are completed.

HP DE-2: Whether to start examining the internal conditions of the reactor containment vessel will be decided when development of a method and system of examining the internal conditions of the containment vessel is completed.

HP DE-3: Whether to start repair work of the upper part of the reactor containment vessel will be decided when development of a device for repairing (stopping leakages) the upper part of the containment vessel is completed.

HP DE-4: Whether to start examining the internal conditions of the reactor containment vessel will be decided, after confirming that development of the method and system for examining the internal conditions of the containment vessel is completed and pouring water up to the upper part of the containment vessel (including the reactor pressure vessel) is completed.

HP DE-5: Whether to start extracting fuel debris will be decided, confirming that development of techniques which can reasonably cope with the characteristics, criticality management, accountancy and control, and extraction of fuel debris and with the conditions and situations of each viewpoint of long-term storage and disposal processing is completed.

HP DE-6: Method of processing and disposing of fuel debris will be decided, in light of consistency with related research and development and the government’s policy.

4-3. Other specific plans and holding points necessary for implementing the Mid-and Long-Term Roadmap

(1) Continuous monitoring cold shutdown status of reactor and cooling plan

To properly cool the fuel debris of Units 1 to 3 and thereby to keep the reactors in a stable condition, water injection and monitoring parameters such as temperature will be continued and, at the same time, reliability will be maintained and improved through maintenance and management. In addition, circulative cooling will be continued to properly keep the spent fuel stored in the spent fuel pools cooled. Further, creating a small circulation loop of the reactor water injection and cooling line (containment vessel circulative cooling) will be reviewed before water injection to the reactor containment vessel is stopped, so as to take out the fuel debris in the future.

① Continuous monitoring cold shutdown status of reactor pressure vessel and reactor containment vessel

<Basic policy> Regarding the temperature of the reactor pressure vessel, it has been confirmed that the existing thermometers of Units 1 and 3, which are required by safety regulations to be monitored, are almost sound so that the temperature is kept monitored by these thermometers. Since only one of the existing thermometers of Unit 2, which is required by the safety regulations to be monitored, is functioning and the others are out of order, one replaceable thermometer has been additionally installed to monitor the temperature. A location where the temperature can be monitored will be selected so that temperature monitoring of each Unit will be kept backed up.

To monitor the temperature of the reactor containment vessel of Units 1 and 2, permanent monitoring gages (thermometer and water level gage) were installed when the internal conditions of the containment vessel were checked and monitoring is continued. Permanent monitoring gages will also be installed for Unit 2. The radiation dose is high at Unit 3. Therefore, work environment will be improved, the internal conditions of the containment vessel will be examined, and permanent monitoring gages will be installed in the future.

In addition to keeping monitoring the temperature of each Unit, the concentration of radioactive gas (xenon 135) has been confirmed at all Units 1 to 3 by using a containment vessel gas management system, in order to monitor a sign of criticality of fuel debris. The cold shutdown status will be kept monitored in the future.

<Specific plan> Regarding the thermometers in the reactor pressure vessel, a mock-up test will be conducted to establish a pipe revamping technique (for cutting and connecting pipes) by the middle of 2013, so that additional thermometers can be installed for Unit 1 in preparation for a failure in the existing thermometer. The environment of Unit 3 will be improved by March of 2014 through decontamination and shielding. After that, the inspection will be conducted (to check the radioactive level and measure the dimensions) and a specific system candidate for piping that can be used to install additional thermometers will be selected. Since it is preferable to install additional thermometers for Unit 2 so that the internal conditions of the reactor can be examined at an early stage, it is aimed to install thermometers (including reactor internal condition investigation) by inserting an endoscope and thermometer into the TIP guide pipe in September 2013.

Permanent monitoring gages will be installed for Unit 3 to monitor the temperature inside the reactor containment vessel by improving the work environment of the reactor building by the end of 2013. An attempt is being made to install thermometers that can help further examination of the lower part of the reactor containment vessel of Unit 2, which will be kept studied.

② Improving reliability of circulative water-cooling facility

<Basic policy> Since fuel debris is continuously cooled by pouring water to it, it is necessary to take measures for preventing the water leakages. To this end, the materials of the circulative water injection line will be changed to those with high reliability and plural backup systems will be installed.

When polyethylene pipes are used for piping, aging evaluation and fire prevention measures will be securely reinforced.

<Specific plan> To further improve the reliability of the circulative water injection line, the water source will be changed from the existing buffer tanks to more reliable condensate storage tanks by June 2013 from the viewpoints of ① lowering a risk of water loss due to reduction of the reactor water injection line, ② improving the seismic resistance, ③ increasing the tank capacity, and so on. In addition, the pipes will be replaced with polyethylene pipes, a simplified trench for outdoor piping will be installed, and the pumps will be started and their flow will be adjusted through remote control, so as to improve the resistance to earthquake and tsunami, and to lower the risk of exposure to radiation.

③ Reducing circulative line/using small circulation loop

<Basic policy> At present, a circulative water injection line (large circulation) is used to treat accumulated water and inject water. However, effort will be made to realize a small circulation loop with an eye to continuously improving the reliability of the circulative water injection line, extracting fuel debris, and completion of accumulated water treatment.

<Specific plan> Effort will be made to complete, by the end of 2014, construction of an indoor circulation loop that injects the water staying inside building to the reactor without via the

existing accumulated water treatment facility, in view of the circumstance that the quality of the water staying in buildings are improving.

Since circulative water injection cooling uses the turbine building as the water source, it is necessary to systematically change the source of water, taking into account the progress of stopping water leakages between buildings and in the reactor containment vessel, and treatment of the water staying in the buildings. Taking these into consideration, ultimately constructing a small circulation loop (containment vessel circulative cooling) of the reactor water injection line will be studied.

[Target schedule]

Second half of FY2014	Completion of constructing circulation loop in buildings
First half of FY2015	Start of circulation loop in buildings
Middle of FY2016 to middle of FY2017	Completion of facility to take water from reactor building and lower part of containment vessel toward determining method of repairing (stopping water leakages) lower part of containment vessel (HP CR-1)
Middle of FY2018	Constructing small circulation loop (circulative cooling of containment vessel) of reactor water injection cooling line

④ Circulative cooling of spent fuel pool

<Basic policy> Soundness of spent fuel will be secured by continuing circulative cooling of the spent fuel pools. Chlorine ion concentration that can affect the soundness of the spent fuel pools was lowered to a value below the limit (100 ppm) by March 2013. In the future, circulative cooling will be sustained by improving the reliability of the facility and, at the same time, parameters such as temperature will be monitored and the concentration of chlorine ion will be maintained.

<Specific plan> Circulative cooling of the spent fuel pools will be continued while parameters such as temperature will be monitored. Reliability will be maintained and improved by systematically performing maintenance and inspection. In addition, spare parts of the facility will be prepared and improvement of response procedures will be continued.

As a countermeasure against outage of the onsite power system, construction work for multiplexing the power supply was completed by March 2013. In the future, a study on additional deployment of a portable diesel generator will be put forward (it is planned to add a portable diesel generator for the spent fuel pool while using the existing portable diesel generator as common equipment). In addition, effort is being made to diversify cooling of the spent fuel pool by deploying concrete pump vehicles, and this arrangement will be continued.

(2) Contaminated water treatment plan

① Preventing inflow of ground water

(a) Bypassing ground water

<Basic policy> Preparations will be made to bypass the ground water flowing from the mountain side to the ocean by pumping it up at the upstream of buildings, changing the passage of the water, lowering the water level around the buildings, and suppressing inflow of the water into the buildings. At that time, the quantity of water pumped up will be increased in stages while evaluating a decrease in the level of the ground water around the buildings, in order to prevent contaminated water in the buildings from flowing out.

(b) Water level management by sub-drain

<Basic policy> A sub-drain is installed in the vicinity of the building to pump up ground water and balance its level with an eye to preventing inflow of the ground water into the bottom of the building and buoyancy applied to the building. Before the Great East Japan Earthquake, the sub-drains of Units 1 to 4 pumped up about 850 cubic meters of ground water a day. In the future, wells (sub-drain pits) that became unable to operate due to the influences of the earthquake will be recovered, new wells will be drilled, and facilities that purify the sub-drains will be installed. In this way, the level of the ground water around a building can be more directly controlled and, by recovering the sub-drains and pumping up the ground water around the building, inflow of the ground water into the building will be held back.

[Target schedule]

FY2013 Installation of new sub-drain pits and recovery work of sub-drains, including installation of sub-drain purification facility

Middle of FY2014 Aiming at operating sub-drains

(c) Installing land watertight bulkhead

<Basic policy> Watertight bulkheads will be installed on land surrounding buildings where contaminated water from Units 1 to 4 is accumulated, so that ground water flowing from mountains toward the buildings can be shut off, that the water level around the buildings can be lowered, and that inflow of the water into the buildings can be held back. These watertight bulkheads at the land side will be installed and, as soon as possible, constructed and operated. To effectively suppress the inflow of ground water, a ground water observation network will be created to control the range of the ground water to be enclosed by the bulkheads and a study on facing (preventing rainwater from going underground by covering the ground with asphalt, etc.) will be conducted. Since the committee on countermeasures for contaminated water treatment has judged that construction work with frozen soil is appropriate, solutions to technical problems will be verified in the future while conceptual design will be put forward.

Enclosing a building over a long time with land watertight bulkheads of frozen soil is a challenge the world has never experienced and many technical problems are anticipated. Instead of entrusting contractors with this task, therefore, the government will take a step forward to support tackling this challenge, studying supports to research and development and to other relevant regulatory issues. In this case, adequately controlling the balance between the ground water around a building and the level of the contaminated water in the building will also be an important technical challenge.

[Target schedule]

From June 2013 Conceptual design, detailed design, and making construction work plan

First half of CY2013 Expansion and early preparation of ground water observation network

December 2013 Verification of workability and effect of land watertight bulkheads and water level control method (HP IW-1)

Within FY2013 Conducting feasibility study of land watertight bulkheads

First half of 2015 Start of operating land watertight bulkheads

(d) Stopping water flowing into through-holes of buildings

<Basic policy> The buildings of Units 1 to 4 have a total of 880 through-holes on their outer walls. Of these, those that are submerged in ground water and connected to the outside highly likely serve as an inflow passage of ground water. Filling these through-holes is expected to suppress the inflow of ground water. Water flowing through the through-hole may be stopped by injecting grout to the torus room. By taking these feasible measures for stopping water inflow, ground water flowing into the building will be controlled.

[Target schedule]

<Stopping water flowing into through-holes of buildings>

First half of CY2013 Analysis and planning on stopping water flowing into through-holes of buildings and start of water-stopping work from locations at which such work can be started

*Effort to stop water will be continued until feasibility of other measures is made clear

<Stopping water by filling up torus room with grout>

First half of CY2013 Start of feasibility study

Within FY2014 Aiming at making a construction plan based on the result the feasibility study

FY2017 Aiming at completing water stopping

② Removing contaminated water from seawater pipe trench

<Basic policy> Contaminated water of high concentration is accumulated in the seawater pipe

trench of Units 2 to 4. To treat the contaminated water in the seawater pipe trench at an early stage, the concentration of the radioactive substances in the contaminated water will first be measured again. Then water in the part of the trench connected to a building will be stopped, the contaminated water within the trench will be transferred, and the trench will be filled up. In addition, environment improving measures such as lowering the concentration will be taken. It is aimed at completing these measures before the land watertight bulkheads that enclose a building start operating.

[Target schedule]

Within FY2014	Aiming at completion of removal of contaminated water from seawater pipe trench

③ Reinforcing water treatment system

<Basic policy> Radioactive substances will be removed from contaminated water treated by the contaminated water treatment facility (such as the Advance Liquid Processing System (ALPS)) so that their concentration will sufficiently lower below an announced limit, and the water will be separated to purified water and to waste with the volume reduced, to decrease the quantity of the treated water stored in the contaminated water treatment facility.

To improve the reliability of the contaminated water treatment facility, the pipes of the treated water transfer line will be replaced with polyethylene pipes and the line transferring cooling water will be shortened.

[Target schedule]

Middle of FY2013	Start of full operation of part of ALPS

④ Plan to increase tanks

<Basic policy> A plan to increase the number of tanks will be made, by estimating the tank capacity needed over a middle to long term, so that contaminated water, which will increase to some extent even if measures for controlling inflow of ground water are taken, can be adequately stored. In addition, the plan to increase the number of tanks will be

flexibly reviewed and operated, while evaluating progress of each measure, so that a quick response can be made in case the measure does not function.

[Target schedule]

Middle of CY2015	Increasing tank capacity to 700,000 cubic meters
Within FY2016	Increasing tank capacity to 800,000 cubic meters (to be studied specifically in the future)

⑤ Road to completion of accumulated water treatment

<Basic policy> In the first term, measures are being taken with a policy for lowering the level of ground water so that the level of water staying in the turbine building does not rise above the ground water level. In particular, as measures to control inflow of ground water, water level will be controlled by bypassing ground water and using sub-drains, and land watertight bulkheads will be installed.

In the second term (early), drainage pumps will be installed in the reactor building to discharge contaminated water from the building. This will advance ground water level control and decrease the quantity of ground water flowing into the building. In the second term (middle), the situations of stopping water between the reactor building and turbine building and at portions of the reactor containment vessel from which water leaks will be examined and a circulation line will be build accordingly. In the second term (late), treatment of contaminated water will be completed, after water leak from the reactor containment vessel is stopped, by lowering the levels of contaminated water in the reactor building and others and of ground water around the buildings and decontaminating the inside of the buildings.

[Target schedule]

First half of CY2015	Installation of drainage pumps in reactor building
Within CY2018	Completion of stopping water from containment vessel
Within CY2020	Completion of contaminated water treatment in buildings

(3) Plan toward reducing radiation dose of entire plant and preventing expansion of

contamination

① Preventing expansion of ocean pollution

<Basic policy> In some areas of the harbor in front of the water intake channels of Units 1 to 4, concentration of the radioactive substances in seawater has not fallen below the limit of concentration defined for areas other the supervised area by a notification that sets forth the dosage limit, etc. (hereafter referred to as the “Notification”). Therefore, radioactive cesium in seawater will be eliminated. Regarding radioactive strontium which is difficult to eliminate, elimination technologies will be studied and effort will be made to bring its concentration down below the limit defined by the Notification (by 2015 at the earliest). In preparation for leakage of contaminated water into ground water, installation of sea watertight bulkheads will be completed and diffusion of radioactive substances contained in seabed sand will be blocked to improve the environment in the harbor.

Monitoring the qualities of ground water and seawater will be continued to ascertain that no additional radioactive substances spill out, and monitoring fishes in the harbor will also be continued.

<Specific plan> By the end of 2013, a fibrous absorbent purification system will be installed for the purpose of eliminating radioactive cesium from seawater in front of the water intake channels of Units 1 to 4, and the effect of this system will be verified.

Methods of getting rid of radioactive cesium and strontium in seawater and their effects will be studied at a study meeting of outside experts.

Installation of sea watertight bulkheads that are intended to prevent ocean pollution in case contaminated water leaks into ground water was fully started in April 2012 and will be completed by the middle of 2014. Earth and sand in the harbor will be gathered and covered during dredging that is performed to secure the depth necessary for large-size ships to sail, and diffusion of contamination will be prevented with an eye to improving the environment (construction work will be started in the second half of 2013).

② Waste management and reduction of radiation dose at property boundaries

<Basic policy> Emission of gas waste will be strictly controlled so that the concentration limit defined by the Notification is not exceeded, and the concentration will be reduced as much as possible by using rational techniques. Gas waste will not be released to the ocean without approval from the relevant authorities.

To reduce the radiation dosage at property boundaries, the effects of radiation additionally discharged from the plant and radiation from the debris generated after the accident and stored in the site and from the water-treated secondary waste will be lowered, and radiation dose at these property boundaries will be decreased.

<Specific plan>

(a) Gas waste management

Emission of gas radioactive substances contained in buildings will be controlled and monitored to improve the accuracy of emission control. Specifically, the quantity of the gas released to the environment will be suppressed by using a reactor containment vessel gas control system and, at the same time, dust will be kept monitored at the outlet of an exhaust system and openings of the reactor building, turbine building, waste processing building, etc.

The spent cesium absorption tower temporary storage facility and storage facilities (such as tanks and underground reservoir) are sources of emission without an exhaust system. To check if additional radioactive substances are released from these facilities, the surrounding area will be kept monitored. In addition, the accuracy of the monitoring method will be improved (within 2013).

Concentration of radioactive substances in the air around the property boundaries will be continuously monitored and ascertained that it falls below the concentration limit defined by the Notification for areas other than the supervised area.

How to take out fuel from Units 1 and 2 will be decided by HP1-1 and HP2-1.

As for Units 3 and 4, a cover will be installed on the work area to prevent dispersal of radioactive substances when fuel is extracted from the spent fuel pool, and a ventilation system will be installed (fuel extraction from Unit 3 will be started in June 2015 and from Unit 4 in November 2013).

(b) Liquid waste management

Radioactive substances of liquid waste, such as accumulated water, are cleaned by storing or a water treatment facility. Treated water produced as a result of cleaning will be appropriately managed in the future by storing it in tanks or desalinating and reusing it.

(c) Reducing radiation dose at property boundaries

A target of reducing the effective dose of radiation additionally discharged from the plant and radiation from the debris generated after the accident and stored in the site and from the water-treated secondary waste to less than 1 mSv/year by the end of 2012 was attained.

In April 2013, however, water leaked from an underground reservoir. Consequently, contaminated water staying in the underground reservoir has been transferred to the southern area in the site and the dose due to this water at the property boundaries is evaluated at 7.8 mSv/year, which exceeds a target value. By purifying the contaminated water with the ALPS, therefore, the dosage will be reduced as soon as possible.

In the future, storage and management of radioactive substances will be continued in accordance with the basic policy and the dose at the property boundaries will be lowered as much as possible. In addition, monitoring will be continued in the land and sea areas.

③ Onsite decontamination

<Basic policy> Onsite decontamination will be carried out in stages by selecting target areas, giving a priority to areas where many workers enter, setting a target dose rate, and making a specific plan according to the “Roadmap”. The target dose rate will be lowered in stages to, in the end, a level close to that before the accident.

<Specific plan> Dose around the important anti-seismic building and front gate, and in an area of entry/exit control building construction has been reduced. In 2013 and 2014, decontamination will be conducted around the welfare building and business building, Units 5 and 6 (target dose rate: 10 to 5μSv/h), and main roads (target dose rate: 30 to 20

μSv/h). From 2015, decontamination will be conducted in more places, taking the site conditions into consideration.

After the second term, onsite decontamination will be continued, taking the radiation dose in the offsite environment into account, and conditions close to those before the accident will be created in the end.

(4) Storage and management of solid waste and plan to processing and disposing of it

<Basic policy>

① Storage management

To store and manage solid waste, it is important to keep the quantity of waste generated as low as possible from the viewpoints of effective use of the site, easiness of management, and mitigating the load of processing and disposing the waste. Therefore, the top priority will be given to preventing packing materials and machines from being brought in the site, and generation of waste will be kept reduced according to priorities of “prevention of brining in materials > minimizing waste generated > reusing materials > recycling materials”.

A temporary storage area will be secured to store waste that is generated nevertheless with the top priority given to ensuring safety, so that storage measures will be continued and that effort toward disposing of the waste is smoothly made. In addition, permanent storage facilities that can shield and prevent dispersal of waste will be systematically introduced to store the waste correctly.

Measures to suppress generation of waste and to store waste will be combined as a storage management plan and periodically updated and materialized according to the progress of the work.

② Processing and disposal

Processing and disposing of solid wastes that were generated after the accident give rise to technical challenges because they have differ features from waste generate at ordinary nuclear power stations, such as n adhesion of radioactive substances deriving from damaged fuel and salt content.

Technical prospects on safety of processing and disposing of the solid wastes will be obtained by 2021 when it is expected that necessary information will be sufficiently accumulated as grasping the characteristics of the wastes and decommissioning work make progress through research and development. In parallel with that, it is necessary to conduct studies on necessary regulatory measures and make clear safety regulations and technical standards concerning processing and disposal. Based on the result of these studies, processing facilities will be installed in the plant and production of wastes to be transported to disposal sites will be started.

Extensive study and evaluation on the methods and concept of processing and disposing of solid wastes will be conducted at present to narrow down on processing and disposal technologies as grasping the characteristics of the solid wastes and decommissioning work make progress and thus knowledge and information are accumulated. Because the solid wastes generated as a result of the accident include those that have no record of having been processed or disposed of in Japan, studies will be conducted with extensive cooperation from related industries, research institutions, academic societies, and universities in Japan and abroad.

To understand the characteristics of the wastes, a radioactive substance analysis/research institute that is planned to start operating in 2017 as one of research bases should be fully used to accelerate research and development.

<Specific plan>

① Storage management

Measures for reducing the quantity of solid wastes generated will be taken in accordance with the content and priority of each measure. To prevent packing materials and machines from being brought into the plant, a vehicle maintenance facility will be newly installed in 2013 to prevent bringing in new vehicles, so that a mechanism that allows measures to prevent packing materials and machines from being brought into the plant will function in the plant will be studied. Regarding reuse and recycling of materials, some heavy machines and materials used for construction work have already been reused for other construction work but a study will be conducted in 2013 to create an environment where reuse and recycling will be further promoted. To reduce the volume of wastes, an incinerator will be installed in 2014 to process wastes that can be burned, such as used protective gears. Burned ash generated in the process of incineration will be put into drums and sealed, and stored in facilities having a shielding function, such as solid waste storage house.

As storage measures, solid wastes with a high radiation dose will be continuously stored in the existing solid waste storage shed and soil-covered temporary storage facility and will be shielded by installation of sand bags, so as to reduce exposure to radiation by workers and radiation dose at the property boundaries. Cut down trees (branches, leaves, and roots) with a higher dose rate than the surrounding environment will be stored in a cut-down tree temporary storage tank. To store these trees more appropriately, a permanent storage facility that can store 23,000 or more drums will be started to be designed in 2013 and planned to operate in 2015. Conceptual design of other permanent storage facilities will begin from 2013, taking into consideration the storage conditions of wastes and forecast of waste generation.

Storing water-treated secondary wastes requires measures based on the result of basic research in heat dissipation, gas generation, and corrosion of containers. Therefore, the long-term soundness of storage containers initially introduced will be evaluated at the end of 2013 and, as necessary, a policy on updating facilities will be concluded at the end of 2014.

② Processing and disposal

To store water-treated for long time and to process and dispose of all other solid wastes, grasping their characteristics (such as radionuclide contained, chemical composition, and physical properties) is indispensable. In 2013, the characteristics of wastes, such as debris and water-treated secondary wastes, will be grasped, techniques to analyze nuclides difficult to measure will be developed, and databases will be created. In addition, document information on concept of processing and disposing of wastes and safety evaluation, which is necessary for studying technical prospects toward safe processing and disposal, will be collected and put in order. Further, preliminary study on disposing of fuel debris, which is considered important for proceeding with disposing of wastes, will be started.

Grasping the characteristics of wastes will be continued and, by the end of 2016 when it is expected that the nuclide composition of each waste and features of contamination level can be estimated to some extent, applicability of the processing and disposal techniques extensively extracted will be studied and techniques to analyze nuclides difficult to measure, and inventory evaluation techniques will be developed. Even at this point, however, data on the characteristics of the waste will still be limited and therefore grasping the characteristics of wastes will be continued.

Based on the information gathered by the end of 2016, “basic concept on processing and disposing of wastes” will be compiled in 2017 and used as a HP to start a systematic study.

Even after 2017, a radioactive substance analysis/research facility to be newly established will be used to grasp the characteristics of solid wastes, accumulate analysis data by using development technologies, and improve the accuracy of inventory evaluation.

In parallel with obtaining technical prospects on safety of processing and disposing of wastes by 2021, regulatory measures will be studied as needed, and technical standards concerning processing and disposal must be crafted and safety regulations must be met.

Based on these, a processing facility will be installed in the plant around after 2012 and production of wastes will be started.

(5) Plan for decommissioning reactor facilities

<Basic policy> Because the reactor facilities of Units 1 to 4 at Fukushima Daiichi Nuclear Power Station are different from ordinary reactor facilities, a scenario for decommissioning those facilities will be studied and created, assuming various cases, so that decommissioning will be rationally conducted (hereafter this scenario is referred to as the “decommissioning scenario”), and a plan to decommission the reactor facilities will be made after fuel has been taken out from the spent fuel pool, water staying under the ground of the buildings has been treated, and fuel debris has been extracted from the reactor.

A decommissioning scenario will be made after estimating the assumed type and quantity of wastes, their influences on the environment, exposure to radiation by workers, techniques and processes to be applied, and prospects of disposing of the wastes.

Toward making a decommissioning scenario, necessary data, such as contamination status of the buildings and equipment and the quantity of fuel debris remaining in the reactor pressure vessel/reactor containment vessel, which can be gathered through such work as decontamination of the buildings, examination of the reactor pressure vessel/reactor containment vessel, stopping water between buildings, and taking out fuel debris, will be gathered and accumulated.

<Specific plan> Due to the influences of the accident, there is a possibility that the use range of the remaining facilities and the types and quantity of waste differ from the conditions for decommissioning ordinary nuclear power facilities. Therefore, a rational decommissioning scenario will be studied and created by referring to a wide range of examples in both Japan and abroad for concept of securing safety during decommissioning, keeping in mind the final form of decommissioning. In addition, points of discussion, such as how safety regulations should be met and a road toward institutionalization to be needed in the future, will be put in order.

The decommissioning scenario will be reviewed at a studying meeting of experts in Japan, in cooperation with academic societies.

Before starting decommissioning the reactor facilities, it shall also be noted that technical standards for disposing of wastes should be established and prospects of disposal should be obtained.

5. Creating system and environment for smoothly carrying out work

Many operations are expected to be performed in an environment with high radiation dose even after the first term. Against this background, securing workers is necessary while ensuring their safety by accurately observing a limit of 100 mSv/5 years and maintaining a cooperation system with cooperative companies as ever.

5-1. TEPCO’s implementation system toward mid- and long-term work

To smoothly carry out mid- to long-term decommissioning work, TEPCO decided in February 2012 to centrally check the health and exposure to radiation of workers, by ① creating a special system to accurately proceed with mid- and long-term decommissioning work, installing "Fukushima Daiichi Response Project Team" at the main office, and ② providing consultation on health and medical checkup to the workers in and outside the company in accordance with the level of radiation to which the workers have been exposed, creating "Nuclear Power Health & Safety Center" at the main office. TEPCO also decided in April 2013 to smoothly improve the facilities for maintaining and reinforcing stability and the reliability of operation management by creating "Emergency Special Headquarters for Improving Reliability of Fukushima Daiichi", with the president serving as the director, to quickly study and take measures against ③ risks at the on-site facilities, in light of occurrence of troubles in power facilities, spent fuel pool cooling facilities, and accumulated water storage facilities.

5-2. Worker plan toward mid- to long-term work

(1) Prospect of the necessary number of workers

The number of workers deemed necessary for the work planned for the next three years was estimated and it was confirmed that the number of workers in each year would be in the same scale as before.

In the middle to long term, work different from that in the past, such as work in the reactor building where the radiation dose is high and extraction of fuel debris, must be done, and technologies necessary for such work must be developed in the future. Therefore, the number of workers necessary will be reviewed each time the Roadmap is revised.

(2) Prospect of securing workers

In the short term, the necessary number of workers is expected to be secured because it is not expected at this point that the necessary number of workers rapidly increases, judging from the trend of the number of workers and employees registered, an increase in the number of workers whose total radiation dose is constant or higher than a specific level, the trend of new people entering the site, and the number of workers planned to be necessary in the future.

In the middle to long term, work different from that in the past, such as work in the reactor building where the radiation dose is high and extraction of fuel debris, will be necessary and technologies must be developed in the future. Therefore, the prospect of the necessary number of workers will be reviewed each time the Roadmap is revised, and effort toward securing the necessary workers will be studied.

(3) Future approach toward securing workers

① Short-term approach

In the short term, TEPCO, united with the cooperative companies, will try to stably secure workers while proceeding with technical studies on work methods and processes. In addition, by presenting future work plans to the cooperative companies early, it will make systematic arrangements for workers.

Specifically, these measures will be taken: ① placement of necessary workers by the cooperative companies or change of the placement based on expected dose to which workers will be exposed in carrying out work, ② improvement of the work environment to lighten the load of workers (reduction of exposed dose at workplace and rest area), ③ providing consulting services to respond to requests from workers to solve problems and improve labor conditions, and ④ providing training on radiation control based on the needs of the cooperative companies.

② Mid-term approach

Having compared the exposed dose of experienced workers and that of general workers, it was found that the experienced workers were exposed to a slightly higher radiation dose than the general workers. To accurately proceed with decommissioning over a long time, therefore, appropriately deploying human resources with advanced skills and abundant knowledge in the middle and long terms is important, and therefore, workers will be systematically trained and secured.

To this end, measures to train and secure human resources will be taken. These measures will include ① systematic training of skilled workers by early presenting the future work plan to the cooperative companies, and ② study of procurement policy giving consideration to securing workers over a middle and long terms, appropriate control of radiation dose to which skilled workers are exposed, and stable local employment.

5-3. Plan toward improving work environment and conditions

（１） General work safety

① Continued safety activities

As a result of conducting prior study meetings and safety patrol, the number of the injured decreased in 2012 to 25, less than half of 59 in 2011. Since work under severe environment and new work different from than that before are required in 2013, effort will be made to eradicate injuries of workers by repeatedly raising the safety awareness of the workers, and ① conducting prior study meetings witnessed by TEPCO's construction work supervisor, ② evaluating in advance the safety of new construction methods and work peculiar to Fukushima Daiichi Nuclear Power Station, and ③ continuously holding a safety promotion liaison meeting with the cooperative companies.

② Improvement of rest area

Rest areas for workers working at Fukushima Daiichi Nuclear Power Station is being expanded and improved systematically. Specifically, these measures are being taken: ① revamping the old registration center so that it can be used as a rest area (use of the whole of this area will be started in the second half of 2013, though part of it has already been used) and ② creating a large-size rest area near the front gate (planned to be used at the end of 2014).

③ Heat stroke preventive measures

The number of workers suffering from a heat stroke decreased in 2012 to seven from 23 in 2011 as a result of continuously taking measures to prevent a heat stroke in the season of intense heat. Since the effect of the heat stroke preventive measures was confirmed, effort will be made to reduced the number of those who suffer from a heat stroke by continuously taking measures such as ① shortening work time by using WBGT[4] and changing the content of work, ② limiting the duration of work under the blazing sun (14:00 to 17:00 in July and August), and ③ encouraging workers to wear cooling vest.

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[4] Wet Bulb Globe Temperature: Index by which to judge the degree of risk when working under environment of intense heat

(2) Radiation control

① Optimizing protective gears

Areas where a full-face mask does not have to be worn will be gradually expanded to lighten to the load of the workers and improve workability by confirming that concentration of radioactive substances in the air is sufficiently below the level requiring the workers to wear a full-face mask and by making every possible effort to control exposure to radiation.

For work in an area where a full-face mask does not have to be worn, wearing a disposable dust mask is permitted for work in an area where concentration of dust is low, and wearing a surgical mask is permitted at the front gate and in the neighborhood of an entry/exit control area (area where the radiation substance concentration of the soil is below 1×10^4 Bq/kg). Protective gears will be optimized in stages to mitigate the workload of the workers and improve the workability.

② Improving exit/entrance base

At present, exit from and entrance to Fukushima Daiichi Nuclear Power Station are controlled (i.e., screening, wearing and taking off protective clothes, and wearing a radiation meter) at J Village. This function will be transferred to Fukushima Daiichi Nuclear Power Station as the danger zone and evacuation directive zone will be reviewed, and an entrance/exit control facility is being constructed near the front gate of the power station (this facility will start operating in the first half of 2013).

Of the exit/entrance control functions, screening and decontaminating the exterior of vehicles have already implemented at Fukushima Daiichi Nuclear Power Station since August 2012.

(3) Health care

① Continuously securing medical delivery system

Until the regional medical delivery system is restored to some extent, the medical delivery system at each base, including Fukushima Daiichi Nuclear Power Station and Fukushima Daini Nuclear Power Station, will be continuously secured to ensure the safety and security of the workers, by ① deploying medical workers, including doctors, and necessary medical equipment, materials, and supplies, ② deploying paramedics, and ③ maintaining a system to transport patients to external medical institutions.

③ **Implementation of long-term health care**

Based on “Guideline to Health Promotion of Emergency Workers, etc., at TEPCO's Fukushima Daiichi Nuclear Power Station” set forth by the Ministry of Health, Labor and Welfare of Japan, long-term health care of the workers will be implemented even after they have left decontamination and decommissioning work or retired from the company by ① providing a health care consulting service and ② continuously taking measures such as examination for cancer.

(4) Approach toward securing appropriate labor conditions

Understanding that ensuring that all the workers performing decontamination and decommissioning work at Fukushima Daiichi Nuclear Power Station can work under correct labor conditions is of vital importance for recovery from the accident, and following instructions by the supervisory authorities, approach of the cooperative companies to securing correct work conditions will be examined in cooperation with the prime contractor, and activities to provide, spread, and enlighten workers on correct labor conditions will be continued, and requests from workers sent to the contact point of the consulting services will be responded.

6. Research and development, and human resources development

6-1. Research and development

Not only TEPCO but also the government should play a leading role in analyzing radioactive substances and research and development such as development and experiment of remote control systems when promoting decommissioning of Fukushima Daiichi Nuclear Power Station.

The Government of Japan and TEPCO Council on Mid-to-Long-Term Response for Decommissioning which was established as a system that will work on decommissioning under the supervision of Nuclear Emergency Response Headquarters was abolished, and the Council for the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station was newly established in February 8, 2013. As the members, major institutions related to decommissioning as well as TEPCO participate in the council to reinforce effort toward taking out fuel debris and integrally promote management of progress of work at the site and research and development.

(1) Basic concept in conducting research and development

To proceed with decommissioning, it is important to always reflect the situations and knowledge and information at the site on the content of research and development. In particular, alternative policy will be studied in solving problems that are considered to have high technical hurdles, such as repairing techniques for filling the reactor containment with water, because there is a possibility that the techniques that can be applied substantially differ depending on the result of on-site survey.

The Agency of Natural Resources and Energy will play a leading role in compiling budget for research and development and managing projects in close cooperation with the Ministry of Education, Culture, Sports, Science, and Technology, and related organizations. The Japan Atomic Energy Agency (JAEA) will support the research and development with its expertise and efficient use of facilities and steadily put forward basic and fundamental research and development, responding to the site, putting its focus on securing and training human resources from the mid- to long-term viewpoints.

When a test or experiment is conducted at the site to promote research and development, the top priority must be given to the safety of the local residents and at workplace. It is also important to meet the relevant regulations quickly.

(2) Research and development project

The research and development project crafted in June 2012 will be reviewed as the processes involving in extraction of fuel debris are advanced.

The first term will be an intensive preparatory period toward decommissioning, in which preparations for starting taking out fuel from the spent fuel pool will be made, research and development necessary for extracting fuel debris will be started, and on-site survey will be started.

In the second term, research and development and work to repair the reactor containment vessel will be fully started toward extracting fuel debris. The third term will be an execution period that will start from taking out fuel debris and end with completion of decommissioning.

6-2. Basic concept of research and development promotion system

Research and development will not be conducted individually but a plan will be crafted according to the overall progress and the system will be flexibly reviewed by establishing a research and development operation organization that takes charge of central management.

At the Council for the Decommissioning held March 7, 2013 (first time), it was reported by four members, including TEPCO, that preparation for establishing the research and development operation organization would be accelerated. After that consultation was repeatedly conducted among parties concerned, preparation for launching the research and development operation organization is being made.

6-3. Improving research and development base facilities

To establish a technical basis for analysis and research of radioactive substances and disaster response robots, facilities that develop and experiment on remote control equipment and system (mock-up facilities) and radioactive substance analysis/research facilities will be set up. These facilities will be used for research and development toward decommissioning nuclear power plants, including response to Fukushima Daiichi Nuclear Power Station. In establishing such facilities, international joint research and acceptance of human resources from abroad will also be considered.

At present, the JAEA is studying establishment of these facilities, playing a central role in construction and operation of the facilities.

6-4. Human resources development from mid- to long-term viewpoints and cooperation with universities and research institutions

Since it is expected that completion of decommissioning requires 30 to 40 years, it is important to secure and develop human resources from the mid- to long-term viewpoints in moving ahead the work at the site and research and development projects related to decommissioning. To this end, it is necessary to develop human resources in cooperation with education and research institutions, such as universities, JAEA, and private sector, under the powerful human resources development promotion system of the government.

In that event, the Council for the Decommissioning will set priority areas related to human resources development from the mid- to long-term viewpoints and select core universities and research institutions (core bases) with cooperation from the government, JAEA, and private sector.

7. Cooperation with international community

To efficiently and effectively take large-scale and long-term approach to decommissioning, it is important to gather and use wisdom and intelligence from Japan and abroad and to effectively use the knowledge and experience of other countries in responding to nuclear accidents. It is important for Japan to actively send information to the world and put decommissioning forward in a manner transparent to the international community as a country where the nuclear accident like this occurred, taking responsibility for the international society.

In April 2013, a review mission (research group comprising of experts) from the IAEA was accepted and its evaluation and advices on various problems related to the mid- to long-term roadmap and decommissioning work were received. It is planned to accept the second review mission in fall of 2013.

Continuously, the cooperation with the international society will be enhanced through multilateral cooperation frameworks such as the IAEA, Organization for Economic Cooperation and Development (OECD)/Nuclear Energy Agency (NEA), and bilateral cooperation frameworks such as with the US, the UK, France, and Russia.

In addition, appointment of an international adviser who gives advices to the research and development operation organization to be newly established with an eye to decommissioning and forming an international decommissioning expert group made up of international cooperation departments and experts in various fields are considered, and, by taking these measures, cooperation with the overseas and domestic research institutions and parties concerned will be reinforced.

It is also important to quickly improve an environment that encourages participation of overseas research institutions and businesses having knowledge and information on decommissioning measures in decommissioning work at Fukushima Daiichi Nuclear Power Station. For example, some overseas companies, though having knowledge and information on decommissioning, are concerned about risk of lawsuits for possible compensation that may accompany decommissioning work and are hesitating in participation.

8. Coexistence with regions and communication with all layers of nation

8-1. Coexistence with regions

Activities to decommission Fukushima Daiichi Nuclear Power Station are concerned with the safety and security of the residents in the neighboring regions and it is important to carry out each process of work from the viewpoint of coexistence with these regions. In addition, it is expected that local businesses and manpower are actively used in developing technologies, including systems and equipment, and procuring materials. Therefore, local economy should be revitalized by encouraging local companies, which will supply machines and materials needed for decommissioning, and founding new companies. TEPCO will encourage its supplies to place an order for materials with local companies.

It will also try to revitalize the local economy through its efforts to provide opportunities to local companies to find customers in Fukushima prefecture.

In addition, local employment will be created through establishment of facilities that develop and experiment on remote control equipment and systems intended for decommissioning (mock-up facilities) and of radioactive substance analysis/research facilities.

8-2. Reinforcing communication with all layers of nation, including local residents

(1) Active supply of information

The government will keep supplying information to Fukushima prefecture and 13 related cities, towns, and villages through television conference system and by periodically explaining the progress of the mid- to long-term roadmap through direct visit to individuals.

TEPCO will provide municipalities with information on the progress of decommissioning at the power station regularly and on shutdown of the nuclear fuel cooling function and nitrogen sealing system immediately, based on “Agreement Concerning Securing Safety around Nuclear Power Station” and “Agreement Concerning Report on Nuclear Power Station” that TEPCO concluded with the municipalities. TEPCO will also supply information in appropriate manner and at appropriate time to the society, not least the local residents. Especially, information on an accident or a trouble must be quickly and accurately transmitted to the society. It is also important to supply information in response to changes of what the society is interested in and changes in the situation. TEPCO is taking seriously the cases in which it was late in announcing in the past and will make improvements. In the future, it will make clear its criteria on announcing accidents and troubles.

TEPCO and the government will continue creating easy-to-understand brochures and documents to supply detailed information to the local residents, and delivering them to each household in cooperation with the municipality. Effort will also be made to supply information through bidirectional communication activities. In addition, policy for deepening communication with the local residents further will be studied.

(2) Risk communication

Decommissioning work involves risk to a greater or lesser extent, and the basic concept of risk management is to minimize such risk. It is important to accurately assess risk and keep having a dialog with the society over risk and policy for reducing the risk.

9. Conclusion

TEPCO and the government will steadily make mid- and long-term effort toward decommissioning in accordance with this Roadmap with an appropriate cooperation system in order to allow the residents who have evacuated to return their home as soon as possible and to remove the anxiety of the people in the region and across the nation.