

Supplementary Document 1

Research and Development Road Map for Decommissioning Units 1–4 at
TEPCO's Fukushima Daiichi Nuclear Power Plant

July 30, 2012
Nuclear Emergency Response Headquarters
Government-TEPCO Med-and-long Term
Response Council

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1. Introduction

In addressing the disaster at the Fukushima Daiichi Nuclear Power Plant, following the completion of Step 2 we will be moving from initiatives aimed at stabilizing the plant towards initiatives aimed at maintaining those conditions. At the same time, we will be taking a medium to long-term approach towards actions (removing fuel assemblies stored inside spent fuel pools, removing intra-core fuel debris, etc.) necessary for decommissioning the plant.

To this end, an expert committee was formed by the Atomic Energy Commission of Japan in August of this year to consider medium to long-term solutions. In addition to identifying the technological challenges and establishing the areas in which R&D will be performed, the committee has issued a report that establishes a goal to begin the removal of fuel debris within 10 years, while also stating that a period of more than 30 years would be required to complete the decommissioning process.

Based on the above report, on November 9 Yukio Edano, the Minister of Economy, Trade and the Industry, and Goshi Hosono, the minister in charge of nuclear accident settlement and prevention, requested that the Agency of Natural Resources and Energy, the Nuclear and Industrial Safety Agency (NISA), and TEPCO draft a R&D road map for decommissioning the facility.

In response, the Agency of Natural Resources and Energy and TEPCO devised this R&D road map in collaboration with the Ministry of Education, Culture, Sports, Science and Technology, the Japan Atomic Energy Agency, and Toshiba Corporation and Hitachi / Hitachi-GE Nuclear Energy, Ltd. , which are plant manufacturers with expertise in and experience with the design and construction of TEPCO's Fukushima Daiichi Nuclear Power Plant.

On December 21 the “Mid-and-long-Term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1-4, TEPCO” was determined along with this R&D plan at the government/TEPCO Mid/Long-Term Countermeasures Headquarters and an operations committee and Research and Development Headquarters (hereinafter referred to as, “Headquarters”) were established to oversee progress.

Since its establishment in December of last year, Headquarters held a total of seven meetings as of June of this year and engaged in concentrated discussions about individual R&D project management, detailed efforts for gathering knowledge from domestic and overseas sources, the research base concept and securing/cultivating personnel.

Furthermore, along with holding an international symposium in March of this year as part of efforts to disseminate information worldwide, a workshop will be held in August of this year to share information and exchange opinions with corporations and research institutions from the Fukushima region.

In accordance with this plan we will continue steadfastly with research required to proceed over the mid and long-term with efforts aimed at the decommissioning of TEPCO Fukushima Daiichi Units 1~4.

2. Fundamental philosophy behind conducting the R&D

(1) Addressing needs in the field

The goal of this R&D is to—after completing processes up to Step 2—establish methods for effectively maintaining stable conditions at the plant while at the same time place prime importance on securing the safety of those working at and residing near the facility in coming up with the necessary technological solutions required to certainly and efficiently carry out a plan to remove fuel from spent fuel pools, remove intra-core fuel debris, and complete other steps in the process of decommissioning the plant.

This R&D will differ from research normally conducted in that the results of this R&D will be used directly in work involved in the decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Plant. As such, the scope of this R&D will include conducting technology demonstrations in the field.

Thus, we will consistently ascertain the needs of those in the field and see that those needs are addressed in R&D at all stages of the R&D plan, from planning to execution, while also applying R&D results as quickly and accurately as possible to problems in the field.

When R&D achievements are realized, the determination as to whether or not to proceed to the next stage will be made after evaluating the feasibility and validity of the technologies developed. We will also coordinate thoroughly with related organizations concerning conditions in the field and progress made with R&D and work processes, revising plans along the way as needed.

In particular, as the results of field surveys may find it necessary to use completely different technologies, we will be looking into alternate policy ahead of time for challenges such as water cutoff technologies that could present considerable technical hurdles.

(2) Desired government involvement and support

The decommissioning of this facility will involve technical challenges the likes of which we have yet to experience. The Agency of Natural Resources and Energy will therefore be playing a lead role in R&D plan creation and project management, and will be coordinating closely with the Ministry of Education, Culture, Sports, Science and Technology as it puts together an R&D framework utilizing the expertise of those in Japan and around the world.

The Nuclear and Industrial Safety Agency (new regulatory agency) will implement safety regulations in accordance with the necessary legislative system for tests and demonstrations performed in the field as part of R&D.

As the organization that established the Fukushima Daiichi Nuclear Power Plant, TEPCO assumes responsibility for fieldwork involved in the decommissioning and will be moving steadily forward with the decommissioning plan.

(3) Open and flexible framework for action which pools wisdom from Japan and

abroad

From planning to execution, at each stage we will be considering how to fully apply the technologies and knowledge of experts from Japan and other countries to the R&D we will need to conduct to carry out medium and long-term initiatives aimed at plant decommissioning.

It will be critical that we properly evaluate and assess the information and advice from, as well as the feasibility of specific collaboration with, government-affiliated organizations in other countries, international organizations, and private enterprises as we build an R&D framework that is effective and efficient.

(4) Securing and cultivating personnel over the mid to long-term

In order to steadfastly continue with long-term efforts, such as the removal of fuel debris within 10 years and the decommissioning of the reactor within 30 to 40 years, an issue that must be addressed is securing and cultivating personnel over the mid to long term. Therefore, the R&D Promotion Headquarters will proactively promote efforts that contribute to securing and cultivating personnel while promoting fundamental research and enhancing coordination with universities and researchers tuitions as it deems the cultivation of personnel and important subject over the mid to long-term.

3. Research and development road map

Along with confirming the progress status of the research and development plan created in December 2011 based on actual work details aimed at decommissioning and technical issues that must be overcome in order to decommission the facility, a portion of the plan was revised based on needs in the field.

We have classified all R&D into "R&D related to the removal of fuel from spent fuel pools", "R&D related to preparation for removal of fuel debris", "R&D related to processing and disposal of radioactive waste", and "R&D concerning remote control devices" and have created the necessary R&D plans for each of these categories.

This road map, like the "Medium to Long-Term Road Map Aimed at Decommissioning Units 1-4 at TEPCO's Fukushima Daiichi Nuclear Power Plant", defines the first R&D phase as the point when Step 2 is completed up to the beginning of the removal of fuel from spent fuel pools (to be completed within two years as per the current goal). Many preparations aimed at decommissioning will be made during this phase, including preparations for beginning the removal of fuel from spent fuel pools, beginning the necessary R&D for removing fuel debris, and conducting the first field surveys.

The second phase is defined as the point when the first phase ends up to the beginning of fuel debris removal (to be completed within 10 years as per the current goal). During this period, many R&D initiatives and primary

containment vessel repair processes aimed at removing fuel debris will move into full swing. The "beginning", "mid", and "end" phases will also be used for the purpose of gauging progress during this period.

The third phase is defined as the point when the second phase ends up to the end of decommissioning (30 to 40 years from now as per the current goal). During this period, all processes from fuel debris removal to decommissioning will be carried out.

As precise a timeline as possible has been established for actions to be taken following FY2015, but the timing and content of measures taken may require major revision as a result of field conditions, R&D results, etc. Because there will be numerous technical challenges involved in work performed during this period, it will be necessary to carry out work in stages based on field conditions, R&D results, and safety requirements. Thus, in determining whether or not to move onto the next process, it will be critical to consider whether or not to conduct additional R&D and to review work processes and procedures. These have been organized into holding points and are noted after each related R&D category.

Concerning R&D into remote dismantling technologies for the sake of dismantling reactor facilities, we will continue to look at the necessity of research that includes whether or not existing technology can be used after constructing a basic database containing information about contamination conditions, etc.

(1) R&D related to the removal of fuel from spent fuel pools

a. Master plan for work concerning the removal of fuel from the spent fuel pools

In the spent fuel pools installed on the top floors of the reactor buildings at Units 1–4, there are currently 3,108 fuel assemblies (of which 2,724 are spent fuel) being stored. Although the tsunami temporarily compromised cooling functions, concrete pump vehicles were able to inject coolants to the pools, allowing fuel in spent fuel pools to continue to be cooled.

At the beginning, seawater was injected into the spent fuel pools at Unit 2-4 as an emergency measure. Hydrogen explosions at Units 1, 3 and 4 severely damaged the reactor buildings. And it is also possible that fuels in the spent fuel pools were damaged by falling debris..

Currently, the following steps are planned for the fuel removal process.

1. Remove debris from the upper sections of reactor buildings
2. Install covers (or containers) and install or repair equipment for handling fuel
3. Design and manufacture in-site transport casks and storage canisters
4. Secure open space in the common storage pool and perform the necessary restoration
5. Remove fuel from spent fuel pools
6. Store and manage the removed fuel

<Fieldwork progress status and the current plan>

Currently, work is underway to remove debris from the top of the Unit 3 and Unit 4 reactor buildings, and at Unit 4 construction on a fuel removal cover began in April 2012.

In regards to the distribution of debris within the spent fuel pools, at Unit 4 the condition of the entire pool was confirmed during a pool survey conducted in March 2012 and a debris removal plan will be proposed in the future. At Unit 3, since only a partial confirmation of fuel and debris conditions within the pool were ascertained during a survey conducted in April 2012, more surveys will be implemented in accordance with the status of debris removal from the top of the reactor building.

In regards to the water quality of the spent fuel pools for Units 2~4, since seawater was injected as an emergency measure desalination devices are being used to improve water quality and the water quality of Unit 2 has already been improved. Water quality will continue to be monitored and countermeasures and improvements will be implemented as necessary.

Furthermore, the soundness of the Unit 4 spent fuel pool was confirmed by measuring the height of the four corners of the pool and the perpendicularity of the outside walls of the building to confirm that the building is not tilting, and also by testing the strength of the concrete.

b. Areas of research and development

Removing fuel from spent fuel pools is possible using existing technology and methods. However, the spent fuel has been exposed to seawater and maybe deformed or damaged, and it is important to guarantee the soundness of fuel assemblies after they have been removed. At present time the results of spent fuel pool water analyses have shown that radiation concentrations are not that much higher than normal, so it is assumed that most of the fuel is intact, however storing the fuel assemblies over the long term while maintaining soundness and deliberating the effect on the processing are necessary when deciding how spent fuel is to be handled. That is why the following research and development will be implemented.

(1-1) Evaluation of the Long-term Integrity of Fuel Assemblies Removed from the Spent Fuel Pool (FY2011–2015)

<Objective>

- ◇ As fuel assemblies in spent fuel pools were exposed to seawater and possibly damaged, assessment of the impact of safe and long-term storage is required.

<Overview>

- ◇ Based on the actual condition of fuel assemblies removed from the Fukushima Daiichi Unit 1~4 spent fuel pools, a materials test of the fuel assemblies exposed to seawater will be performed in order to

<Progress status to date and future plans >

- ◇ In order to assess the degree of degradation of fuel cladding which was subject to a unique environment following the accident, a basic test was first implemented. During this basic test, ① zircaloy cladding tubes were assessed, ② an analysis code for corrosion environment evaluation was developed, and ③ the synergistic effect of radiation and seawater was evaluated. These tests confirmed that there is little chance of the zircaloy cladding tubes corroding due to seawater, and that the corrosion atmosphere can be mitigated by adding hydrazine.
- ◇ In addition to unirradiated zircaloy cladding tubes, tests were also performed using irradiated materials in an effort to accumulate more data related to corrosion as preparations continue to prepare total plans per projects scheduled to commence in FY2013.

(1-2) Examination of Methods for Processing Damaged Fuel, etc. Removed from the Spent Fuel Pool (FY2013–2017)

<Objective>

- ◇ Fuel assemblies (Units 2–4) stored in spent fuel pools were exposed to seawater, and those at Units 1, 3, and 4 are possibly damaged due to falling debris. It will be necessary to examine the impact on reprocessing operations, such as the preprocessing and chemical treatment processes.

<Overview>

- ◇ Investigating the impact of spent fuel that was damaged or exposed to seawater on the chemical treatment, waste treatment, and product collection processes. Examining processing methods, and establishing criteria for the feasibility of preprocessing and reprocessing will facilitate investigation into methods of processing these fuel assemblies.

(HP-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. [Second Phase (end)]

(2) R&D related to preparation for removal of fuel debris

a. Master plan for work concerning fuel debris removal preparations

Core meltdown is suspected to have occurred at Units 1–3 at the Fukushima Daiichi Nuclear Power Plant and the possibility exists that nuclear fuel melted together with core internals and then re-solidified (became fuel debris). This

debris may be at the bottom sections of reactor pressure vessels and inside primary containment vessels.

Collaborating organizations are currently using numerical calculation simulations of reactor conditions to analyze the degree of fuel debris present while working to further improve the precision of these efforts. It will be critical to use the results of these analyses as a reference and verify actual field conditions and samples.

While we do not yet have a detailed picture of the location or characteristics of fuel debris, or of where damage has been done to primary containment vessels and reactor pressure vessels, operational procedures aimed at removing fuel debris will be similar to those employed at Unit 2 of the Three Mile Island Nuclear Generating Station (hereinafter "TMI-2"). That is, we drafted the R&D plan with the underlying intent to remove fuel debris after submerging it in water in order to reduce radiation exposure as work is performed.

The following are the fuel debris removal procedures planned at the present time.

1. Decontamination of the reactor building interiors
2. Inspections of areas with leakages inside primary containment vessels
3. Reactor building water cutoff, and primary containment vessel underside repair
4. Partially filling up the primary containment vessels with water
5. Inspections and samplings of primary containment vessel interiors
6. Repairs to the upper sections of primary containment vessels
7. Filling up primary containment vessels and reactor pressure vessels with water
8. Reactor core internal investigation and sampling
9. Fuel debris removal technology preparation, and removal work
10. Safe storage, processing, and disposal of removed fuel debris

<Fieldwork progress status and current plans>

A survey of the extent of contamination (dose and radiation source survey) inside the reactor building was implemented for Units 1 through 3 and multiple contamination samples were taken in accordance with contamination form. Based on the results of these surveys/analyses decontamination technology will be selected and remotely operated devices will be developed.

In an attempt to ascertain conditions inside the reactor primary containment vessels and imaging scope was inserted into Unit 2 to partially observe the interior by which conditions, such as water level, temperature, and those, were directly confirmed. A similar survey will be implemented at Unit 1 based on the field survey results and experience with Unit 2. Furthermore, current high atmospheric doses inside the reactor building make it difficult to perform a similar survey of the reactor primary

containment vessel of Unit 3 so the timing for this survey will be determined in accordance with the progress of development of environment improvement technology.

Existing technology and devices were used to perform surveys of the containment vessels. As research and development continues existing technology and devices will be used to confirm conditions inside the reactor building and the information acquired shall be applied to the development of survey equipment.

Before an assessment of the application of devices and methods developed for repairing the bottom parts of containment vessels to actual containment vessels can be conducted, drill boring robots and S/C repair robots must first be examined using a sector model that is an exact replica of a containment vessel. It is also necessary to use the sector model facilities in order to check workability, the details of work improvements, and train workers with the skills needed to work on actual units. Therefore, these facilities will be manufactured and put into use.

b. Areas of research and development

<R&D aimed at the removal of fuel debris>

①. Fuel debris removal using remote control equipment and devices

In order to perform work in the currently highly radioactive interiors of reactor buildings at Units 1–3 at the Fukushima Daiichi Nuclear Power Plant, decontamination procedures will need to be performed. We will also need to identify and repair damaged areas in primary containment vessels in harsh environments that are narrow and highly radioactive in order to remove fuel debris while underwater. To this end, in addition to developing new technologies and work methods, we will also be developing methods and equipment that will help to determine the locations and conditions of fuel debris and to remove this debris.

(2-(1)-1a) Development of Technologies for Remote Decontamination of the Reactor Building Interior (FY2011–2013)

<Objective>

- ◇ Exposure must be minimized while making it possible for workers to access certain areas to conduct investigations of leakages, perform repairs, and carry out other work necessary to remove fuel debris.

<Overview>

- ◇ In addition to estimating and evaluating the extent of contamination, we will be performing decontamination testing via simulated contamination after determining which decontamination technologies can be used.
- ◇ The technology catalog will be leveraged in the development of

<Progress to date and future plans >

- ◇ In order to acquire basic field data on the conditions of contamination a survey of the extent of contamination (dose and radiation source survey) inside the reactor building was implemented for Units 1 through 3 and a multiple contamination samples were taken in accordance with contamination form. Based on the results of these surveys/analyses decontamination technology will be selected and remotely operated devices will be developed.

<Current actual objectives >

- ◇ By the end of FY2012 remotely operated decontamination devices will be designed, manufactured, put through mockup tests, and demonstrated/improved in actual facilities (inside the Unit 1 through 3 reactor buildings) in preparation for use in areas that are relatively easy to access, such as building corridors in accordance with the results of contamination surveys in the field and it decontamination tests using simulated contamination in the factory.

(2-(1)-1b) Creation of General Plan for Reducing Radiation (FY2012~FY2013)

<Objective>

- ◇ To propose a general dose reduction plan that includes various dose reduction measures and remotely operated decontamination technology for the purpose of reducing worker exposure.

<Overview>

- ◇ Currently remotely operated decontamination devices are being developed in accordance with the development of remotely operated decontamination technology for use inside buildings . In conjunction with this general dose reduction plans that mix various effective dose reduction measures (for example shielding, flushing, etc.) will be deliberated and a plan created in order to reduce worker exposure.

<Progress to date and future plans >

- ◇ Research and development on remotely operated technology is being conducted as part of development of remotely operated technology for use inside buildings in accordance with contamination conditions. As part of this research and development,

<Current actual objectives >

- ◇ By the end of FY2012 dose reduction measures will be created for the first floor of the reactor building, which needs to be accessed as early as possible to conduct PCV internal surveys and leak point surveys, and for upper floors of the building which were damaged in the explosion and have yet to be accessed due to high dose levels (fourth floor, fifth floor, etc.).

(2-(1)-2) Development of Technologies for Identifying Leak Areas in the PCV (FY2011–2014)

<Objective>

- ◇ Performing the underwater fuel debris removal will require repairing leaks in primary containment vessels and filling them up with water. Before this, inspections will be conducted to identify primary containment vessel leakages.

<Overview>

- ◇ As leakages are expected to be in areas that may be highly radioactive, underwater and in narrow sections, we will be developing technologies for accessing these areas via remote control and technologies for detecting leakages.

<Progress to date and future plans>

- ◇ As research and development continues, existing technology and devices are being used in the field to survey conditions. At Unit 1 a CCD camera was used to confirm the extent of accumulated water in the basement of the reactor building, and at Unit 2 existing remotely operated robots were used to check the basement of the reactor building. As research and development continues, existing technology and devices will be used to confirm the conditions within the reactor buildings and the information obtained will be applied to research and development.
- ◇ Desktop predictions are being used to identify possible leak points and pinpoint leak sources based on survey results from the field and reports concerning the research of severe accidents that have occurred in the past. In the future devices will be developed in order to identify leaks in these potential problem areas which will eventually lead to more detailed leak point surveys of submerged and narrow areas and the identification of areas that need to be surveyed and repaired.

<Current actual objectives >

- ◇ By the end of FY2012 devices will be designed for identifying leak

(2-(1)-3) Development of PCV Repair Technologies (FY2011–2017)

<Objective>

- ◇ We will repair any identified leakages, stop any leakages between the reactor buildings and turbine buildings, and set up boundaries for partial filling up of the bottom sections of primary containment vessels.

<Overview>

- ◇ As leakages are expected to be in areas that may be highly radioactive, underwater and in narrow sections, we will be developing technologies and methods for accessing and repairing these leakages via remote control. The development of methods for repairing primary containment vessels will be a necessary step in the process of removing fuel debris, and we assume there will be major technological difficulties involved. We therefore assume difficulties will be encountered in the development of repair technologies based on the results of inspections of primary containment vessel leakages, and will be moving forward with the development of repair methods as we look at alternative methods along the way.

<Progress status to date and future plans>

- ◇ Concept proposals of survey and repair methods (leakage stop) existing technology are being made and actual repair (leakage stop) devices will be developed in accordance with the results of containment vessel leak point surveys.
- ◇ Before an assessment of the application of devices and methods developed for repairing the bottom parts of containment vessels to actual containment vessels can be conducted, drill boring robots and S/C repair robots must first be verified using a sector model that is an exact replica of a containment vessel. It is also necessary to use the sector model facilities in order to check workability, the details of work improvements, and train workers with the skills needed to work on actual units. Therefore, these facilities will be manufactured and put into use.

<Current actual objectives >

By the end of FY2012 devices for repairing (stopping leaks) areas for which it is highly likely that damage has occurred (flanges, hatches, penetration seals, etc.) will be designed.

(HP-2): Determination methods for repairing lower parts of PCV, determining water stop method

- Through inspections of primary containment vessel leakages, we

- 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. [Second Phase (beginning)]

(HP-4) Determining methods to repair upper parts of PCV

- Once the areas requiring repair in these sections are identified 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 primary containment vessels. Depending on R&D 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 primary containment vessels. [Second Phase (mid)]

(2-(1)-4) Development of Technologies for Investigation of the PCV Interior (FY2011–2016)

<Objective>

- ◇ As the current amount of fuel debris is unknown, we will need to survey the locations and conditions of fuel debris inside primary containment vessels in preparation for removing said debris while verifying the status of pedestals, etc. supporting reactor pressure vessels.

<Overview>

- ◇ In order to develop technology for surveying the inside of the containment vessels inspection survey equipment will be designed and manufactured upon examining technology that can be applied in anticipation of the environment (narrow spaces, high doses, etc.). In conjunction with this, measures for preventing the dispersion of radioactive material during survey work will be deliberated.

<Progress to date and future plans >

- ◇ Unit 2 containment vessel entry work in the field has confirmed that the environment inside the containment vessel will make it extremely difficult to work (high doses, dripping water, etc.)
- ◇ Along with continuing to deliberate survey criteria, survey methods, access routes, and device constructions for surveying the inside of

<Current detailed objectives>

- ◇ Based on the latest knowledge gained from containment vessel entry work in the field, a detailed deliberation of survey methods and the development/design/manufacturing of equipment will be conducted and an advanced survey of the containment vessel performed (planned for FY2013).

(HP-3) Completion of flooding of lower parts of PCV, determining PCV internal investigation methods

- In determining when to begin internal investigations of PCVs, we will first verify that both the repair of any leakages present in the lower parts of the primary containment vessels and the filling of these vessels have been completed, and that internal investigation methods and the development of any necessary equipment has been completed. [Second Phase (mid)]

(2-(1)-5) Development of Technologies for Investigation of the RPV Interior (FY2013–2019)

<Objective>

- ◇ We need to ascertain conditions inside reactor pressure vessels (concerning fuel debris, damage to reactor interiors, status of decontamination equipment, etc.) in preparation for removing fuel debris.

<Overview>

- ◇ In order to survey fuel debris conditions and other aspects of reactor pressure vessel interiors, we will be looking at technologies that can be used in the expected environments (highly-radioactive, high-temperature, highly-humid, etc. environments). We will design and manufacture devices for surveying pressure vessel interiors based on the results of primary containment vessel interior surveys.

(HP-5) Completion of flooding of upper parts of PCV, determining RPV internal investigation methods

- In determining when to begin opening the top lids of 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 [Second Phase (end)]

(2-(1)-6) Development of Methods and Devices for the Removal of Fuel Debris and Internal Structures in the Reactor (FY2015–2021)

<Objective>

- ◇ We will use TMI-2 as a reference in proceeding with fuel debris removal work. However, whereas the Fukushima Daiichi Nuclear Power Plant has boiling water reactors (BWR), TMI-2 has pressurized water reactors (PWR). As we anticipate that there is a large amount of core structures inside reactor pressure vessels and that some fuel debris has moved into primary containment vessels, we will need to develop technologies aimed at methods for removing this fuel debris.

<Overview>

- ◇ After determining the technologies that can be used by looking at TMI-2 and other events, we will examine methods for removing fuel debris at the Fukushima Daiichi Nuclear Power Plant and design and manufacture the necessary devices based on the results of investigations of reactor pressure vessel interiors. Following our mock-up tests, we will use these devices in fuel debris removal procedures as we continue to assess and improve their performance.

(2-(1)-7) Development of Technologies for the Containment, Transport and Storage of Reactor Fuel Debris (FY2013–2019)

<Objective>

- ◇ Unlike the situation at TMI-2, fuel debris at the Fukushima Daiichi Nuclear Power Plant has been submerged in seawater the degree of burn up is high. We will therefore need to develop new storage containers in light of the unique characteristics of this fuel debris.

<Overview>

- ◇ We will investigate the technologies that can be used to contain, transport, and store fuel debris that has been submerged in seawater and choose the materials to be used for the containers. We will examine storage methods appropriate for the form of the fuel debris as well as its molten state, manufacturing equipment to handle it and containers to store it in and conducting mock-up tests. After examining methods for efficiently transporting and storing the fuel debris and designing and manufacturing the required equipment, we will conduct a mock-up tests while conducting assessments and making improvements.

(HP6) Determining fuel debris removal methods and completion of preparation of fuel debris containers, etc.

- In determining when to begin fuel debris removal, we will first look at the results of the internal inspections of PCVs and reactor pressure vessels to verify that the development of fuel debris

(2-(1)-8) Development of Technologies for Assessment of RPV/PCV Integrity (FY2011–2016)

<Objective>

- ◇ We anticipate that reactor pressure vessels and primary containment vessels exposed to seawater will continue to remain in diluted seawater environments for a long time to come. We will need to ensure the health of equipment up until fuel debris removal while continuing to provide stable cooling.
- ◇ We will also need to verify the impact of the history of high temperatures and seawater immersion on reinforced concrete structures supporting reactor pressure vessels and primary containment vessels.

<Overview>

- ◇ We will acquire corrosion data necessary for making suitable assessments and forecasts concerning the progress of corrosion degradation related to reactor pressure vessels and primary containment vessels. Workers will acquire data on reinforcement corrosion and concrete degradation for reinforced concrete structures and perform structural integrity assessments. We will also apply measures to control corrosion and degradation and verify the results.

<Progress status to date and future plans>

- ◇ Original plans focus on evaluating soundness in the face of corrosion and high temperatures. Corrosion tests and high temperature strength tests using various structural materials are planned.
- ◇ In addition to the above, after determining what areas need to be evaluated for soundness it was decided that an assessment of the damage to the reactor pressure vessel pedestal concrete caused by falling high-temperature fuel debris will be implemented.

<Current actual objectives>

By the end of FY2012 reactor pressure vessel/containment vessels structural material corrosion tests and pedestal reinforced concrete degradation tests will be implemented, and the data inputted into remaining lifespan assessments for structures.

(2-(1)-9) Development of Technologies for Controlling Fuel Debris Criticality (FY2012–2018)

<Objective>

- ◇ Criticalities will need to be prevented for even situations where water levels or the form of fuel debris have changed as a result of water injection or removal work. This therefore requires we develop pre-criticality assessment and monitoring technologies.

<Overview>

- ◇ We will develop analysis methods that allow criticality assessment in response to changes concerning water injection requirements or intra-reactor conditions. We will also develop a criticality monitor that can be used in effluent treatment and cooling. Based on results of primary containment vessel interior investigations, we will develop as needed a criticality monitor via neutron detection for reactor interiors. We will also develop a neutron absorption material that can be used during work involving the removal, transport, and storage of fuel debris as we examine methods for using it.

<Current actual objectives >

- ◇ Primary parameters that affect criticality will be identified for scenarios that include the possibility of criticality.
- ◇ In preparation for developing core internal re-criticality detection technology, from FY2013 the specification requirements for a neutron detection system that analyzes and evaluates the distribution of neutron rays inside and outside the reactor primary containment vessel, and a system for detecting nuclear fission byproducts with short lives will be created and inputted.
- ◇ Specification requirements will be created and inputted for the development of a sub-criticality monitor used to detect criticality in conjunction with the flow and accumulation of fuel debris into waste processing facilities and cooling facilities (to start in FY2013).
- ◇ In preparation for fuel debris removal work, criticality prevention technology will be deliberated and the results inputted into the deliberation of the development of criticality prevention materials and removal methods which will start in FY2013.

②Ascertaining and analyzing reactor core status

Estimating and ascertaining conditions inside the reactor are indispensable for drafting safety plans and mid-and long-term countermeasures related to fuel debris removal. However, direct observation of the damaged core is difficult amidst high radiation levels. Meanwhile, whereas accident development analysis technology, which may be an alternative solution, will allow an overview of accident development to be ascertained, there is much uncertainty associated with the obtained results making it difficult to estimate the location and form of fuel debris and the extent of damage to the pressure vessel. Therefore, it is necessary to continually engage in efforts to estimate and

ascertain conditions inside the core using advanced accident development analysis technology being developed along with information acquired from site observation.

Furthermore, the knowledge and experience obtained from these efforts in particular will be of great use to advancing analysis technology both in Japan and overseas as well as understanding accident development.

(2-(2)-1) Further Advancement of Technologies for Analysis of Accident Progression to enable Understanding of Status of Reactor Interiors (FY2011– 2020)

<Objective>

- ◇ To estimate/evaluate conditions inside the reactor, reduce the breadth of uncertainty, and contribute to the deliberation of fuel debris survey and removal methods.

<Overview>

- ◇ Create more advanced severe accident analysis codes based on an analysis of the Fukushima Daiichi NPS accident and knowledge gained from severe accident simulation tests.
- ◇ Estimate conditions inside the reactor using codes other than severe accident analysis codes.
- ◇ Analyze and evaluate information obtained from efforts aimed at stabilizing and decommissioning the facility.
- ◇ Predict conditions inside the reactor with reduced uncertainty by comprehensively evaluating knowledge obtained from advancing severe accident analysis codes, the knowledge obtained from analysis using other analysis codes, and the knowledge obtained from efforts aimed at stabilizing and decommissioning the facility.

<Progress status to date and future plans>

- ◇ The areas for advanced development have been identified for the severe accident analysis codes MAAP and SAMPSON.
- ◇ In regard to the MAAP code, EPRI/FAI, the manager and developer of MAAP since FY2012 has been asked to use the latest version of the MAAP code to analyze the Fukushima Daiichi NPS accident and to further advance and examine the latest version of the code by FY2013.
- ◇ In regard to the SAMPSON code, code improvements will be gradually made by FY2016, and the code that reflects the improvements made up until the previous fiscal year will be used to continue analyzing the Fukushima Daiichi NPS accident and examine the code.

< Current actual objectives >

- ◇ To estimate and ascertain conditions inside the reactor based on the results of advancing both the MAAP and SAMPSON codes, knowledge gained from other analysis codes and simulations, and

- ◇ To strive to estimate and ascertain conditions inside the reactor while leveraging knowledge obtained from international benchmarks, etc.
- ◇ Conditions inside the reactor that have been estimated and ascertained through the above methods will be inputted into fuel debris removal work, etc. and other related projects.

③Ascertaining the characteristics of and preparing to process fuel debris R&D into processing fuel debris will move into actual operation after we are able to remove some of the debris. To do this, it will be best to acquire basic and fundamental data after first prediction on the characteristics of the debris. Acquiring basic data will take time therefore; we will need to proceed with systematical development.

(2-(3)-1) Study of Characteristics using Simulated Fuel Debris (FY2011–2015)

<Objective>

- ◇ Before beginning actual fuel debris removal and processing, we believe it will be beneficial to first examine specific methods for removing, processing and performing assessments using simulated debris. As the circumstances of the accident that occurred at Fukushima Daiichi Nuclear Power Plant differs from those at TMI-2 (seawater exposure, duration of meltdown, etc.), we will need to manufacture simulated fuel debris based on past studies.

<Overview>

- ◇ We will manufacture simulated fuel debris based on past accidents at the Fukushima Daiichi Nuclear Power Plant and acquire data concerning fuel debris characteristics (mechanical and chemical characteristics). We will also compare these characteristics with TMI-2 debris and consider the information that will be useful for actual fuel debris removal.

<Progress status to date and future plans >

- ◇ Documents related to TMI-2 and severe accidents are being examined, and physical attribute data for manufacture simulated debris is being obtained.
- ◇ The mechanical attributes of debris are vital for developing equipment to sample debris during surveys of reactor primary containment vessel/pressure vessels, and equipment for full-scale debris removal, and analysis of these attributes will steadily continue in coordination with these projects.

<Current actual objectives >

- ◇ In coordination with ascertaining conditions inside the reactor and

(2-(3)-2) Analysis of Properties of Actual Fuel Debris (FY2015–2020)

<Objective>

- ◇ When examining the safety of long-term storage of fuel debris and how to process and dispose of it after it is removed, we will need to ascertain the solubility, chemical stability, and other chemical characteristics of the fuel debris.

<Overview>

- ◇ We will conduct analyses of the mechanical and chemical characteristics of actual fuel debris removed from inside and outside of reactor cores.

(2-(3)-3) Development of Technologies for Processing of Fuel Debris (FY2011–2020)

<Objective>

- ◇ To gain insights into how best to process and dispose of fuel debris after it is removed, we will need to examine the feasibility of using existing processing technologies and look at disposal technologies.

<Overview>

- ◇ We will evaluate the feasibility of both wet and dry processing using simulated debris and actual debris sample. We will examine whether or not to create waste form from both waste generated through processing and that of directly disposal of, as well as the applicability of disposing of such wastes.

< Progress status to date and future plans >

- ◇ Deliberation on processing scenarios for fuel debris after it is removed has been started due to the existence of multiple scenarios, such as storage and processing.

<Current actual objectives >

- ◇ Data required for deliberating scenarios related to debris measures will be acquired and deliberation conditions determined. Furthermore, data related to deliberating the applicability of existing processing technology will be accumulated in an effort to ascertain technical issues.

(HP-7) Determination methods for treatment and disposal of fuel debris

- We will act in conformity with any related R&D and national policy in devising methods for the future processing and disposal of removed fuel debris. [Third Phase]

(2-(3)-4) Establishment of a new accountancy method for Fuel Debris

(FY2011–2020)

<Objective>

- ◇ With fuel debris, the standard nuclear material accountancy method where 1 fuel assembly equals 1 unit does not apply. Before removing and storing fuel debris, a new nuclear material accountancy method should be developed for the transparent and efficient removal of fuel debris.

<Overview>

- ◇ After analyzing the existing nuclear material management technologies and methods used during the TMI-2 and Chernobyl accidents, measurement technologies and accountancy method should be developed for assessing the weight of nuclear material inside the fuel debris. We will be coordinating closely with the IAEA and other related organizations in this scheme.

<Progress to date and future plans >

- ◇ Currently, along with obtaining useful information from disclosed documents concerning accident precedents (TMI-2 and Chernobyl) and visits by the NIH to TMI-2 and Chernobyl, tests to obtain basic data on nuclear fuel material, measurement technology have begun. Methods for measuring and managing fuel debris will be constructed based on management conditions on site.

<Current actual objectives >

- ◇ By the end of FY2013 nuclear fuel material measurement technology that can be applied to the field will be identified and used to construct rational measurement and management methods based on accident precedent examinations and basic test data for nuclear fuel material measurement technology.

* Nuclear material accountancy: a method for accurately controlling the shape, volume, and transferring during a fixed period of nuclear material inside nuclear facilities to prevent it from being used in nuclear weapons.

(3) R&D related to processing and disposal of radioactive waste

a. Master plan for work concerning the processing and disposal of radioactive waste

Radioactive waste (waste zeolite, sludge, etc.) is being generated at the Fukushima Daiichi NPS in conjunction with the processing of contaminated water accumulated in the turbine building, etc., (accumulated water) and highly radioactive debris created by the hydrogen explosions exists inside and outside the buildings. Since the nature and form of this waste differs from waste normally generated at a nuclear power station, safe and streamlined

methods for processing and disposing of this waste must be thought of and implemented after analyzing and ascertaining the attributes of the waste. Furthermore, the waste must be suitably stored and managed since it is anticipated that a long time will be needed before the waste can be processed and disposed of.

Furthermore, waste generating conjunction with work to remove fuel debris, and the dismantling waste generated in conjunction with the decommissioning of the nuclear facility will be suitably processed and disposed of while forecasting the quantity and the form of this waste based upon deliberations concerning facility contamination status surveys and dismantling methods.

b. Areas of research and development

We will need to set a projection concerning technologies for processing and disposing of debris and secondary waste being generated from contaminated water processing while also establishing a policy for safely storing it in the long term. We will look into the feasibility of applying existing disposal methods in this endeavor, and will need to develop new technologies for the processing and disposal of any waste for which existing methods cannot be used.

Concerning the processing and disposal of all waste resulting from the above and from reactor facility dismantling, we will draft an R&D plan that will ensure a rational flow to the entire process, after which we will conduct R&D in line with the plan presented here.

(3-1) Development of Technologies for the Processing and Disposal of Secondary Waste produced by the Treatment of Contaminated Water (from 2011 on)

<Objective>

- ◇ Secondary waste generated from contaminated water treatment will need to be turned into waste package and disposed of after intermediate storage. In order to safely and rationally process and dispose of radioactive waste, we will be conducting R&D focused on waste disposal. This will include evaluating the characteristics and safety implications of any secondary waste generated, examining the idea of waste conditioning, and determining optimal disposal methods.

<Overview>

- ◇ In addition to assessing characteristics (amount produced, chemical composition, radioactive concentration, heat release value, etc.) of secondary waste in the form of zeolite waste, sludge, and concentrated liquid waste, we will examine methods for the long-term storage of this waste while taking into account safety evaluation for hydrogen gas generation and heat generation, seawater exposure, and high radioactivity, etc. We will also look into turning waste into waste bodies and evaluating the characteristics

<Progress to date and future plans >

- ◇ Analysis required to evaluate the radiation concentration of secondary waste, which is needed to deliberate long term storage countermeasures and develop processing/disposal technology, has begun. Analysis results to date have shown that there is a need to improve analysis methods that can deal with samples that contain a large amount of Cs and Sr. We have also learned that the waste contains isotopes that must be processed/disposed of and for which analysis methods have not been established, therefore we will continue to ascertain the form of this waste in addition to planning the development of analysis technology.
- ◇ Since the waste must be stored in a stable manner until processing/disposal technology for secondary waste can be established, we will continue to deliberate countermeasures for long-term storage that take hydrogen generation, heat generation, and corrosion into consideration.
- ◇ In regard to waste bundled technology, we will continue to examine waste zeolite and sludge and perform basic waste bundled tests, such as solidification with cement.
- ◇ Assessing the form, and deliberating long-term storage countermeasures and waste bundle technology surveys will also be deliberated for secondary waste generated from new contaminated water processing systems (secondary cesium absorption device, polynuclear species removal device).

< Current actual objectives >

- ◇ Analysis of isotope composition shall continue while developing and improving analysis methods
- ◇ Deliberation of countermeasures for long-term storage of waste zeolite and sludge shall be conducted by FY2013.
- ◇ The waste zeolite/sludge waste bundle technology survey results shall be compiled in FY2012.

(3-2) Development of Technologies for the Processing and Disposal of Radioactive Waste (from 2011 on)

<Objective>

- ◇ Debris, dismantling waste produced from future plant decommissioning, and decontamination effluents produced in the course of building and system decontamination at the Fukushima Daiichi Nuclear Power Plant significantly differ from the radioactive waste normally produced in terms of characteristics and composition, requiring that we conduct studies and R&D into

<Overview>

- ◇ A form assessment (quantity, chemical composition, radiation concentration, amount of generated heat, physical form, etc.).
- ◇ As with the development of processing/disposal technology for secondary waste generated from contaminated water processing, the development of waste bundling technology and the applicability of existing disposal concepts will be deliberated.
- ◇ It is possible that among the radioactive waste that must be processed and disposed of, such as secondary waste generated from contaminated water processing, debris, dismantling waste and contaminated water, etc., there will exist waste to which existing disposal concepts cannot be applied. Therefore, new processing/disposal research and development will be implemented, including the formulation of new disposal concepts, as needed.

<Progress status to date and future plans >

- ◇ Since waste generated by the accident is different in nature from waste generated conventionally by nuclear power stations, such as being adhered with radionuclides that originated from damaged fuel, and containing a lot of salt that has a detrimental effect on disposal site performance, research and development must be conducted upon thoroughly analyzing and ascertaining the characteristics of this waste. From this perspective, along with preparing analysis equipment required to ascertain form, the approach to deliberating waste characteristic assessment methods and disposal concepts was deliberated. Going forward along with beginning analyses in order to ascertain the shape of waste, such as the isotope composition of debris, more detailed research and development plans will be created.

<Current actual objectives >

- ◇ Along with performing an analysis of debris, etc., necessary to ascertain the characteristic of waste and accumulating data, during FY2012 a close examination of those research and development issues required for the safe processing/disposal of waste generated by the accident will be conducted and reflected in research and development plans.

(HP-8) Verification of applicability of existing concepts in response to waste characteristics

- Based on the results of research into waste characteristics, we will be verifying the possibility of applying previously examined disposal concepts to the situation.
- As it may be problematic to apply existing disposal concepts to some waste, including highly-saline waste, we may need to examine new

(HP-9) Verification of prospects for safety of waste during processing and disposal

- We will verify that safety can be assured concerning the processing and disposing of waste generated after the accident based on the possibility of completing development of required technologies. We will also be gathering information needed to construct a safety regulation framework for waste processing and disposal.
- We anticipate that fuel debris removal and dismantling work will yield new information concerning waste characteristics. As it is also possible that decontamination performed during work will produce new waste, we will continue with R&D and improve the safety of processing and disposal methods as the situation requires. [Second Phase (end)]

(HP-10) Determination of specifications / method to produce of waste packages

- Based on the results of R&D into radioactive waste processing and disposal, we will be constructing a regulatory framework and outlining conditions (waste packages specs, site requirements demanded by disposal sites, and disposal site design requirements) for waste processing and disposal, as the case requires.
- We will then establish specifications and conditioning methods for waste packages based on the above conditions. [Third Phase]

(HP-11) Installation of equipment for production of waste packages and securing of firm prospects for disposal

- After completing the installation of production equipment for producing waste packages and verifying the ability to dispose of them, we will begin production and carry them out of the facility. [Third Phase]

(4) Research and development into remote control equipment and devices

In addition to decontamination and various surveys much work is being done after buildings, but there are still many areas needed for fuel debris removal that are restricted from entry by personnel due to high radiation levels, therefore the development of remotely operated devices and technology is needed so as to be able to achieve work objectives in the aforementioned environment.

This is the first time that such research and development has been performed in the world and much difficulty is anticipated before expected results can be achieved. Preparing for potential difficulties with remotely operated technology and thinking in advance about methods to deal with difficulties that arise in ongoing plans, such as those stressed in TMI

precedents, is vital. That's why as part of each research and development promotion headquarter project, the latest remote technology, solutions, and backup plans will be deliberated and proposed for remote technology that is, or may be, difficult to achieve.

Furthermore, it is necessary to proactively coordinate across the board with fundamental research and development underway at other expert research and development organizations in regards to remotely operated technology that must be deliberated.

<Progress test to date and future plans >

✧ In hopes of finding new solutions to problems that have concepts different from each project, a task force comprised of experts in robot manufacturers with a wealth of knowledge has been established, and discussions have begun. The task force will engage in discussions about detailed technical issues, such as how to take dose measurements on operating floor walls and ceilings

<Current actual objectives >

✧ Amidst the projects underway discussions of the latest technology and solutions will be held in regard to work that is expected to be especially difficult using remotely operated devices, such as searching for the points in the suppression chamber.

✧ In regard to common base technology, the application of technology currently under development as part of disaster countermeasures projects, etc. shall be deliberated.

4. Framework for conducting research and development

(1) Fundamental philosophy behind the framework for conducting research and development

The tasks to be undertaken will present major challenges almost completely without precedent in the world. As such, we will be pooling the wisdom of experts in the industry internationally and constructing a framework to enable a flexible and agile approach to these issues.

To make steady and effective progress forward with individual R&D projects, we will put together an organization tasked with overall management which will conduct appropriate assessments of all R&D projects and take a flexible approach to reviewing and partially revising or abolishing plans or the project framework based on overall progress.

We will also need to quickly and appropriately share information about situations in the field at the Fukushima Daiichi Nuclear Power Plant as well as project needs and the results of applying newly developed methods and other technologies as we flexibly review plans to tackle individual R&D challenges.

(2) Research and development action framework

1. Objectives and roles

In order to give comprehensive and intensive focus to R&D involving

medium and long-term measures aimed at the decommissioning of Units 1–4 at Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant, we have formed the "Research and Development Headquarters" (hereinafter "R&D Headquarters") which will be planning and performing overall fine-tuning of R&D efforts.

2. R&D Headquarters Composition

The R&D Headquarters is comprised of the Agency of Natural Resources and Energy, the Ministry of Education, Culture, Sports, Science and Technology, TEPCO, the Japan Atomic Energy Agency (JAEA), the National Institute of Advanced Science and Technology (AIST), the Central Research Institute of Electric Power Industry (CRIEPI), the Japan Atomic Energy Commission (AEC), the Toshiba Corporation and Hitachi, Ltd./Hitachi GE Nuclear Energy, Ltd., which are plant manufacturers with extensive expertise in and experience with the design and construction of the TEPCO Fukushima Daiichi NPS, in addition to other persons with relevant knowledge and experience. (Refer to the attachment for a list of members).

As the administrative organization of the R&D Headquarters, the Japanese government will assign a suitable individual to the position of the Director of R&D Headquarters, whose role will be to provide R&D management. It will also appoint a deputy director of R&D Headquarters to assist the Director. It will also establish in the R&D Headquarters offices needed to carry out the duties of the abovementioned R&D projects.

In addition to drafting an overall R&D plan, the R&D Headquarters will perform comprehensive assessments of evaluations of progress made by working teams in each field, conduct research project prioritization and budgetary allocation, and make decisions that will have profound impact on how projects are run and on the overall coordination of the challenges being addressed by each team.

3. Working teams

Japanese Government and TEPCO will establish the below working teams and sub working teams in the R&D Headquarters while planning and providing overall coordination of R&D in each field.

With a view to providing across-the-board management of R&D projects for each field, we will draft R&D plans for these fields in addition to providing the necessary instruction for each of these projects. Specifically, we will approve action plans being considered for each R&D project and assess progress while requesting revisions as needed.

- (A) Working team for spent fuel pool countermeasures
- (B) Working team for preparation of fuel debris removal
 - Sub-working team for equipment/device development,

- Sub-working team for core status assessment and analysis
 - Sub-working team for fuel debris property assessment and treatment preparation
- (C) Working team for radioactive waste processing and disposal
 (D) Joint task force for remote technologies (cross-field matters)

4. Administrative office

We will establish an administrative office which will be comprised of representatives from related organizations and which will oversee clerical work pertaining to overall management of R&D. The Agency of Natural Resources and Energy will act as executive secretary.

As it will also be important to coordinate closely with workers in the field, administrative offices for each working team will be supervised by TEPCO, which oversees work in the field.

We will also assign supervisors for each working team who will carry out information infrastructure building activities to facilitate the effective and efficient execution of R&D projects. While coordinating with administrative office personnel, the supervisors will manage the collection, organization, and sharing of information concerning both internal and external related technologies and will perform duties including coordinating cooperative efforts with related research institutions and other overseas organizations.

(Note) The ideal structure of the Research and Development Headquarters

- According to the “Results of Deliberation on Mid to Long-Term Measures at TEPCO Fukushima Daiichi Nuclear Power Station” compiled by the nuclear committee in December of last year, it is expected that “the research and development motion headquarters will be operated as a full-time organization” to efficiently promote research and development over the long-term.
- In order to construct the very best system for dealing with issues that come to light, further enhancing the mechanism for promoting research and development projects, including building facilities that are the full point of research, is at issue at hand.

(Reference: Excerpt from the Results of Deliberation on Mid to Long-Term Measures at TEPCO Fukushima Daiichi Nuclear Power Station)

In order to efficiently promote the comprehensive management of the Research and Development Headquarters over the long term the Research and Development Headquarters shall be managed as a full-time organization. Whereas current Research and Development Headquarters activities have started while utilizing the existing organizational framework, it is important to not be shackled by conventional frameworks

and think flexibly as quickly as possible about the structure of the organization in order to maximize results.

5. Research Base Concept ~Making Fukushima the Focal Point of International Research~

(1) Basic thinking in regard to the research base concept

In order to deal with the extremely difficult technical issues that we are faced with as we prepare to decommission the TEPCO Fukushima Daiichi Units 1~4, all the strength of the government is needed to engage in research and development projects and the knowledge and experience gained through the course of these projects will be of great benefit to even other areas of industry. Therefore, based on the Basic Plan for Fukushima Recovery we aim to make Fukushima the future focal point of international research by engaging in research and development that gathers wisdom from both domestically and overseas.

To do this we shall leverage the expert knowledge of the Japan Atomic Energy Agency (JAEA) and its existing facilities while engaging in efforts to secure and cultivate personnel for the future. Maximum consideration will also be given to contributing to regional employment and the local economy.

In order to hash out the details of this new research base concept which has been deliberated up till now deliberations on concept design and basic design for required facilities and equipment will commence.

(Reference) Basic Plan for Fukushima Recovery (July 13, 2012 cabinet decision, excerpt)

Clause 6 basic criteria for policies that should be steadily implemented by the government in order to predominately promote efforts to contribute to creating new industries and strengthening international competitiveness of those industries, as well as other pioneering measures.

In the course of recovering and rebuilding Fukushima's industry, it is important that Fukushima's hopes for the future are drastically restored and rebuilt in a way that allows the recovery and regeneration to be felt by the people of Fukushima and that Fukushima becomes the model for reforming Japan's socioeconomic structure.

In order to do this, recovery and rebuilding will be further accelerated by identifying new sources of appeal and merits for Fukushima by proactively and predominately promoting pioneering efforts, and Fukushima will be made the frontier for leading Japan in these new areas.

(Measures for promoting research and development)

In order to create an environment in which local residents can live rich lives at ease and to establish regional industries that can develop in a sustained manner, it is important to create various research bases that can contribute to the creation of new industry.

Especially based on the potential of Fukushima, it is important to create focal points for research and development and the creation of industry in such fields as renewable energy, pharmaceuticals and medical equipment, environmental restoration/creation, and decommissioning technology.

To do this, the government and Fukushima prefecture must build the various facilities in Fukushima based on the “Fukushima Research and Development/Industry Creation Focal Point Concept (proposed)”.

(middle passage omitted)

Furthermore, in regards to decommissioning measures/accident reoccurrence prevention countermeasures, Fukushima shall be made the focal point for research and development/project promotion aimed at the decommissioning of TEPCO Fukushima Daiichi Nuclear Power Station Units 1~4, and the cultivation of regulatory side personnel under the new nuclear safety regulatory system.

(2) Facilities to be newly built in accordance with the research base concept

① Facilities for developing and testing remotely operated devices and equipment

In anticipation of having to work in environments with extremely high radiation levels until fuel debris can be removed, it is necessary to develop equipment and devices that can be operated remotely in order to reduce worker exposure. In order to do this a facility that can allow repeated testing of remotely operated equipment and devices should be built in order to avoid as much as possible the testing the devices on a trial and error basis in on-site locations with high radiation levels.

This facility shall contain a full size mockup of an actual reactor in order to verify the applicability to actual equipment of remotely operated repair and survey devices that will be used to identify and repair leaks in the bottom portions of the containment vessels, which is a matter of urgent concern. Furthermore, the top of the containment vessel, fuel removal equipment, and other equipment will be deliberated in the future.

② Facilities for analyzing radioactive material

It is necessary to deliberate enhancing the following facilities and building new facilities in order to deal with the necessities to analyze radioactive material in the course of decommissioning.

– Enhancing the existing analysis facility of TEPCO Fukushima Daiichi NPS

– Leveraging existing facilities of the Japan Atomic Energy Agency (JAEA)

– Building new analysis facilities (analysis center (tentative name))

In particular, new analysis facilities will be gradually equipped with multiple functions. In conjunction with this it is necessary to cultivate personnel to engage in analysis work at the aforementioned facilities.

- Analyze and establish analysis technology for ascertaining the form of radioactive waste and confirming decontamination performance.
- Analyze and establish analysis technology for ascertaining the form of fuel debris.

③ Other

In order to further the research base concept the establishment of facilities for international cooperation and information dissemination shall be deliberated. At the same time coordination with related parties shall be fostered while keeping in mind that when the new analysis facilities are built, the off-site analysis of isotopes and highly reactive samples that are difficult to measure will be necessary. Also, deliberation will continue to examine how these facilities can contribute to the off-site handling of current problems, such as soil decontamination and the recycling of debris.

6. Ideal state of international cooperation

As stated above, it will be necessary to pool both domestic and international wisdom in order to efficiently and effectively execute medium and long-term strategies aimed at decommissioning Units 1–4 at the Fukushima Daiichi Nuclear Power Plant. To this end, in addition to acquiring technical knowledge from a wide variety of fields in Japan, as collaborating with international organizations will be critical, we will also be utilizing the expertise and experience of these organizations concerning measures taken with the TMI-2 and Chernobyl accidents.

- To apply the world's expertise to a host of unprecedented and difficult challenges, we will be publicizing and sharing in a timely fashion a wide array of information concerning the status of plans and initiatives regarding all medium and long-term measures including R&D challenges.
- We will be accurately assessing the possibility of concrete collaborative efforts with foreign governmental organizations, international organizations, and private enterprises to receive information and advice as well as financial support, and will work to conduct R&D effectively and efficiently. We will also be taking a flexible and agile approach to incorporating devices and systems that have proved useful overseas. However, we will not be merely purchasing equipment and systems from overseas; full consideration will be given to long-term reliability and achieving compatibility with domestic technologies.
- The wisdom and expertise acquired through R&D will contribute to the technological capabilities of participating domestic corporations and research institutions. It will also be of benefit not only in responding to the Fukushima Daiichi Nuclear Power Plant accident, but also in reinforcing a safety infrastructure for future nuclear facility decommissionings internationally. For these reasons, this

At the same time, we recognize our responsibility to the international community for the accident our country has caused and the obligation to proactively share information with the world so that we can gather knowledge from Japan and abroad and apply it towards the many issues we will face as we move forward. To this end, it will be vital that we share research plans and achievements at international conferences and other such events.

In March 2012, an international symposium was held in Tokyo with the cooperation of the IAEA, OCED/NEA. In June, an information sharing event was held in Vienna during the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. In December of this year, a cabinet meeting on nuclear safety will be held in cooperation with the IAEA in Fukushima. These types of efforts will continue in the future.

Furthermore, there are many research topics for which the leading researchers in the world should be invited to work on and measures of how to leverage these connections as much as possible shall be deliberated since Fukushima may wind up being the world's foremost focal point of international research.

Actual research topics related to international cooperation are expected to include the international cooperation project related to accident development analysis/verification as proposed during the international symposium in March of this year, as well as fuel debris form analysis/sampling, and waste processing methods in regard to which detailed deliberations shall proceed.

7. Securing and cultivating personnel over the mid to long-term

Since it is anticipated that decommissioning of the facilities will take anywhere from 30 to 40 years, it is necessary to secure and cultivate personnel over the mid-to long-term in order to proceed with field work related to decommissioning and research and development projects.

Related parties, such as TEPCO, the JAEA, plant manufacturers, etc., will proceed with efforts aimed at cultivating personnel internally while clarifying the needs for mid to long-term personnel procurement and cultivation. They will proceed with efforts that promote the acceptance of personnel from external sources, including fields other than nuclear energy (machinery, civil engineering and construction, etc.). Furthermore, whereas it is important to enhance cooperation with universities and research agencies that will be responsible for cultivating personnel needed in the future, the expert knowledge and existing facilities of the JAEA should be leveraged while sharing our concept of technology and personnel that are required in the mid to long-term, and external agencies should be proactively leveraged such as

through joint research and consigning parts of research and development projects.

In order to do this the Research and Development Headquarters shall determine what areas are important for cultivating personnel over the mid-to long-term and select universities and research institutions (core bases) that shall become the core of these efforts. It is expected that these core bases in each field will promote based research projects with other universities and research agencies as well as take a leadership role in regards to efforts to cultivate personnel in order to acquire wide participation by researchers and students. Furthermore, along with supporting joint courses, interscholastic programs, concentrated workshops and seminars aimed at enhancing cooperation between universities and research institutions such as the core bases, deliberations on a mechanism for archiving information and data and updating data based on the latest conditions in order to closely share and provide information related to technical needs and the latest conditions and data from the field.

In this instance cooperation will be enhanced with universities and research institutions in Fukushima Prefecture and the Tohoku region with the aims of vitalizing research and development and securing personnel from the region for the future.

End of document

<Attached Documentation>

Attachment 1: R&D Master Plan

Attachment 2: Image of Main R&D Issues Related to Fuel Debris Removal

Attachment 3: Image of R&D Issues Related to Radioactive Waste Processing and Disposal

Attachment 4: R&D Headquarters Framework

Attachment 5: Areas of R&D (one page per area)

(1-1) Evaluation of the Long-term Integrity of Fuel Assemblies Removed from the Spent Fuel Pool

(1-2) Examination of Methods for Processing Damaged Fuel, etc. Removed from the Spent Fuel Pool

(2-(1)-1a) Development of Technologies for Remote Decontamination of the Reactor Building Interior

(2-(1)-1b) Creation of General Plan for Reducing Radiation

(2-(1)-2) Development of Technologies for Identifying Leak Areas in the PCV

(2-(1)-3) Development of PCV Repair Technologies

(2-(1)-4) Development of Technologies for Investigation of the PCV Interior

(2-(1)-5) Development of Technologies for Investigation of the RPV Interior

(2-(1)-6) Development of Methods and Devices for the Removal of Fuel Debris and Internal Structures in the Reactor

(2-(1)-7) Development of Technologies for the Containment, Transport and Storage of Reactor Fuel Debris

(2-(1)-8) Development of Technologies for Assessment of RPV/PCV Integrity

(2-(1)-9) Development of Technologies for Controlling Fuel Debris Criticality

(2-(2)-1) Further Advancement of Technologies for Analysis of Accident Progression to enable Understanding of Status of Reactor Interiors

(2-(3)-1) Study of Characteristics using Simulated Fuel Debris

(2-(3)-2) Analysis of Properties of Actual Fuel Debris

(2-(3)-3) Development of Technologies for Processing of Fuel Debris

(2-(3)-4) Formulation of Method for Quantification Management of Fuel Debris

(3-1) Development of Technologies for the Processing and Disposal of Secondary Waste produced by the Treatment of Contaminated Water

(3-2) Development of Technologies for the Processing and Disposal of Radioactive Waste

Attachment 6: Research Base Concept

Attachment 7: Mid to Long-Term Personnel Cultivation Program

Attachment 8: Major Achievements of the Research and Development Headquarters to Date

Annex Committee Member List