

(Provisional translation)

Mid-and-long-Term Roadmap towards the
Decommissioning of Fukushima Daiichi Nuclear
Power Station Units 1-4, TEPCO

December 21, 2011

Nuclear Emergency Response Headquarters
Government and TEPCO's Mid-to-Long Term
Countermeasure Meeting

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1. Introduction

After the accident at TEPCO Fukushima Daiichi nuclear power station, TEPCO and the government prepared the “Roadmap towards Restoration from the Accident at Fukushima Daiichi Nuclear Power Station”, and pursued planned action on that basis towards an early resolution to the accident. The first objective of the above roadmap, the “steady downward trend in radiation levels” was achieved in July 2011, and the objective of Step 2, “Release of radioactive materials is under control and radiation doses are being significantly held down” has recently been achieved. Through these efforts, the reactors have reached a state of cold shutdown, and it is now possible to maintain an adequately low level of radioactive exposure at the site boundaries, even in the event of unexpected situations. Therefore, in addition to the reactors of TEPCO Fukushima Daiichi nuclear power station to reaching a stable state, the impact of radiation beyond the plant site has been adequately reduced.

After the end of Step 2, there will be a transition from efforts up to that point, aimed at plant stabilization, to efforts to reliably maintain that stable state. In parallel, it is vitally important that the removal of fuel from the spent fuel pools of units 1–4, removal of fuel debris¹ from the reactor pressure vessels and primary containment vessels (PCVs) of units 1–3, and other measures towards decommissioning, should continue over the mid-and-long term, so that evacuated residents will be able to return to their homes as soon as possible and the people of the region, and of the country as a whole, will be able to live without fear.

For this kind of mid-and-long term efforts, the Expert Group for Mid-and-long Term Action at TEPCO Fukushima Daiichi Nuclear Power Station (referred to below as the “Japan Atomic Energy Commission Expert Group”), which was established by the Japan Atomic Energy Commission in August, is examining technical challenges and research and development points. It has concluded that “The target is that it will take no more than ten years before removal of fuel debris starts. We estimate that the completion of decommissioning will take at least 30 years”.

On November 9, Mr. Edano, the Minister of the Economy, Trade and Industry, and Mr. Hosono, the Minister for the Restoration from and Prevention of Nuclear Accident, issued an order (referred to below as “the joint ministerial order”) on the writing of a mid-and-long term roadmap for decommissioning and other objectives (referred to below as “this roadmap”) to TEPCO, the Agency for Natural Resources and Energy, and the Nuclear and Industrial Safety Agency.

Furthermore, with the completion of Step 2, the Government-TEPCO Integrated Response Office was abolished and the Government and TEPCO’s Mid-to-Long Term Countermeasure Meeting was established under the Nuclear Emergency Response Headquarters to manage the preparation and progress of this roadmap.

This roadmap was written by the above three parties, in response to the joint ministerial order, and decided by the Council.

This roadmap defines the period from the completion of Step 2 to the start of fuel removal from the spent fuel pools (target is within two years), as Phase 1. In addition to work preparing to start removing fuel from the spent fuel pools, this phase will include

¹ Material in which fuel and its cladding tubes etc. have melted and resolidified.

research and development necessary for the removal of fuel debris, the start of site investigations using the results of that R&D, and other tasks in a period of intensive preparation for decommissioning to begin in earnest.

Beyond Phase 1, this roadmap defines the period targeted to start ten years after the completion of Step 2 and continuing to the start of fuel debris removal, as Phase 2, and the subsequent period to the end of decommissioning as Phase 3.

The implementation of this roadmap is a long-term task that faces many technically difficult challenges that have never been experienced before, so it is important to bring together the collective wisdom of the nation as the government and TEPCO work in close partnership.

2. Basic Policy towards Addressing the Mid-and-long Term Issues

[Policy 1] Systematically tackle the issues while placing top priority on the safety of local citizens and workers.

[Policy 2] Move forward while maintaining transparent communications with local and national citizens to gain their understanding and respect.

[Policy 3] Continually update this roadmap in consideration of the on-site situation and the latest R&D results etc.

[Policy 4] Harmonize the individual efforts of TEPCO, ANRE, and NISA to achieve our goal.

- ◆ Based on the above policy, TEPCO, the Agency for Natural Resources and Energy, and the Nuclear and Industrial Safety Agency, will take appropriate action on the basis of the following policies, aware of the importance of realizing this roadmap.
 1. With the shared awareness that many of the tasks involved are unprecedented and of great technical difficulty, they will collaborate with relevant industries and research agencies to implement the necessary research and development, and to apply it to the site.
 2. TEPCO will set detailed Holding points at each juncture as these results are obtained, and take on-site conditions into consideration in appraising the feasibility and suitability of the technologies to be applied, as it works steadily through action in the mid-and-long term and builds an organization to that end.
 3. The Agency for Natural Resources and Energy will take a leading role in budgetary provisions and project management for the above research and development, and provide appropriate guidance and supervision to the work of TEPCO.
 4. The Nuclear and Industrial Safety Agency will prepare necessary regulatory systems for work in the mid-and-long term, and confirm that safety is assured in work by TEPCO.
 5. TEPCO, the Agency for Natural Resources and Energy, and the Nuclear and Industrial Safety Agency will maintain transparency by periodically reviewing this plan and publishing the status of work in the mid-and-long term.

3. Approach to Ensuring Safety

3-1. Basic Policies on Ensuring Mid-and-long Term Safety

(1) Facilities Operation Plan Based on the Concept of Ensuring the Mid-Term Safety

To ensure the safety of Fukushima Daiichi nuclear power station after the accident, Step 1 and Step 2 provided cooling to the damaged reactor cores through injection and circulation of water, provided circulating cooling to the spent fuel pools, processed and prevented the leakage of water contaminated with high-level radioactivity, injected nitrogen gas into the PCVs to prevent hydrogen explosions, and restored power supplies lost in the accident, among other actions. Furthermore, key equipment was installed with redundancy and diversity to ensure availability of necessary functions in the event of an accident. With the completion of Step 2, the cooling of the reactors is maintained in a stable state, and the amount of public exposure to additional emissions from PCVs has been greatly suppressed.

To ensure the safety of the public and workers in the period extending from the completion of Step 2 to the start of specific work towards decommissioning, the Nuclear and Industrial Safety Agency published “SAFETY DIRECTIVE Ensuring the Mid-Term Safety” on October 3rd, and TEPCO responded by publishing its “Facilities Operation Plan Based on the SAFETY DIRECTIVE Ensuring the Mid-Term Safety”.

The Nuclear and Industrial Safety Agency confirmed that this facilities operation plan provided suitable measures for the following:

- It must be possible to appropriately remove decay heat from the reactor pressure vessels and PCVs.
- Hydrogen explosions in the PCVs must be prevented.
- Decay heat must be appropriately removed from the spent fuel pools and transported to a location for ultimate release.
- It must be possible to prevent criticality in the reactor pressure vessels and PCVs.

These measures together, devised appropriately, make it possible to rapidly restore cooling function from backup functions in the event that an accident causes a loss of cooling function, and even if extremely severe conditions are envisaged for such an accident, it is confirmed that radioactive exposure levels at the site boundaries would be adequately low.

Over the coming three years, TEPCO is to ensure to implement this facilities operation plan, reporting regularly to the Nuclear and Industrial Safety Agency. NISA will check and assess the safety of TEPCO's efforts, based on those reports and its own independent investigations. Based on the results of those assessments, it can revise individual items in “SAFETY DIRECTIVE Ensuring the Mid-Term Safety” at any time, as the need arises, and make an overall review at least once per year, to ensure the safety of the power station.

(2) Main basic goals for ensuring the safety of mid-and-long term actions

In the mid-and-long term, removal of fuel from the spent fuel pools, removal of fuel debris from reactor cores, and other tasks will be performed to move fuel from the accident-affected pools in the reactor buildings and fuel from the reactor cores to

common pools and storage containers, which are in more stable condition. Safety measures must be devised for this fuel removal work, to prevent accidents such as dropped fuel in the removal process causing new emissions of radioactive substances.

TEPCO will continue to consider specific working methods for these tasks on the basis of basic targets indicated by the Nuclear and Industrial Safety Agency. At each stage, it will assess the safety of equipment and procedures (including earthquake resistance) and the radioactive impact on the surrounding environment, and will receive assessment and confirmation from the Nuclear and Industrial Safety Agency before implementation.

<Main basic goals for ensuring the safety of mid-and-long term actions>

1. It must be possible to identify emission sources of radioactive substances, devise appropriate anti-emission measures, and perform monitoring.
2. It must be possible to appropriately remove decay heat from the reactor pressure vessels, PCVs and spent fuel pools.
3. It must be possible to prevent criticality in the reactor pressure vessels, PCVs and spent fuel pools.
4. It must be possible to appropriately detect, manage and process flammable gases.
5. The effective dose caused by the reactor facilities must be reduced as far as is rationally attainable.
6. Even in the event of any temporary loss of safety-related function, the amount of exposure due to additional emissions of radioactive substances at the site boundaries must have no adverse effect on safety.
7. Worker radiation exposure must comply with the law.

3-2. Policies for Ensuring Safety

(1) Equipment safety

In the same way as Step 2, Phase 1 will maintain and strengthen [1] functions for the suppression and management of radioactive substance emissions, [2] cooling functions in the reactors and spent fuel pools, [3] criticality prevention functions, and [4] hydrogen explosion prevention functions. Specifically, in addition to improvement of accumulated water processing facilities and addition of continuous monitoring functions against recriticality, the operational status of the equipment will be checked continuously, and necessary measures will be devised, to further improve reliability. The plan to start removing fuel from the spent fuel pool and further stabilize the plant is in parallel with that work.

In Phase 2 and beyond, the equipment necessary to maintain plant stability in the long term will continue to receive work to enhance its reliability, including appropriate maintenance and management. The removal of fuel debris and other operations will transition the plant into a state that can be maintained stably without depending on the above equipment, to be followed by final decommissioning.

(2) Working safety

General working safety, radiation management and health management for workers will continue and expand the work that was under way up to Step 2, including preliminary safety assessment, dose reduction measures, medical treatment organization development, and other measures.

For radiation management, monitoring of the working environment will be expanded, dosage management will be implemented thoroughly, dosage due to decontamination etc. will be reduced. Robots and other remote operation technologies will be applied as appropriate in high-radiation environments. These and other measures will cut amounts of exposure to workers to below exposure limits.

(3) Reduction and management of radiation levels at site boundaries

The reactors are now being cooled stably, emissions of radioactive substances from PCVs have been suppressed, and as a result, annual radiation exposure at site boundaries is assessed at a maximum of 0.1 mSv/year. Furthermore, the target to be achieved within FY2012 is to cut effective dose at the site boundaries to below 1 mSv/year. This is to be achieved by reducing the impact of additional emissions from the power station as a whole, and of radiation from rubble etc. and secondary waste from water processing (used cesium adsorption towers, sludge, etc., collectively referred to below as "secondary waste from water processing"), which are generated after the accident and stored on site.

In addition to the above, decontamination within the site will be implemented systematically to further reduce radiation at the site boundaries.

For gaseous waste, efforts to further reduce environmental emissions will continue, together with emission monitoring. For liquid waste, the following necessary deliberations will be made in future and used to devise countermeasures, and discharges of contaminated water to the ocean will not be made lightly.

[1] Radical countermeasures against inflow of groundwater to reactor buildings, which raises water levels

[2] Measures to raise the decontamination capacity of the water purification facilities and ensure their stable operation, including substitute facilities to use in case of failure

[3] Further installation of land-based facilities for contaminated water management

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

To confirm that there is no abnormal situation, airborne radiation dosage rates and radioactivity of environmental samples will be monitored continuously, near the boundaries of the perimeter monitoring areas and in nearby areas.

(4) Other safety matters

Appropriate measures will be implemented, under the relevant laws and the guidance of the national government and related agencies, concerning physical protection of nuclear material, and nuclear material safeguards.

4. Phase Divisions and Timed Targets in the Mid-and-long Term Roadmap

Appendix 1-1 presents the main schedule of this Mid-and-long-term Roadmap for Decommissioning Reactors 1–4 of Fukushima Daiichi Nuclear Power Station. This roadmap was prepared jointly between TEPCO, the Agency for Natural Resources and Energy, and the Nuclear and Industrial Safety Agency, based on December 7 report from the Japan Atomic Energy Commission Expert Group and the joint ministerial order issued on November 9, and drawing on currently-available knowledge, such as the case of stabilizing the US TMI-2 accident². The three parties performed the roles stated in Chapter 2, and are working steadily on the implementation tasks stated in this roadmap.

The processes and tasks in this roadmap are subject to revision due to future on-site circumstances, research and development results and other inputs, and will be revised accordingly through an ongoing process of verification.

4-1. Approach to Categorization in the Mid-and-long Term

This roadmap employs the following definitions for Phase 1–3.

- Phase 1: From the completion of Step 2 to the start of fuel removal from the spent fuel pool (target is within two years)
 - In addition to work preparing to start removing fuel from the spent fuel pool, this phase will include research and development necessary for the removal of fuel debris, the start of site investigations, and other tasks in a period of intensive preparation for decommissioning.
- Phase 2: From the end of Phase 1 to the start of fuel debris removal (target is within ten years)
 - Within this phase, we will step up many research and development tasks towards the removal of fuel debris, and tasks such as reinforcement of PCV.
 - This phase will be further divided into three steps: early, mid, and late, as a guideline for judging progress within the phase.
- Phase 3: From the end of Phase 2 to the end of decommissioning (target is 30–40 years)
 - This is the phase for implementation of tasks from fuel debris removal to the end of decommissioning.

4-2. Timed Targets and Holding points in the Mid-and-long Term Roadmap

For the immediate period of approximately three years (to the end of FY2014), including Phase 1, we have set the progression for each year, with timed targets wherever possible. In FY2015 and beyond, the timing and content of measures are subject to major change in response to on-site circumstances, research and development results, and other inputs. Therefore, rough timed targets have been set as far as possible. The tasks within each Phase also face many technical issues, and will have to proceed in a phased process, based on on-site circumstances, research and development results, safety requirements, and other circumstances. Therefore, at the key points for judgment on progression to subsequent processes, there will be

² Unit 2 of Three Mile Island nuclear power station at US.

further deliberation and judgment, including additional research and development and revision of process and task content. These are set as Holding points (HP).

The main timed targets and holding points (HP) in this roadmap are as follows:

(1) Reactor cooling / accumulated water³ processing

- Methods to improve the reliability of the existing water processing facilities will be considered, with implementation of the main measures by FY2012, and ongoing improvements thereafter.
- Multi-nuclide removal facilities will be installed within 2012 that will be able to remove radioactive substances other than Cesium, which are difficult to remove with the existing facilities.
- Scale down of circulation loop will be implemented in stages, by improving the reliability of the existing water processing facilities, and by measures in Phase 2 (mid), such as stopping inter-building water leakage and repairing lower part of the PCV.
- Accumulated water processing of water in the turbine building and reactor buildings will be completed in Phase 2 (late).

<Holding points concerning accumulated water processing>

Methods for working to reduce accumulated water could change according to the success or failure of stopping inter-building water leakage and repairing lower part of the PCV, so the following related holding point is set:

(HP1-1): Completion of stopping inter-building water leakage between reactor and turbine buildings and repairing lower part of the PCV [Phase 2 (mid)]

(2) Plans to Mitigate Sea Water Contamination

- Should underground water be contaminated, in order to prevent underground water flowing into the ocean, installing water shielding walls by mid FY2014
- A silt fence will be installed on the side of units 5 and 6, and the seabed areas in front of units 1-4, and of units 5 and 6, will be covered with solidifying seabed soil, to prevent diffusion of seabed soil. In addition, circulating seawater purification facilities will continue to operate in the area in front of the intake canal for units 1-4, with the target of reducing radioactive substance concentrations in seawater in the port below the limit outside of the environment surveillance area, as stipulated by government notification, within FY2012.

(3) Plans for Radioactive Waste Management and Dose Reduction at the Site Boundaries

- Plans to reduce the effective radiation dose at the site boundaries to below 1 mSv/year within FY2012 as a target date, due to additional emissions from the whole site and radioactive waste stored on the site after the accident (secondary waste materials via water processing and debris etc.).

³ Contaminated water accumulated in the turbine buildings and reactor buildings of units 1-4

- Based on the form of secondary waste due to water processing that is now in progress, and the estimated lifespan of storage containers, a facility renewal plan for storage containers etc. will be adopted by the end of FY2014.
- Facilities will be updated as necessary, in Phase 2 (late) and beyond.

(4) Plan to Remove Fuels from Spent Fuel Pools

- Plan to start fuel removal from Unit 4 within 2 years after completing Step 2 (within 2013).
- Plan to start fuel removal from Unit 3 approximately 3 years after completing Step 2 (end of 2014).
- As for Unit 1, plan to develop a specific fuel removal plan based on knowledge and experiences at Units 3 & 4 and investigations of rubble, and finish fuel removal in the Phase 2 (mid).
- As for Unit 2, plan to develop a specific fuel removal plan based on the situation after the inside-building decontamination etc. and investigations of the installed facilities, and finish fuel removal in the Phase 2 (mid).
- Plan to complete fuel removal from all Units during Phase 2 (late).
- Plan to determine reprocessing and storing methods for removed fuels during Phase 2 (late).

<Holding points concerning removed fuel>

The following holding points are set for the handling of removed fuel, because it will be necessary to base such handling on assessment of the soundness of long-term storage and research and development results for reprocessing.
 (HP2-1): Determination of methods for reprocessing and storing spent fuel
 [Phase 2 (late)]

(5) Fuel Debris Removal Plan

- Plan to start fuel debris removal in the first unit within 10 years after completion of Step 2.
- Research and development concerning construction methods, equipment development and other topics will be implemented for realization of the plan. Implementation of this plan will include thorough demonstration of the suitability of technologies produced by this research for use on the site (referred to below as "field test").
- The products of the development of remote decontamination technology, to be completed by the end of FY2013, will be applied on site, as appropriate. Other than decontamination within the reactor buildings, this technology will be used to develop technology for identification of PCV leakage point (by around mid-FY2014, including field test). That will be used for decontamination within reactor buildings by the end of FY2014, to gain access to building interiors, and begin surveying PCV leakage point, and making PCV internal investigations of reactor containment from outside.

<Holding points concerning fuel debris removal work etc.>

The following holding points are set on the basis of the on-site situation,

research and development results (including field test), and the situation of safety requirements, etc. Holding points are also set concerning the handling of the removed fuel debris.

- (HP3-1): Determining methods for repairing PCV, determining water stop methods [Phase 2 (early)]
(Target research and development timing)
End of field test of PCV repairing technology (inter-building, lower parts of PCV)
: Around the end of FY2015
- (HP3-2): Completion of flooding of lower parts of PCV, determining PCV internal investigation methods [Phase 2 (mid)]
(Target research and development timing)
End of field test of PCV internal investigation technology: Around the end of FY2016
- (HP3-3): Determining methods to repair upper parts of PCV [Phase 2 (mid)]
(Target research and development timing)
End of field test of PCV upper part repairing technology: Around the end of FY2017
- (HP3-4): Completion of flooding of upper parts of PCV, determining RPV internal investigation methods [Phase 2 (late)]
(Target research and development timing)
End of field test of reactor pressure vessel internal investigation technology: Around mid-FY2019
- (HP3-5): Determining fuel debris removal method and completion of preparation of fuel debris containers, etc.
[Phase 2 (late)]
(Target research and development end timing)
End of field test of fuel debris removal technology: Around the end of FY2021
End of development of fuel debris containers: Around the end of FY2019
Establishment of a fuel debris weighing and management policy: Around the end of FY2020
- (HP3-6): Determining processing / disposal methods of fuel debris. [Phase 3]

(6) Reactor Facilities Demolition Plan

- Plan to complete the reactor facility demolition in Units 1 to 4 within 30 to 40 years after the completion of Step 2.
(Reference) Demolition of one reactor unit is expected to take over 20 years, judging by the time taken for fuel debris removal at TMI-2 (over four years) and the standard demolition process for regular reactor facilities (around 15 years).
- The plan for establish a basic database of on-site contamination status etc., which will be required for consideration of demolition and decontamination engineering methods, is to be written within FY2012.

- A basic database for use in demolition of reactor facilities will be built between Phase 1 and Phase 2 (mid).
- Research and development of remote demolition (disposal standards etc. for demolition waste) for remote demolition of reactor facilities, based on the above database, will be implemented between Phase 2 (mid) and Phase 3.

<Holding point for demolition of reactor facilities>

- (HP4-1): Determining demolition and decontamination engineering methods. Developing disposal standards for dismantled waste. [Phase 3]
-> Begin the design and manufacture of devices and equipment necessary for demolition and disposal.
- (HP4-2): Outlook for disposal of demolition waste. Complete research & development and make plans. [Phase 3]
-> Begin demolition.

(7) Radioactive Waste Processing and Disposal Plan

- The form of waste generated after this accident differs from that generated normally in nuclear power stations (nuclide composition, salt content, etc.), so a plan for research and development related to its processing and disposal will be written within FY2012.
- The form of waste materials will be identified and their quantities assessed by the end of FY2014.
- The disposal concept will be devised in Phase 2 on the basis of the results.

<Holding points for radioactive waste processing and disposal>

The aim is to carry these wastes to disposal sites at the end of Phase 3 together with waste generated in the demolition works, subject to the setting of the following holding points. Consideration of this area will continue, reflecting research results.

- (HP5-1): Confirm the suitability of existing disposal concepts for the forms of waste [Phase 2 (mid)]
- (HP5-2): Confirm the outlook for safety in the processing and disposal of waste [Phase 2 (late)]
- (HP5-3): Confirm solid waste specifications and manufacturing methods [Phase 3]
- (HP5-4): Installation of solid waste manufacturing equipment and the outlook for processing [Phase 3]

5. Specific Plans for Mid-and-long Term Action

5-1. Efforts for Maintaining Plant in an Ongoing Stable State

(1) Plan for reactor cooling

1. Ongoing monitoring of reactor cold shutdown states

The reactors have already reached a state of cold shutdown in Step 2. In the period until the end of fuel debris removal in Phase 1 and beyond, cooling by water injection will continue as the reactor interior is reliably cooled. The stable

maintenance of the state of cold shutdown will be monitored continuously, using parameters such as temperature and pressure. To complement the above monitoring, optical fiber instruments will be inserted into the PCVs, first in Unit 2, to permit at least partial observation of the interior, for direct confirmation of water level, temperature, and other circumstances. Implementation for units 1 and 3 will be judged on the basis of results from Unit 2 and the findings of on-site investigations.

2. Improving the reliability of circulating water injection cooling equipment

The equipment for coolant water injection to the reactors current draws water from the turbine building and stores water that has been processed by accumulated water processing equipment in the processed water buffer tank. The stored water is used as the source for injection to units 1–3, via three normal reactor injection pumps on the hill and water injection lines.

As a backup for this equipment, two systems of tanks and water injection lines have been ensured as water sources, for diversity and redundancy. Furthermore, the condensate storage tank (CST) and the processed water buffer tank for Unit 3 are used as the water source for a normal water injection line fed by a water injection pump in the turbine building. These are to be added at the start of 2012, and will achieve highly reliable water injection.

In Phase 1, some of the pipes and other elements that make up the line will be strengthened and made more earthquake resistant, as a measure to further improve reliability, based on the operating status etc. of the line.

3. Decreasing circulation loop

In Phase 2, the water intake source will be systematically changed from the current turbine buildings to the basement levels of the reactor buildings and the PCVs. This change will be implemented to ensure consistency with the plan to block inter-building leakage between the reactor buildings and the turbine buildings and reinforce leaking points in the PCVs, which will use the results of future research and development.

After reinforcement of the leaking points in the PCVs is complete, the interiors of the PCVs will be filled with water, and consideration will be given to decreasing the circulation loop of coolant circulation and cleaning, to use only water held inside the PCVs. That would make cooling more stable.

(2) Plan for accumulated water processing

1. Improvement of the reliability of accumulated water processing facilities

Processing facilities for contaminated water (accumulated water) that has accumulated in turbine buildings will have their designs improved, based on various problems which occurred early in their operation, and redundancy will be added, to enhance their reliability. Leakage detectors within the embankment will be installed by the end of Step 2, in response to the water leakage from the evaporative concentration apparatus that happened on December 4th.

In Phase 1, reliability improvement etc. for the existing facilities will be considered, and the plan is to implement the main countermeasures in FY2012, to

maintain stable operation. In combination, countermeasures will be implemented to reduce risks of leakage from pipes etc., focusing on shortening the circulation lines from the current length of approximately 4km. Furthermore, multi-nuclide removal equipment, able to greatly reduce concentrations of radioactive substances in processed water⁴, will be installed within 2012. The equipment will be managed so as to keep radioactive substance concentrations in processed water well below density limits by the announcement for out of supervised areas.

In Phase 2 (mid), the further reduction of circulation lines will be considered in response to the state of closure of leaks between reactor and turbine buildings, and of leaks from the PCV, which will be implemented on the basis of future research and development.

Storage facilities for waste etc. necessitated by water processing will be dealt with as necessary, such as by expanding existing storage facilities.

2. Rapid processing of accumulated water

Sub-drainage⁵ has yet to be raised from within the pits (wells) built around the turbine buildings etc., in which low-level contamination has been confirmed. Therefore, groundwater is constantly flowing into the turbine buildings etc.

In Phase 1, sub-drainage will be purified and confirmed free of contamination, and the level of accumulated water in the turbine buildings etc. will be managed so that it does not rise above the sub-drainage level, which will be gradually reduced. In this way, measures will be implemented on the basis of the state of sub-drainage purification etc., to suppress the volume of groundwater inflow and reduce the volume of accumulated water in the turbine buildings.

In Phase 2 (mid), once leakage between the reactor buildings and turbine buildings, and leaks from PCVs, have been blocked, there will no longer be any increase of accumulated water due to leakage of reactor coolant water. Therefore, accumulated water processing will continue to be implemented steadily, with the aim of completing processing accumulated water below ground in the turbine buildings and reactor buildings by Phase 2 (late).

For the processing of accumulated water, the following necessary deliberations will be made and used to devise countermeasures, and discharges of contaminated water to the ocean will not be made lightly.

- Radical countermeasures against inflow of groundwater to reactor buildings, which raises water levels
- Measures to raise the decontamination capacity of the water processing facilities and ensure their stable operation, including substitute facilities to use in case of failure
- Further installation of land-based facilities for contaminated water management

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

⁴ Water from which cesium has been removed by the current water purification facilities.

⁵ Groundwater that has flowed into pits (wells) built around buildings.

(HP1-1) Completion of stopping inter-building water leakage between reactor and turbine buildings and repairing lower part of the PCVs

- Based on the ability to adequately suppress inflow of groundwater into buildings by blocking inter-building leakage between reactor buildings and turbine buildings and reinforcing the lower parts of PCVs, and by managing the level of sub-drainage, the volume of accumulated water below ground level in the turbine buildings and reactor buildings will be systematically processed and reduced.

5-2. Plan to Reduce Radioactive Dosage in the Power Station as a Whole, and to Mitigate Sea Water Contamination

(1) Plans to Mitigate Sea Water Contamination

1. Reduction of the risk of expanded sea water contamination when contaminated water leaks

Until now, a portion of the accumulated water in the buildings has passed through pits etc. to flow into the sea, so a variety of countermeasures have been devised, including blocking pits etc., installation of silt fences⁶ in the port, and installation of circulating seawater purification facilities. The level of accumulated water inside buildings is managed to suppress its outflow into the ground, and that management will continue.

In addition to these measures, work began in October to install water shielding walls on the front of the existing breakwaters in front of Units 1–4, to prevent the dispersion of sea water contamination in the event of contaminated water into groundwater. It is planned for completion by mid-FY2014.

2. Reduction of radioactive substance concentrations in sea water in the port (below announced density)

The silt fence on the side of Units 5 and 6 will be installed by the end of FY2011, and seabed soil in the area in front of the intake canals for Units 1–4, and for Units 5 and 6, will be covered with solidifying soil by mid-FY2012. These measures will prevent diffusion of seabed soil. In addition, circulating seawater purification facilities will continue to operate in the area in front of the intake canal for Units 1–4, with the target of rapidly reducing radioactive substance concentrations in sea water in the port below the density limit by the announcement for out of supervised areas. Mud raised by dredging the port to a depth sufficient for the passage of large vessels will be accumulated within the port, and prevented from dispersing by covering it with solidifying soil, or other measures.

Also, in addition to the maintenance and management of constructed facilities etc., the quality of groundwater and sea water will be monitored constantly until decommissioning is complete.

(2) Plans for Radioactive Waste Management and Dose Reduction at the Site Boundaries

1. Solid waste management

⁶ This is an underwater fence consisting of curtains hung in the water, to retain dispersing silt.

The earthquake, tsunami and hydrogen explosions generated rubble etc. within the power station site. The rubble that has been recovered mainly consists of concrete and metal and varies widely from low to high radioactive dose rates. The accident restoration work also generates felled trees, secondary waste from water processing, used protective clothing, etc.

The rubble etc. is sorted, as far as possible, by dose rate and material, and that which risks airborne dispersion of radioactive substances will be protected by dispersion countermeasures (placement in containers, sheet covering, etc.) for temporary storage. Secondary waste from water processing will be stored in temporary storage facilities, based on consideration of radiation shielding.

Used protective clothing etc. will be packed in bags or containers and stored temporarily in a predetermined location. Felled trees will be stored temporarily in a predetermined location, and treated against fire.

As rubble etc. will require a long period of temporary storage before it is moved to disposal sites in Phase 3, a management plan will be written for ensuring and appropriately managing areas corresponding to the volumes and radioactive levels of waste generated in future. The plan will be implemented systematically, and reviewed as necessary. Within that plan, countermeasures will be implemented using shielding etc. according to the radioactive impact of the rubble etc. on the site boundaries. Consideration will also be given to reducing the volume of rubble, and reusing it.

Storage areas will also be ensured according to the quantities of secondary waste from water processing generated in future, and measures such as further shielding will be implemented, according to the radioactive impact of the waste on the site boundaries, to reduce that impact. Also, based on the form of secondary waste from water processing that is now in progress, and the estimated lifespan of storage containers, a facility renewal plan for storage containers etc. will be adopted by the end of FY2014.

In Phase 2 (late), measures implemented up to that time will continue, and storage containers and other equipment for secondary waste from water processing will be renewed as necessary.

2. Gaseous waste management

By now, with the cooling of the reactor, the annual radiation exposure at site boundaries due to emission of radioactive substances from PCVs is assessed at a maximum of 0.1 mSv/year, and new emissions have been suppressed.

In Phase 1, the PCV gas control system now installed and in operation on Units 1 and 2 will be installed as soon as possible on Unit 3, in order to suppress the emission of gaseous waste. Radiation monitors on that equipment, and on the reactor building covers and filter outlets will provide continuous monitoring.

When the level of accumulated water containing radioactive substances in the underground parts of turbine buildings for Units 1-4, waste processing buildings and centralized waste treatment buildings falls, drying could lead to the airborne re-dispersion of radioactive substances, so underground openings are blocked. Such emissions will continue to be monitored in each building, as far as is

appropriate and possible, in Phase 1 and beyond.

Airborne concentrations of radioactive substances will be monitored in areas near the site, to confirm that they are below airborne concentration density limits by the announcement for out of supervised areas. As all supervised areas are currently set as areas requiring the same level of management as controlled areas, airborne concentrations of radioactive substances will be monitored in perimeter monitoring areas as well, to confirm that they are below airborne concentration limits by the announcement.

3. Liquid waste management

Accumulated water and other liquid wastes will be stored, or treated (purified) in water purification facilities to reduce their levels of radioactive substances. Processed water generated by purification processes will be stored in tanks, and will be appropriately managed, such as by reuse after desalination.

Contaminated water will be handled as stated in 3-2 (3).

4. Reduction of dosage at site boundaries (attainment of dosage <1 mSv/year at site boundaries due sources such as new emissions of radioactive substances etc. from the power station as a whole)

The aim is to reduce the effective radiation dose at the site boundaries to below 1 mSv/year within FY2012, including effective dose due to additional emissions of radioactive substances from the power station as a whole, and radioactive waste produced after the accident and stored on the site (secondary waste from water processing, rubble, etc.), through appropriate implementation of the above measures.

5. Continuous implementation of environmental monitoring

To confirm that there is no abnormal situation, airborne radiation dose rates and radioactivity of environmental samples are monitored near the boundaries of the supervised areas and in nearby areas. Monitoring in the environment, both on land and at sea, will continue in Phase 1 and beyond. Current monitoring covers, to the extent possible, the environmental impact of radioactive substances released at the time of the accident, and watches for further abnormal emissions. In future, environmental monitoring will be performed in line with environmental radiation monitoring policies that are based on measurement targets and measured parameters etc. that were used before the accident.

(3) Plan for Decontamination within the site

Decontamination within the site will eventually cover the entire site, but in order to reduce exposure doses to the general public and to workers, and to facilitate work for smoother accident response in future, the site will be grouped into four areas, and specific decontamination plans will be devised and gradually implemented for those areas.

<Area categories within the site>

- Executive areas: Areas that are intended to be made into non-controlled areas (Main anti-earthquake buildings, etc.).

- Working areas: Areas in which many workers are engaged in restoration work.
- Access areas: Main roads on the site for access to working areas.
- Other areas: Forests and other areas not included in the above.

The decontamination plan will set orders of priority, based on area categories, for areas to receive decontamination, and decontamination will be implemented sequentially. The plan will be revised, checking effects on dose rate reduction and improving decontamination methods. Executive areas will be assigned the highest priority, to make them into non-controlled areas as soon as possible. Decontamination of working areas and access areas will start from areas of higher dose rates.

In Phase 2 and beyond, decontamination within the site will proceed with linkage to the state of reduction in the dosage environment as radioactive sources outside the site are eliminated. Ultimately, decontamination will cover the entire on-site area.

Work will begin promptly in checking whether rubble that was scattered by the hydrogen explosions has accumulated within the power station premises, and will end within FY2014 at the latest.

5-3. Plan for Fuel Removal from the Spent Fuel Pool

(1) Current situation

The impact of the tsunami caused the spent fuel pools of Units 1–4 to temporarily lose cooling function, but the injection of coolant water using concrete-pumping vehicles maintained cooling of fuel in the spent fuel pools. Fuel is now stably cooled by circulating cooling systems. Cooling function must be maintained until fuel removal is complete, so the maintenance management of the equipment will carry on, with equipment replacement as necessary, to maintain and improve reliability. The results of analysis of radioactive substance concentrations in the spent fuel pool water indicate that most of the fuel is in sound condition.

Sea water was injected into the spent fuel pools of Units 2–4 as an initial emergency measure, leading to corrosion of the lining⁷ of those spent fuel pools, and of equipment within the pools. Therefore, the water quality is now being improved using a desalting facility installed in Unit 4. The plan is to improve water quality in Units 2 and 3 in future, in the same way as in Unit 4. In Unit 3, rubble from the hydrogen explosion that dropped into the pool raised the pH of the pool water, so water quality was improved by the injection of a neutralizing agent (boric acid). Water quality will be monitored continuously in future, and countermeasures and improvements will be applied as necessary.

(2) Summary of Fuel Removal Work (see appendix 2)

The plan for the removal of fuel from the spent fuel pools is to remove rubble that was dropped onto the refueling deck by the hydrogen explosions, install covers (or containers) to improve the working environment that includes the fuel handling

⁷ The lining applied to the inner walls of the spent fuel pools.

equipment, and then transfer fuel to the common pool inside the power station, for a more stable storage situation.

Appendix 2 shows the steps involved in fuel removal from the spent fuel pool. By now, the first step of this process, which is the removal of rubble from the upper part of the reactor building, and preparations for subsequent steps, including covers for fuel removal, fuel handling equipment, and on-site transportation containers, are being considered and designed for Units 3 and 4.

[1] Removal of rubble from upper parts of reactor buildings

The upper parts of the reactor buildings for Units 1, 3 and 4 were damaged and rubble was scattered over the refueling deck and into the spent fuel pools. As a result, fuel removal must be preceded by the use of heavy equipment and fuel handling equipment to clear rubble from the fuel handling floor and the spent fuel pools. A plan will be devised for rubble removal, including removal of the cover installed on Unit 1, and implementation will follow the plan.

[2] Cover (or container) installation and installation or restoration of fuel handling equipment

The upper parts of the reactor buildings for Units 1, 3, and 4 are damaged, so covers (or containers) will be installed to cover the fuel replacement areas, to maintain a working environment for fuel removal by blocking wind and rain. New fuel handling equipment will be installed inside for the fuel removal work.

The soundness of the fuel handling equipment in Unit 2 has not yet been checked, because of the high dosage within the reactor building. In future, the equipment will be inspected and repaired once decontamination etc. makes it possible to approach the fuel handling equipment.

[3] Design and manufacture of on-site transportation containers and storage drums

The movement of undamaged fuel from the spent fuel pools to the common pool will employ existing or newly constructed on-site transportation containers.

If fuel is confirmed to be damaged, it will be placed in newly designed and manufactured storage drums, then placed in on-site transportation containers for movement, so that it can be handled with the same level of safety as moving undamaged fuel.

[4] Ensure/ remodel space within the common pool

To ensure an area to receive and store the fuel removed from the spent fuel pools, the undamaged spent fuel currently stored in the common pool will be stored in dry casks and moved out of the common pool. New dry cask temporary storage equipment will be installed within the power station site as the destination for these dry casks. The dry cask temporary storage equipment will be a modular type with flexible storage capacity. For the time being, it will house the existing dry casks now stored in the cask repository, in addition to

dry casks received from the common pool.

Also, as the fuel removed from the spent fuel pools may be damaged by, or encrusted with salt, the necessity of washing it will be considered, and equipment will be remodeled and added, such as by installing a dedicated storage location.

[5] Fuel removal from the spent fuel pools

A crane will be used to lower on-site transportation containers into the spent fuel pools in the reactor buildings, and fuel handling machinery will be used to move fuel from spent fuel racks into the on-site transportation containers. The crane will then lower on-site transportation containers to ground level, where a trailer will be used to move them from the reactor building to the common pool on the power station site.

The soundness of the fuel will be checked before it is placed in the on-site transportation containers, and any fuel that is confirmed to be damaged will be placed in the above-mentioned storage drums for transportation.

[6] Storage and management of removed fuel

In the common pool, pool cooling and purification systems will improve and maintain the purity and transparency of the water. Water in the transportation containers will be changed to avoid bringing water from the spent fuel pool, which was injected with sea water, into the common pool.

(3) Plan for Fuel Removal from the Spent Fuel Pool (schedule)

Removal of fuel from the spent fuel pool differs between units in aspects such as fallen rubble, damage to buildings, equipment and fuel etc., and dosage levels, so periods required for preparation and movement will also differ. Therefore, the plan will consider the state and characteristics of each unit, specific plans for later units will reflect knowledge and experience gained in earlier ones. Other than receiving the removed fuel, the common pool will be used in parallel for the inspection of existing dry casks, placement of fuel into dry casks and relocation, preparations for receiving removed fuel, and other diverse operations. Therefore, the plan will consider ensuring safety, reducing confusion between tasks, and faster working.

The plan for fuel removal from Units 1–4 will be considered and formulated to optimize the fuel removal process as a whole, with the focus on ensuring safety and removing fuel as early as possible. It will include cask manufacture, port restoration, and dry cask temporary storage equipment.

The aim is to complete removal of rubble from the upper parts of the reactor buildings ([1] above) for Unit 4 in mid-2012. The state of fallen rubble in Unit 3 has not been adequately checked, so it is expected to be completed around the end of FY2012. After rubble has been removed, installation of fuel removal covers and fuel handling equipment ([2] above), and the design and manufacture of on-site transportation containers etc. ([3] above), will be implemented in parallel. Units where dosage is high in working areas will have fuel handling

equipment and on-site transportation containers capable of remote operation. In preparation for receipt of removed fuel into the common pool, the equipment will be inspected and restored, and dry cask temporary storage equipment will be installed, by around the end of 2012. Over around one year after that, fuel will be gradually moved from the common pool to the dry cask temporary storage equipment, to clear the space necessary for receiving the removed fuel ([4] above).

The newly installed fuel handling equipment etc. will be used to remove rubble from inside the pools, the fuel will be investigated, and preparations will be made in the reactor buildings and the common pool. Once these are complete, fuel removal will begin ([5] above). The targets for the timing of the start of fuel removal will be within two years from the completion of Step 2 for Unit 4, which is scheduled to begin removal first, followed by Unit 3 within three years of the completion of Step 2. Knowledge and experience will be gathered from Units 3 and 4 concerning removal of rubble, the operability and faults of remote operation equipment, and investigation. The rubble will also be investigated, and then a specific plan for Unit 1 will be studied and formulated. For Unit 2, decontamination of the building interiors and use of shielding will be based on the establishment of remote decontamination technologies. Once it is possible to approach the fuel handling equipment, the equipment will be investigated, and then a specific plan for inspection, repair and fuel removal in Unit 2 will be studied and formulated. Fuel removal from Units 1 and 2 depends on conditions on the site, and other factors, but the aim is to start within Phase 2 (mid).

It is assumed, based on the envisaged future working environment, that removal of undamaged fuel in Unit 4 will employ the same equipment, working organization and procedures as in normal operation, taking around two years on that basis. If a normal environment can be produced in Unit 2, it would take around 1.5 years. If dosage is high in Units 1 and 3, fuel removal by remote operation would use newly-installed fuel handling equipment and transportation containers, necessitating detailed consideration in future, but the target is to take 2–3 years per unit. The working environment, the state of the fuel, and other factors will be checked in future, and working organizations, procedures and times etc. will be considered in order to formulate specific plans. The aim is to complete removal of fuel from Units 1–4 by Phase 2 (late).

The issues listed below, which could impact the process, must be solved in order to realize fuel removal according to plan. The work will be implemented through collaboration and liaison between all those involved, with the highest priority on ensuring safety.

- Rubble removal

- Many aspects of rubble scattering and dosage levels etc. have yet to be confirmed, and it is possible that the work could be prolonged, or require additional tasks.

- Installation of covers for fuel removal

- There are still many uncertain factors, such as the condition of building

damage, dosage levels, and the condition of underground structures that obstruct foundation construction, and it is possible that the work could be prolonged, or require additional tasks.

- Common pool restoration and removal of fuel from the common pool

Equipment is being checked for the restoration of the common pool, and it is possible that unanticipated faults could occur or be discovered, necessitating repairs.

- Step by step handling up to the start of usage

Equipment related to fuel removal will be approved through a process with the steps of [design-> manufacture-> installation-> start of operation], and the process will be created with the approval periods in mind.

- Confirmation of fuel soundness

Effective confirmation methods and procedures etc. will be devised with working efficiency in mind.

- Removal of fuel from the pools

If the proportion of damaged fuel is higher than anticipated, or the degree of damage is more severe, it is possible that the work could be prolonged, or require additional tasks.

There is no experience of remote operation, and particularly of handling faults, inspection and repair, and the handling of physical distortion etc. of fuel through remote operation. The aim will be to improve equipment reliability and safety and make the work faster, and equipment and working procedures will be improved to reflect knowledge and experience gained on the earlier units.

(4) Research and development into the handling of fuel after removal

Fuel removed from the spent fuel pools will be stored in the common pool for the time being. At the same time, assessment of the long-term soundness of fuel, taking the effects of sea water into account, related countermeasures, and research and development on reprocessing. will be implemented. (See the separate "Research and Development Plan" for details).

(HP2-1): Determination of methods for reprocessing and storing spent fuel

- Future processing and storage methods for spent fuel removed from the spent fuel pools will be decided on the basis of assessment of its long-term soundness and the results of research and development into its reprocessing.

5-4. Fuel debris removal plan

(1) Present status

When the earthquake occurred, there were a total of 1,496 containers of fuel loaded into the reactor core at Units 1-3 (in operation at the time). The reactor cores at all Units are damaged. Consequently, the fuel inside the reactor became fuel debris, and it is surmised that a portion of that debris is flowing out from reactor pressure vessels and into PCVs.

The coolant that is still being injected into the reactor cores is flowing into the adjoining turbine and other buildings via the lower basement levels of the reactor buildings from the bottom of the PCVs, and coolant is currently leaking into both the reactor pressure vessels and PCVs.

At the current time, neither the status of the fuel debris nor the exact outflow locations are known.

(2) Overview of the fuel debris removal plan

Work that will be required before beginning fuel debris removal presents a number of technological challenges considering as this work will need to be carried out in high dosage conditions inside reactor buildings. Thus, deciding definitively on a specific course of action is difficult at the present time. It is believed that removing the fuel debris while underwater (as was done at TMI-2) due to the excellent radiation shielding afforded will be the most reliable method.

At TMI-2, filling the reactor pressure vessel was accomplished without difficulty. As is mentioned above, however, at Units 1–3 the coolant added to the reactors in their current state is currently leaking out of the PCVs. Thus, creating the necessary boundaries for water filling will be an important step in removing fuel debris.

Consideration was thus given to the workflow that would be required to allow the underwater removal of fuel debris. The resulting plan that we formulated is comprised of the below work steps (1) through (10) and 6 holding points. We also included at each work step the technological challenges and necessary research and development—for which will seek assistance with from the national government, nuclear plant manufacturers and research institutes—necessary to resolve them. Having received the agreement of the Japan Atomic Energy Commission Expert Group concerning the validity of this research and development, the necessary research and development is to begin this fiscal year.

<Work steps involved in fuel debris removal>

Attachment 3 shows the work steps involved in fuel debris removal. Details of work steps (1) through (10) are provided below. Multiple holding points have been created for each process based on the idea that future site conditions and the results of research and development will require review of the content provided below. Developmental achievements will be assessed at each step and applied to the next step wherever possible.

1. Decontamination of the inside of the reactor building

Past inspections have identified rubble scattered about and the existence of areas of high dosage (several hundred to 1,000 mSv/h) inside reactor buildings. Decontamination work will thus be prioritized for the necessary areas inside buildings.

Decontamination work will be performed by workers in areas of relatively low dosage and remote removal will be used for high-dosage areas.

Thorough measures (shielding, work hour management, etc.) will therefore

be taken to reduce exposure while workers perform their duties, and remote contamination inspection devices and other useful decontamination technologies (or the development of remote decontamination devices using such technologies) will be used—or serve as a basis for developing remote contamination devices—as dosage conditions require.

2. Inspections of leakages inside PCVs

Performing the underwater fuel debris removal will require repairing leaks in PCVs and filling them up with water. Before this, inspections will be conducted to identify PCV leakages.

Because leakages may be located in highly radioactive environments, under water and in narrow parts, technologies for remotely accessing these areas and detecting leakages will be developed and applied.

3. Reactor building water stop, and PCV lower parts repair

Leakages identified through the inspections described in 2 will be repaired, leakages between the reactor buildings and turbine buildings stopped, and boundaries set up for partial filling up of the lower parts of PCVs.

Because leakages may be located in highly radioactive environments, under water and in narrow parts, technologies for remotely accessing these areas, as well as technologies and methods for performing repairs, will be developed and applied.

Also, it will be necessary before stopping any leakages from reactor buildings to switch intake sources for circulating water cooling from under turbine buildings to under reactor buildings or the lower parts of PCVs, which will require downsizing circulating injection loops.

To prepare for filling up PCVs, evaluating structural strength and seismic resistance and performing the necessary reinforcements will also be required.

4. Partially filling up the PCVs

The lower parts of the PCVs will be filled up by continuously injecting them with water after making repairs to and stopping leakages in the PCVs, as per 3.

When doing this, because the cooling water flow rate around the fuel debris will change, due consideration will also need to be given to critical detection and prevention measures.

5. Inspections and samplings of the insides of the PCVs

After partially filling up the PCVs as per 4, workers will remotely access the insides of PCVs and by performing thorough inspections and samplings, ascertain fuel debris distributions and characteristics.

Because the insides of PCVs are highly radioactive and we presume the contaminated water inside is murky, remote inspection technologies and jigs will be developed and used.

6. Repairs to the upper parts of PCVs

After performing inspections as per 5, workers will repair the upper parts of PCVs in an effort to raise water levels inside these PCVs.

Repair equipment utilizing remote repair technologies will also be developed here.

7. Filling up PCVs and reactor pressure vessels

After repairing the upper parts of PCVs as per 6., workers will fill up reactor pressure vessels and PCVs with consideration for critical detection and prevention measures.

After the above water filling procedures are completed, thorough safety checks for radioactive substance emissions and radioactive environments will be performed. Workers will then open the upper lids on PCVs and reactor pressure vessels and remove the steam separators and moisture separators, which are structures on the upper part of reactor pressure vessels.

Before starting the process of opening the upper lids, workers will install reactor building containers (or modify the covers) to create confined spaces. Because these reactor building container (or modified cover) structures will need to conform to fuel debris removal methods and equipment, further consideration will be made while assessing research and development progress.

8. Reactor core inspections and sampling

After completing the PCV and reactor pressure vessel opening procedures as per 7. above, workers will set up work cars for working on the upper parts of these vessels and ascertain the distributions and characteristics of fuel debris by performing inspections and samplings of the insides of reactor pressure vessels.

Because the insides of PCVs are highly radioactive and we presume the contaminated water inside is murky, remote inspection technologies and jigs will need to be developed and used.

9. Fuel debris removal technology preparation, and removal work

Workers will perform fuel debris removal with regard for critical detection and prevention measures using work carts, as per 8. After storing the removed fuel debris in special canisters, workers will transport them to a specified location.

As the removal work will likely entail a variety of processes including crushing, holding, vacuuming, etc. the fuel debris, methods, equipment, and jigs for performing this work remotely will be developed and used.

10. Safe storage, processing, and disposal of removed fuel debris

Because seawater was pumped into the core for a short time at Units 1–3, it is assumed that the fuel debris will be highly saline. Thus, in addition to the normal requirement specifications concerning cooling functions, sealing functions, etc., fuel debris will be stored in storage canisters developed to resist

corrosion caused by salt. The canisters will then be removed and, for the time being, safely stored in suitable storage facilities.

(3) Research and development to facilitate the above

We will work with the support of and collaboration with the national government, industry, and research institutes in conducting the research and development mentioned in 1 through 10 above. These research and development efforts will be conducted as per the schedule in Chapter 4, and we will try to move schedules forward as much as possible. Along with research and development, we will also be making preparations for work using any machinery developed, as the case may be. (See Supplementary Document 1: "Research and Development Plan" for more details)

➤ Shared platform technology development

Given the high-dosage environments present inside reactor buildings, it will be necessary to develop and use robots and other remote-control technologies to perform various kinds of work such as decontamination, inspections, and repair work to remove fuel debris from inside these buildings.

As these remote-control technologies will need to be usable with in a number of different work processes performed inside reactor buildings, we will clarify what is required for each process and identify the kind of shared platform (shared elemental technologies, basic technologies, etc.) that will be needed and then developing them with an eye to modularizing and standardizing them.

➤ Consideration of alternative policy

The development of methods for repairing PCVs will be a necessary step in the process of removing fuel debris, and we suppose there will be major technological difficulties involved. We therefore suppose difficulties will be encountered in the development of repair technologies based on the results of inspections of PCV leakages, and will be moving forward with the development of repair methods as we look at alternative methods along the way.

➤ Maintaining the structural integrity of reactor pressure vessels and PCVs

Maintaining the structural integrity of reactor pressure vessels and PCVs will be extremely vital to performing the proper removal of fuel debris. Currently, to prevent the corrosion of reactor pressure vessels and PCVs, we are conducting water quality management measures including the inhibition of chloride ion concentrations and deaeration (dissolved oxygen reduction via nitrogen bubbling) of the treated water being pumped in. We will also gather data from various assessments and examine anticorrosion measures aimed at ensuring the long-term integrity of the reactor pressure vessels and PCVs.

(4) Fuel debris removal schedule

Looking at TMI-2 as a point of reference, the Japan Atomic Energy Commission

Expert Group has established the goal of beginning fuel debris removal within 10 years. Based on the fact that both ministers have instructed this same goal to be met, we will be conducting the necessary research and development to begin fuel debris removal for the first Unit within 10 years (beginning with the completion of step 2).

We surmise that all removal procedures for all Units will be completed in 20 to 25 years' time (10 to 15 years for removal). This is due to the fact that fuel debris distribution here is much broader in comparison to TMI-2, as evidenced by such phenomena as fuel debris having fallen into even PCVs.

To achieve this goal, we will be working in collaboration with the national government, industry, and research institutes in research and development, the results of which we will apply and use to complete plant work. However, based on the fact that site conditions are unknown and that there are many uncertainties concerning the development of repair technologies for leakages, we will be making revisions to the removal plan to ensure it is always optimal. As far as work processes, we have established several holding points and, in addition to applying the necessary development results achieved up to that point, we will be taking into consideration related site work conditions, the status of preparations regarding work processes and safety equipment aimed at the next step, progress made with regulatory procedures, etc.

Concerning the decontamination of reactor buildings, we will begin with areas of relatively light contamination as determined by current technologies and, by effectively combining remote contamination removal technologies that are developed along the way, remove contamination in stages from highly contaminated areas. Through these efforts, we will enable the areas around PCVs (the lower parts in particular) to be accessed by the end of FY2014.

We are also aiming for a full scale start to internal inspections performed from outside PCVs and inspections of leakages in PCVs by the end of FY2014 depending on the results of the above decontamination and onsite conditions.

(HP3-1): Determining methods for repairing lower parts of PCV, determining water stop methods

- Through inspections of PCV leakages, we will identify leaks and conditions present in the lower parts of PCVs and building basement levels and verify that the development of the methods and equipment required to repair these parts has been completed. At the same time, we will verify the extent to which these technologies can be used, and that circulating coolant can be removed from these areas, etc. before determining when to begin repair work (water cutoff) in these areas.
- At this time, we will also decide the Unit order for the repair of these parts based on the locations of leakages, which will allow us to conduct primary evaluations of Unit order for the removal of fuel debris.

(HP3-2): Completion of flooding of lower parts of PCV, determining PCV internal investigation methods

- In determining when to begin internal inspections of PCVs, we will first verify

that both the repair of any leakages present in the lower parts of the PCVs and the filling of these vessels have been completed, and that internal inspection methods and the development of any necessary equipment has been completed.

(HP3-3): Determining methods to repair upper parts of PCV

- Once the areas requiring repair in these parts are identified as and we verify that the development of the necessary methods and equipment has been completed, we will determine when to begin repair work on the upper parts of the PCVs.
- Depending on research and development progress and on site conditions and number of personnel required, it may be possible to perform these repairs in tandem with repairs to the bottom parts of PCVs.

(HP3-4): Completion of flooding of upper parts of PCV, determining RPV internal investigation methods

- In determining when to begin the opening of the top lids on RPVs and reactor inspections, we will first verify that water has been pumped in up to the upper parts of PCVs (including the reactor pressure vessels), that reactor building containers have been created or covers modified to create confined spaces, and that the development of methods and equipment for inspecting reactors has been completed.

(HP3-5) Determining fuel debris removal methods and completion of preparation of fuel debris containers, etc.

(Target : to accomplish within 10 years from the completion of step 2)

- In determining when to begin fuel debris removal, we will first look at the results of internal inspections of PCVs and reactor pressure vessels to verify that the development of fuel debris removal methods and equipment, as well as storage containers (storage canisters) needed for removal, has been completed and that there are places to store the removed fuel debris.

(HP3-6) Determining processing / disposal methods of fuel debris

- We will act in conformity with any related research and development and national policy in devising methods for the future processing and disposal of removed fuel debris.

- (*) We will continuously refer to the below holding points and make revisions as necessary concerning Unit priority for fuel debris removal established in HP3-1.

5-5. Plan for Disassembly of Reactor Facilities and Processing and Disposal of Radioactive Waste

(1) Plan for disassembly of reactor facilities

1. Outline

With regard to the disassembly of Units 1–4, following the removal of fuel from the spent fuel pools and fuel debris from the reactor cores, it will be necessary to

proceed on the basis of a plan for the disassembly of the reactor facilities that takes into consideration factors including the projected type and quantity of radioactive waste, the impact on the environment (including the general public), the risk of exposure for workers, the work methods and procedures applied, and the prospects for disposal of the waste.

Given this, in line with the status of progress in decontamination of buildings, the surveying of reactor pressure vessels and PCVs, the removal of fuel debris and other work, from this point onwards we will collect the necessary data for the formulation of a decommissioning plan, encompassing factors including the state of radioactive contamination of buildings and equipment (including evaluation of the degree of migration of radioactive substances due to the buildup of high-level contaminated water in reactor buildings, turbine buildings, main process buildings, etc.) and the amount of fuel debris remaining in the reactor pressure vessels and PCVs, in addition to conducting the research and development necessary for the development of technologies including remote disassembly technologies and technologies for the decontamination and reduction in volume of concrete and metal.

Based on the standard procedural schedule examined in accordance with the system of allowances for disassembly of nuclear facilities, a period of approximately 15 years is projected for disassembly of reactor facilities. The first 10 years of this standard procedural schedule is devoted to waiting for the decay of radioactive substances in order to minimize the dose to which workers will be exposed, in addition to the commencement of disassembly of the turbine buildings and other comparatively lightly contaminated areas. The final five years sees the commencement of disassembly of the reactor cores.

It will be essential to determine the disassembly method to be employed in the present case with consideration of the fact that due to the effects of the tsunami disaster it is highly possible that the disassembly of the reactor facilities of Fukushima Daiichi Nuclear Power Station Units 1–4 will differ from normal reactor disassembly procedures in terms of the type and amount of radioactive waste products involved. In addition, prior to commencement of disassembly procedures for the reactor facilities, it will be important to upgrade technological standards and establish a firm outlook for the disposal of the waste products produced by the disassembly. The government and TEPCO will cooperate in these areas.

Based on the above, a target of 30–40 years has been set for the completion of the disassembly of the reactor facilities of Fukushima Daiichi Nuclear Power Station Units 1–4. Work will proceed with consideration of the points listed below. The disassembly work will commence from Unit 4, in which there is no fuel debris in the reactor core.

2. Schedule for disassembly of reactor facilities

(HP4-1) Determination of method of disassembly and decontamination.
Formulation of standards for disposal of waste products from disassembly

It is predicted that the type and quantity of radioactive waste products

produced by the disassembly will differ from the case of a normal nuclear plant due to the effects of the tsunami disaster. Given this, the design and manufacture of the necessary devices and equipment will commence following verification of the completion of a review of standards for waste disposal, a research and development program for decontamination and reduction of the volume of waste produced, and the development of a method of disassembly that reduces exposure during the course of the work, in response to the type of radioactive substances which will be encountered.

(HP4-2) Formulation of outlook for disposal of waste produced by disassembly. Completion of necessary research and development

Disassembly procedures will be commenced when a firm outlook for disposal of the waste products from the procedures has been obtained.

(2) Radioactive Waste Processing and Disposal Plan

1. Outline

Basic guideline: Depending on the characteristics of the radioactive waste (the radionuclides it contains and its level of radioactivity), it will be subject to processing such as being sealed in containers and encased in concrete to form blocks of waste (termed "Processing" below) and transported to a waste disposal site and buried (termed "disposal" below).

The waste products produced following the tsunami disaster differ from the waste products conventionally produced by nuclear reactors in a variety of characteristics, including the fact that radionuclides originating in damaged fuel are adhering to them and they contain high quantities of salt, which will have a negative impact on the performance of the disposal sites.

Because of this, realizing the Processing and disposal of the waste will necessitate the implementation of research and development based on adequate analysis and understanding of the characteristics of the waste and the determination of a firm outlook for its safe Processing and disposal.

Safety regulations and technological standards for the Processing and disposal of the waste will be clarified via a determination of the outlook for safety and a process of examination of the necessary systemic measures.

To make it possible to install Processing equipment in the power station and commence the production of blocks of waste for transportation to the disposal sites following this process, for the present waste will continue to be stored after sorting to ensure that it does not impede the future Processing and disposal procedures. The research and development necessary for the Processing and disposal of the waste will be conducted on the basis of collaboration between the national government, TEPCO, related industries and research organizations. (For details, see "Research and Development Plan" in Supplement 1)

2. Schedule for Processing and disposal of radioactive waste

A Research and Development Plan towards the Processing and disposal of

radioactive waste will be formulated in FY2012, when it is projected that the removal of the debris from the reactor buildings of Units 3 and 4 will have been completed.

In addition, because it will be necessary to proceed in stages, revising the outlook for safety based on the outcomes of research and development, the following points for judgment have been established based on the process of review concerning the disposal of radioactive waste which has been employed in Japan up to the present.

(HP5-1): Verification of applicability of existing concept of disposal to characteristics of radioactive waste

- The applicability of the adopted concept of waste disposal will be verified based on the results of research on the characteristics of the waste.
- Given that there is a possibility that it may be difficult to apply the existing concept of waste disposal to some of the waste (for example, waste with a high salt content), as necessary, new methods of Processing and disposal (construction of artificial barriers, etc.) will be examined, research and development plans will be formulated, and research will be commenced.

(HP5-2): Verification of safety of waste Processing and disposal

- The prospects for safe Processing and disposal of the waste products, etc. resulting from the tsunami disaster, will be verified based on technological viability. In addition, the information necessary for the creation of a framework for a safety system for waste Processing and disposal will be compiled.
- It is predicted that new data will be obtained concerning the characteristics of the waste products as the removal of fuel debris and disassembly work proceed. In addition, it is also possible that new waste products will be produced in the process of decontamination during the work. Given this, research will be continued as necessary in order to increase the safety of waste Processing and disposal.

(HP5-3): Determination of specifications and method of manufacture of blocks of waste

- Based on the results of research and development in relation to the Processing and disposal of radioactive waste, as necessary, the system of regulations will be revised, and the necessary conditions for Processing and disposal (specifications of blocks of waste, essential site requirements for disposal sites, design requirements for disposal sites) will be clarified.
- The specifications and method of manufacture of blocks of waste will be determined based on the above conditions.

(HP5-4): Installation of equipment for manufacture of blocks of waste and prospects for waste disposal

- The manufacture and shipment of blocks of waste will be commenced when the installation of equipment for their manufacture has been completed and firm prospects for disposal have been confirmed.

6. Establishment of Systems and Optimization of Environments for Facilitation of Work to be Performed at Fukushima Daiichi Nuclear Power Station

It is predicted that even from the first stage of the disassembly work, operations will be conducted in numerous environments with a high level of radioactive contamination. Against this background, it will be necessary to secure personnel over the long-term, while ensuring the safety of employees by limiting exposure to 100 mSv/5 years and maintaining the system of cooperation between TEPCO and its contractors, as has been the case up to the present.

This section will deal with the formulation of a Personnel Plan based on the necessary work procedures to be conducted and total potential exposure as projected at present and the evaluation of the feasibility of this plan, in addition to a Safety Plan for onsite operations which encompasses measures to increase the motivation of personnel and guidelines for the management of radioactivity.

6-1. TEPCO System of Implementation in relation to Mid-and-long-term Initiatives

Tokyo Electric Power Company will establish a full-time dedicated organization at its headquarters in order to ensure that mid-and-long-term initiatives proceed steadily. This organization will cooperate with the Fukushima Daiichi Stabilization Center, which is responsible for overseeing operations at the site, and the Fukushima Daiichi Nuclear Power Station, in activities including the formulation of basic guidelines for mid-and-long-term initiatives, and the management and design of the overall project and the obtaining of the relevant permissions.

Taking familiarity with the site and experience in proceeding to Step 2 into consideration, the system for the realization of mid-and-long-term initiatives will involve Tokyo Electric Power Company and approximately 400 contractors, and work will proceed according to the system of implementation used up to the present for site operations of the same type.

A dedicated system for integrated exposure and health management for workers of TEPCO and other companies will be established in TEPCO's headquarters, conducting procedures including the provision of health consultations and examinations in response to exposure levels.

6-2. TEPCO Personnel Plan in relation to Mid-and-long-term Initiatives

(1) Personnel Plan and feasibility of Plan

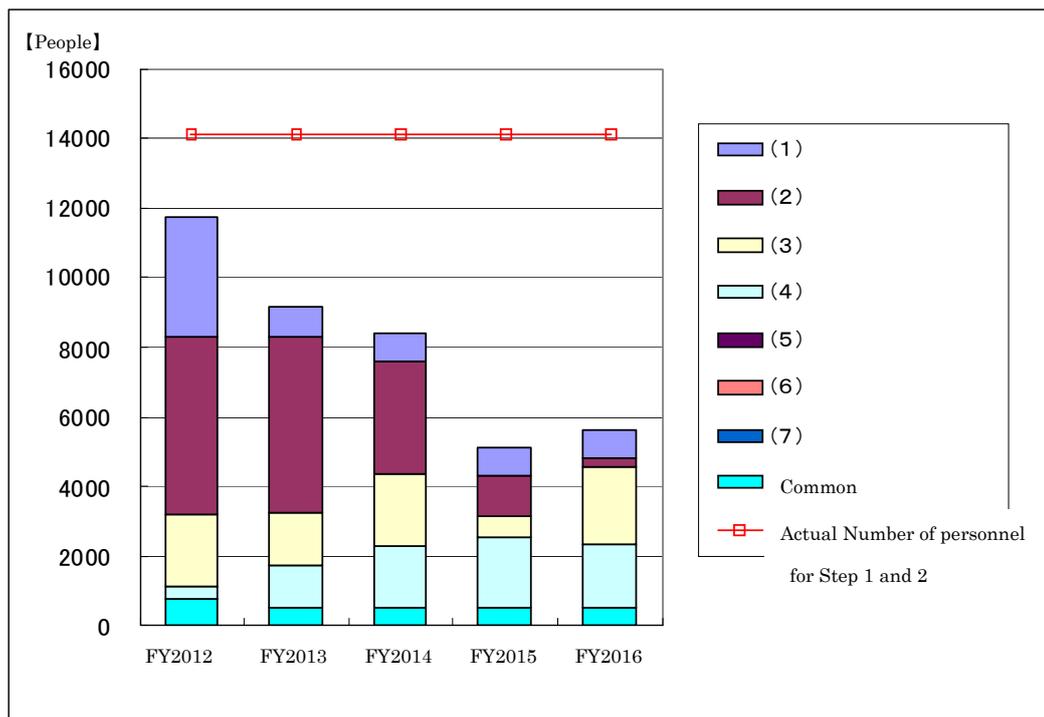
TEPCO has projected the number of personnel required for work scheduled for the next five years* and the cumulative exposure of those personnel, and has verified the feasibility of its Personnel Plan.

*: Based on factors including the accuracy of the outlook for the work to be performed and a limit of 100 mSv/5 years for exposure management, the projected period for the Personnel Plan was set at five years.

1. Essential number of workers and projected level of exposure

Taking the figure of 100 mSv/5 years into consideration, it is projected that the following numbers of workers will be required to ensure an annual level of exposure per person of 20 mSv or less (excepting certain operations entailing a higher level of exposure*).

*: Operations including increasing the reliability of the processing facilities for accumulated water and reducing the loops are expected to involve exposure to levels of 40 mSv.



- | | |
|---|---|
| (1) Plan for Maintaining Plant in an Ongoing Stable State
(Improvement of reliability of circulating water cooling system, etc.) | (4) Fuel Debris Removal Plan
(Stopping inter-building water leakage, etc.) |
| (2) Plan to Reduce Radioactive Dosage in the Power Station as a Whole, and to Mitigate Sea Water Contamination
(Construction of shielding walls, etc.) | (5) Plan for Disassembly of Reactor Facilities and Processing and Disposal of Radioactive Waste |
| (3) Plan for Fuel Removal from Spent Fuel Pools
(Fuel removal, etc.) | (6) System of Implementation/Personnel Plan |
| | (7) Plan for Ensuring Work Safety |
| | Common // Actual number of personnel for Steps 1 and 2 |

Note): This plan is based on provisional calculations performed within the scope that can presently be projected. The number of required personnel may increase or decrease in future based on changes in circumstances, for example if further procedures come to be deemed necessary as onsite surveys proceed.

Note): The actual number of personnel for Steps 1 and 2 is the number of employees of TEPCO and major companies engaged in operations at TEPCO's Fukushima Daiichi Nuclear Power Station during

the relevant period (aggregated from March to November).

The actual number of personnel involved in Steps 1 and 2 was approximately 14,100, and it is projected that it will be possible to secure at least this number of personnel in the future. The required number of personnel for the first five years based on current projections (Maximum: Approximately 11,700 for the first year) is lower than that figure, and it is therefore predicted that there will be no impediment to onsite operations due to a shortage of personnel.

From 2017 onwards, in addition to continuous work for the processing of accumulated water, etc., major operations for the placing of the reactor building containers and the removal of fuel debris will be due to commence. It is therefore predicted that in the future also it will be necessary to secure a constant number of personnel, and we will continue to work to secure these personnel with consideration of employment in the local region.

2. Future initiatives to secure personnel

From 1, the actual number of personnel involved in Steps 1 and 2 exceeded the number of personnel that will be required for operations in the future, but we will also implement the following initiatives in order to increase the certainty of securing personnel.

- Allocation of personnel based on predicted dose
Personnel will be allocated in a planned manner based on advance predictions of the individual dose for personnel engaged in specific procedures.
- Systematic training of personnel
Training will be essential for particularly specialized operations, and training of personnel will therefore be carried out in a systematic manner.
- For processing of water
TEPCO will be introducing water processing equipment for the first time, and the processing system is complex. Given this, prior to the allocation of personnel, theoretical training will be provided concerning elements including the design of equipment and the positioning of devices, and hands-on training will be provided concerning the operation and maintenance of transport and processing equipment, etc.
- For management of radioactivity
We will continue the education and training programs that we presently conduct for employees of TEPCO and its contractors to foster personnel engaged in taking measurements of radioactivity, and into the future we will foster personnel involved in radiation-related procedures, given the increasing need for these personnel.
- Measures for further reduction of exposure
In addition to continuing measures such as the employment of shielding equipment and avoidance of areas of high radioactivity, we will engage in the development of equipment enabling procedures to be performed remotely and will ensure further decontamination of work areas.
- In order to increase the accuracy of the Personnel Plan, we will revise the plan

on an annual basis.

(2) Measures to increase motivation

To enable TEPCO and its contractors to continue the decommissioning work into the future, conditions will be improved as follows to ensure that personnel are able to work with peace of mind.

- Improvement of meals
 - We will continue to examine possibilities for the diversification of the food menu and the improvement of the nutritional balance provided by meals.
 - We will continue to examine the possibility for the provision of hot meals.
- Improvement of environments
 - The Main Anti-earthquake Building, in which personnel were resident for an extended period providing directions and instructions for operations in the plant, is being made into a non-controlled area (to April 2012) . With regard to the corporate buildings, in response to the needs of contractors, while maintaining the order of precedence, radiation levels will be reduced in the buildings for which the need is most urgent within FY2012.
 - The level of radiation will be reduced in the site as a whole.
 - We will examine the establishment of rest areas which come to be required in response to changes such as changes in the scale of the work or the areas in which it is being conducted.
 - Depending on the environment, protective measures will be reduced in stages, for example by expanding areas in which no masks are required.
 - Continuing efforts will be made to improve the working environment, for example by increasing working space and offering increased benefits.
- Monitoring of effects of improvements
 - In order to verify the effects of the improvements above, in addition to the improvements in health management discussed in 6-3(3), effects will be periodically monitored via twice-yearly questionnaires and other measures, and further improvements will be made as necessary.

6-3. Plan for Ensuring Work Safety

Work safety management and radiation management are important elements in ensuring workers' safety and maintaining their health.

Guaranteeing safety is a prerequisite for our future mid-and-long-term initiatives. Complex operations which diverge from standard procedures will be ongoing in future, and all personnel involved will share a strong awareness of safety which stresses care in avoiding major accidents and excessive exposure, and will conduct the activities described below. In addition, we will conduct constant checks in an attempt to make continuous improvements to operations.

(1) Overall work safety

Following the tsunami disaster, up to the present we have been forced to respond to working environments and types of operations for which we had no previous experience, and this has seen us conducting advance evaluations of safety, share information and enhance cooperation with contractors, establish rest areas, and

adopt measures for heat exhaustion.

Complex operations which diverge from standard procedures will be ongoing in future, and we will therefore place an emphasis on the following four items in order to prioritize safety.

- Continuous safety activities
 - To ensure safety in work operations, we will conduct continuous advance examinations of work methods, safety measures, safety education, and the effect of the work on other equipment. In particular, work that will be conducted under special conditions, and work that involves the introduction of new technologies or new methods, will be subject to deliberations by the (in-house) Advance Safety Evaluation Committee, and safety patrols and monitoring devices will be employed to check on the status of the work, in an attempt to improve safety initiatives.
- Cooperation with contractors
 - We will continue to hold safety liaison meetings with contractors working within the site (once weekly), sharing information concerning safety in order to increase safety awareness among personnel.
 - We will also attempt to improve working environments in order to facilitate communication.
- Maintenance and expansion of rest areas
 - In addition to appropriately maintaining the rest areas that we established from the stage of Step 1 and the facilities provided in these areas, we will examine the conditions for the establishment of rest areas which come to be required in response to changes such as changes in the scale of the work or the areas in which it is being conducted.
- Prevention of heat exhaustion
 - In areas in which there is concern over the possibility of heat exhaustion, we will monitor the environment using Wet-Globe Bulb temperature (WBGT) devices⁸, encourage reductions in working hours and increased fluid intake, and provide cooling vests, among other measures for the prevention of the condition. We will also educate personnel concerning ways to prevent heat exhaustion.

(2) Radiation management

- Establishment of entrance and exit points
 - As the result of an increase in the level of radioactivity due to the large-scale release of radioactive substances, values for doses originating in external doses, the concentration of radioactive substances in the atmosphere, and the density of radioactive substances on contaminated wall surfaces in monitored areas exceed values for controlled areas. Because of this, at present monitored areas are being considered as areas subject to controls, requiring the same level of management as

⁸ Instrument for measuring indicators that detect humidity, radiant heat, and temperature, the three elements that have the largest impact on human heat balance.

- controlled areas.
- At present, access management for areas subject to controls (screening, fitting of protective clothing and dosimeters) is being conducted in areas separated from the areas subject to controls, but in future, we will select access management areas that enable procedures to be conducted close to areas subject to controls.
 - Expansion of continuous monitoring of work environments
 - Area monitoring of radiation in existing buildings is not presently functioning. However, because the frequency of entry to the buildings is low and the areas in question are limited, we are presently working to detect any abnormalities by having employees themselves measure radioactivity in the vicinity of these areas.
 - This means that in the case of work in areas subject to control, in an attempt to reduce the dose to which employees are exposed to the lowest reasonably achievable level, as necessary workers take measurements of the dose equivalent rate for external radiation and the concentration of radioactive substances in the air prior to and during the work procedures, and perform the work after identifying the procedures for which the dose is highest.
 - In future, taking the frequency of entry and the expansion of areas into consideration, we will proceed with studies to enable us, as necessary, to make the transition to management using conventional area radiation monitors. In addition, with regard to outdoor areas and buildings which have been established since the tsunami, we will position area radiation monitors in areas which personnel are using for the purposes of equipment operation, monitoring, inspection, etc., and we will conduct continuous monitoring of radiation levels to enable us to understand the status of radiation environments and share information concerning protection from exposure.
 - Implementation of individual radiation management
 - In future, in addition to increasing the reliability of data management, including integrated management of issuance of dosimeters and management of individual dose histories, we will centralize data including external dose data, the results of internal dose measurements and dates of examinations for effects of ionizing radiation to enable systematic provision of whole body counts (WBC)⁹ (incorporating the rationalization of evaluation frequency in line with the improvement of working environments) and management of the due dates for health checks. (to April 2012)
 - Examination and implementation of measures for reduction of dose optimized for individual work operations
 - Attempting to reduce the dose to which employees are exposed to the

⁹ Instrument for measuring personal internal exposure and whole-body radioactivity by measuring radioactive materials ingested in the body from outside the body.

lowest reasonably achievable level, for the performance of individual work operations, essential conditions such as the need for protective clothing and equipment, the number of personnel involved, and time limitations will be decided in advance in response to the working environment, and rational work plans will be formulated taking the individual exposure history of the employees who will be performing radiation-related duties into consideration.

- In order to enable the determination of the abovementioned essential conditions for work plans, advance training in work operations and the use of robots will be considered.
- Reduction of protective measures
 - Following the thorough implementation of dose management measures, protective measures will be reduced in stages as appropriate for the environment (for example, areas in which no masks are required will be expanded), and consistent management will be instituted.
 - To enable this, it will be essential to reduce the level of radiation in the site, and decontamination operations will therefore be conducted in stages, in a systematic manner.

(3) Health management

- Ongoing provision of healthcare system
 - Until local healthcare services recover a fixed level of function, a healthcare system will be provided on a continuing basis at the Fukushima Daiichi Nuclear Power Station, the Fukushima Daini Nuclear Power Station, and J-Village in terms of personnel safety and security. Specifically, healthcare personnel including physicians will be allocated as necessary, and the necessary equipment, devices and pharmaceuticals will be procured. In addition, a system for transportation to external medical facilities will be maintained. Operational improvements will also be made constantly to ensure the optimum quality of healthcare and rapid transportation.
- Implementation of long-term health management
 - Based on “Guidelines for the protection of the health of emergency workers at the Fukushima Daiichi Nuclear Power Station” published on October 11, 2011 by the Ministry of Health, Labour and Welfare, we will institute long-term health management measures for emergency workers. In addition to operating a health consultation center, we will provide extensive support for health checkups including cancer screenings. This support will also be provided for the employees of companies which are cooperating in the work on the site.

7. Cooperation with the International Community

Viewing transparency in relation to the international community as an issue of the greatest importance, the Nuclear Emergency Response Headquarters has made

available the information it has obtained rapidly and accurately, providing “Additional Report of the Japanese Government to the IAEA –The accident at TEPCO’s Fukushima Nuclear Power Stations–”reports concerning the status of the accident at the Fukushima Daiichi Nuclear Power Station to the International Atomic Energy Agency in June and September.

It is essential to bring together knowledge from all sources in responding to the Fukushima accident, and up to the present many nations around the world have offered support and cooperation. From the initial stage of the decommissioning work, we will continue to proceed on the basis of cooperation with the governments of other countries and international organizations.

In order to conduct the research and development necessary to a large-scale and long-term reactor decommissioning project effectively and efficiently, we will make extensive use of knowledge and experience gained from responses to overseas accidents and other sources, in addition to enhancing cooperation with overseas government-affiliated research organizations and private companies.

8. System of Implementation for Mid-and-long-term Initiatives

Following the tsunami disaster, the government and Tokyo Electric Power Company formulated the “Roadmap towards Restoration from the Accident at Fukushima Daiichi Nuclear Power Station, TEPCO”, and cooperated in initiatives for recovery from the incident while revising the Roadmap as necessary in response to the status of progress.

In implementing the new Roadmap, it is essential that the government and Tokyo Electric Power Company once again establish a strong cooperative system, ensuring transparency and securing the understanding of local residents and the broader Japanese public while proceeding steadily with efforts towards the decommissioning of the reactors on the basis of technological knowledge in a broad range of fields sourced both domestically and internationally. To this end, with the completion of Step 2, Government-TEPCO Integrated Response Office been disbanded, and Government and TEPCO’s Mid-to-Long Term Countermeasure Meeting has been created under the Nuclear Emergency Response Headquarters in order to formulate and supervise the implementation of this Roadmap.

In addition, because essential research and development in relation to the examination and implementation of mid-and-long-term measures towards the decommissioning of the reactors faces numerous complex issues which are unprecedented on a global scale, it will be necessary to proceed on the basis of cooperation from relevant domestic and overseas institutions. To enable this cooperation, it will be necessary to create a system of implementation for research and development plans and formulate concrete implementation plans for each issue involved, in addition to establishing solid linkages between onsite work and research and development projects.

9. Conclusion

Seeking to ensure the earliest possible return for local residents displaced by the accident to the Fukushima Daiichi Nuclear Power Station and to alleviate the anxiety felt both in this region and across the nation, Tokyo Electric Power Company, the Agency for Natural Resources and Energy, and the Nuclear and Industrial Safety Agency intend to commence mid-and-long-term work towards the decommissioning of Fukushima Daiichi Nuclear Power Station Units 1–4 on the basis of this Roadmap, under an appropriate cooperative framework.

At the same time, based on factors including the conditions at the site and the outcomes of research and development, Tokyo Electric Power Company, the Agency for Natural Resources and Energy, and the Nuclear and Industrial Safety Agency will periodically revise this plan, and will ensure transparency by announcing the status of mid-and-long-term initiatives.

This Roadmap compiles details of technological procedures related to decommissioning work, essential research and development, etc. No estimates of costs were made in the process of their examination.

The functions of the Nuclear and Industrial Safety Agency will be transferred to a new regulatory agency scheduled to be created in April 2012. The new agency will take on the responsibility for this Roadmap and its purport.

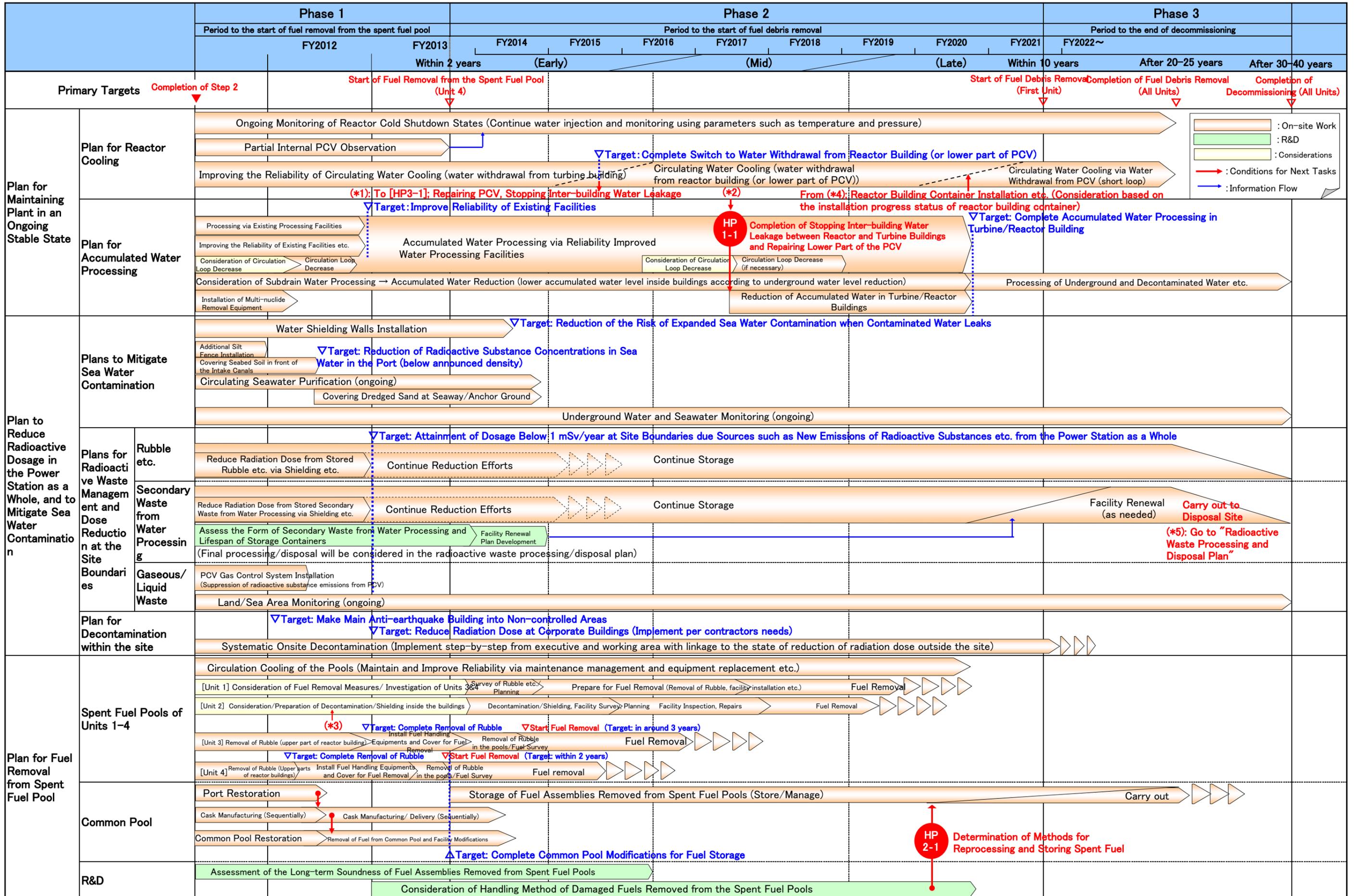
<Attached materials>

- Attachment 1-1: Main Schedule of Mid-and-long-term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1-4, TEPCO
- Attachment 1-2: Mid-term Schedule
- Attachment 2: Procedural Steps for the Removal of Fuel from the Spent Fuel Pools
- Attachment 3: Procedural Steps for the Removal of Fuel Debris

<Supplementary materials>

- Supplement 1: Concerning the Research and Development Plan related to the Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1-4, TEPCO

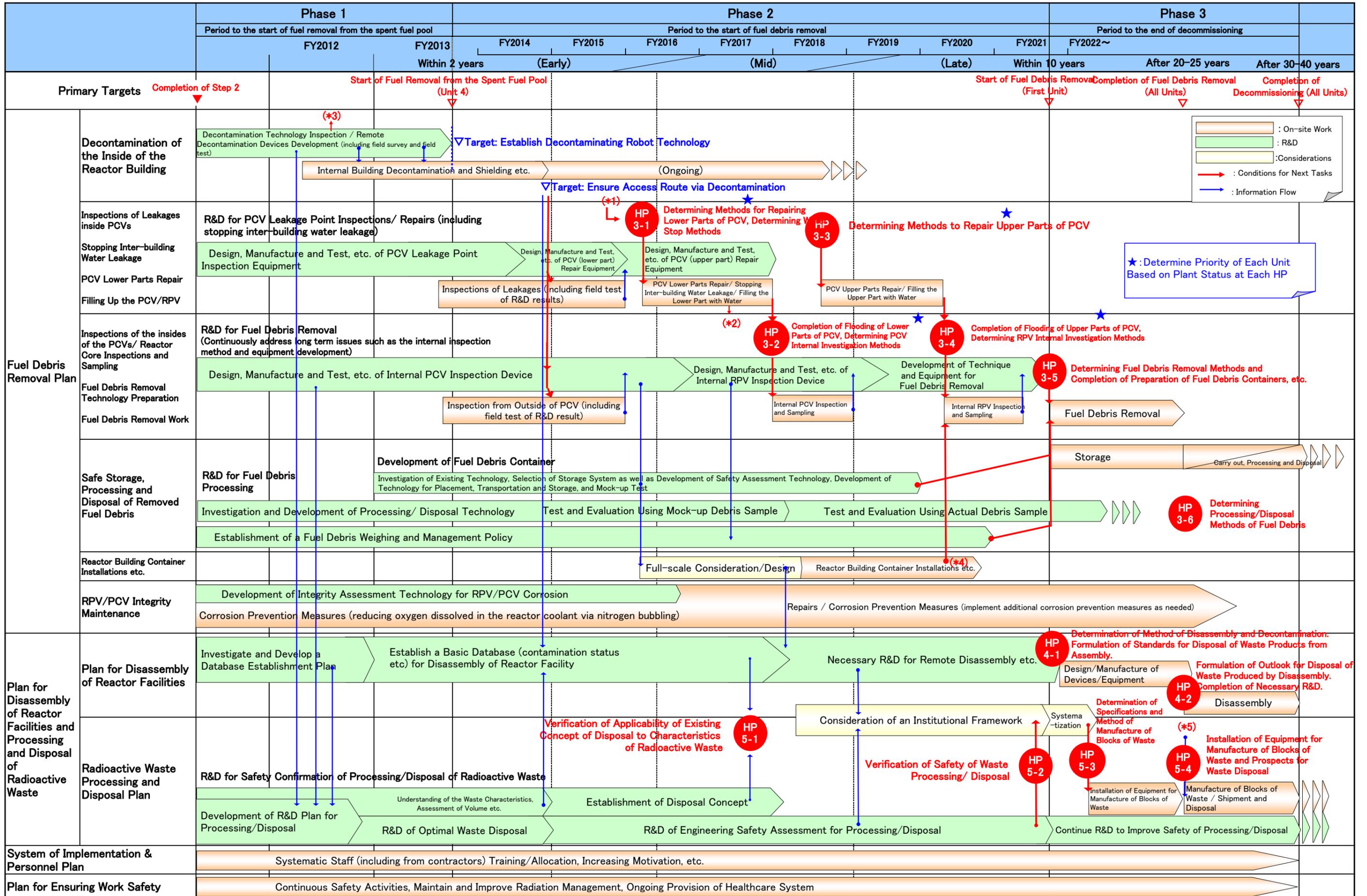
Main Schedule of Mid-and-long-term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1-4, TEPCO



*This roadmap will be updated in consideration of the on-site situation and the latest research and development results.

HP: Holding Point (Points of Judgment)

Main Schedule of Mid-and-long-term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1-4, TEPCO



*This roadmap will be updated in consideration of the on-site situation and the latest research and development results.

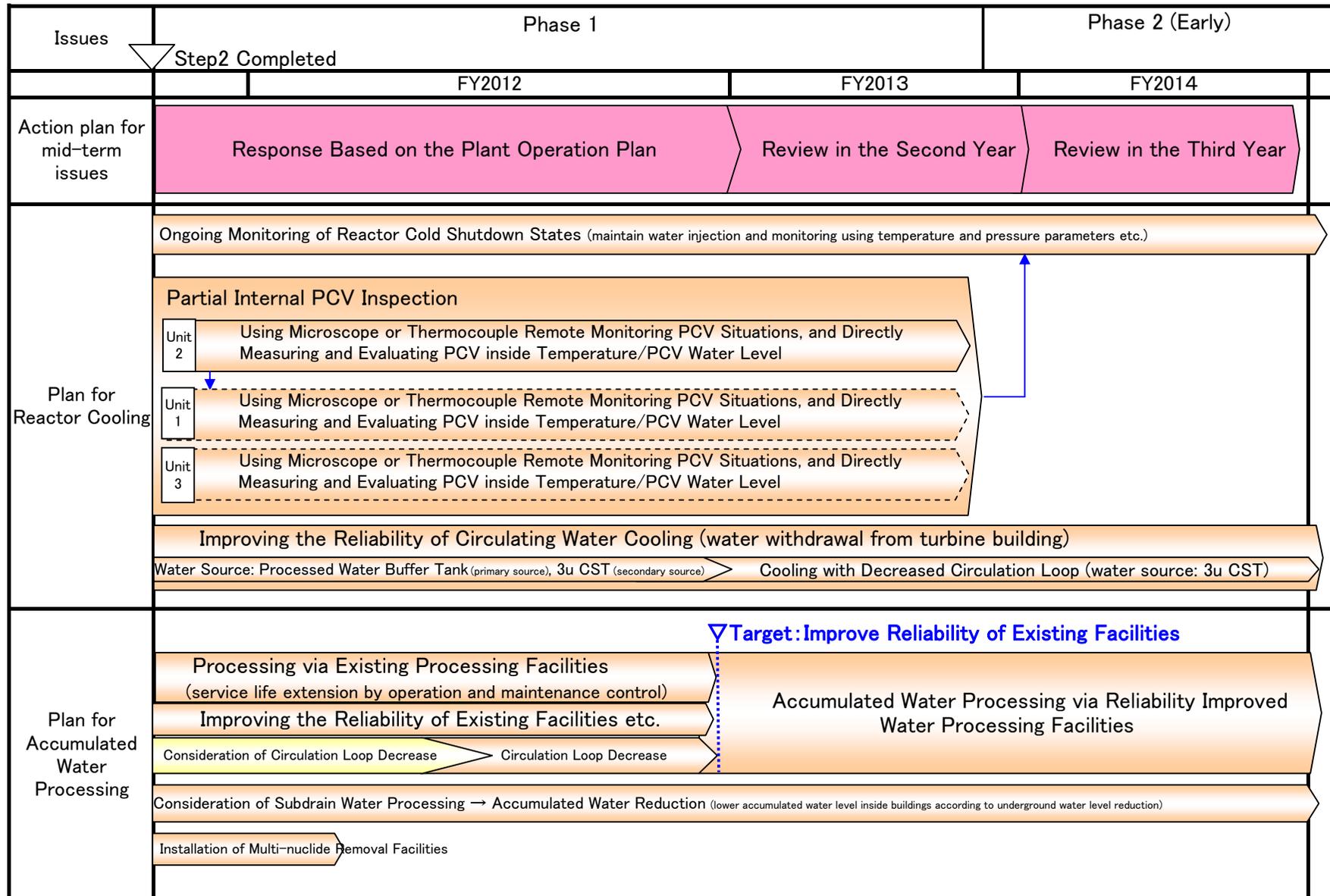
HP: Holding Point (Points of Judgment)

Mid-Term Main Schedule towards the Decommissioning of Fukushima Daiichi Nuclear Power Station

Issues		Step2 Completed	Phase 1		Phase 2 (Early)	
			FY2012	FY2013	FY2014	
Action plan for mid-term issues		Planning Plant Operation	Response based on the plant operation			
Plan for Reactor Cooling Maintaining Plant in an Ongoing Stable State	Plan for Reactor Cooling	Condition Equivalent to Cold Shutdown	Ongoing Monitoring of Reactor Cold Shutdown States (Maintain water injection and monitoring using temperature and pressure parameters etc.)			
			Partial Internal PCV Inspection			
			Improving the Reliability of Circulating Water Cooling (water withdrawal from turbine building)			
	Plan for Accumulated Water Processing	Reduction of total amount of Accumulated Water	Processing via Existing Processing Facilities Improving the Reliability of Existing Facilities etc.		Accumulated Water Processing via Reliability Improved Water Processing Facilities	
Consideration of Subdrain Water Processing → Accumulated Water Reduction (lower accumulated water level inside buildings according to underground water level reduction)						
Plans to Mitigate Sea Water Contamination Plan to Reduce Radioactive Dose in the Power Station as a Whole, and to Mitigate	Plans for Radioactive Waste Management and Dose Reduction at the Site Boundaries	Mitigate Ocean Storage/Management	Water Shielding Walls Installation			
			Covering Seabed Soil in front of the Intake Canal, Circulating Seawater Purification (ongoing) etc.			
			Underground Water and Seawater Monitoring (ongoing)			
	Rubble etc.	Mitigate Scattering	Continue Storage		Continue Reduction Efforts	
			Reduce Radiation Dose from Stored Rubble etc. via Shielding		Continue Reduction Efforts	
	Secondary Waste from Water Processing	Mitigate Scattering	Continue Storage		Continue Reduction Efforts	
			Stored Water Processing via Shielding etc. Reduce Radiation Dose from Secondary Waste		Continue Reduction Efforts	
	Gaseous/Liquid Waste	Mitigate Scattering	Assess Characteristics of Secondary Waste from Water Processing and Storage Container Lifespan		Facility Replacement Plan Development	
			PCV Gas Control System Installation		Land/Sea Area Monitoring (ongoing)	
	Onsite Decontamination	Decontamination (Start)	Systematic Onsite Decontamination			
Plan for Fuel Removal from Spent Fuel Pool	SFPs of Units 1-4	More Stable Cooling	Circulation Cooling of the Pools (Improve Reliability via maintenance and replacement etc.)			
			Removal of Rubble/Cover for Fuel Removal /Cask Procurement/Install or Repair of Fuel Handling Equipments			
	Common Pool		Site Harbor Restoration (crane/road)		Storage of Fuel Assemblies Removed from SFP (store/manage)	
			Cask Manufacturing (sequentially)		Cask Manufacturing/ Delivery (sequentially)	
	R&D		Common Pool Restoration		Common Pool Fuel Removal and Facility Modifications	
Fuel Debris Removal Plan	Decontamination of the Inside of the Reactor Building	Condition Equivalent to Cold Shutdown	Decontamination Technology Investigation / Remote Decontaminating Equipment Development			
			Internal Building Decontamination and Shielding etc. (Ongoing)			
	Inspections of Leakages inside PCVs		Design, Manufacture and Test, etc. of PCV Leakage Point Survey Equipment		Investigation of Leakage Points (including field test of R&D results)	
			Design, Manufacture and Test, etc. of Internal PCV Inspection Device		Investigate Outside of PCV (including field test of R&D results)	
	Fuel Debris Removal		Development of Fuel Debris Container (investigation of existing technology, selection of storage system as well as development of safety assessment technology)			
			Investigation and Development of Processing/ Disposal Technology			
	Reactor Building Container Installations etc.		Establish Measuring Method to Weigh Fuel Debris			
Development of Integrity Assessment Technology for RPV/PCV Corrosion						
Reactor Dismantling & Radioactive Waste Processing/Disposal Plan	Reactor Dismantling Plan	Reactor Dismantling Plan	Investigate and Develop a Database Establishment		Establish a Basic Database (contamination status etc) for Reactor Facility Dismantlement	
			Radioactive Waste Processing/Disposal Plan	Development of R&D Plan for Processing/Disposal		Grasping Waste Characteristics, Assessment of Volume etc. R&D of Optimal Waste Disposal
Organization & Staff Planning		Enhancement of Environment Dependence		Systematic Staff (including from partner companies) Training/Allocation, Improving Motivation, etc.		
Worker Safety Plan			Enhancement of Radiation Dose Control	Continue to Promote Safety, Maintain and Improve Radiation Protection Measures, Continuously Maintain Medical Care System		

Progress Status of Each Plan (1)

[Provisional Translation]



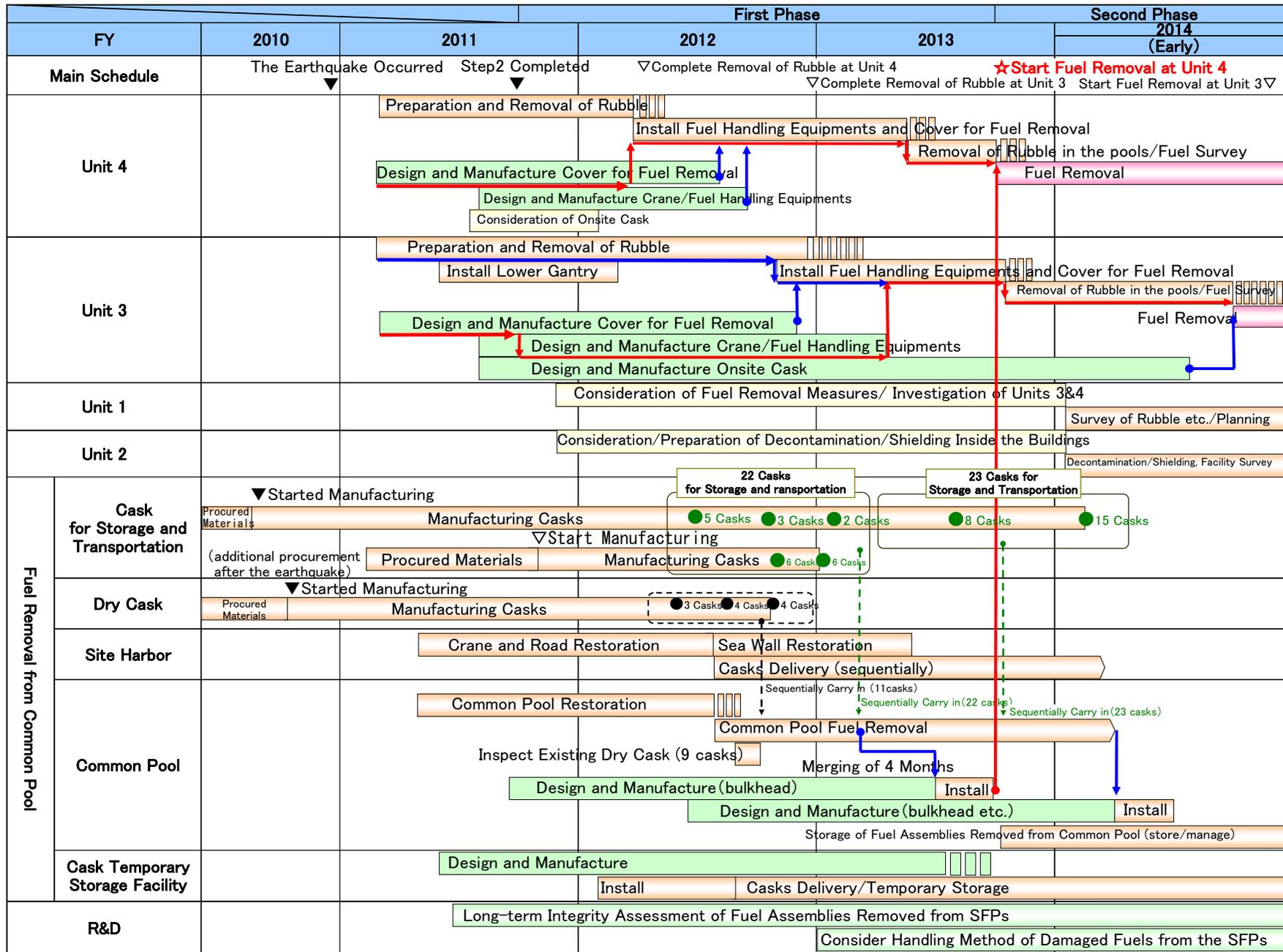
Progress Status of Each Plan (2)

[Provisional Translation]

Issues	Phase 1		Phase 2 (Early)		
	Step2 Completed	FY2012	FY2013	FY2014	
Plans to Mitigate Sea Water Contamination	▽Target: Reduction of the Risk of Expanded Sea Water Contamination when Contaminated Water Leaks ▽				
	Water Shielding Walls Installation				
	Additional Silt Fence Installation	▽Target: Reduction of Radioactive Substance Concentrations in Sea Water in the Port (below announced density)			
	Covering Seabed Soil in front of the Intake Canal				
	Circulating Seawater Purification (ongoing)				
	Covering Dredged Sand at Seaway/Anchor Ground				
	Underground Water and Seawater Monitoring (ongoing)				
Plans for Radioactive Waste Management and Dose Reduction at the Site Boundaries	Rubble etc.	▽Target: Attainment of Dosage Below 1 mSv/year at Site Boundaries due Sources such as New Emissions of Radioactive Substances etc. from the Power Station as a Whole			
		Continue Storage			
		Reduce Radiation Dose from Stored Rubble etc. via Shielding <small>(repair existing storage, install additional storage with shielding, store logged tree with cover soil)</small>	Continue Reduction Efforts		
	Secondary Waste from Water Processing	Continue Storage			
		Stored Water Processing via Shielding etc. Reduce Radiation Dose from Secondary Waste	Continue Reduction Efforts		
		Assess Characteristics of Secondary Waste from Water Processing and Storage Container Lifespan	Facility Replacement Plan Development		
	Gaseous/Liquid Waste	PCV Gas Control System Installation			
		Unit 2: In Operation			
		Units 1, 3: Install	In Operation		
		Land/Sea Area Monitoring (ongoing)			
Onsite Decontamination	▽Target: Change Main Anti-earthquake Building into an Area where Radiation Controls are not Required ▽Target: Reduce Radiation Dose at Corporate Buildings <small>(implement per partner companies needs)</small>				
	Systematic Onsite Decontamination <small>(sequentially implement from executive and working area in conjunction with efforts to reduce radiation dose outside of the site)</small>				

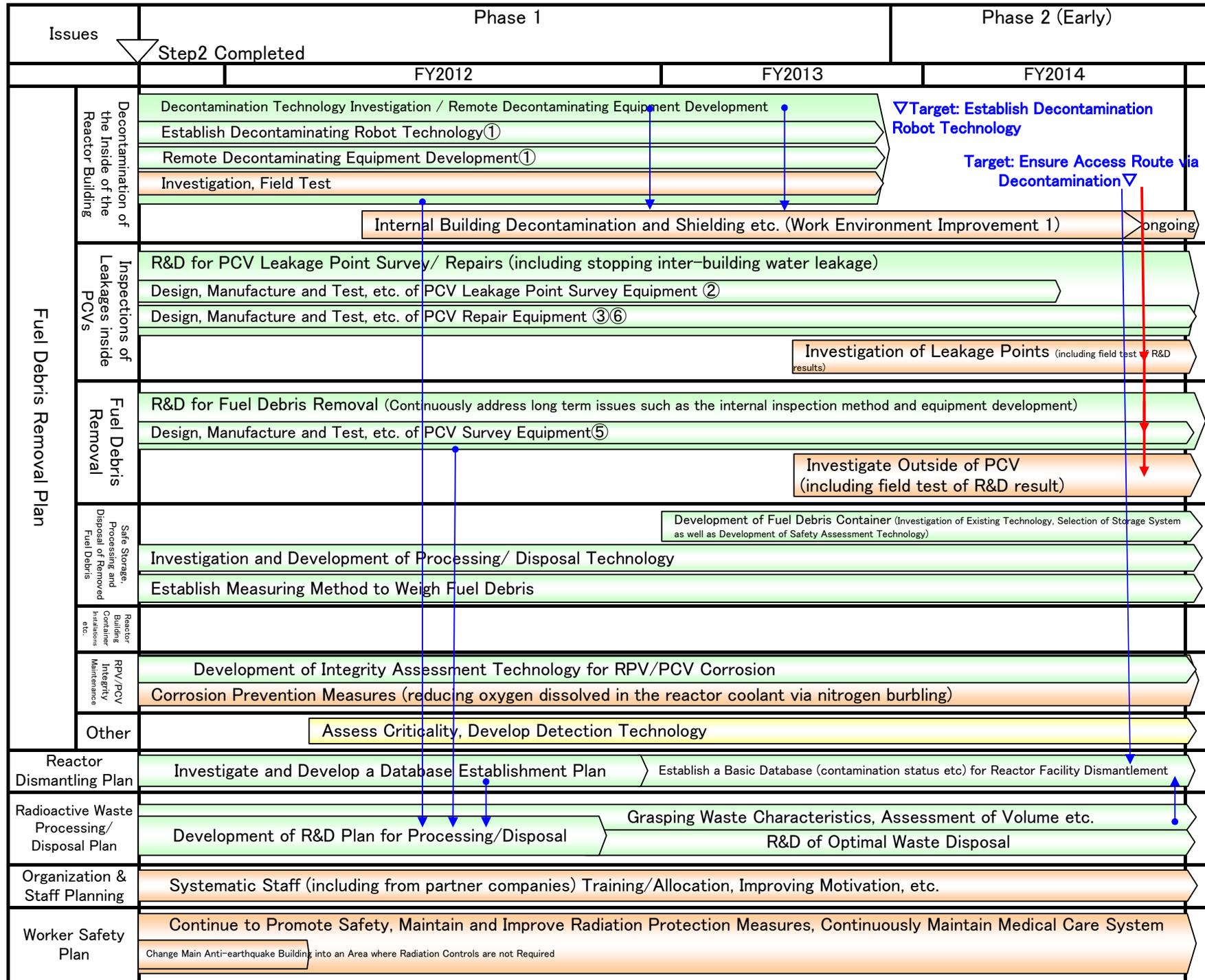
Progress Status of Each Plan (3)

[Provisional Translation]



Progress Status of Each Plan (4)

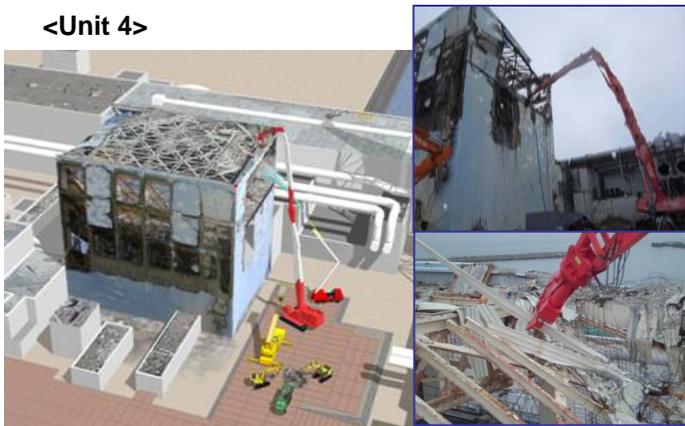
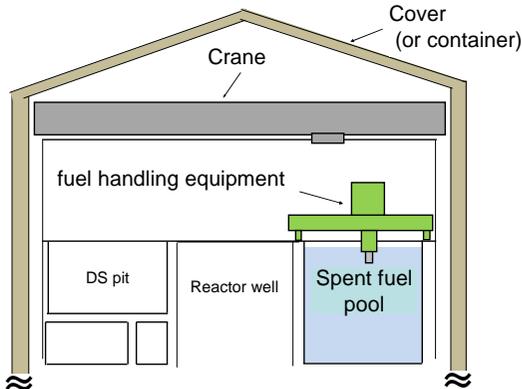
[Provisional Translation]



Steps Involved in Fuel Removal from the Spent Fuel Pool (1/2)

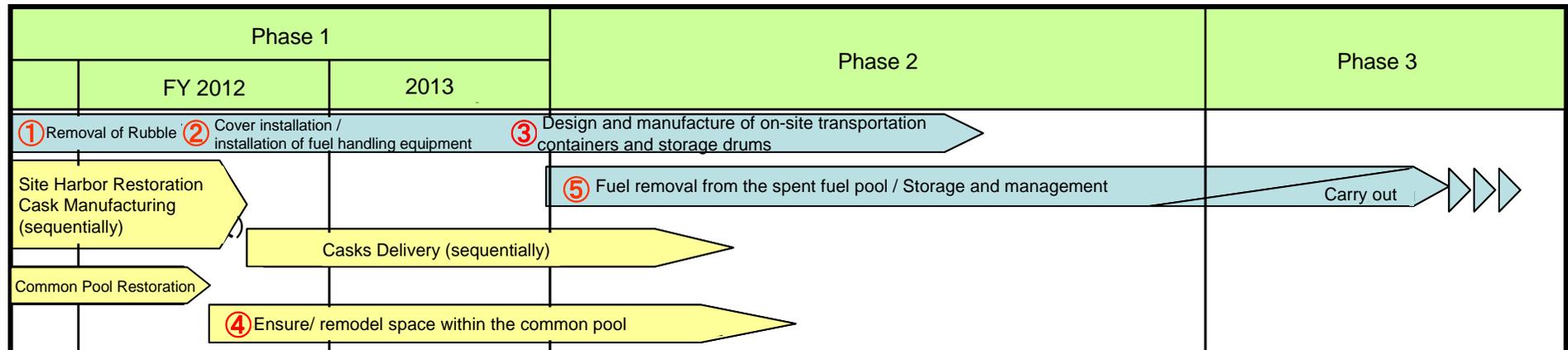
Appendix 2
[Provisional Translation]

Phase 1		Phase 2	Phase 3
FY 2012	2013		
① Removal of Rubble ② Cover installation / installation of fuel handling equipment		③ Design and manufacture of on-site transportation containers and storage drums	
Site Harbor Restoration Cask Manufacturing (sequentially)		⑤ Fuel removal from the spent fuel pool / Storage and management	
Common Pool Restoration		Carry out	
Casks Delivery (sequentially)			
④ Ensure/ remodel space within the common pool			

Steps	① Removal of rubble from upper parts of reactor buildings On going at Units 3&4	② Cover (or container) installation / installation of fuel handling equipment	③ Design and manufacture of transportation containers and storage drums
Images	<Unit 4> 		<Example of transportation containers: NH-25 >  <p>(Source: Manufacturer material)</p>
Contents	Removal of rubble from upper parts of reactor buildings by the use of heavy equipment and a crane	Cover (or container) installation in order to blocking wind and rain / installation of a crane and fuel handling equipment	Design and manufacture of transportation containers and storage drums in order to move fuels from the spent fuel pools to the common pool
Points to Note on Development	—	—	—
Points to Note on Ensuring Safety	-Maintain spent fuel pool cooling in a stable state -Prevent radioactive materials scattering on removal of rubble -Environment Monitoring -Reduce workers exposure (using remote control etc.)	-Maintain spent fuel pool cooling in a stable state -Reduce workers exposure (reduce radioactivity of work area etc.)	—

Steps Involved in Fuel Removal from the Spent Fuel Pool (2/2)

[Provisional Translation]



Steps	④ Ensure/ remodel space within the common pool	⑤ Fuel removal from the pool														
Images	<p><Current situation></p> <table border="1"> <thead> <tr> <th>Unit</th> <th>Number of stored fuels</th> </tr> </thead> <tbody> <tr> <td>Unit 1</td> <td>392</td> </tr> <tr> <td>Unit 2</td> <td>615</td> </tr> <tr> <td>Unit 3</td> <td>566</td> </tr> <tr> <td>Unit 4</td> <td>1,535</td> </tr> <tr> <td>Total</td> <td>3,108</td> </tr> <tr> <td>Common pool</td> <td>6,375</td> </tr> </tbody> </table> <p>○ Remodeling • Washing / inspection equipment • Damaged fuel rack</p> <p><i>In the meantime, temporarily stored in the onsite temporary cask storage</i></p>	Unit	Number of stored fuels	Unit 1	392	Unit 2	615	Unit 3	566	Unit 4	1,535	Total	3,108	Common pool	6,375	
Unit	Number of stored fuels															
Unit 1	392															
Unit 2	615															
Unit 3	566															
Unit 4	1,535															
Total	3,108															
Common pool	6,375															
Contents	Undamaged spent fuels currently stored in the common pool will be removed in order to ensure an area. Fuel reception partition, fuel washing and inspection equipment, and damaged fuel rack etc. will be installed.	Damaged fuels will be placed in storage drums, then placed in transportation containers in order to movement														
Points to Note on Development	-Wash fuels encrusted with salt or damaged / Decontamination / Consideration of method to inspect fuels	-														
Points to Note on Ensuring Safety	-Reduce workers exposure (usual management)	-Maintain spent fuel pool cooling in a stable state -Prevent fuel dropped -Reduce workers exposure (use remote equipment, reduce radioactivity of work area etc.)														

Work Steps Involved in Fuel Debris Removal (1/3)

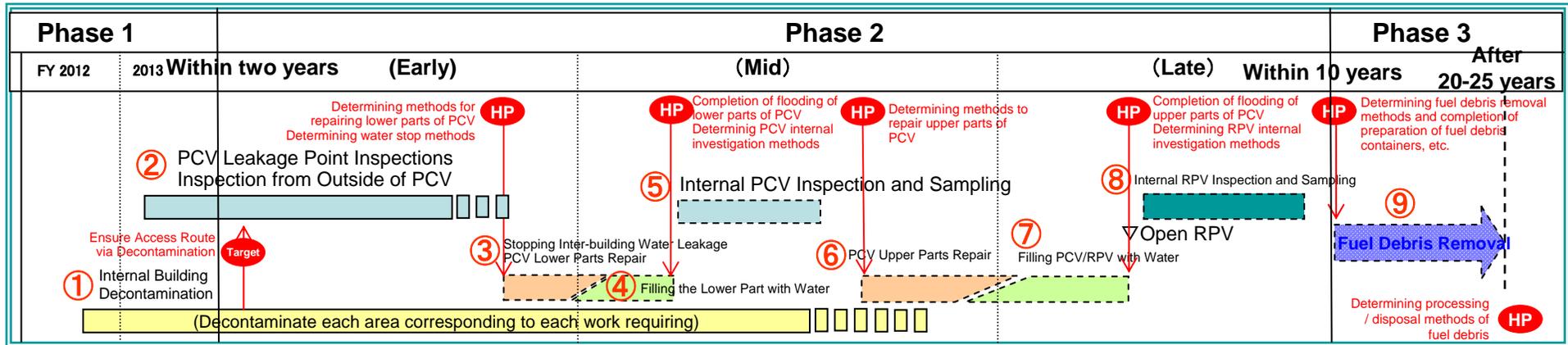
Phase 1		Phase 2			Phase 3	
FY 2012	2013	Within two years (Early)	(Mid)	(Late)	Within 10 years	After 20-25 years
		<p>① Reactor Building Decontamination (Decontaminate each area corresponding to each work requiring)</p> <p>② PCV Leakage Point Inspections Inspection from Outside of PCV</p> <p>③ Stopping Inter-building Water Leakage PCV Lower Parts Repair</p> <p>④ Filling the Lower Part with Water</p> <p>⑤ Internal PCV Inspection and Sampling</p> <p>⑥ PCV Upper Parts Repair</p> <p>⑦ Filling PCV/RPV with Water</p> <p>⑧ Internal RPV Inspection and Sampling</p> <p>⑨ Fuel Debris Removal</p>				
		<p>Determining methods for repairing lower parts of PCV Determining water stop methods</p> <p>HP</p> <p>HP</p> <p>HP</p> <p>HP</p> <p>HP</p> <p>HP</p> <p>HP</p> <p>HP</p> <p>HP</p>				
		<p>Ensure Access Route via Decontamination</p> <p>Target</p>				

※ Work steps of removing the fuel debris underwater (as was done at TMI-2) : Technical holding points, further deliberation and judgment, including additional research and development and revision of process and task content

Steps	① Reactor Building Decontamination (Decontaminate each area corresponding to each work following ② sequentially)	② PCV Leakage Point Inspections Inspection from Outside of PCV	③ Stopping Inter-building Water Leakage PCV Lower Parts Repair
Images			<p>After achieving stopping inter-building water leakage, switch intake sources for circulating water cooling from accumulated water in turbine buildings to torus.</p>
Contents	In order to easily access PCVs, decontaminate work area via high-pressure washing, coating, and scraping, etc.	Inspect leakage points in the PCV and reactor building via manual or remote dose measurement, and camera, etc. Estimate and inspect the status of PCV inside via measurement of gamma ray from outside of PCV, and acoustic inspection, etc.	Repair PCV leakage points and then stop water leakage because it is believed that removing debris while underwater due to the excellent radiation shielding afforded will be the reliable method. First, repair points at lower parts of PCV for internal inspection.
Points to Note on Development	<p>◆The existence of areas of high dosage (several hundred to 1,000 mSv/h).</p> <p>◆Access restriction due to rubble scattered about inside R/B.</p> <ul style="list-style-type: none"> Remote decontamination methods corresponding to the above need to be considered and established. 	<p>◆Inspection areas may be located in highly radioactive environments, under contaminated water, and in narrow parts.</p> <ul style="list-style-type: none"> Develop leakage point inspection methods and devices. Develop methods and devices for internal inspection from outside of PCV. 	<p>◆While continuing water injection for circulating water cooling, stop water leakage under highly radioactive and water running conditions.</p> <ul style="list-style-type: none"> Develop technologies and methods to repair leakage points and stop water leakage. Consider and develop alternatives.
Points to Note on Ensuring Safety	<ul style="list-style-type: none"> Maintain RPV cooling in a stable state Prevent radioactive materials scattering during decontamination Reduce worker exposure (remote control, shielding, etc.) 	<ul style="list-style-type: none"> Maintain RPV cooling in a stable state Reduce worker exposure (remote control, shielding, etc.) 	<ul style="list-style-type: none"> Maintain RPV cooling in a stable state Reduce worker exposure (remote control, shielding, etc.)

Work Steps Involved in Fuel Debris Removal (3/3)

[Provisional Translation]



※ Work steps of removing the fuel debris underwater (as was done at TMI-2)

HP : Technical holding points. further deliberation and judgment, including additional research and development and revision of process and task content

Steps	⑦ Filling PCV and RPV with Water ⇒ Open the upper cover on RPV	⑧ Internal RPV Inspection and Sampling	⑨ Fuel Debris Removal
Images			
Contents	After filling PCV/RPV with water enough to ensure shielding, open the upper cover on RPV.	Ascertain conditions of fuel debris and internal RPV structures by internal RPV inspections and samplings etc.	Remove debris inside RPV and PCV
Points to Note on Development	(Place top priority on the construction of PCV boundaries as per ⑥)	<p>◆ Restricted access route due to high radioactive conditions and unknown internal RPV conditions (thickness of internal water, existence of debris, etc.)</p> <ul style="list-style-type: none"> • Develop remote inspection methods and sampling methods based on the above. 	<p>◆ Expand technology development scope depending on distribution status of fuel debris (No experience of fuel removal of inside PCV at TMI)</p> <ul style="list-style-type: none"> • Develop more sophisticated technologies and methods than those of TMI
Points to Note on Ensuring Safety	<ul style="list-style-type: none"> • Maintain RPV cooling in a stable state • Subcritical assessment • Prevent radioactive substances from PCVs releasing 	<ul style="list-style-type: none"> • Maintain RPV cooling in a stable state • Subcritical assessment • Store the removed fuel debris (containment etc.) • Reduce worker exposure (remote control, shielding, etc.) 	<ul style="list-style-type: none"> • Maintain RPV cooling in a stable state • Subcritical assessment • Store the removed fuel debris (containment etc.) • Reduce worker exposure (remote control, shielding, etc.)