# Technical Strategic Plan 2020 for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.

## Overview

October 6, 2020

Nuclear Damage Compensation and
Decommissioning Facilitation Corporation

NDF

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# 1 Introduction

Almost 10 years has passed since the accident at the Fukushima Daiichi Nuclear Power Station, and the phase of decommissioning work is shifting from the short-term response to the mid-and-long term response. During this period, concrete progress has been made, such as stabilization of measures at a certain level for contaminated water management that required emergency responses immediately after the accident, completion of fuel removal from spent fuel pool (hereinafter referred to as “fuel removal from SFP”) in Unit 4 and start of fuel removal from SFP in Unit 3. At the same time, a significant reduction in the radiation dose within the power station has been achieved.

In the future, definite measures to retrieve fuel debris, which is the core of decommissioning work, must be promoted. The government's “Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO.’s Fukushima Daiichi Nuclear Power Station” (hereinafter referred to as “Mid-and-Long-term Roadmap”), revised in December 2019, clearly states that the retrieval of fuel debris will start from Unit 2 by the end of 2021. To achieve this, Tokyo Electric Power Company Holdings, Inc. (hereinafter referred to as “TEPCO”) announced in March 2020, the “Mid-and-Long-term Decommissioning Action Plan 2020” (hereinafter referred to as the “Mid-and-Long-term Decommissioning Action Plan”) as the main work process for the overall decommissioning project. Through this announcement, TEPCO, as a nuclear power operator, has made clear its stance of taking the initiative in decommissioning in order to materialize complicated and long-term work prospects and to make the decommissioning project transparent to the local community and society.

In ”Technical Strategic Plan for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.” (hereinafter referred to as “Strategic Plan”), the technical strategy from the Mid-to-Long-term perspective is presented in overlooking total approach for decommissioning of the Fukushima Daiichi NPS to steadily implement decommissioning by TEPCO based on the new milestone directed in the Mid-and-Long-term Roadmap.

Strategic Plan 2020 is characterized by the formulation of a Mid-and-Long-term Decommissioning Action Plan, the identification of requirements necessary for considering fuel debris retrieval methods towards the further expansion of fuel debris retrieval, the clarification of the concept of ensuring safety in decommissioning work, and the strengthening of management systems in response to the growing importance of research and development.

## 1) Structure and system toward the decommissioning of the Fukushima Daiichi Nuclear Power Station

Looking mid-to-long-term decommissioning, TEPCO has reinforced its management structure for decommissioning operation and shifted to project-based organization to respond each issues in a strategic manner and to make steady progress of decommissioning operation since April 2020. In terms of funding, the reserve fund for decommissioning is managed by Nuclear Damage Compensation and Decommissioning Facilitation Corporation (hereinafter referred to as “NDF”) since May 2017 to ensure the immediate decommissioning. In this duty, it was determined that (1). TEPCO sets aside an amount of funds at NDF every year that NDF determines to be necessary for the appropriate and steady implementation of the decommissioning and is authorized by the Minister of Economy, Trade and Industry, (2). TEPCO proceeds with the decommissioning while withdrawing the reserved funds in accordance with “Withdrawal plan for reserve fund for decommissioning” (hereinafter referred to as the “Withdrawal Plan”), which was jointly prepared by NDF and TEPCO and approved by the said minister (Fig. 1).

In this duty, NDF plays even greater roles and responsibilities as the major supervisor and administrator of the decommissioning project conducted by TEPCO. These include (1) appropriate management of the funds for decommissioning, (2) maintenance of an appropriate system for executing the decommissioning, and (3) steady work management based on the decommissioning reserve fund system. NDF presents to TEPCO the work targets and major tasks to be included in the Withdrawal Plan in accordance with “The Policy for Preparation of Withdrawal Plan for Reserve Fund for Decommissioning” (hereinafter referred to as the “The Policy for Preparation of Withdrawal Plan”) that was developed based on the Strategic Plan. NDF also assesses the adequacy of TEPCO’s efforts in the course of jointly preparing the Withdrawal Plan in terms of project execution including local community engagement (Fig.2).

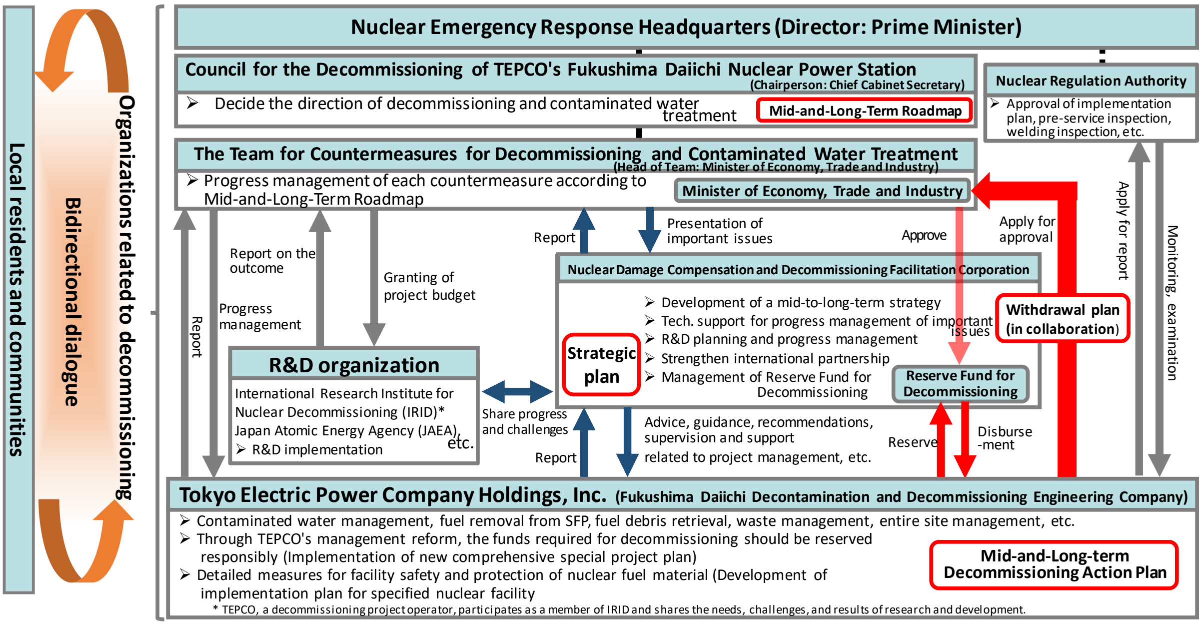


Fig.1 Division of roles of related organizations responsible for decommissioning of the Fukushima Daiichi NPS

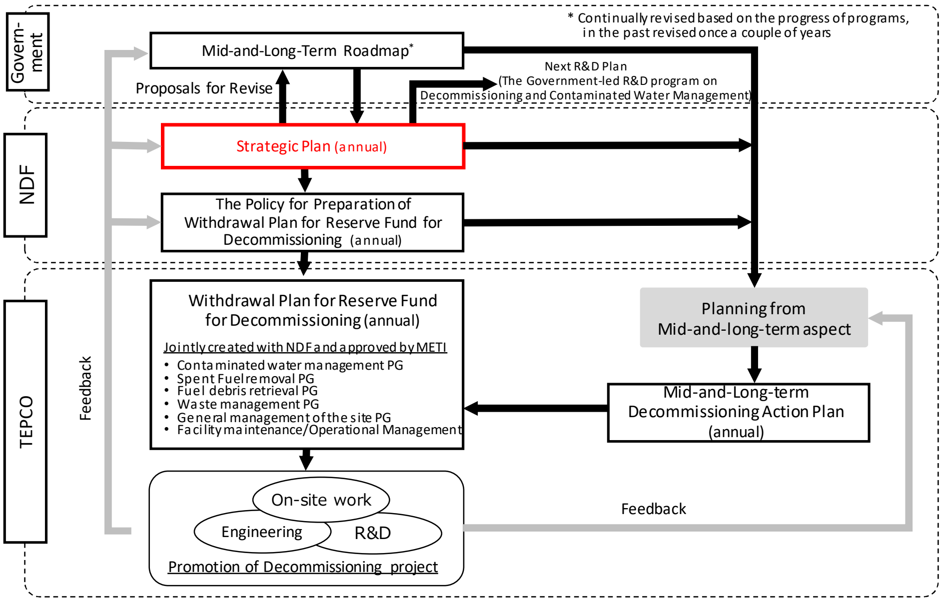


Fig.2. Positioning of the Strategic Plan based on the Reserve Fund

## 2) The Strategic Plan

NDF has issued the Strategic Plan every year since 2015, with the goals of providing a solid technical grounds for the Mid-and-Long-term Roadmap, contributing to its smooth and steady implementation and update, and accomplishment of the target shown in “Target map for Reducing the mid-term risk of Fukushima Daiichi NPS” provided by the NRA, moreover, providing a reliable basis for The Policy for Preparation of Withdrawal Plan. The Strategic Plan would affect every year’s revision of the Mid-and-Long-term Decommissioning Action Plan from technical point of view.

In response to the revision of the Mid-and-Long-term Roadmap made at the end of last year, The Strategic Plan 2020 presents a mid-and-long-term technical strategy that oversees the entire efforts of Fukushima Daiichi NPS to ensure the steady decommissioning implemented by the operator in accordance with the new target process. In particular, the retrieval of fuel debris, which is a highly difficult task, is coming very close, and the roles of the government, NDF, TEPCO, research institutes, etc., have become even greater for the realization of this task. This document also takes these viewpoints into consideration.

The specific technical strategies in each field are stated from the following chapters.

# 2 Concept on risk reduction and safety assurance for decommissioning of the Fukushima Daiichi NPS

## 1) Basic concept of the decommissioning of the Fukushima Daiichi NPS

Concerning the Fukushima Daiichi NPS decommissioning, the basic concept is to continuously and quickly reduce the risk caused by radioactive materials that do not exist in the normal NPS. In promoting decommissioning, it is important that, "to ensure the safety of decommissioning work, measures should be taken by considering the balance of risks from a long-term perspective based on safety characteristics, and a flexible strategy should be considered for risk reduction."

## 2) Concept of reducing risk caused by radioactive materials

### i. Quantitative grasping of risk

In the Strategic Plan, the method based on the Safety and Environmental Detriment score (hereinafter referred to as "SED") developed by the Nuclear Decommissioning Authority (hereinafter referred to as "NDA") is used to express the magnitude of risk (risk level) for radioactive materials. In this method, risk level is expressed as the product of "Hazard Potential," which is used to indicate the level of impact of internal exposure caused by intake of a radioactive substance into the human body, and "Safety Management," which is used as an index to indicate the likelihood of occurrence of such event.

### ii. Identification of risk source and risk assessment

The major risk sources identified at the Fukushima Daiichi NPS are summarized in Table 1, and the current condition of the risk levels of each risk source are expressed as Fig. 3, by focusing on "Hazard Potential" and "Safety Management."

In the Mid-and-Long-term Roadmap, management of these risk sources is broadly classified into three major categories: (1) Relatively high risks given high priority (stagnant water in buildings and fuel in the spent fuel pools), (2) Immediate risk unlikely, but risk may grow when handling with haste (fuel debris), and (3) Increased risk unlikely in the future, but appropriate decommissioning efforts required (solid waste such as sludge generated from the decontamination device). Their priorities are set, and appropriate measures are taken.

Table 1 Major risk sources of the Fukushima Daiichi NPS

| | | |
|---|---|---|
| Fuel debris | | Fuel debris in RPVs/PCVs in Units 1-3 |
| Spent fuel | Fuel in SFPs | Fuel assemblies stored in the spent fuel pools (SFPs) in Units 1-3 |
| | Fuel in the Common Spent Fuel Storage Pool | Fuel assemblies stored in the Common Spent Fuel Storage Pool |
| | Fuel in dry casks | Fuel assemblies stored in dry casks |
| Contaminated water, etc. | Stagnant water in buildings | Contaminated water accumulated in the reactor buildings/the turbine buildings in Units 1 to 4, process main building and high-temperature incinerator building, |

| | | |
|---|---|---|
| | | and sludge containing α-nuclides at the bottom of buildings in Units 1-3 |
| | Zeolite sandbags | Sandbags containing zeolite placed on the basement floors of process main building and high-temperature incinerator building |
| | Stored water in welded tanks | Strontium-treated water and ALPS-treated water stored in welded tanks |
| | Residual water in flanged tanks | Concentrated salt water and residual ALPS-treated water left at the bottom of flanged tanks |
| Secondary waste generated by water treatment | Waste adsorption vessels, etc. | Spent adsorbents used in the cesium adsorption apparatus, a second cesium adsorption apparatus, a third cesium adsorption apparatus, advanced multi-nuclide removal equipment, mobile-type strontium removal equipment, a second mobile-type strontium removal equipment and mobile-type treatment equipment, etc. |
| | HIC slurry | Slurry produced during treatment by the multi-nuclide removal equipment and added multi-nuclide removal equipment, and stored in high integrity containers (HIC) |
| | Sludge generated from decontamination device | Flocculated sludge generated during the operation of the decontamination system |
| | Concentrated liquid waste, etc. | Concentrated liquid waste generated by evaporative concentration of concentrated salt water with further volume reduction by concentration, and carbonate slurry collected from the concentrated liquid waste |
| Rubble, etc. | Solid waste storage facility | Rubble with high-dose (30 mSv/h and above) stored in the solid waste storage facility |
| | Soil-covered temporary storage, etc. | Rubble stored in the soil-covered temporary storage facility and containers (1-30 mSv/h), fallen trees stored in the temporary storage pool |
| | Outdoor storage, etc. | Rubble stored in outdoor sheet-covered storage (0.1-1 mSv/h), rubble stored in outdoor storage (below 0.1 mSv/h), fallen trees stored in outdoor storage |
| Contaminated structures, etc., in the buildings | | Structures, pipes, components, and other items inside the reactor buildings and PCVs/RPVs that are contaminated with radioactive materials dispersed due to the accident; and activated materials generated from operation before the accident |

Major risk sources identified at the Fukushima Daiichi NPS are shown in Table 1. However, when looking at the overall decommissioning work over the long term, there is waste that existed before the accident and those that are not adequately controlled in a stable manner although their hazard potential is not necessarily high. Since the introduction of the Strategic Plan 2019, these issues have also been presented. In particular, regarding the facilities containing risk sources that had not been expressly considered in the past, investigations and examinations are being conducted in consideration of external events such as earthquakes, tsunamis, and rainwater.

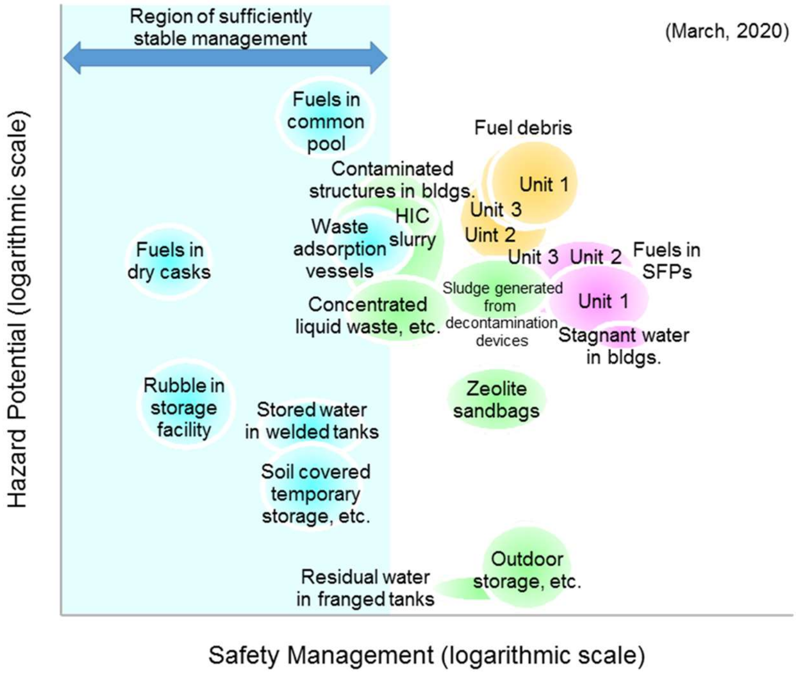


Fig. 3 Example of risk levels assigned to the major risk sources at the Fukushima Daiichi NPS

### iii. Risk reduction strategy

#### (1) Interim targets of the risk reduction strategy

Measures for risk reduction include the reduction in “Hazard Potential” and the reduction in “Safety Management.” The examples of reduction in “Hazard Potential” include the decrease in inventory and decay heat associated with radioactive decay, and changing the form of liquid and gas into a form that is hard to move. To process contaminated water to change into secondary waste is an example of form change.

The examples of reduction in “Safety Management” include transfer of fuel in the pools to the common spent fuel storage pool, and placement of rubble stored outdoors into storage. Of the various risk reduction measures, the reduction in “Safety Management” is generally considered to be easily realized. Consequently, the immediate target of the risk reduction strategy is to bring the risk levels into the “Sufficiently stable management” region (pale blue area) as shown in Fig. 3. SED is a quantitative indicator of the current status of risks attributable to radioactive materials, and is an effective method for prioritizing the measures against risk sources. With regard to Fig. 3, what was changed from last year is that zeolite sandbags were added[1] as part of contaminated water management after the accident. It was revealed in December 2019 that they would be present in a state of high radiation dose in the process of treatment of stagnant water in buildings (For details, see Chapter 3, Item 3).

[1] In the Strategic Plan 2019, zeolite sandbags were identified as one of the major risk sources that include radioactive materials exists in site of Fukushima Daiichi NPS other than major risk sources. Strategic Plan 2020 added it to the major risk sources.

## (2) Basic approach to risk reduction

Decommissioning of the Fukushima Daiichi NPS is a project with considerable uncertainties involved. To date, the internal status of Units 1 to 3 has been estimated to some extent through the simulation of the accident development process, estimation of the places with fuel debris by muon-based fuel debris detection technology, placement of investigation equipment into the Primary Containment Vessel (hereinafter referred to as "PCV"), dose measurement and video photographing in the buildings, and others. There was still significant uncertainty, however, to eliminate uncertainties, many resources and, in particular, a considerably long time are required. In order to realize prompt risk reduction it is necessary to make integrated decisions through a flexible and prompt approach, based on the directions determined with previously obtained experience and knowledge, and with experiment and analysis based simulation, placing safety as the top priority, even though a certain extent of uncertainties remain.

As the viewpoint to make these comprehensive decisions, NDF summarizes the following five guiding principles:

(Five guiding principles)

| | |
|---|---|
| Safe | Reduction of the risks posed by radioactive materials and ensuring of work safety |
| Proven | Highly reliable and flexible technologies |
| Efficient | Effective use of resources (e.g. people, things, money and space) |
| Timely | Time consciousness |
| Field-oriented | Comprehensive three-reality policy by checking actual site, actual goods, and actual situation |

If the five guiding principles are applied to the actual site, it is important to proceed with the decommissioning operation after greatly emphasizing on safety assurance for the purpose of protecting human beings and environment from radioactive materials associated with the operations, thoroughly conducting radiological consequence evaluation, and taking appropriate radioprotective measures. ("Safe")

For the decommissioning of the Fukushima Daiichi NPS, because the public risk level is rising with time as the degradation of facilities damaged by the accident progresses, while controlling this risk as low as reasonably achievable ("Efficient") as promptly as possible ("Timely") in light of the situation at the site, and proceeding with the decommissioning in a reliable manner ("Proven") by feasible ways in the harshest condition on-site ("Field-oriented") will lead to ensuring safety in medium-to-long-term.

As for the result judged based on these five guiding principles, it is also important to work to disseminate information carefully so that the results of this judgment will be widely accepted by society.

### 3) Approach to ensuring safety during decommissioning

#### i. Basic policy for ensuring safety based on the characteristics of Fukushima Daiichi NPS

Decommissioning of the Fukushima Daiichi NPS containing the reactor involved in the accident is an unprecedented activity that takes place in a special environment different from that of a normal reactor, and therefore, to ensure safety, following characteristics (peculiarity) in safety should be fully recognized.

- A large amount of radioactive materials (including α-nuclides that have a significant impact on internal exposure) are in an unsealed state, as well as in unusual and various (atypical) forms
- The barriers to contain radioactive materials, such as reactor buildings and PCV, are incomplete
- Significant uncertainties exist in the condition of these radioactive materials and containment barriers, etc.
- Difficulty in accessing the site and installing instrumentation devices to obtain on-site information due to constraints such as high radiation levels on site
- Since the current level of radiation is high and there is a concern about further degradation of containment barriers, etc., it is necessary to take measures considering the time axis without prolonging the decommissioning activities

Consequently, TEPCO, as the operator of the decommissioning project, needs to pay special attention to the following points in proceeding with the decommissioning work when considering the work based on Five guiding principles.

Firstly, with regard to “safety”: There is great uncertainty about the status of radioactive materials and confinement barriers, and on-site access and installation of instrumentation devices to reduce the uncertainty are also restricted. Under these circumstances, a large amount of atypical and unsealed radioactive materials will be handled in an incompletely confined state. Therefore, the starting point for all reviews should be confirmation of the feasibility of ensuring safety with a wide range of possibilities (cases) assumed. At the same time, with regard to “safety”, it is important not to prolong the work period, while paying attention to risk reduction over the entire work period. Therefore, it is necessary to avoid excessive safety measures and to take optimum safety measures (ALARP[2]). Such perspective on “safety” (the safety perspective) should be reflected in the decommissioning work review.

Secondly, with regard to “field-oriented”:

- The on-site environment is under special conditions such as a high level of radiation, and therefore, attention should be paid to the feasibility of construction and implementation of safety measures on site.

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[2] An abbreviation for As Low As Reasonably Practicable. It means that radiological impacts must be as low as reasonably practicable.

・ An approach through design alone has limitation due to significant uncertainties.

From the above-mentioned reasons, it is essential to accurately reflect the actual on-site information into engineering. For this purpose, the views and senses of the individuals and organizations (operators) that are responsible for the on-site work (including operation, maintenance, radiation control, instrumentation, analysis, etc.) and very familiar with actual site should be highly respected. And their perspectives and judgements directly based on the site (the operator's perspective) are important.

In the actual design of the decommissioning work in the project, TEPCO, as the project executor, should clearly define the "requirements" for the work in advance, and should design specific safety measures to achieve them. In doing so, it is essential to reflect "the safety perspective" and "the operator's perspective" to respond to the characteristics (peculiarity) of decommissioning of the Fukushima Daiichi NPS.

### (1) Optimization of judgement with safety evaluation as its basis and ensuring the timeliness in decommissioning

In proceeding with the decommissioning work with an aim for risk reduction, it is most important to take appropriate safety measures and ensure safety of the work handling a large amount of radioactive materials that is technically difficult and has significant uncertainties, such as fuel debris retrieval. Thus, decommissioning work should be carried out by concentrating on "the safety perspective". Specifically, when designing safety measures for each decommissioning activity, it is essential to make decisions based on Five guiding principles after conducting a thorough safety evaluation and confirming that the required safety is ensured.

In addition, as "the safety perspective" unique to the decommissioning of Fukushima Daiichi NPS, the importance of making progress in the decommissioning work without delay (the importance of time-axis-conscious action) can be mentioned. Considering high radiation effects that have already become materialized, and the possibility of further degradation of containment barriers, etc., making progress in the decommissioning work without delay will significantly contribute to ensuring the safety of the entire decommissioning process from a mid-and-long term perspective. Therefore, unlike ensuring safety for normal reactors, which have a certain margin in terms of human, physical, and financial resources and have low radiological impacts and high stability, it is particularly required to make rational and time-axis-conscious judgement on making progress in the decommissioning work without delay and the resource input. This judgement should be made on the condition that safety is secured and based on the relationship with the overall balance.

### (2) Ensuring safety by incorporating "the operator's perspective"

To ensure that safety measures are truly effective, it is necessary to satisfy the needs from the standpoint of those who actually perform operations and tasks on site. For this purpose, "the operator's perspective" (perspectives and judgements from the standpoint of those who are familiar with the site and perform operations and tasks on site) is important. In addition to this standpoint, the Fukushima Daiichi NPS is a facility that has suffered from an accident, and its decommissioning requires an unprecedented approach that could be carried out in the special environment such as high radiation levels, unlike normal reactors. Therefore, when determining the feasibility of safety measures on site, special on-site conditions such as high radiation levels and the environment shall be considered.

In addition, it is important for ensuring safety to complement design by operations including operating controls and to utilize the information in design obtained through monitoring, analysis, etc.

### ii. Preliminary implementation and utilization of the obtained information in the later stages

On-site conditions of the Fukushima Daiichi NPS containing the reactor involved in the accident includes considerable uncertainties. If whole operation of large-scale project such as fuel debris retrieval is to be designed under such circumstances, assumptions of extremely large safety margin and wide range of technical options will be needed. Thus, extension of work period or risk of rework will be unavoidable. As a result, feasibility or predictability of the entire project may reduce and that leads to delay in entire decommissioning, rise in decommissioning cost, or increased radiation exposure of workers.

On the other hand, considering current environment with already high radiation level, further deterioration of containment barrier, and the possibility of future major natural events (such as earthquake or tsunami), it is necessary to improve such risk state and reduce uncertainties as quickly as possible. Therefore, a “sequential type approach” is important where dividing the whole operation is divided into several stages, “operation at first stage” is implemented for which practical safety can be ensured, and then the information obtained there is utilized to the next stage. In this approach[3], the operation proceeds with its safety ensured through monitoring the condition inside reactor, restricting operational actions and flexible on-site responses[4] at each stage of the process. The information obtained at each stage of operation is utilized in the design of subsequent stages. This approach allows to reduce uncertainties in the operation of subsequent stage as well as to improve the reliability of safety assurance and rationalize design.

TEPCO is required to quickly introduce approach like this into actual engineering and project management. It is important to accumulate experiences that went well or failed acquired in this approach. It will lead to steady progress in decommissioning and contribute to ensuring safety in decommissioning the Fukushima Daiichi NPS from the perspective of risk reduction in the mid-and-long term.

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3 The same approach is applied in the UK including the decommissioning site in Sellafield and it is called “Lead & Learn”.

4 For example, taking measures including installing nuclear instrumentation system, limiting processing volume of debris and restricting operations with the control value of radioactive dust concentration stipulated.

The approach to risk reduction and ensuring safety in the decommissioning of the Fukushima Daiichi NPS, as described in this chapter, needs to be promoted with the broad understanding of not only the people directly involved but also the local people. Consequently, it is necessary for local communities, the government (Ministry of Economy, Trade and Industry, Nuclear Regulation Authority), NDF, TEPCO, and others to cooperate with each other to reduce risks based on the approach to ensuring safety based on their respective positions. In doing so, it is important to establish a system for on-going risk monitoring which enables a wide range of people to easily understand how the overall risks at the site have been continuously reduced through the decommissioning work. NDF and TEPCO are considering such a system, and TEPCO needs to introduce such a system in the future.

# 3 Technological strategies toward decommissioning of the Fukushima Daiichi NPS

## 1) Fuel debris retrieval

### i. Targets and progress

(Targets)

(1) Retrieve fuel debris safely after thorough and careful preparations including safety measures, and bring it to the state of stable storage that is fully managed.

(2) Beginning trial retrieval of fuel debris from Unit 2, the first implementing unit within 2021, then start the gradual expansion of fuel debris retrieval and a series of operations timely. Through this process, acquire knowledge and experience necessary for the further expansion of fuel debris retrieval in the future.

(3) To further expand fuel debris retrieval, thoroughly examine the result and progress of the fuel debris retrieval from the first implementing unit, through internal investigation, R&D (the government-led Program on Decommissioning and Contaminated Water Management and TEPCO's voluntary project), on-site environmental conditions. Through this process, study the best methods of contain, transfer, and store.

(Progress)

According to the Mid-and-Long-term Roadmap, Unit 2 is designated as the first implementing unit for fuel debris retrieval, and trial retrieval will be started by the end of 2021. After that, the operation to gradual expansion of fuel debris retrieval will be promoted. For a trial retrieval, the retrieval device is inserted through an existing opening part that leads to the inside of the PCV. TEPCO has presented the work schedule up to 2031 in the Mid-and-Long-term Decommissioning Action Plan, and is working according to this schedule.

①Unit 1

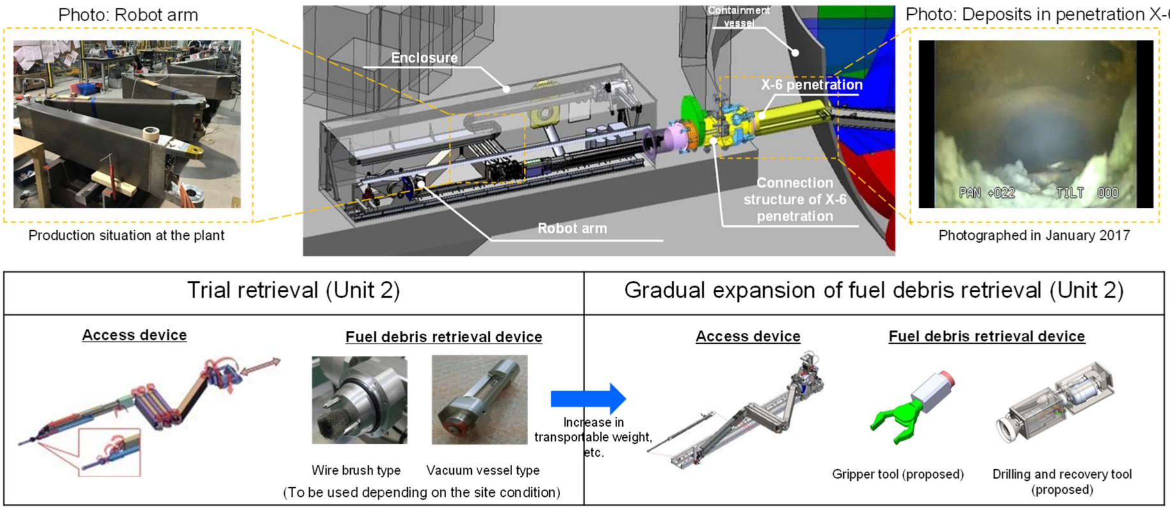
Since the second half of FY 2020, further detailed information inside PCV is planned to be gained by inserting a boat-type access investigation device with diving capabilities (an underwater ROV) into PCV and investigating the internal status such as distribution of deposits widely scattered at the bottom of outside the pedestal, presence or absence of fuel debris involved in deposits, and structures inside the pedestal. In preparation for the start of this investigations, removal of obstacles within the PCV is being promoted while taking measures to control dust dispersion and monitoring dust concentration by considering the change in dust concentration when opening the inner door at the penetration X-2.

②Unit 2

An arm-type access investigation device (a robot arm) is being manufactured (Fig.4), and measures to control dust dispersion are under consideration in preparation for the trial retrieval and the start of internal investigations of PCV by the end of 2021.

A plan to gradual expansion of fuel debris retrieval is also underway, and the retrieval device will be improved by increasing the weight capacity and enhancing accessibility while complying with specifications for the devices for trial retrieval and internal investigations of PCV. The retrieved fuel debris is transferred to the receiving/delivery cells on site and stored in temporary storage installations. In addition, some of the fuel debris will be collected in the receiving/delivery cells for analysis and transported to the facility for analysis. At present, the retrieval device, receiving/delivery cells, and temporary storage installations are being designed.

In response to the unprecedented approach to retrieving fuel debris from the first implementing unit, NDF is considering confirming the actual site applicability of the device and the results of the review on modifications to the safety system from the viewpoints of safety, reliability, reasonability, timely, and the field-oriented stance, in accordance with the progress of engineering at TEPCO.




(TEPCO material edited by NDF)

Fig.4 Image of fuel debris retrieval system (Trial retrieval and subsequent gradual expansion of fuel debris retrieval

③Unit 3

As for Unit 3, due to high water levels in the PCVs, it is planned to gradually lower the PCV water levels, taking into account the improvement of earthquake resistance of the suppression chamber (hereinafter referred to as “S/C”) and conducting internal investigations of PCV. The concentration of radioactivity may be high in the S/C-encapsulated water, and measures depending on the water quality in S/C should be taken. Therefore, in the design and construction of a PCV water intake installation and in the planning of water treatment, activities are under way to determine water quality by sampling the S/C-encapsulated water.

**ii. Key issues and technical strategies to realize them**

Since the research and development necessary for understanding the situation inside the PCVs and for fuel debris retrieval is still limited, the current design and the plan for on-site operations related to fuel debris retrieval should be continuously reviewed based on the knowledge that will be obtained in the future. In addition, considerations are given and the research and development for fuel debris retrieval is being promoted, which should lead to an accurate reflection of the outcome thereof.

### (1) Trial retrieval and internal investigation of PCV, gradual expansion of fuel debris retrieval

With regard to the trial retrieval, there are uncertainties and difficulties in the development of robot arms and the removal of deposits and obstacles due to a limited understanding of the conditions inside the PCV. Therefore, it is important to conduct a mock-up test simulating the site from the operator's perspective, while adequately confirming safety and the actual site applicability to steadily proceed.

In addition, it is also important for TEPCO to take the initiative in promoting engineering based on the considerations in (1) to (3) that have been gained from past experience under the strengthened project management system.

Based on the engineering schedule led by TEPCO, NDF will set in advance the points to be confirmed, such as the actual site applicability of access devices, results of examinations on modifications to the safety system, and the safety assessment of dry storage, and will confirm the outcome of research and development and engineering results from the viewpoints of safety, proven, efficient, timely, and the field-oriented stance. At Unit 2, while reviews have proceeded toward the start of a trial retrieval and internal investigations of PCV using the same robotic arm by the end of 2021, the review process should be proceeded with after ensuring safety by reaffirming that safety is most important. Furthermore, due to the restricted attendance of engineers and technicians because of the recent worldwide spread of the coronavirus, it is assumed that the planned work would be more difficult than before, and therefore, more deliberate and careful attention should be paid to ensuring safety.

Although small in scale, a trial retrieval and internal investigations of PCV are conducted in a fundamental form of site construction for future retrieval work, in which an opening will be newly provided in the PCV to extend the containment barrier outside the PCV. This presents an approach that enters a new stage. Since the operations are associated with maintaining the containment barrier function, a review shall be performed with considerable attention to safety in particular, and preparations, verifications and training shall be made in a more deliberate and careful manner.

The removal of obstacles, a trial retrieval, and internal investigations of PCV, shall be conducted based on the information obtained on site and the varying site conditions, etc. According to the state of obstacles actually obtained in the PCV and the internal conditions, the sequence and method of removing obstacles, a trial retrieval, and internal investigations of PCV may vary depending on the observation results obtained at that time. Therefore, these activities shall be deemed as integrated work.

① Promoting the project with a strong awareness of safety from the initial stage

When opening the inner door of the penetration X-2 to conduct Internal investigations of PCV of Unit 1, the dust monitor for monitoring the work reached the control value, and the measures to control dust dispersion and dust concentration monitoring were carried out by taking sufficient time. Despite the unknown conditions inside the PCV, these measures were taken by carefully working while newly obtaining knowledge on dust dispersiveness. Giving more consideration to dust dispersion control from the viewpoint of safety at the initial stage of the project will enable the work to be implemented systematically. To smoothly proceed with the project by utilizing this experience, safety assessments should be conducted more often than ever from the initial stage of the examination and the requirements should be defined clearly by considering the actual site applicability.

② Clarification of quality requirements considering actual site applicability

Based on the experience obtained in the research and development and the TEPCO-led engineering, development of devices will be carried out for gradual expansion of fuel debris retrieval and further expansion of fuel debris retrieval. Depending on the amount of fuel debris to be retrieved, the scale of the device becomes large and stable reliability should be ensured over the long term. Consequently, it is important to proceed with the development of the devices after clarifying the specifications such as the functional requirements, in consideration of the actual site applicability in advance. Quality control of the fuel debris retrieval device is especially important. TEPCO is required to proceed with the development of the devices on the premise that TEPCO will ensure the quality by sorting out the quality level and the basic requirements concerning quality in advance according to the situation at the Fukushima Daiichi NPS.

In addition, it is expected that more and more efforts will be made in the future in considering the fuel debris retrieval and in the construction work by combining with knowledge and experiences from overseas. In the research and development carried out with overseas companies, etc., we have experienced several challenges in the process control other than quality control, as well as in understanding the design and production capabilities of the suppliers. To exploit overseas knowledge and experience, more detailed process control must be carried out also by contractors and their subcontractors.

③ Acquisition and utilization of information during fuel debris retrieval

TEPCO has begun to consider the selection of data to be acquired and the installations for acquiring such data, aiming for gradual expansion of fuel debris retrieval and further subsequent expansion. This study involves difficulties in overcoming various limitations such as the weight capacity of the handling equipment, the cumulative dose of the equipment, remote operability, etc.

Although the on-site situation is uncertain, it is important to acquire data through condition monitoring, such as instrumentation monitoring and visual observation during the fuel debris retrieval operation to make simulation-based assessments, and to acquire the parameters to be used as design conditions for safety systems and various devices. Thus, an approach is required to link the data to the results of analyses that will be separately conducted, and to utilize them in considering the retrieval method and the safety assessment.

In addition, it is necessary to study the methods for storage and control of solid waste generated during fuel debris retrieval. It is important to collect various samples, improve data, and repeat analyses and assessments from the viewpoint of contributing to the examination of processing and disposal methods, in addition to the acquisition of data indispensable for immediate storage and management during the stage of trial retrieval and gradual expansion of fuel debris retrieval. For this purpose, the analysis and assessment should be proceeded with in a systematic and flexible manner as required.

The most important thing in the debris retrieval work and in the handling of the waste generated during retrieval is to proceed with the work under strict work safety management.

**(2) Further expansion of fuel debris retrieval**

To further expand fuel debris retrieval, more consideration should be given to study the retrieval method from the perspective of the entire Fukushima Daiichi NPS, in association with the scale-up of operations, devices, and facilities. Since TEPCO is at the stage of making a very important decision for decommissioning as the project executor, TEPCO is required to set up a basic policy with the perspectives on cost, duration, and total exposure dose, while giving top priority to ensuring safety, and taking responsibility for carrying out the project. The outcome and information newly obtained from R&D and internal investigations should be reflected in the study of the retrieval method, and an approach has to be taken in a flexible manner considering the retrieval method. In addition, it is important to ensure safety through design and on-site operations, such as reflecting the information obtained from on-site operations in the design of subsequent stages, based on the concept of proactive implementation and making use of acquired information in subsequent stages, while paying attention to social aspects such as the impact attributable to the long-term decommissioning project.

① Study flow of the retrieval method

With regard to further expansion of fuel debris retrieval, consideration will be given to the methods including those for collection, transfer, and storage of fuel debris, by ascertaining the progress in the fuel debris retrieval at the first implementing unit, Internal investigations of PCV, research and development, and the on-site environmental improvement, etc. In doing so, operations, devices and equipment, and facilities will be larger in scale and the scope of construction will be wider than in the case of retrieving fuel debris from the first implementing unit (Unit 2). Therefore, much more attention should be paid in overviewing the entire Fukushima Daiichi NPS, including other work. In addition, due to a wider range of operations to be done and studies in technical fields to be conducted, consideration should be given to the retrieval method by continuously gathering international insights. In addition, because of the high dose on site and the limited understanding of the situation inside the PCVs, the scope of operations will be enlarged. Therefore, it is important to specify the requirements required for operations and devices more clearly and to proceed with the study of the systematic retrieval method. The study flow of the retrieval method (conceptual diagram) is shown in Fig.5.

In view of the sufficiency of information and the site conditions, Unit 3 will be able to commence debris retrieval and obtain information earlier.

By representing a certain unit as a representative one, it will enable advancement of engineering including study of retrieval method, and earlier obtainment of technical points and items to be further studied. Utilizing the results in other units will lead to reducing the overall risk of fuel debris in Units 1 to 3. From the above, it is deemed appropriate to consider Unit 3 as a pilot unit.

In this way, while taking a preceding approach at Unit 3, the status of other units and the review results should be reconfirmed, and the unit under review as a pilot unit may need to be reconsidered, depending on the outcome. Even if the first implementing unit (Unit 2) is in the process of retrieving fuel debris, the method of proceeding with the fuel debris retrieval shall be flexibly considered in light of optimizing the overall decommissioning work, for example, by starting the retrieval from another unit that is in preparation for retrieval.

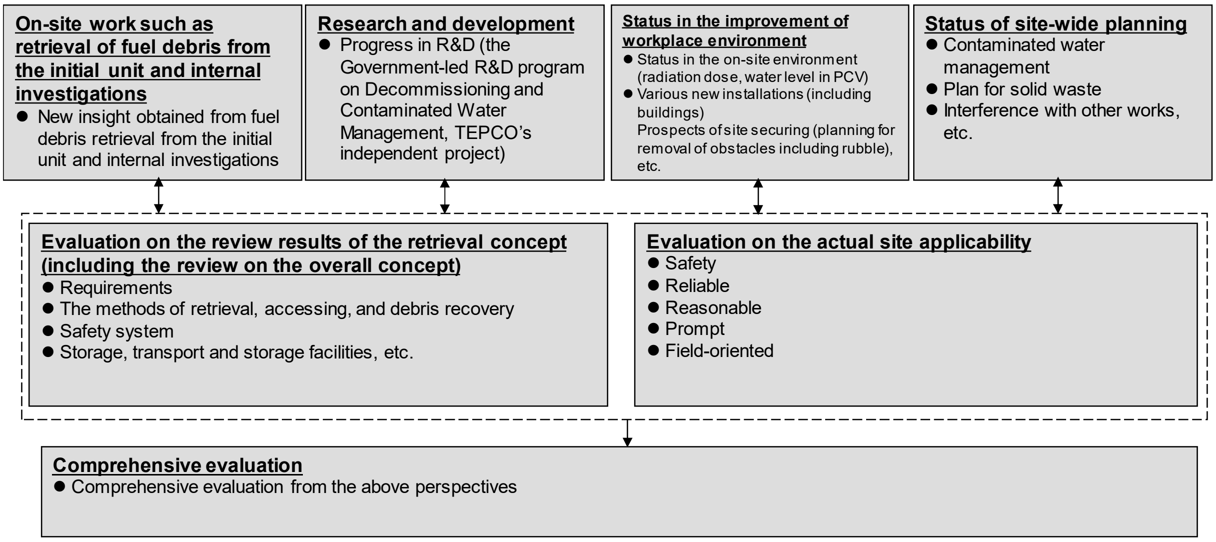



Fig. 5 Study flow of the retrieval method (Conceptual diagram)

② Concept of important requirements for the retrieval method (Boundary conditions)

At present, TEPCO is studying the retrieval method by tentatively setting preconditions for requirements based on the research and development.

To proceed with the examination of a systematic retrieval method in the future, it is required to reexamine the important requirements related to the determination of a retrieval method (the boundary conditions) among the preconditions established at the initial stage of research and development based on the information and the results of the analyses that have been obtained to that point to clearly define the requirements, and to revise them as required. In addition, the appropriateness of the concept of the construction method devised at the research and development stage should be considered and, with regard to a realistic methods, it is also required to carry out engineering processes such as a trial manufacture in design, performance verification by mock-up, design improvement, addition of functions in view of the approach to safety, ancillary preparatory work, and design of the surrounding installations on a considerable scale.

Based on the basic policy, including the perspective described at the beginning of this section, when stipulating the requirements and proceeding with the study on retrieval methods, TEPCO is required to clearly define the important requirements (the boundary conditions) as the project executor. The important requirements (the boundary conditions) shall be stipulated based on the safety perspective and the operator's perspective, regarding which requirements to be defined as important and which level of performance is required.

③ A flexible approach in studying the retrieval method

TEPCO is examining retrieval methods according to research and development. Going forward, after the aforementioned important requirements (the boundary conditions) are stipulated, it is required to take a flexible approach depending on the situation, including the review of methods, according to the assessment of the actual site applicability to be implemented based on the cases of dust dispersion during the opening work of the inner door of the penetration X-2 for the Internal investigation of PCV at Unit 1, the results to be obtained from future research and development, and the information to be acquired from a trial retrieval, Internal investigations of PCV, and gradual expansion of fuel debris retrieval at Unit 2.

In addition to the outcome obtained through these studies, a repetitive and iteration-based approach will be required in studying by incorporating newly obtained information to verify the appropriateness of the preconditions to be established based on the safety perspective and the operator’s perspective, and to review the retrieval method based on the results.

④ Ensuring safety through design and on-site operation

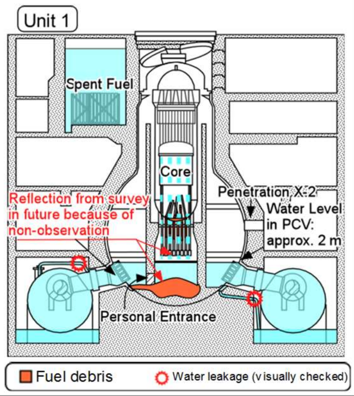
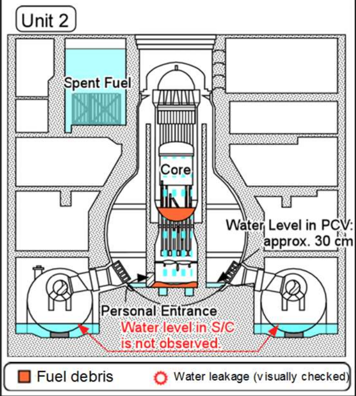
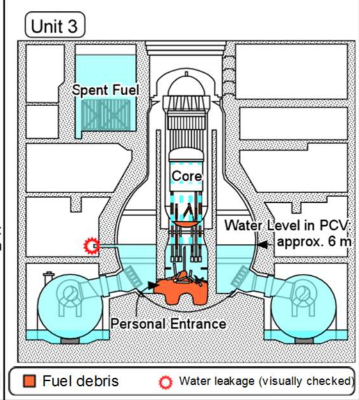
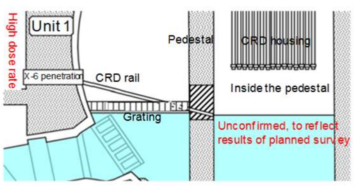
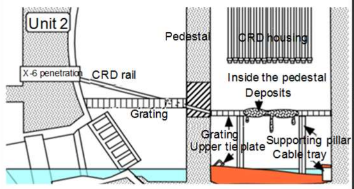
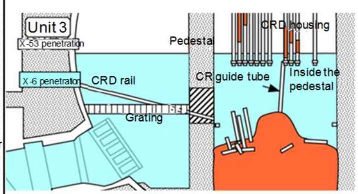
Since the decommissioning of the Fukushima Daiichi NPS is an unprecedented approach, the perspective and awareness of those responsible for on-site operations (operation, maintenance, radiation control, instrumentation, analysis, construction, etc.) are more important than those for conventional reactors. In addition to these, it is necessary to acquire information through on-site operations such as analysis while conducting trial retrieval, gradual expansion of fuel debris retrieval, as well as investigations and work, and reflect the information in the next design to ensure safety.

**(3) Continuation of internal investigations, etc., and steady implementation of the Mid-and-Long-term Decommissioning Action Plan**

Fig. 6 shows the comprehensive analysis and the evaluation results of the distribution of fuel debris, access routes to fuel debris and condition of the structures around fuel debris of Units 1 to 3. These results were derived from actual measured values of plant parameters obtained during the accident, results of the severe accident progression analysis, information obtained by internal investigations of PCV, and the knowledge obtained through various examinations. Although the state of distribution may vary, the analysis indicates that fuel debris exists both inside the Reactor Pressure Vessel (hereinafter referred to as “RPV”) and at the bottom of the PCV. In order to retrieve fuel debris from each unit, better understanding of the conditions inside the RPV and PCV through continuous implementation of internal investigations as well as research and development.

The Mid-and-Long-term Decommissioning Action Plan presents the work schedule for trial retrieval, gradual expanded scale of the retrieval, and further expanded scale of the retrieval, and will be reviewed and revised on an ongoing basis, based on the knowledge to be obtained through future Internal investigations of PCV, etc. The work schedule should be broken down into more specific items to realize steady implementation of preparatory work toward fuel debris.

Technical issues and future plans described in this section are summarized as shown in Fig.7.

| | Unit 1 | Unit 2 | Unit 3 |
|---|---|---|---|
| |  |  |  |
| Core region | · Little fuel debris remains. | · Little fuel debris remains.<br>(Partially intact fuel might exist in the peripheral region) | · Little fuel debris remains. |
| At RPV lower head | · A small amount of fuel debris is present<br>· A small amount of fuel debris is present inside and on the outer surface of the CRD housing. | · Large amount of fuel debris is present<br>· A small amount of fuel debris is present inside and on the outer surface of the CRD housing. | · Part of fuel debris is present<br>· A small amount of fuel debris is present inside and on the outer surface of the CRD housing. |
| At the PCV bottom (Inside the pedestal) | · Most of the fuel debris is present. | · A certain amount of fuel debris is present. | · Amount of fuel debris in Unit 3 is more than that in Unit 2. |
| At the PCV bottom (Outside the pedestal) | · Fuel debris may have spread outside the pedestal through the personal entrance. | · The possibility of fuel debris spreading outside the pedestal through the personal entrance is low. | · Fuel debris may have spread outside the pedestal through the personal entrance. |
| Radiation dose in operation site*1 | · Radiation dose around the penetration X-6 on the first floor of R/B is high (630 mSv/h). | · Radiation dose on the first floor of R/B had reduced to approx. 5 mSv/h as a whole. | · Radiation dose on the first floor of R/B is higher than tens of mSv/h. |
| |  |  |  |
| Information on the access route to fuel debris*2 | • The D/W bottom outside the pedestal is accessible from the upper side of the steel grating.<br>• Condition around the CRD rail connecting into the pedestal from the penetration X-6 has not been observed. | • No large obstacles have been observed on the CRD rail and around the pedestal entrance.<br>• The bottom inside the pedestal is accessible through the pedestal entrance. | • The bottom inside the pedestal is accessible through the pedestal entrance. |
| Information on the condition of structures around the access route | · No significant damage has been observed on the wall surface outside the pedestal on the steel grating upper side. | • While a part of fuel assemblies have fallen, no damage has been observed on the CRD housing support in the examined range .<br>• No damage has been observed on the wall surface and the structures (CRD exchanger, etc.) inside the pedestal. | • Some damaged structures and fallen objects (which may include internal structures), and the fall and deformation of a part of the CRD housing support have been observed inside the pedestal.<br>• No damage has been observed on the wall surface inside the pedestal. |

*1 Data provided by TEPCO

*2 Results obtained through PCV internal investigation performed up to date were presented for judging whether any obstacles such as fallen objects may exist on the route to the inside of the pedestal from X-6 penetration, which is considered as a dominant access route for fuel debris retrieval by the side access method.
Other access routes through the equipment hatch and others have been investigated under the Governmental-led R&D program on Decommissioning and Contaminated Water Management.
Due to high dose rate around X-6 penetration of Unit 1, an access route through the equipment hatch may be used in case that it is difficult to improve the environmental condition around X-6 penetration.
PCV internal investigation of Unit 1 will be performed through X-2 penetration (equipment hatch) considering accessibility of devices for PCV internal investigation.

(Created based on “Reference 1 : Water sampling included inside the suppression chamber (S/C)” in Unit 3, The 81st Study on Specified Nuclear Facility Monitoring and Assessment, etc.)

Fig.6 Estimated fuel debris distribution, access route and surrounding structures of Units 1 to 3

### (4) Technical issues for technical requirements and future plans

#### a. Technical issues for ensuring safety of fuel debris retrieval work

As for fuel debris retrieval, the conditions of fuel debris and containment barriers have significant uncertainties (unsealed, atypical). It has the safety features that a large amount of fuel debris needs to be handled in a deficient containment condition under such uncertain conditions. It is necessary to organize the approach to ensuring safety considering these circumstances and share it with stakeholders.

NDF is currently organizing the approach to ensure safety on the basis of (1) optimizing decision-making with safety evaluation as its basis, (2) ensuring timeliness in decommissioning, and (3) complementing design with operating controls, monitoring, analysis, and on-site operation at the time of abnormalities. Along with organizing the concept of ensuring safety, we are establishing the key technical requirements to ensure safety during fuel debris retrieval and conducting intensive study.

① Establishing the containment functions (gas-phase)

We expect that existing safety systems will be able to cope with the retrieval of fuel debris, such as gripping and suction, in the case of a trial retrieval or gradual expansion of fuel debris retrieval. In the subsequent work such as fuel debris cutting, it is necessary to construct the containment function of the gas phase system in consideration of re-scattering of Cs, etc., that adhere to the equipment and structures in the PCV, aerosolization of water that contains radioactive materials, and generation of short-lived iodine and noble gases if criticality should occur.

In addition to re-scattering of Cs, etc., it is concerned that dispersed fine particles (α-dust) containing α-nuclides may be generated and the radioactivity concentration in the PCV gas-phase part may increase. Accordingly, it is reasonable to expand the retrieval scale while understanding the tendency of dust dispersion at each stage of expanding the fuel debris retrieval scale, and verifying the appropriateness of the containment function built in the subsequent stage. In the engineering conducted by TEPCO, the improvement of dust monitoring installations inside and outside the reactor buildings and the study of equalizing or reducing pressure in the PCV using existing equipment are being carried out based on the outcome of the Government-led R&D Program on Decommissioning and Contaminated Water Management. In the future, the effect on the surroundings will be assessed based on the monitoring results of the changes in condition such as the dispersion of α-dust associated with the work, and the retrieval scale of fuel debris will be gradually expanded.

In doing so, we are considering establishment of a secondary containment function and study its necessity, while assuming the possibility of an increasing impact on the surroundings.

② Establishing the containment functions (Liquid-phase)

To mitigate the dispersion rate of generated α-dust and to minimize the transition to the gas phase, fuel debris cutting, etc., would be performed by pouring water over the fuel debris for fuel debris retrieval. Existing safety systems are expected to be capable of fuel debris retrieval by gripping and suction. For the subsequent work such as fuel debris fabrication and removal of obstacles, a large amount of α-particles will flow into cooling water (liquid phase). To prevent the cooling water containing α-particles from affecting the environment, it may be of great importance to establish a cooling water circulation/purification system, and a liquid phase containment function.

For this reason, it is necessary to examine technologies for removing soluble nuclides that may be leached from fuel debris to the circulating cooling water as well as treatment technologies for solid matter trapped by the filter equipped in the circulating cooling water system. Accordingly, the Government-led R&D Program on Decommissioning and Contaminated Water Management has been promoting research and development. In parallel with this, the establishment of a PCV circulating cooling system that takes water from the PCV and injects it into the reactor for cooling, which is beneficial in terms of preventing the spread of cooling water containing α particles, was considered in research and development by the Government-led R&D Program on Decommissioning and Contaminated Water Management.

To establish a reasonable containment function in each phase of the scale expansion of fuel debris retrieval, it is rational to monitor the radioactive concentration of cooling water per phase and verify the validity of the containment function to be built in the subsequent phase. As with the containment function (gas phase), from the viewpoint of verifying/investigating the impact of the retrieval work on the liquid phase, TEPCO, through the engineering work, has been discussing monitoring of the circulating water system as well as system addition/installation, etc., for the purpose of reducing the concentration of radioactive materials at the inlet in the existing water treatment systems according to the results of the Government-led R&D Program on Decommissioning and Contaminated Water Management. The scale of fuel debris retrieval will be expanded gradually, based on the results of monitoring changes in the condition of waste fluid containing α-nuclides. The water level in the reactor building is required to be maintained lower than the groundwater level to prevent the outflow of cooling water to groundwater and to appropriately control the water level in the PCV. Safety systems are to be established taking this into consideration.

③ Maintaining the cooling functions

Fuel debris generates decay heat. For example, Unit 2 is estimated to generate heat of up to 69 kW. Currently, the temperature is maintained below 100°C (cold shutdown state) with circulation cooling by injecting water into the reactor.

In maintaining this cooling function, the technical issues to be addressed for the time being include setting of the target temperature inside the PCV to make each task feasible, as well as the countermeasures to be taken under the assumption of cooling function abnormalities when each task is performed. While essential countermeasures would be to continue cooling by early recovery of the cooling water circulation system or by flexible countermeasures, etc., it is necessary to evaluate changes in the PCV internal condition based on the time margin in an emergency and to consider emergency response measures and procedures, etc., including collection of devices.

In addition, during the fuel debris retrieval operation, the processing of cutting fuel debris while spraying water is conceivable from the viewpoint of dust dispersion control, and attention should also be paid to water level control inside the PCV, as well as controlling of the contaminated water generated.

From the above, monitoring parameters and their criterion need to be studied and prepared through engineering work in order to carefully promote fuel debris retrieval work while observing how this work will affect the existing circulating water cooling and purification system, as well as its cooling function.

However, the possibility should be considered that cooling by injection of cooling water may become redundant in the future due to further decrease in the amount of decay heat along with reduction in the remaining amount of fuel debris.

④ Criticality Control

Based on the predicted state of fuel debris at the Fukushima Daiichi NPS, criticality is considered to be less likely to occur, judging from an engineering perspective. To expand the scale of retrieval, however, consideration must be given to the possibility of changing the shape of fuel debris. In reviewing a work plan for fuel debris retrieval, an appropriate control method needs to be established to ensure prevention of criticality, and prompt detection/shutdown should criticality occur.

In the initial phase of fuel debris retrieval work, fuel debris should be retrieved by methods that will not significantly change the fuel debris shape or limit the treatment amount. For the phase of expanding the retrieval scale, technical development is in progress to implement criticality control according to the increase in the amount of retrieval with a combination of measures such as preparation for adding neutron absorbers, pre-work subcriticality measurement, and monitoring by verifying the fluctuation in neutron signals around fuel debris.

⑤ Ensuring the structural integrity of PCVs and buildings

As for the main devices in the PCV/PRV pedestal, etc., and reactor buildings, their structural integrity has been evaluated in post-accident studies by TEPCO and the Government-led R&D Program on Decommissioning and Contaminated Water Management. As a result, it has been confirmed that the main devices and reactor buildings have a certain level of seismic margin.

Hereafter, the existing main devices and reactor buildings, as well as devices/systems (hereinafter referred to as "systems") and buildings (including modified areas of the existing systems and building) to be newly installed for fuel debris retrieval over a relatively long period, should satisfy the functional requirements and (1) be capable of performing operations safely and (2) ensure the required level of safety against external events such as earthquakes and tsunamis. Assuming (3) long-term maintenance management, in addition, it is important to (4) feedback new knowledge to be gained from planned Internal investigations of PCV and debris analysis results, etc., to the design of fuel debris retrieval systems and the study of retrieval methods.

Furthermore, with further progress in designing, the loading conditions (layout, size, weight of the new systems, new openings on PCV/biological shielding walls, etc.) during fuel debris retrieval will be specified. In order to ensure the structural integrity of systems and buildings, while reflecting the site conditions, promotion of steady examinations will be required based on the latest design information.

⑥ Reduction of radiation exposure during work

In accordance with the Mid-and-Long-term Roadmap and TEPCO's Mid-and-Long-term Decommissioning Action Plan, removal of obstacles and radiation dose reduction in the reactor buildings are in progress as improvement of the work environment in work areas and access routes.

As a related operation to fuel debris retrieval, removal of equipment with high radiation doses is planned, in which reduction of exposure during operation is an issue.

The main work areas are high radiation dose areas such as inside the reactor buildings. Also, there comes the need to handle nuclear fuel materials containing α-nuclides from fuel debris with a large dose contribution in the case of internal exposure. Accordingly, enhanced control of not only for external exposure but also for internal exposure is essential for reduction of exposure.

In particular, concerning the reduction of radiation exposure of workers in the reactor building, it is important to conduct sufficient investigations on the dose distribution and contamination conditions, including the contribution of the surroundings of work areas, to identify source locations and intensity to the extent possible, and to develop a plan for radiation dose reduction that defines the target dose rate in light of the margin for the legal radiation exposure dose limit for workers. In high radiation dose areas, planning is important to reduce the total radiation exposure dose to as low as reasonably achievable with respect to work hours in accordance with dose limits and required work hours to accomplish operations.

Management methods and systems will be required for α-nuclides in a series of work processes that are capable of containment and leakage detection in preparation for diffusion in the air and the water treatment system. To further expand the retrieval scale, a database or the like should be established to share information and promptly provide feedback to the next work plan. In addition, adequate radiation exposure control should be implemented after formulating a long-term work plan so as not to concentrate workers' radiation exposure on individual workers and to help reduce overall worker radiation exposure

**b. Technical issues related to fuel debris retrieval methods**

① Securing access route

For transporting, installing, and unloading the devices and equipment used for fuel debris retrieval work, and transporting fuel debris and waste, access routes should be established by removing obstacles on the access routes and reducing the radiation dose in the R/B to the level at which such tasks can be performed. When establishing new openings in the PCV or the like to construct the access routes to fuel debris, it should be kept in mind suppressing of the release of radioactive materials from the PCV and RPV and integrity maintaining the existing structures.

Toward a trial retrieval and gradual expansion of fuel debris retrieval, TEPCO is currently proceeding with specific engineering studies to conduct an access route from penetration X-6 at Unit 2.

On the other hand, in order to further expand the retrieval scale, the construction of an access route from the side opening of the PCV to fuel debris is under consideration based on the results of research and development by the Government-led R&D Program on Decommissioning and Contaminated Water Management. The issue for the access route construction is to address containment, shielding to connect structures between newly installed heavy structures and the side-opening of the PCV, and seismic displacement. As for the upper access method from the operating floor, the Government-led R&D Program on Decommissioning and Contaminated Water Management is currently examining improvement of throughput by applying a method to retrieve and transport interfering structures as a single or large unit while ensuring containment and shielding.

In the future, based on the above-mentioned tasks, it is necessary to clearly define the access route to be built in the next phase from the data obtained in each phase, and it is important to promote research and development for scale expansion.

② Development of devices and equipment

Devices and equipment for fuel debris retrieval should be developed with a focus on safety, reliability, and efficiency. In order to flexibly respond to the situation on site, devices and equipment must consider radiation resistance, maintainability, remote operability, high reliability, relief mechanisms that do not disturb subsequent work if trouble occurs, and efficiency of fuel debris retrieval.

The devices for trial retrieval and gradual expansion of the retrieval scale are under development as part of research and development activities by the Government-led R&D Program on Decommissioning and Contaminated Water Management. After the gradual expansion of fuel debris retrieval, TEPCO needs to take over and substantiate the development results. TEPCO is proceeding with the engineering of robot arms, etc., to be applied to Unit 2, while preparing education/training for the operation of fuel debris retrieval using these remote devices.

As for devices and equipment for further expansion of fuel debris retrieval, development is underway for construction methods for improving efficiency, retrieval/handling systems according to diverse conditions of fuel debris, and dust collection systems for dust generated during fuel debris crushing.

As for how to proceed with development, it is required to continue development for emerging important issues based on the information obtained from preceding investigations and retrieval work. The developed devices and equipment need to be verified continuously through mockup tests to confirm that they can demonstrate safe and reliable performance at the actual site. Mockup testing should be performed in a facility that simulates a harsh on-site environment with major uncertainties. To achieve this, the NDF and TEPCO are considering how to proceed with remote mockup test planning.

③ Establishment of system equipment and working areas

Assuming to ensure safety functions, and considering avoiding excessive system specifications, it is required to examine the establishment of system installations, etc., take necessary measures such as system additions based on the results of such examinations, and then to operate them properly. In examinations, sufficient areas should be secured to satisfy the required environmental conditions while considering installing shields for reducing radiation exposure for workers in addition to system installation, operation/maintenance management.

The system equipment include a negative pressure control system required for establishing a containment function (the air phase), a circulating water cooling/purification system required for maintaining the containment function (the liquid phase) and cooling function, and a criticality control system required for controlling criticality. Moreover, realization of measurement systems (for pressure, temperature, water level, radiation, etc.) to monitor the PCV internal conditions is a significant issue, which is essential for fuel debris retrieval. In order to build safety systems incorporating the above, TEPCO has been examining through engineering work. The working area required for installing fuel debris retrieval equipment/related devices and system installations is now being calculated. Considering the handling of high radiation dose areas in the reactor buildings and interference with other tasks, study of setting up the systems, including outside of the existing buildings, is underway.

**c. Technical issues related to safe and stable storage of fuel debris**

① Handling of fuel debris (collecting, transferring and storing)

Before initiating fuel debris retrieval work, a comprehensive system should be established that consists of a series of steps from containing and transferring to storing of retrieved fuel debris furnished with safety functions such as maintaining subcritical condition, containment function, countermeasures against hydrogen generation, and cooling. The following examinations are in progress accordingly.

- Development of basic specifications for containers (total length, inner diameter, etc.), planning, and implementation of structural verification testing for containers
- Examination of a practical prediction method for hydrogen gas generation from fuel debris, consideration on specifications of the exhaust structure of containers, and study on safe transfer conditions based on examination results
- Drying technology development applicable to fuel debris, and study on a drying system using this technology

In the future, based on the results of these studies, specific systems and devices/installations for containing to storing fuel debris should be developed with consideration of the amount of fuel debris retrieval per day, the container filling rate, and in coordination with other associated projects. In developing the specific facilities and systems for containing and storing retrieved fuel debris, it is also necessary to include responses to safeguard requirements.

It is important to reflect various measurement data collected and accumulated during the gradually expanded-scale retrieval, such as the amount of generated hydrogen, as well as knowledge and experience on handling fuel debris during the operations from receiving containers for on-site transportation to temporary storage, into the design of equipment and facilities for containing, transporting, and storing fuel debris safely, reliably, and reasonably at further expanded scales of retrieval.

The Mid-and-Long-term Roadmap stipulates that the processing/disposal method of the retrieved fuel debris shall be investigated and fixed during the third phase after starting the fuel debris retrieval work.

② Classifying of fuel debris and radioactive waste during fuel debris retrieval

In each operation phase from fuel debris retrieval, preparations for that to cleanup, etc., obstacles and structures, etc., with nuclear fuel materials attached or fused will be retrieved in addition to the fuel debris. For this reason, it is recommended to develop criteria for sorting fuel debris and radioactive waste, and measurement techniques required for sorting.

Prior to fuel debris retrieval, however, it is practically difficult to accumulate, organize, and analyze sufficient information necessary for sorting, such as the distribution of fuel debris and structures in the PCV and their geometry. Therefore, it is recommended to aim for sorting fuel debris based on the measurement results of the amount and concentration of nuclear fuel materials. As a first step in addressing this, a survey was conducted on which work processes should be performed for sorting up to storage (scenario review) and on techniques that may be able to measure the amount and content of nuclear materials. According to these studies, it was considered difficult at present to measure or estimate the mass and concentration of nuclear fuel materials contained in the objects to be retrieved from the PCV.

However, it is expected that development of sorting criteria and necessary measuring techniques/devices for fuel debris and radioactive waste in preparation for a further expanded-scale retrieval will contribute to achieving reasonable and safe decommissioning, such as by allowing reduction in the physical amount of materials to be stored as fuel debris. For this reason, it is recommended to continue development of criteria for sorting fuel debris and radioactive waste, and measurement techniques/equipment required for sorting. It is also important to continue activities to enhance the practical applicability of sorting methods/techniques and their efficiency by leveraging knowledge and information, including sample analyses to be gained from planned internal investigations, trial retrieval, and gradual expansion of the retrieval scale.

③ Examining safeguards methods

Material accountancy and safeguards to be applied to the retrieved fuel debris are unprecedented, TEPCO may face technical issues in examining and applying them to the site. In response to that, NDF will support the examinations aimed at solving such technical issues from an engineering viewpoint, and will share information on the progress of the project with TEPCO in order to ensure that system arrangements related to the application of safeguards do not affect the decommissioning process.

The main technical subjects and plans described in this section are summarized as shown in Fig. 7.

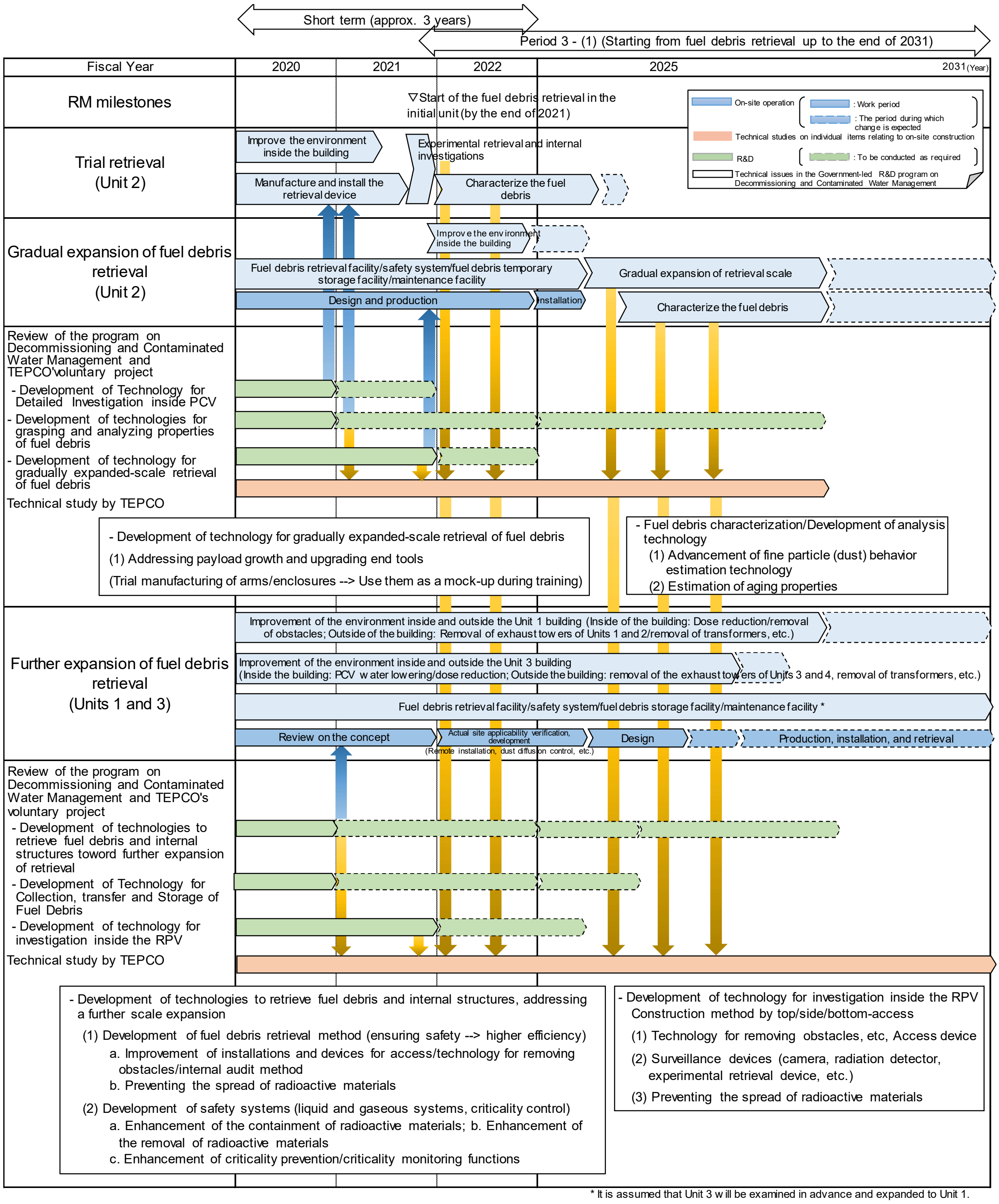



Fig.7 Technical issues and future plans on fuel debris retrieval (progress schedule)

## 2) Waste management

### i. Targets and progress

(Targets)

(1) The Solid Waste Storage Management Plan ("Storage Management Plan") is appropriately developed, revised and implemented including waste prevention, volume reduction and monitoring, with updating the estimated amount of solid waste to be generated in the next ten years periodically.

(2) Countermeasures integrated from characterization to processing/disposal of solid waste are studied from the expert point of view, and the prospects of a processing/disposal method and technology related to their safety should be made clear by around FY2021.

<Key Points of "Basic Policies on Solid Waste">

(1) Thorough containment and isolation
Thorough containment and isolation of radioactive materials to prevent their dispersion/leakage and human access to them, in order not to cause harmful radiation exposure.

(2) Reduction of solid waste volume
The amount of solid waste generated by decommissioning is reduced as much as possible.

(3) Promotion of characterization
Proper characterization addressing an increase in the number of analysis samples to proceed with study on processing/disposal method of solid waste.

(4) Thorough storage
Generated solid waste should be stored safely and reasonably according to characteristics of solid waste. Storage capacity should be secured to ensure that the waste can be stored within the site of the Fukushima Daiichi NPS.

(5) Establishment of selection system of preceding processing methods in consideration of disposal
To establish selecting methods of processing for stabilization and immobilization (preceding processing) and select a method of the preceding processing before technical requirements of disposal are established.

(6) Promotion of effective R&D with a bird's-eye-view of overall solid waste management
To confirm required R&D tasks after cooperating with each field of R&D for characterization and processing/disposal and overviewing the overall management of solid waste.

(7) Development of continuous operational framework
In order to continue safe and steady solid waste management, the continuous operational framework including development of relevant facilities and human resources must be undertaken.

(8) Measures to reduce radiation exposure of workers
Radiation exposure control, safety management and healthcare programs should be implemented thoroughly based on the relevant laws/regulations.

(Progress)

Since a large amount of solid waste with various characteristics is generated in association with decommissioning of the Fukushima Daiichi NPS, a flexible and reasonable waste stream (the flow of the measures united from characterization to processing/disposal) is being developed in addition to improvements in characterization analysis ability. Specifically, the related organizations are promoting efforts based on each role in accordance with the fundamental view for solid waste arranged in the Mid-and-Long-term Roadmap, and NDF is taking the initiative to advance the technical examination for measures united from characterization to processing/disposal of solid waste.

**(1) Storage**

To store solid waste properly, TEPCO releases its Storage Management Plan, and estimates the volume of solid waste that will be generated in the next ten years, and shows their policy such as on building waste management facilities to be required based on the volume.

Based on this plan, TEPCO decided that any outdoor storage of solid waste, excluding secondary waste generated by water treatment and re-use/recycle objects, would be eliminated by the end of FY 2028, and TEPCO is promoting the arrangement of the required system. The concrete rubble which dose level is corresponding to it of the background of the site is being recycled as roadbed material from the standpoint of reducing the waste generation amount. The recycle and re-use of the metal, concrete, and dismantled pieces of flange tanks with a very low surface dose is being studied while they are temporarily stored outside solid waste storage facilities for the time being.

Secondary waste generated by water treatment is planned to be transferred to store in a building, and large waste storage building is being constructed as a storage facility for adsorption vessels. Also, the slurry generated in the Multi-nuclide Retrieval Equipment, etc., and the waste sludge have a comparatively high risk in storage and management due to high mobility. Stabilization (dehydration) treatment will be carried out for the slurry (operation will start in FY 2022) and transfer will be carried out from the underground storage tank in a building, the present storage area to high ground for the waste sludge (to be completed in FY 2023).

For waste generated in association with fuel debris retrieval, the type and amount of materials are evaluated, and studies are being carried out for the storage method, the storing method, and the specifications for containers including measures against hydrogen gas generation, are being carried out in the Government-led R&D Program on Decommissioning and Contaminated Water Management.

**(2) Study on the processing/disposal measures**

With regard to the processing/disposal approach to solid waste, the Mid-and-Long-term Roadmap specifies that the prospects of a processing/disposal method and technology related to its safety should be made clear by around FY2021. The overall picture of solid waste becomes clear step by step according to the progress of the effort. Keeping it in mind that it will still remain in a stage of accumulating necessary information on its characteristics around FY2021, the concrete targets for technical perspective are listed as follows:

- Establish safe and rational disposal concept based on characteristics and volume of the solid waste generated in the Fukushima Daiichi NPS with its applicable processing technology, and develop safety assessment method reflecting features of the disposal concept, with considering examples of foreign countries.
- Clarify radiological analysis and evaluation method for characterization.

- Clarify processing technology that could be expected to introduce the actual equipment for stabilization and immobilization considering disposal for several important waste streams such as secondary waste generated by water treatment.
- Establish method of rationally selecting processing technology to stabilize and immobilize waste based on the above methodology although the technical requirements for disposal are not determined (i.e. preceding processing).
- Have prospect of setting processing/disposal measure for solid waste of which the processing technology considering disposal is not clarified, using a series of methods to be developed by around FY2021.
- Clarify issues and measures concerning storage of solid waste until it is conditioned

To achieve these matters, the applicability of various processing methods (thermal/non-thermal processing) using engineering-scale testing equipment, etc., is being confirmed, the disposal concept based on the characteristics of the waste and applicable processing technologies is being established, and a safety assessment method is being developed, through the Government-led Program of Decommissioning and Contaminated Water Management.

Also, to effectively understand the characteristics of solid waste required for the study, simplified and speed-up analysis methods, analysis ability improvement focusing on the arrangement of Radioactive Material Analysis and Research Facility Building 1 in which waste samples with a low dose will be analyzed, and accuracy improvement of the analytical inventory estimation method are being advanced. Sampling and analysis are being carried out for rubble, contaminated water, secondary waste generated by water treatment, and so on, and the correlation of the nuclide composition for each analyzed waste is becoming clear gradually.

### ii. Key issues and technical strategies to realize them

#### (1) Promotion of characterization and enhancement of analysis systems and technical capabilities

Human resources development for radiological analysis, and transfer/strengthening, technical capabilities on analysis, are important issues in addition to the improvement of facilities to promote characterization steadily. For the time being, it is important to proceed with human resources development for analysis systematically, as well as to proceed with the arrangement of the Radioactive Material Analysis and Research Facility and the reflection of results, such as simplified and speed-up analysis methods.

#### (2) Storage

Since the measures against hydrogen generation become an issue in the safe storage of high dose waste, the concepts for a container with a vent and drying technologies are being studied. Also, since integrity evaluations of storage containers becomes an issue when storage is prolonged, the study, such as the evaluation method and the measures against the generation of corrosion, is being advanced.

### (3) Development of processing/disposal concept and safety assessment method

In order to select candidate technologies for preceding processing methods, the selection of reasonable and feasible processing technologies and the development of suitable safety assessment methods for disposal corresponding to it will proceed.

For the selection of processing technology, it is necessary to confirm the technical feasibility as the whole processing system, including a supply system and an exhaust system, in addition to the confirmation of the feasibility of solidification. Also, the required items and information are collected and arranged to develop a safety assessment method for disposal.

Furthermore, concerning the disposal approach, various possibilities will be studied using overseas examples as reference, due to the fact that the waste from the Fukushima Daiichi NPS is large in quantity, having various properties, and showing characteristics of having large uncertainties.

### (4) Examining further approaches based on the view of the waste hierarchy

Many measures are being implemented based on the concept of the waste hierarchy (desirable approaches in the order of (i) waste prevention, (ii) waste minimization, (iii) re-use, (iv) recycling, and (v) disposal) in the UK and the USA (Fig. 8). The measures based on this concept are being practiced at the Fukushima Daiichi NPS as well. Further possibilities will be studied based on preceding examples in other countries in advancing reasonable waste management.

With regard to the prospects of a processing/disposal method and technology related to its safety based on the results of these efforts, should be made clear by around FY 2021 as the target based on the results of R&D and TEPCO's engineering achievements, etc.

Technical issues and future plans described in this section are summarized as shown in Fig 8.

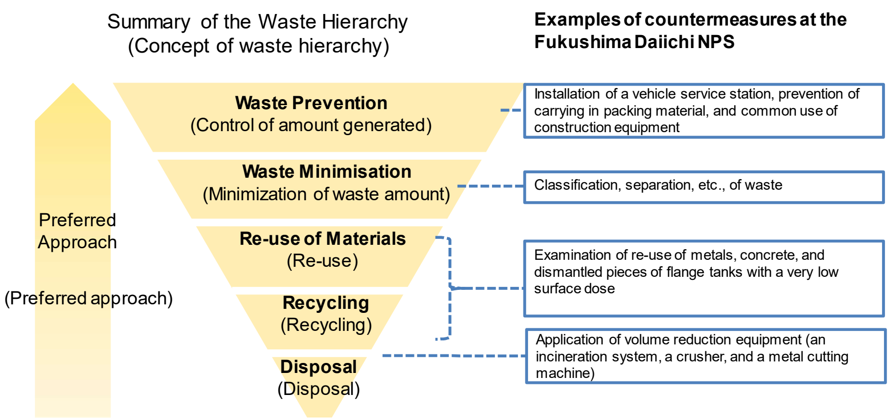



Fig. 8 Summary of waste hierarchy[5] at the NDA, UK, and countermeasures at the Fukushima Daiichi NPS

5 The figure is based on NDA, Nuclear Decommissioning Authority Strategy Effective from April 2016 (2016), p.60, Figure 7. Summary of the Waste Hierarchy.

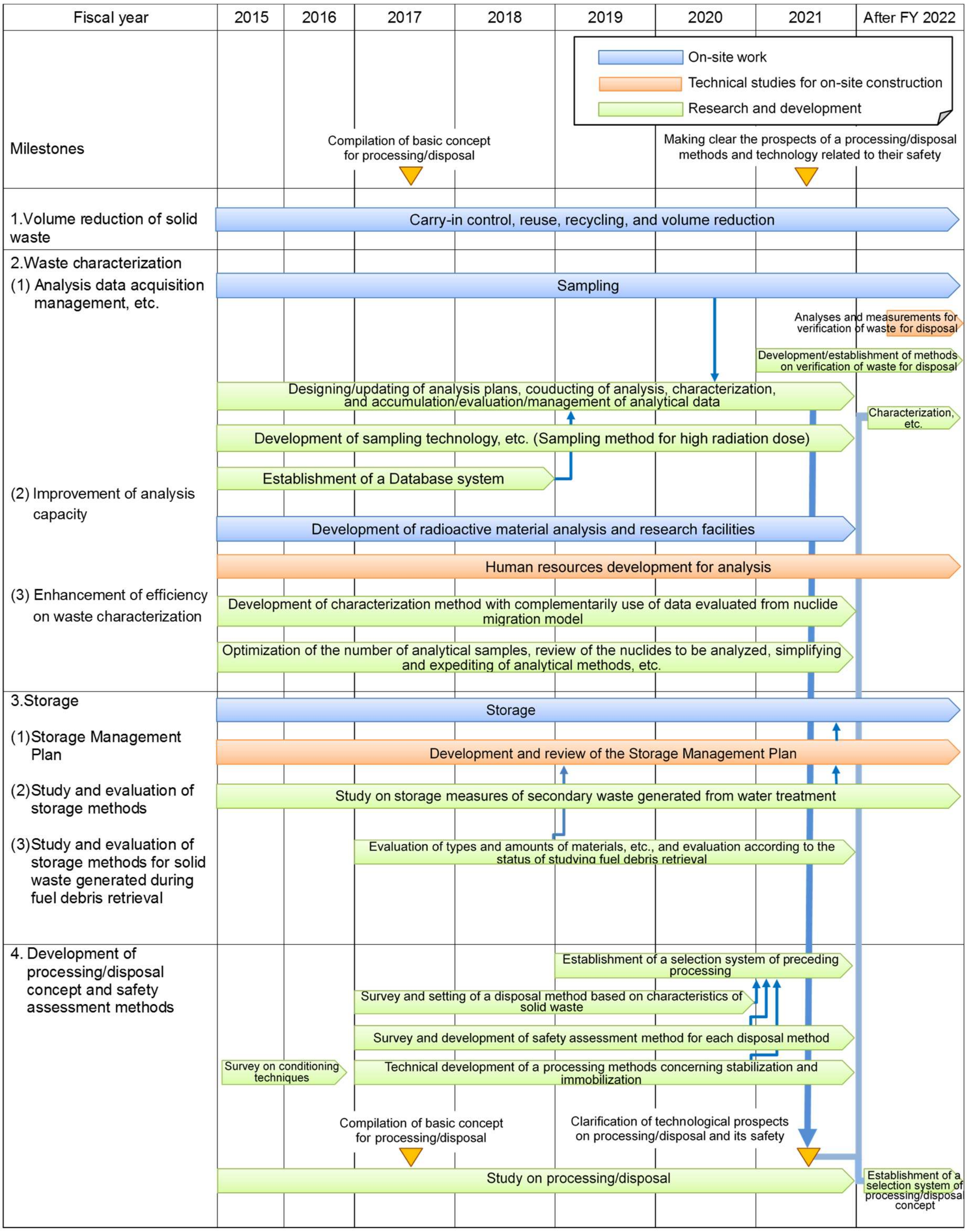



Fig.9 Main technical issues and future plans on waste management (progress schedule)

### 3) Contaminated water management

#### i. Targets and progress

(Targets)

(1) Under three basic policies for the contaminated water problem ("to remove" a contamination source, "not to make water accessible" to a contamination source, and "not to leak" contaminated water), to reduce reactor building stagnant water in FY 2022 to FY 2024 to about the half of the amount of the end of 2020 while continuing the operation of the constructed water-level management system and controlling the generation amount of contaminated water to 100 $m^3$/day or less in 2025.

(2) To arrange the relationship of fuel debris retrieval, etc., which will become serious from now on, with a decommissioning process and to promote the examination of the principles of contaminated water management for mid-and-long-term prospects.

(Progress)

In order to complete the treatment of stagnant water in buildings in 2020, efforts are being promoted for more stable operation based on three principles, excluding the Units 1 to 3 reactor buildings, where circulating water injection is ongoing, and the process building/high-temperature incinerator storing contaminated water temporarily for purification treatment.

With regard to "removing" contamination sources, the third cesium adsorption apparatus (SARRY2) purifying high-concentration contaminated water has started full-scale operation since July 2019, and a system using three units together with two established units (KURION and SARRY) has made possible stable purification treatment.

With regard to "not making water accessible" to a contamination source, the groundwater level around the reactor building is stably managed at a low level by multistory contaminated water management, such as land-side impermeable walls and sub-drains, and the increase of the generation amount of contaminated water during rainfall also tends to be controlled by the site's surrounding pavement and the repair of broken parts of roofs. Through these measures, the generation amount of contaminated water has been reduced to about 180 $m^3$/day (FY 2019) from about 540 $m^3$/day (May 2014) before taking measures. The aim is to control the generation amount of contaminated water at about 150 $m^3$/day in 2020 and below 100 $m^3$/day in 2025.

With regard to "not leaking" contaminated water, since all water purified by the multi-nuclide removal equipment, etc., has been stored in welded type tanks since FY 2019, leakage risk from tanks is reduced. Treatment of the remaining water in the multi-nuclide removal equipment in the bottom of a flange type tank has been completed (July 2020), and only approx. 500 $m^3$ of the concentrated salt water remains in storage (as of the end of August, 2020). Also, efforts and monitoring for the prevention of the spread of contamination are being carried out by the maintenance of a sea-side impermeable wall, and monitoring of groundwater and the harbor.

As a result of the above efforts, treatment of the stagnant water in buildings excluding the Units 1 to 3 reactor buildings, the process building, and the high-temperature incinerator, is planned to be completed in 2020. It is considered that contaminated water management has shifted to a certain level of stability compared with the situation requiring emergency measures immediately after the accident.

In addition, for handling the water treated with the multi-nuclide removal equipment, so-called ALPS, etc., a comprehensive examination, including technical aspects and the social impact such as rumors was conducted by a national subcommittee, and a report was published in February 2020. Based on the report, the government has been arranging opportunities since April 2020 to hear the opinions of citizens at large and a wide range of relevant parties, including local governments and agricultural, forestry, and fishery businesses, in order to determine the policy for handling ALPS-treated water as the government.

### ii. Key issues and technical strategies to realize them

#### (1) Issues in the future treatment of stagnant water in buildings

According to the investigation since March 2019, a relatively high total α is detected at the bottom of the torus chamber of the reactor buildings of Units 2 and 3. In reducing the stagnant water in the reactor buildings to about half of the level at the end of 2020 in FY 2022 to FY 2024, it will be an important issue to prevent the spread of α-nuclides. As measures, it is required to strengthen the monitoring of α-nuclides concentration in each building, and the water treatment system and property analysis. Research and development are also required to establish the approach to remove sludge precipitates containing α-nuclides.

Also, in the process building and the high-temperature incinerator, it became clear in December 2019 that there were zeolite sandbags with a high dose installed at the underground floor after the earthquake disaster. The maximum radiation dose rate on the surface of sandbags is as high as approximately 3000 mSv/h in the process building and approximately 4000 mSv/h in the high-temperature incinerator. Therefore, in order to complete the treatment of the stagnant water in these buildings in the future, dose mitigation measures will be an important issue. The remote recovery method to extract and recover zeolite, etc., and store it in containers, etc., and the remote accumulation method to accumulate zeolite, etc., on the underground floor and temporarily store it in containers, etc., are being examined. It is required to evaluate the radiation exposure dose received during work, long-term safety, and the construction period, etc., comprehensively and to select an appropriate method.

#### (2) Issues of contaminated water management considering the decommissioning process such as fuel debris retrieval

In the fuel debris retrieval, it will be an important issue to examine the whole system of contaminated-water management based on various information, experience, and results obtained in trial retrieval, gradual expansion of retrieval scale, and further expansion of retrieval scale. The possibility that the material derived from fuel debris containing α-particles is mixed into the water treatment system in association with cutting, fabrication, etc., of fuel debris cannot be denied. It is required to take measures, such as the strengthening of monitoring of water treatment systems, installation of α-particle collection systems, and criticality monitoring.

The expansion of the treatment capacity of the water treatment system and the system construction to realize continuous stable operation will be an issue in the further expansion of retrieval scale. Here, it is required to examine the miniaturization of equipment in consideration of an installation location, the operation maintenance under a high dose, how to use the established purification equipment, etc., in addition to the removal system of α-particles and other radioactive materials.

Also, it is required to ensure that a periodical inspection and update of equipment is carried out in order to maintain the effect of contaminated water management over a long period. Furthermore, as for the risk of large-scale natural disasters such as tsunamis and heavy rain, according to the "Review on Large Earthquake Model along the Japan Trench and Krill Trench (Summary Report)" published by the Cabinet Office in April 2020, the impact was re-assessed for tsunamis and the tide embankment of Japan trench is scheduled to be newly installed by 2023. Going forward, the measures should be taken in light of resilience (robustness) based on the re-assessment results.

While the current contaminated water management is shifting to a certain stable state, a long period is required to complete fuel debris retrieval. It is important to see a medium-to-long period, overlook the current contaminated water management anew, and examine the principles of more stable contaminated water management and more appropriate maintenance and management.

The summary of the technical issues and the future plans mentioned in this section is shown in Fig. 7 and Fig. 10.

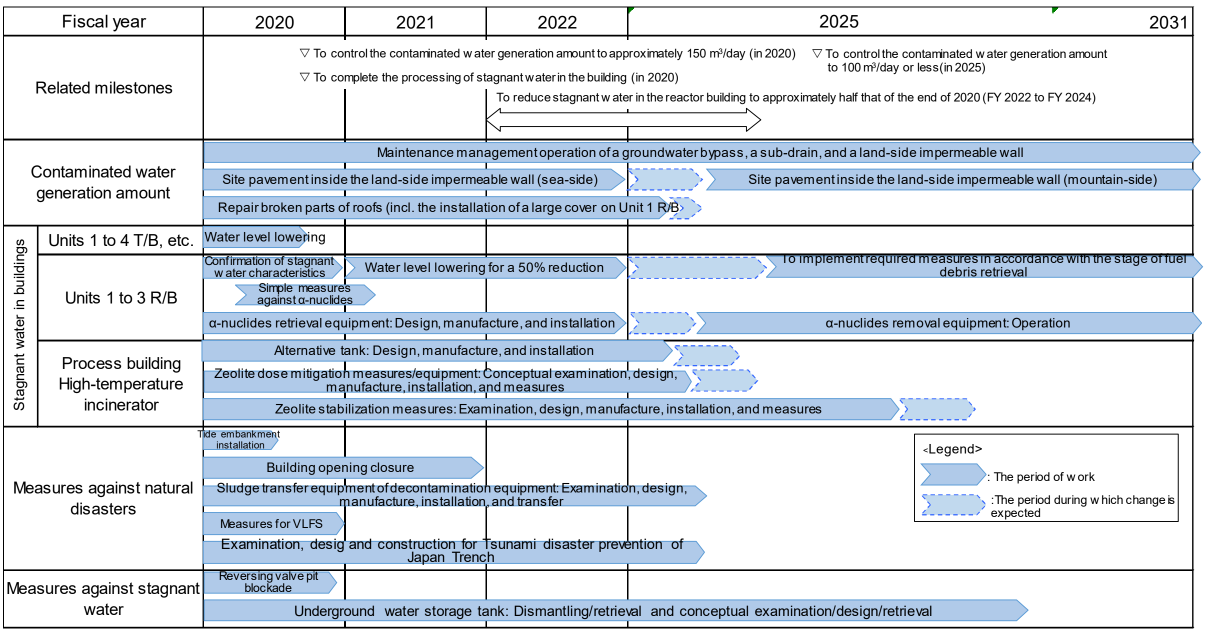



Fig.10 Key technical issues and future plans on contaminated water management (progress schedule)

## 4) Fuel removal from spent fuel pools

### i. Targets and progress

(Targets)

(1) While the return of residents and reconstruction in the surrounding area is gradually advanced, to carry out a risk assessment and ensuring safety certainly including preventing dispersion of radioactive materials and to start the removal of fuel in SFPs (Spent Fuel Pools) in FY 2027 to FY 2028 for Unit 1 and FY 2024 to FY 2026 for Unit 2. To complete the removal of fuel in SFPs in FY 2020 for Unit 3.

(2) The fuel in Units 1 to 4 that were affected by the accident are taken out of the SFPs and transferred to the Common Spent Fuel Storage Pool, etc., where they are appropriately stored so that they are in a stable, management state. In order to secure the Common Spent Fuel Storage Pool capacity, the fuel stored in the Common Spent Fuel Storage Pool is transferred and stored in the Dry Cask Temporary Custody Facility.

(3) To carry out the evaluation of long-term integrity and the examination for treatment for the removed fuel and to decide the future treatment and storage method.

(Progress)

TEPCO is working on the new work plan indicated in the Mid-and-Long-term Roadmap and the Mid-and-Long-term Decommissioning Action Plan.

In Unit 1, due to the hydrogen explosion, a roof stab, building materials, such as steel frames, which constituted the upper part of the building, an overhead crane, etc., have collapsed as rubble on the operating floor. While the residents were returning, from the viewpoint of further reduction of radioactive dust dispersion risk, the whole operating floor was covered with a large cover for the removal of fuel in Unit 1 SFP. The removal method was changed to one in which rubble removal and the removal of fuel in SFP are carried out under the cover. At present, the preparation to install the large cover is advanced, and the operating floor work such as rubble removal is continuing. For Unit 2, new method that the upper part of the operating floor will not be dismantled and accesses from the south side of reactor building is adopted from the viewpoint of further reduction of radioactive dust dispersion risk as well as Unit 1. Also, for dismantling the Units 1 and 2 common exhaust gas stack, which was being carried out as part of the environmental improvement around Units 1 and 2, a local company worked as a principal contractor, and the work was completed in May 2020.

For Unit 3, fuel removal work is being advanced, considering safety the highest priority to complete the removal in FY 2020. As of August 2020, 315 fuel assemblies are removed, and transfer to the Common Spent Fuel Storage Pool is being continued.

For Units 5 and 6, fuel will be appropriately stored in the SFPs of the units for the time being. Then, the fuel will be removed in a range so as not to affect the work in Units 1 to 3. The securing the available capacity of the Common Spent Fuel Storage Pool and the transfer of some fuel in the Common Spent Fuel Storage Pool to the Dry Cask Temporary Custody Facility are required to remove all the fuel in SFPs, including Units 5 and 6, and store them in the Common Spent Fuel Storage Pool. To achieve this, TEPCO is working on plans for expanding storage capacity in Dry

Cask Temporary Custody Facility and for off-site transportation of new fuel.

Efforts will be made to complete the removal of fuel in all units in 2031.

### ii. Key issues and technical strategies to realize them

For Units 1 and 2, it is required to advance the work steadily to realize the determined new removal method.

#### (1) Fuel removal from SFPs

In promoting the project, it is essential to comprehensively consider concerning technical certainty, reasonability, rapidity, actual site applicability, project risk, etc., and a work schedule to response to issues after making all evaluations of safety in association with work and confirming that required sufficient safety is ensured.

For Unit 1, the design and installation of the large cover, and the removal of leftover objects such as rubble on the operating floor will be promoted. There is an overhead crane in an unstable state on the operating floor. Therefore, removing the overhead crane safely and steadily is one of the main issues to prevent it from collapsing onto the fuel handling and falling into the spent fuel pool. Therefore, in the ongoing examination of how to remove the overhead crane, it is required to perform all safety assessments as an assumption, and it is important to carry out a comprehensive examination based on the viewpoints of (i) formulating concrete work procedures and work plans enabling the extraction of risk items, (ii) the risk scenario assumed from (i) and the measures, (iii) extraction of points to consider such as the exposure of workers, etc., from an operator's perspective, and (iv) reasonability and impact on other work.

Regarding the fuel assemblies in the cladding tube was damaged and stored before the accident, specific handling plan needs to be considered.

In Unit 2, fuel in SFP will be removed from the opening on the south side of the outer wall on the operating floor using a fuel handling machine composed by a boom-type crane-system, which has not been used for nuclear facilities in Japan. Since it is a new system, the following is important: (i) to set up a design schedule with appropriate margins, (ii) to carry out a mockup test simulating the situation in the field and an operation method fully reflecting the results on the design/manufacturing certainly, and (iii) to be sufficiently familiar with the operation and functionality of systems beforehand since removal is carried out by remote operation.

For Unit 3, removal of fuel in SFP, in which deformed handle was observed, is scheduled in the second half of FY 2020. It is also required to accumulate knowledge obtained, including experiences at Unit 4, and to leverage it for the subsequent fuel removal from Units 1 and 2, as well as to ensure the measures such as preparation for secure load of such fuel into transport cask by lifting safely from fuel rack, improvement of quality assurance organization, and securing the backup supply.

#### (2) Decision of future treatment and storage methods

The future treatment and storage methods for the fuel in pools need to be decided after considering the impact of seawater and rubble exerted during the accident. The fuel removed from Unit 4 has been evaluated to date and it is expected that the impact of seawater and rubble is small. However, based on the situation of the fuel to be removed, it is required to advance the evaluation of long-term integrity and the examination for treatment and to decide the future treatment and storage methods.

The main technical subjects and plans described in this section are summarized as shown in Fig.11.

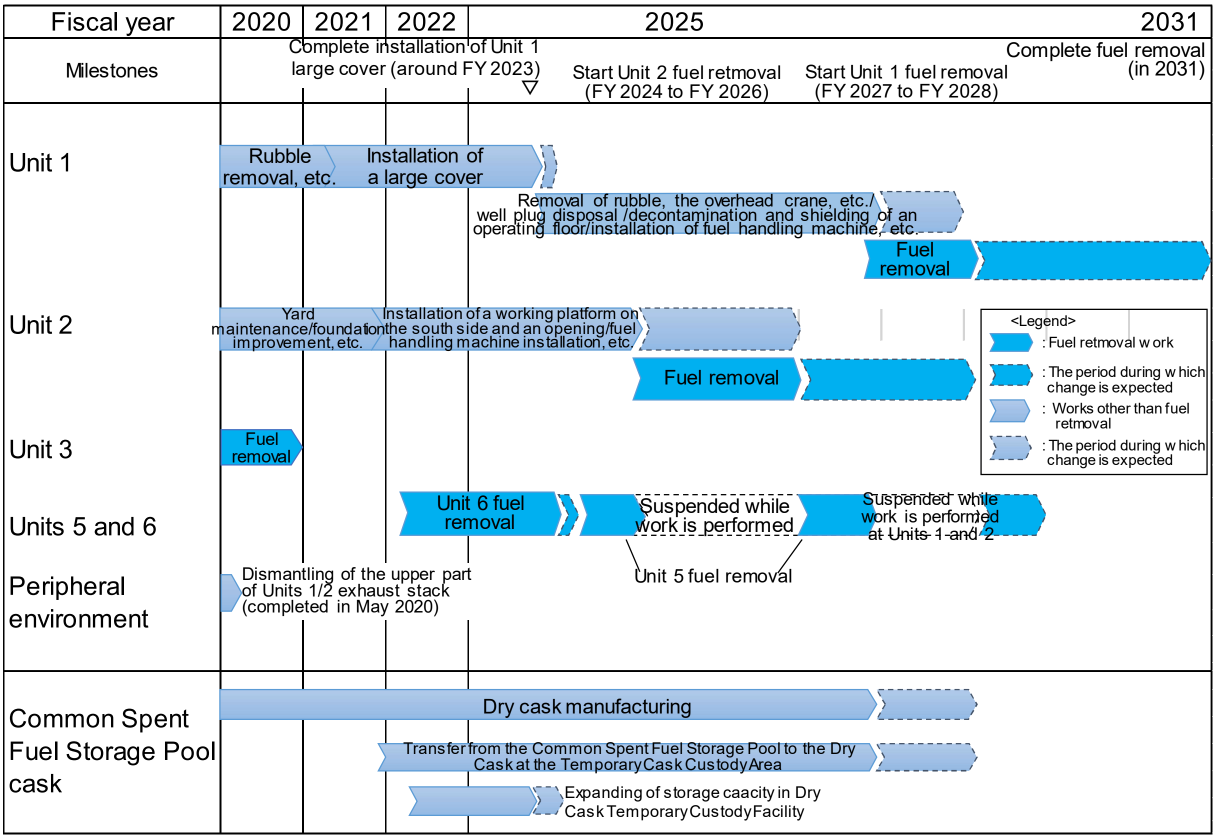



Fig.11 Key technical issues and future plans for fuel removal from SFPs (Progress schedule)

## 5) Utilization of Analysis Results for Smooth Promotion of Decommissioning

### i. Significance and the current status of analysis

To safely and steadily proceed with decommissioning of the Fukushima Daiichi NPS, it is necessary to establish and develop analysis facilities and functions required for handling of waste or fuel debris. In addition, it is important to build a system to effectively utilize analyzed results for each decommissioning operation.

TEPCO currently utilizes three facilities including the laboratory for Units 5 and 6, the chemical analysis building, and the environmental management building, and performs analyses required for facility administration and decommissioning progress, while planning to establish an analytical facility necessary for smooth performance of routine analyses related to processing/disposal of waste and fuel debris retrieval in the future.

The Radioactive Materials Analysis and Research Facility (Facilities Management Building, Building 1, and Building 2) is being developed by JAEA under an official supplementary budget as an essential analytical facility for decommissioning of the Fukushima Daiichi NPS. The analysis results obtained are required to contribute to facilitation of smooth decommissioning, reliable processing/disposal measures of radioactive material in decommissioning operation, and establishment of technical foundation, etc.

### ii. Key issues and strategies

It is necessary to correctly recognize that the analysis results are “an important piece” to reduce the range of uncertainties variously identified for the smooth decommissioning, and to establish and improve the analysis system, as well as facilities and functions for analysis for enabling efficient collection and assessment of analysis results. In particular, analytical data plays an important role in the study on the retrieval method to mitigate excessive safety design while ensuring safety. Therefore, analysis shall be positioned at a higher level in the decommissioning project.

Role sharing among the facilities that are currently planning to conduct analysis shall be appropriately optimized based on the characteristics of each facility, taking into account that the content, quality, quantities, etc., of the analysis required will change with the progress of decommissioning. In doing so, the scalability of facilities and the flexibility of operations should be considered, taking into account a risk that the demand for analysis may increase.

In addition, due to the shortage of human resources required for stable operation of the above-mentioned facilities, consideration should be given to securing and retaining of the analytical engineers. In this respect, it is necessary to consider in advance the qualities expected for analytical engineers in various analytical works that are required for optimization as mentioned above, and to develop a plan so that the required roles are appropriately achieved.

From the viewpoint of speeding up decommissioning, “immediacy” and “readiness” are required for operating the facilities that do not need off-site transportation, such as radioactive material analysis and research facilities. Although the analysis work for fuel debris retrieval is assumed to be very difficult, especially when unknown samples are handled, an important stance is that the decommissioning work shall be carried out on schedule by conducting analyses without delay. It is also important to pursue a reasonable analysis plan by comprehensively utilizing analysis results and on-site information, such as by taking note of the fact that analysis results have functions to benchmark the estimation results of internal conditions given by instrumentation monitoring, visual observation, in-situ measurement, and evaluation of calculations (simulation).

Considering that the content, quality, quantities, etc., of the analysis required will change in the process of the decommissioning project (engineering of construction methods and equipment, safety assessment and safety design, and decommissioning operations), TEPCO should establish a system where TEPCO itself will actively commit control and leadership of the whole of activities related to the analysis, by appropriately developing a role sharing of the organizations and facilities in line with this consideration and make decisions based on comprehensive evaluation. From this viewpoint, TEPCO is required, with the cooperation of outside experts, to start examining the overall strategy and a plan for the analysis of decommissioning work as early as possible.

# 4 Efforts to facilitate research and development

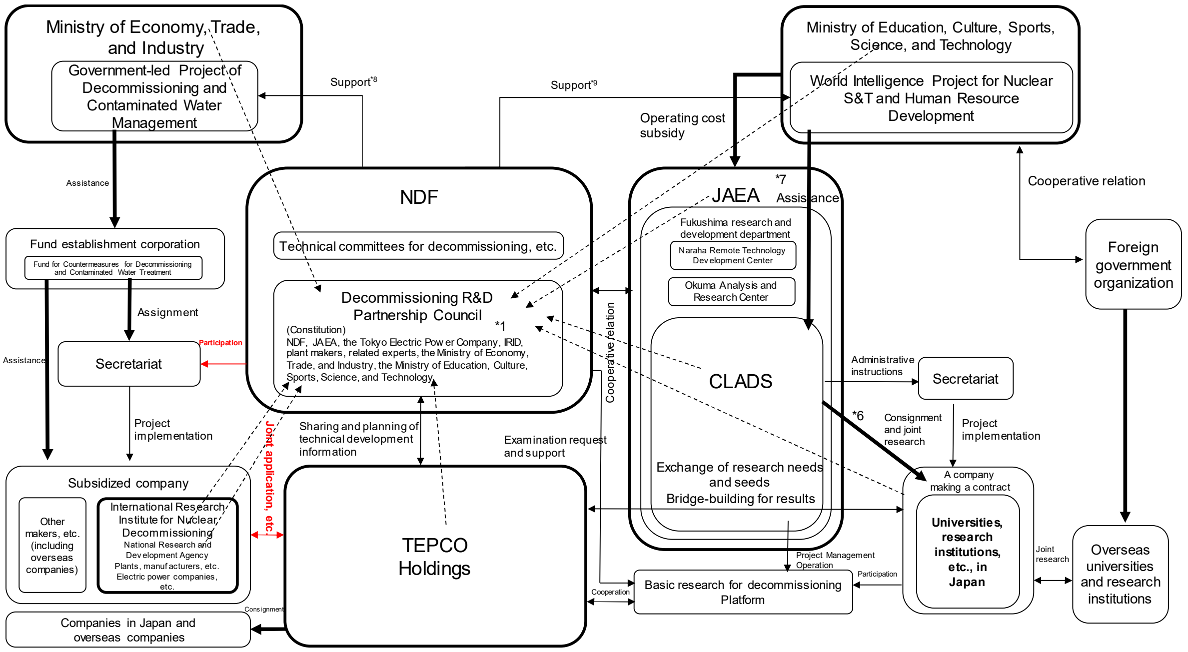
## 1) Significance and the current status of research and development

There are many difficult technical issues requiring research and development to promote the decommissioning of the Fukushima Daiichi NPS from the viewpoints of safety, certainty, reasonability, rapidity, and field orientation. At present, when trial retrieval of fuel debris in 2021 is imminent, it is required to accelerate research and development under the consideration of the application to the site for a gradual expansion of retrieval scale and further expansion of retrieval scale.

In order to solve these technical issues, basic fundamental research and application research by universities in and outside of Japan and research institutions such as the JAEA and practical application research and field demonstrations by International Research Institute of Nuclear Decommissioning (hereinafter referred to as "IRID”), overseas enterprises and TEPCO, etc., are being performed by various entities of industry/academia/government. In order to promote the research and development, the government is supporting highly-difficult ones among applied research, practical application research and field verification by the Government-led R&D Program on Decommissioning and Contaminated Water Management, and ones regarding basic and fundamental research by the World Intelligence Project for Nuclear S&T and Human Resource Development (hereinafter referred to as "World Intelligence Project"). TEPCO is also working on the research and development directly linked with actual site applicability. The outline of the research and development organization i s shown in Fig.12.

NDF established a “Decommissioning R&D Partnership Council,” which examines the issues, such as the information sharing of R&D needs and seeds, the arrangement of research and development based on the needs of decommissioning work, and the promotion of cooperation for research and development and human resources development, with the related organizations as members.

Also, in promoting research and development, it is important to make use of the Naraha Remote Technology Development Center, the Okuma Analysis and Research Center, and Collaborative Laboratories for Advanced Decommissioning Science (hereinafter referred to as “JAEA/CLADS”) and arrange the decommissioning R&D base, including international viewpoints.




*1 The Decommissioning R&D Partnership Council is established in the NDF based on the determination by Team for Countermeasures for Decommissioning and Contaminated Water Treatment.
*2 The arrow drawn in a thick solid line indicates expenditures such as research expenses and operating expenses (excluding facilities expenses), the arrow drawn in a thin solid line indicates a cooperative relation, etc., and the arrow drawn in a dotted line indicates the participation in the Decommissioning R&D Partnership Council.
*3 Some organizations such as JAEA are located at two or more places.
*4 Each organization has cooperative relations with foreign organizations based on MOU, etc., respectively.
*5 Research and development uniquely conducted by the Central Research Institute of Electric Power Industry, etc., are omitted in this figure.
*6 Although among the World Intelligence Project for Nuclear S&T and Human Resource Development the part adopted up to FY 2017 is the consignment from the Ministry of Education, Culture, Sports, Science, and Technology to a company making a contract, it is omitted in this figure.
*7 Although the subsidy for the World Intelligence Project for Nuclear S&T and Human Resource Development is delivered to JAEA, it is expressed as what is delivered to CLADS, to make it easier to understand.
*8 With regard to the Government-led Project of Decommissioning and Contaminated Water Management, based on the policy in the Mid-and-Long-term Roadmap or Strategic Plan and the progress situation of research and development, the NDF formulates a draft plan of the next research and development, and the Ministry of Economy, Trade, and Industry determines it.
*9 The NDF participates as a member in a steering committee of the World Intelligence Project for Nuclear S&T and Human Resource Development.

Fig.12 Overview of the R&D structure of the decommissioning of Fukushima Daiichi NPS (As of FY 2020) (Red: Areas with strengthened systems)

## 2) Key issues and strategies

### i. Strengthening the research and development management organization in the Government-led R&D Program on Decommissioning and Contaminated Water Management

Although TEPCO focused on the research and development for immediate decommissioning work, it has been transferring to strategic efforts based on the mid-and-long-term plan in research and development, such as publishing the Mid-and-Long-term Decommissioning Action Plan. Based on this situation, for the Government-led R&D Program on Decommissioning and Contaminated Water Management, it is required to strengthen the research and development under the consideration of needs and actual site applicability by TEPCO. Therefore, it was decided that NDF and TEPCO should be further involved in the Government-led R&D Program on Decommissioning and Contaminated Water Management in the future.

Specifically, in the Government-led R&D Program on Decommissioning and Contaminated Water Management, the organization resulted in one in which NDF participated in the secretariat of the Government-led R&D Program on Decommissioning and Contaminated Water Management and clarified the involvement of TEPCO as an actual site applying party, with the recognition of issues that the functions of both planning and status control of a project should be strengthened. TEPCO reflects requirements from the viewpoint of actual site applicability by jointly applying for subsidy with R&D implementation entities, and carries out status control cooperating with project management.

TEPCO is required to construct such a scheme and strive to focus on research and development it performs. While strengthening communication by means of information exchange and dialogues with TEPCO, NDF will plan matters considering needs in the field and actual site applicability and manage status control of research and development to achieve research and development conforming to the purpose of research and development and the target period for achieving results.

**ii. Formulating the R&D medium-to-long-term plan foreseeing about ten years for the time being**

The Mid-and-Long-term Roadmap indicated the course of action for about ten years for the time being and the promotion of research and development to support it. With regard to this matter, based on the Mid-and-Long-term Decommissioning Action Plan, NDF and TEPCO decided to formulate the R&D medium-to-long-term plan overlooking the overall research and development for about ten years for the time being in order to appropriately manage the extraction and execution of the required research and development for achieving the further expansion of fuel debris retrieval scale. In the R&D medium-to-long-term plan, the items and content of research and development assumed at present in each stage of fuel debris retrieval are identified in a manner linked with the TEPCO's Mid-and-Long-term Decommissioning Action Plan. Also, formulated based on this R&D medium-to-long-term plan, the next R&D plan formulated every fiscal year will clarify how and where each research and development project corresponds to the decommissioning process. The R&D medium-to-long-term plan will be updated and expanded continuously based on the information made clear by the progress of Internal investigations of PCV, etc., and fuel debris analysis, the progress of research and development, the revision of the TEPCO's Mid-and-Long-term Decommissioning Action Plan, etc.

**iii. Matching of needs and seeds of decommissioning work site and universities/research institutions**

Universities/research institutions bearing basic infrastructure research are expected to maintain and develop human resources and knowledge/infrastructure to make a quick response when technical issues requiring scientific knowledge occur. It is important that universities/research institutions deeply share recognition of issues in the field of decommissioning.

Some basic fundamental research contributing to problem-solving in the field of decommissioning have obtained outstanding research results mainly in the World Intelligence Project of the Ministry of Education, Culture, Sports, Science, and Technology and JAEA/CLADS., It is an important issue to reflect the results in the field of decommissioning directly. In order to achieve this, it is essential to match the needs of the decommissioning site with the seeds of universities and research institutions, build bridges for excellent results obtained, while making use of the overall map of the basic foundation research by JAEA/CLAD. Under the circumstances, joint research with universities was newly started in TEPCO from FY 2019 to find the technical seeds for decommissioning owned by universities based on the result of the World Intelligence Project. The related organizations, such as the government (the Ministry of Education, Culture, Sports, Science, and Technology, the Ministry of Economy, Trade, and Industry), JAEA/CLADS, NDF, and TEPCO, need to strengthen cooperation towards further matching of the needs and seeds and bridging for the results.

# 5 Activities to support our technical strategies

## 1) Further strengthening of project management and improvement of capability required as a decommissioning executor

### i. Significance and the current status of project management

#### (1) Formulating the Mid-and-Long-term Decommissioning Action Plan

Since the accident at the Fukushima Daiichi NPS, TEPCO has conducted decommissioning project in accordance with the requests based on the Act on Special Measures Concerning Nuclear Emergency Preparedness and the Nuclear Reactor Regulation Law[6] and the target process of the Mid-and-Long-term Roadmap determined in the Inter-Ministerial Council for Contaminated Water and Decommissioning Issues. By formulating and publishing the Mid-and-Long-term Decommissioning Action Plan showing the processes for how to achieve such targets, in light of the ten years that have passed since the accident, TEPCO made transparent the decommissioning project to local areas and society, made clear its attitude toward tackling decommissioning independently, and materialized the complicated work prospect over a long period.

The decommissioning work for the Fukushima Daiichi NPS is a project with significant uncertainty. However, since the plan under the consideration of the medium and long term can be formulated for research and development, human resources, and procurement by thinking of the Mid-and-Long-term Decommissioning Action Plan, the meaning of formulating the Mid-and-Long-term Decommissioning Action Plan is significant. It is also important to carry out constant review based on new knowledge, the on-site situation, etc., for utilizing the Mid-and-Long-term Decommissioning Action Plan effectively in the future.

#### (2) Further strengthening of project management

In April 2020, TEPCO changed its decommissioning project to project management-based structure by reorganizing Fukushima Daiichi D&D Engineering Company. However, TEPCO has just stood at the starting point as project management-based organization and the priority is to operate project management structure.

To implement complex, multilayered and large-scale decommissioning project such like fuel debris retrieval in a safe and steady manner over a long period of time, appropriate and efficient operation should be performed while further strengthening project management structure by accelerating improvement of functions to manage project risks as well as managing engineering and R&D in an integrated manner.

### ii. Key issues and strategies

#### (1) Reinforcement of “safety and operator's perspectives” in project activities

When promoting efforts such as design examination (engineering) for construction method and equipment, there is a tendency to focus on realizing a construction method, equipment, etc., physically, especially for issues with severe technical difficulty. However, in order to realize the results of efforts in the field, it is indispensable to fully reflect the following in the construction method and equipment in addition to a physical realization:

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[6] The Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material, and Reactors

- “The safety perspective” as a project executor[7] handling dangerous substances of nuclear fuel material, etc.
- “The operator’s perspective”[8] familiar with the field of the Fukushima Daiichi nuclear power plant decommissioning

Therefore, these perspectives need to be fully reflected in the project activities until a construction method and equipment are realized in the field. Without sufficient feedback, the results of the construction method and equipment that are unsuitable to the site will be brought about, and safe and stable decommissioning will be disturbed.

To avoid such a situation, a business process to incorporate a “safety perspective” and an “operator's perspective” in the upstream of project activities needs to be established at an early stage.

**(2) Improving the owner's engineering capability**

For operations with limited information (accompanied with significant uncertainty) and which are unprecedented and highly challenging, such as fuel debris retrieval, a conventional engineering approach[9] is not always applicable. Rather, target-setting and the specifications required by the operation executor (TEPCO) will not necessarily be clear at the time of initiating the engineering process. Consequently, the establishment of performance requirements, the physical feasibility of engineering methods and equipment, and the extent of performance assurance coverage have to be of a trial-and-error-nature. Therefore, the operation executor’s performance requirements, the establishment of the supply chain’s functions and its engineering process have to be based on iteration[10] to some extent.

For iteration-type engineering, the contract between a project executor and a supply chain is not conventional[11]. Therefore, it is strongly required that TEPCO, as a project executor, “make a judgment on engineering and is responsible for the results.” Therefore, it is required to improve the engineering capability (owner's engineering capability) carried out independently by TEPCO, a project executor as an owner[12], such as the project management capability, the capability to optimize the whole supply chain that should be owned as a project executor, specifically, the

7 Although the fuel debris is in a certain safe state now, the fuel debris retrieval work will cause disturbances to this stable state. Namely, since α-radioactive material is handled in an unsealed state in fuel debris retrieval work and a criticality risk may be increased temporarily, more elaborate work management than before (criticality control, radiation protection, operation management, monitoring strengthening, etc.) is required.

8 An operator is a collective term for the people and organizations handling the site (operation, maintenance, radiation control, instrumentation, analysis, etc.)

9 A supply chain advances engineering based on requirement specifications provided by TEPCO, as a project executor.

10 A method of gradually increasing the completeness of engineering by finding the next result based on a certain result and repeating this cycle.

11 In the conventional construction of nuclear power stations, a supply chain has delivered completed products to a project executor after guaranteeing the performance (Full turnkey contract).

12 An owner here has three positions of a party responsible for disaster occurrence, a specified nuclear facility licensee, and a facility owner. TEPCO is executing the decommissioning project from these three positions. (A project executor of decommissioning)

capability to make an engineering judgment, the capability to evaluate business risk, the capability to materialize order specifications.

With that in mind, in deciding retrieval methods and equipment, it is important that methods and equipment to be adopted in the end will be decided in accordance with ALARP[13] based on safety, through the cycle of "define the safety standards (safety perspective)", "indicate the feasibility on-site (operators' perspective)", and "examine and discuss at project (project management)".

#### (3) Developing and securing human resources

Human resources development is indispensable as infrastructure to implement decommissioning project over a long period smoothly. It is important for TEPCO to assume occupational categories and the number of engineers to be required in the future (design, operation, maintenance, chemical analysis, safety assessment, radiation control, etc.) and the time to be required in light of the Mid-and-Long-term Decommissioning Action Plan, to summarize them as the medium-to-long term human resources development plan, and to promote human resources development and staff securing systematically. In addition, as it is essential to train and secure future researchers and engineers, it is important for industrial-academic-governmental institutions relating to nuclear power, as a whole, to steadily promote these efforts. Therefore, it is necessary to further promote and strengthen measures for securing human resources who will lead the next generation, such as children in elementary and secondary education stage, students in the higher education stage including universities or colleges of technology, young researchers and engineers, etc.

## 2) Strengthening international cooperation

### i. Significance and the current status of international cooperation

In recent years, nuclear reactors and nuclear fuel cycle facilities, constructed in the dawn of nuclear power, are coming to the end of operating life and these decommissioning have already been progressing in the world. At the nuclear reactors experienced severe accidents, stabilization and safety measures have been taken in these facilities for a long time. In addition, for past overseas nuclear-related sites (legacy sites), it is expected that there was significant uncertainty in the management of a variety of radioactive substances and it would take a long period for decommissioning and environmental remediation. Despite facing technical difficulty called "unknown unknowns" (things we don't know we don't know), and issues such as longtime project management and securing a large amount of money, each country continues the challenge for overcoming them.

In order to steadily advance decommissioning of the Fukushima Daiichi NPS handling engineering issues with a high level of difficulty, it is important as a risk reduction strategy to learn lessons from examples such as precedent decommissioning activities and utilize them in decommissioning. Also, to maintain and develop continuous understanding/concern and cooperative relations with international society over decommissioning, it is important to return the knowledge, etc., which was obtained through the accident and decommissioning of the Fukushima Daiichi NPS to international society positively and strategically and to promote reciprocal

[13] It means that radiological impacts must be reduced as far as reasonably practicable.

decommissioning open to international society through information dissemination to international society and participation in the international joint activities.

In regards to the international cooperation, it is important to utilize a multilateral cooperation framework through IAEA, Organization for Economic Co-operation and Development/Nuclear Energy Agency (hereinafter referred to as “OECD/NEA”), etc., in addition to proceed with bilateral cooperation in harmony with the circumstance in each country. These international institutions have an important role including designing the international standard for decommissioning. Participating in the discussion for developing the international standard based on the experience of decommissioning in Japan, it is important for proceeding with the decommissioning of the Fukushima Daiichi NPS in an open manner on the international basis. It leads to share our experience with each country, it is also expected to fulfill the Japan’s responsibility to the international society. From this perspective, NDF, based on these, currently focuses on information dissemination on the decommissioning through taking part in side events of IAEA General Meeting and giving speeches at key international meetings including OECD/NEA Steering Committee.

#### ii. Key issues and strategies

We will soon mark ten years since the accident. From the viewpoint of concentrating the wisdom in the world for the decommissioning of the Fukushima Daiichi NPS, since a recipient's concerns, etc., may change a little from the time of the accident, it is important to provide information considering this point even if it is the same information. Specifically, in addition to providing detailed exact information for experts, it is also necessary to provide intelligible information for non-experts or devise appropriately considering recipients' intelligibility concerning the circumstances of the accident.

While the engineering of the Fukushima Daiichi NPS is put into practice, it is important to always keep up the latest situation of world's superior technologies and human resources and effectively exploit them. Therefore, it is necessary to understand the latest global information, including even the private sector situation, make efforts for continuous communication with these private enterprises, and form an environment in which required technology is accessible when required while sharing information on the progress of decommissioning work.

### 3) Local community engagement

#### i. Significance and the current status of local community engagement

While the residents are returning and reconstruction is progressing gradually in the surrounding area, the confidence from the communities is indispensable to advance decommissioning safely and steadily. Therefore, it is important to listen to uneasiness and questions of the local residents sincerely and make efforts to have them understand and feel ease about the decommissioning work through bidirectional communication of delivering exact information intelligibly and quickly. In addition, to accomplish the long-term decommissioning, it is essential to have continuous cooperation from local businesses and other companies. At the same time, participation of local businesses in the decommissioning project is a crucial pillar for TEPCO to contribute to the reconstruction of Fukushima, because it will revitalize the decommissioning related industry, create jobs and technologies in this area, and spread the results to other regions and industries.

Under the fundamental principle of “coexistence of reconstruction and decommissioning”, TEPCO will also cooperate with efforts to realize the “Fukushima Innovation Coast Framework” holding up decommissioning related industry accumulation to the Hamadori region as priority areas and accomplish decommissioning while coexisting with the region.

Last fiscal year, while obtaining the Fukushima Innovation Coast Framework Promotion Organization's cooperation, TEPCO held a decommissioning project matching event for local businesses. Also, at the end of March 2020, it formulated the “commitment to Fukushima residents for the coexistence of reconstruction and decommissioning” (hereinafter referred to as "Commitment") summarizing the efforts, such as the participation of local businesses in decommissioning project, the attraction of companies outside the area, support for local companies toward human resources development and cooperation with universities, etc. It re-expressed the determination to fully address decommissioning project as a member of the community.

To undertake the efforts of the “Commitment,” TEPCO has set up a joint consultation counter for local companies who are interested in participating in the decommissioning project in cooperation with the Fukushima Innovation Coast Framework Promotion Organization and the Fukushima So-So (Soma and Futaba regions) Reconstruction Promotion Agency, and is preparing to hold business fairs between the prime contractor and local companies. To provide support to help local companies participate in the projects, TEPCO subdivided the medium-to-long-term outlook in the decommissioning project as well as the detail, timing and scale of the project orders to be placed as much as possible, and formulated “Medium-to-long-term outlook in the decommissioning” that specifically states equipment or technology required for each project in September 2020. Now, TEPCO is explaining the outlook to the prime contractor and the local governments and association of commerce and industry.

**ii. Key issues and strategies**

Misunderstanding, concern, and rumors are caused by inappropriate information transmission about decommissioning, which ruins appreciation and confidence in the decommissioning project of the regions and the whole society and leads to the delay of decommissioning. Therefore, TEPCO needs to utilize various tools, such as informational magazines, WEB sites, and motion videos, in addition to the visit of the Fukushima Daiichi NPS and the decommissioning museum (Tomioka-cho), and inform as to the present situation and progress status of decommissioning intelligibly and quickly.

Also, the government, NDF, and the TEPCO, under suitable cooperation, need to provide information more carefully and make efforts to build confidence with regions. Therefore, we need to positively arrange an opportunity to communicate directly with the people in regions. We also need to make efforts for bidirectional communication by dialog, such as listening to uneasiness and questions of the participants sincerely through the events of the International Forum on the Decommissioning of the Fukushima Daiichi NPS, etc., held by NDF, and deliver exact information intelligibly and quickly.

TEPCO must not end this “Commitment” just as a shape, but secure effectiveness. Therefore, the specialized department working on community symbiosis plays a key role to update and add the detail of “Medium-to-long-term outlook in the decommissioning project” as required with the progress of the decommissioning project. In addition, they will positively provide coordination with the local communities by carefully explaining it continuously via the local governments or the association of commerce and industry through dedicated joint consultation centers and business fairs targeting local companies. TEPCO itself is providing support to local companies to enhance their technical capabilities, while inviting companies from outside the region to do business with them. In addition, TEPCO establishes a system where the local companies are encouraged to offer technical guidance to the primary contractors and, if certain results are achieved, incentives are to be given. Efforts are being made to build a foundation for the local economy and foster local businesses and human resources through the decommissioning project. Furthermore, not only the research and development on decommissioning, but as companies outside the region expand their businesses in the area and technical support to local companies progresses, it is expected that the number of engineers and researchers visiting and staying from outside the region will increase. It is required to develop the necessary environment and support so that such external human resources can fit into the regional society and play an active role as a member of the local community.

For carrying out the work of community symbioses, it is also required to strengthen organizations if needed since close cooperation is required between each department. In addition, NDF needs to continue and strengthen cooperation and collaboration with local governments, including Fukushima prefecture, the Fukushima Innovation Coast Framework Promotion Organization, and the Fukushima So-So (Soma and Futaba regions) Reconstruction Promotion Agency, etc.