Technical Strategic Plan 2023 for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.

Overview

October 18, 2023

Nuclear Damage Compensation and

Decommissioning Facilitation Corporation

Table of Contents

1. Introduction

The long-term approach to the decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc. (hereinafter referred to as the “Fukushima Daiichi NPS”) has proceeded under “the Mid-and-Long-term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.” (hereinafter referred to as “Mid-and-Long-term Roadmap”), developed by the Japanese Government. At present, along with preparations for trial retrieval of fuel debris (e.g., internal investigation and fuel debris sampling) at the final stage of Phase 2[1], efforts toward full-scale decommissioning work that will begin after the transition to Phase 3－①[2] are steadily being implemented with the cooperation of the relevant organizations. Fig.1 shows the division of roles of related organizations responsible for decommissioning.

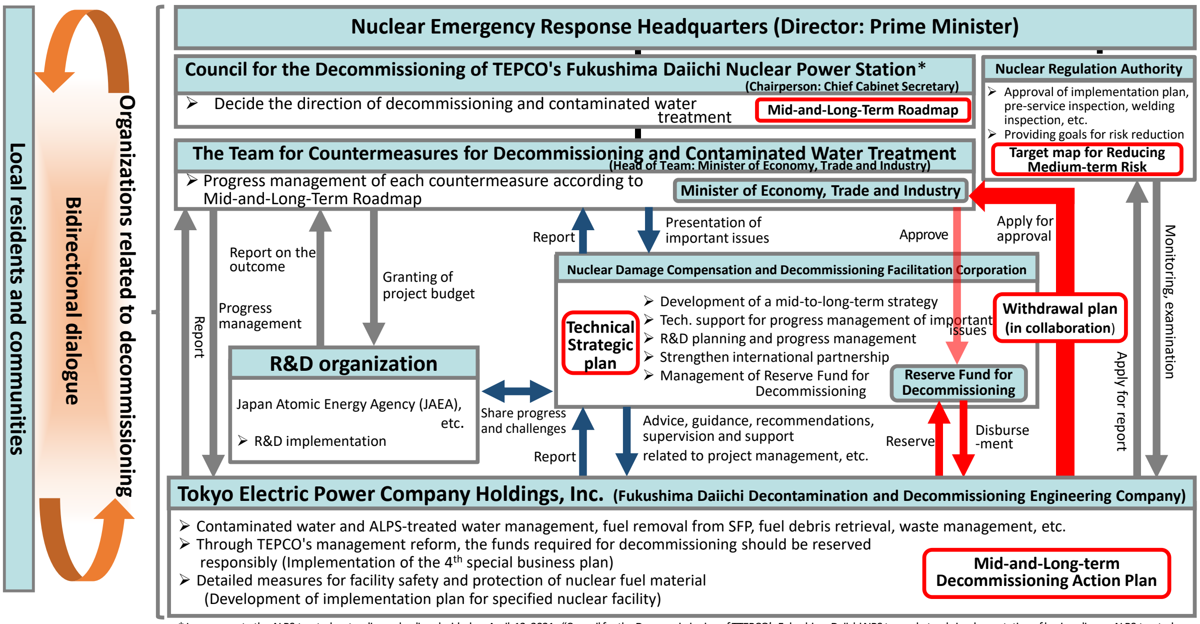
Nuclear Damage Compensation and Decommissioning Facilitation Corporation (hereinafter referred to as “NDF”) has supported efforts related to the decommissioning of the Fukushima Daiichi NPS as an organization that conducts research and development, as well as provides advice and guidance, required for decommissioning since 2014. This “Technical Strategic Plan for Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station” (hereinafter referred to as the “Technical Strategic Plan”), as a part of these supports, has been compiled annually since 2015 with the following objectives.

- Providing a solid technical basis for the Mid-and-Long-term Roadmap and contributing to its smooth and steady implementation, consideration of revisions, and
- Providing a basis for “The Policy for Preparation of Withdrawal Plan for Reserve Fund for Decommissioning”

In addition, since the “Measures for Mid-term Risk Reduction at TEPCO’s Fukushima Daiichi NPS” (hereinafter referred to as “Target Map for Reducing Risks”) formulated by the Nuclear Regulation Authority (NRA) takes into account the process specified in the Mid-and-Long-term Roadmap, the Technical Strategic Plan will also contribute to achieving the goals set forth in the Target Map for Reducing Risks.

---

[1] Period from the end of Phase 1 to the start of the fuel debris retrieval in the first implementing unit as specified in the Mid-and-Long-term Roadmap
[2] Period from the end of Period 2 to the end of 2031 as specified in the Mid-and-Long-term Roadmap



* In response to the ALPS-treated water disposal policy decided on April 13, 2021, "Council for the Decommissioning of TTEPCO's Fukushima Daiichi NPS toward steady implementation of basic policy on ALPS-treated water disposal" was founded.

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

2. Concept for reducing risks and ensuring safety in the decommissioning of the Fukushima Daiichi NPS

2.1 Basic policy for the decommissioning of the Fukushima Daiichi NPS

The basic policy for decommissioning the Fukushima Daiichi NPS is “to continuously and quickly reduce the risks arising from the radioactive materials caused by the accident that do not exist in normal nuclear power plants.” In addition, ensuring the safety of decommissioning work requires measures from a long-term and comprehensive perspective on the balance of risks based on safety characteristics. It is also important to consider flexible risk reduction strategies.

Regarding fuel debris retrieval, in Phase 3-[1] preparations for further expansion of fuel debris retrieval in scale, which will be full-scale decommissioning work, will be promoted. Though the current state of temperature and pressure inside the Primary Containment Vessels (hereafter referred to as PCVs) is stable, conditions will change with the start of fuel debris retrieval. Thus, it is undeniable that risks previously perceived as minor or unknown may become apparent. To effectively respond to risks toward further expansion of fuel debris retrieval in scale, the issue is to improve the ability to observe conditions inside the PCVs where changes in these risks are most likely to occur. Therefore, consideration should be given to expanding the type and number of monitoring targets, while taking into account the current purpose of the monitoring parameters and the number of monitoring devices in the PCVs and difficulties in on-site operation.

2.2 Concept of reducing risks caused by radioactive materials

2.2.1 Quantitative identification of risks

The Technical Strategic Plan uses a method based on the Safety and Environmental Detriment score (SED) to express the magnitude of risk (risk level) posed by radioactive materials. In this method, the risk level is expressed by the product of “Hazard Potential”, an index of the impact of internal exposure by intake of radioactive materials into the human body, and “Likelihood of Occurrig[3]”, an index of the likelihood of an event occurring. The current risk levels assigned to the respective risk sources are expressed in Fig. 2

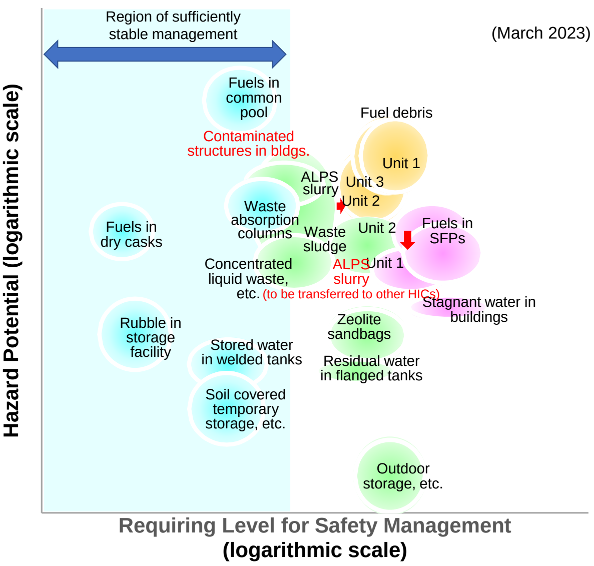


Fig. 2 Risk levels posed by major risk sources at the Fukushima Daiichi NPS

[3] This "Likelihood of Occurring" was named "Safety Management" until the Technical Strategic Plan 2022, the name has been reviewed in the Technical Strategic Plan 2023, but the definition has not been changed. This review was undertaken to explicitly indicate that higher levels of safety management measures are required when the integrity, packaging and monitoring conditions of the facilities containing the risk source are insufficient, or when the risk source itself is highly reactive.

with “Hazard Potential” and “Requiring Level for Safety Management” as the axes. The parts in red represent risk sources that have changed significantly from the Technical Strategic Plan 2022 (assessed as of March 2022), and the starting points of the arrows indicate the location in Technical Strategic Plan 2022.

ALPS slurry (to be transferred to other HICs) was moving downward because Hazard Potential of shifted ALPS slurry (green) has decreased as the progress of the transfer operation. Note that there is little variation in the ALPS slurry (green) on a logarithmic scale, since the shifted percentage of the Hazard Potential of ALPS slurry (green) to the original ALPS slurry (green) is small. For the “contaminated structure in buildings”, Requiring Level for Safety Management increased, reflecting the retaining hydrogen that flowed into the system connected to the PCV at the accident.

2.2.2 Risk reduction strategy

2.2.2.1 Interim targets of the risk reduction strategy

Measures for risk reduction include the reduction of the “Hazard Potential” and the reduction of the “Requiring Level for Safety Management”, reduction of the “Requiring Level for Safety Management” is generally considered to be easily realized from an engineering perspective. The immediate goal, therefore, is to reduce Requiring Level for Safety Management by the methods described above and bring it into a “sufficiently stable management” region (Fig. 2) that is equal to or lower than the level of facilities that are not affected by the accident or facilities that were designed after the accident to allow for a long-term storage. The process to bring it into a “sufficiently stable management” region and the progress of decommissioning work in line with that process are shown in Fig. 3. “Requiring Level for Safety Management” can be expressed as the product of two factors: one pertaining to the sufficiency of the containment function of the facility that contains the risk sources (hereinafter referred to as “containment performance”), and the other pertaining to the long-term stability and handleability of the risk source, such as its characteristics (degradation and activity level), packing, and monitoring conditions. As this method to reduce the likelihood of an event expressed in “Requiring Level for Safety Management”, the first is to improve the containment performance of the facilities that contain risk sources. Measures to improve the containment performance include transferring the risk sources to more sound facilities on higher ground that are less susceptible to tsunamis, as well as repairing damaged parts of existing storage facilities caused by external factors. The second is to improve the long-term stability by reducing uncertainty in handling risk sources and by enabling long-term and stable management based on the characteristics of risk sources. To this end, it is important to obtain sufficient information by investigating the distribution of risk sources, identifying their characterization through analysis and measurement, and improving monitoring conditions, and to reflect this information appropriately in methods of collection and storage according to the characteristics of risk sources. Such efforts to reduce uncertainty in the handling of risk sources also help to keep the temporary increase in risk levels associated with risk reduction measures, such as risk source recovery operation, to a low level.

Fig. 4 shows the transition of Requiring Level for Safety Management corresponding to risk sources and their treatment process indicated in the flow graphically by risk source category. The Requiring Level for Safety Management shown is divided into two components, one for containment performance and the other for long-term stability, which correspond to the methods for reducing the Requiring Level for Safety Management described above. This will help determine whether containment performance or long-term stability measures should be prioritized to bring the risk source into the "Sufficiently stable management" region. In addition, in the processing process that is the scope of a future or ongoing study in the flow, the blue and orange arrows in Fig. 6 (d) indicate what needs to be improved to bring the level of Requiring Level for Safety Management into the Sufficiently Stable Management region (in the pale blue area in the graphs).

Specific risk reduction strategies for each source are detailed in Chapter 3.

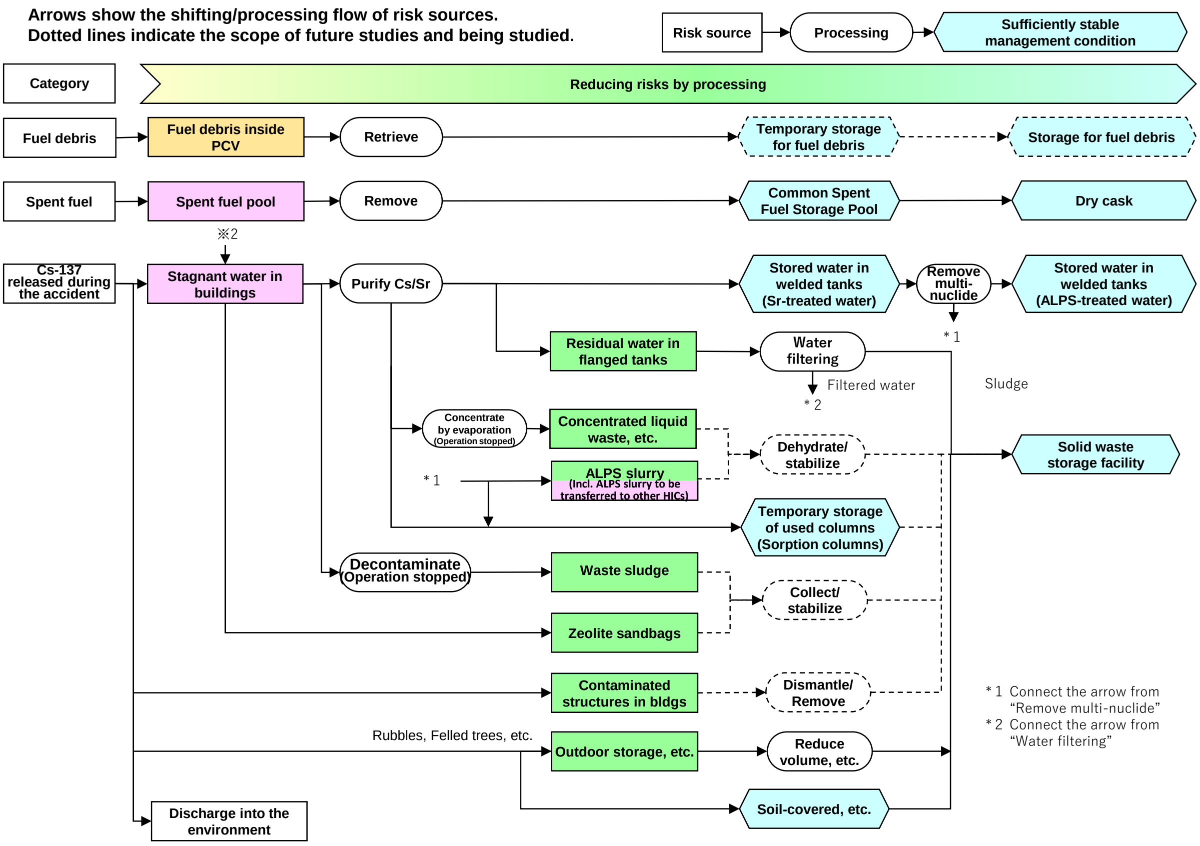
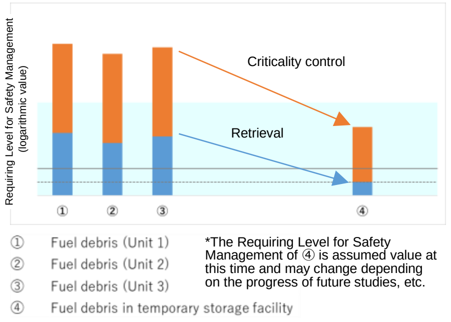
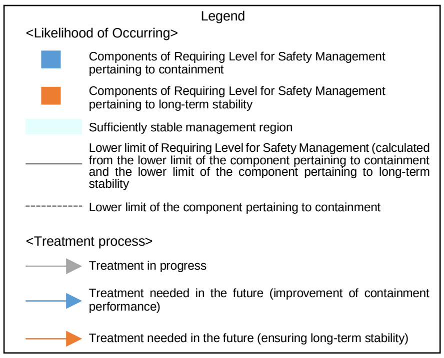
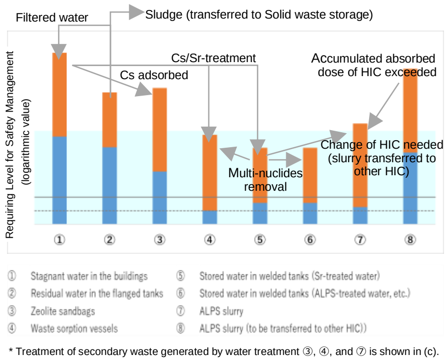


Fig. 3 Risk reduction process for major risk sources and the progress (as of March 2023)



(a) Fuel debris





(b) Contaminated water

(c) Secondary waste generated by water treatment

Fig. 4 Changes in Requiring Level for Safety Management for major risk sources

2.2.2.2 Basic approach to risk reduction

There are still significant uncertainties in decommissioning the Fukushima Daiichi NPS. Eliminating these uncertainties requires many resources and, in particular, a considerable amount of time. However, to realize prompt risk reduction, it is necessary to promote the decommissioning work while ensuring safety as the top priority by making comprehensive decisions based on the knowledge obtained, even though uncertainties remain to a certain extent. Regarding the perspective from which these comprehensive decisions will be made, NDF summarizes the following five guiding principles:

(Five guiding principles)

➢ Safe	Reduce the risks posed by radioactive materials and ensure work safety
➢ Proven	Use highly reliable and flexible technologies
➢ Efficient	Use resources effectively (e.g., people, things, money and space)
➢ Timely	Be conscious of time
➢ Field-oriented	Comprehensive three-realities policy by checking actual site, actual things, and actual situation

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

In 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, controlling this risk to be as low as reasonably achievable (Proven, Efficient) as promptly as possible (Timely) in light of the situation at the site, and proceeding with the decommissioning in a reliable manner by feasible ways in the harshest on-site state (“Field-oriented”) will lead to ensuring safety in the medium-to-long-term.

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

2.3 Approach to ensuring safety during decommissioning

2.3.1 Basic policy for ensuring safety based on the characteristics of Fukushima Daiichi NPS

The decommissioning of the Fukushima Daiichi NPS that contains the reactors involved in the accident is an unprecedented activity taking place in a peculiar environment different from that of a normal reactor, and therefore, to ensure safety, the issue is to sufficiently consider the following characteristics (peculiarities) regarding safety:

- A large amount of radioactive material (including α-nuclides that have a significant impact on internal exposure) is in an unsealed state, as well as in unusual (atypical) and various forms.
- Barriers for containing radioactive materials, such as reactor buildings and PCVs, are incomplete.
- Significant uncertainties exist regarding the state of these radioactive materials and containment barriers, etc.
- It is difficult to access the site and install 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 further degradation of containment barriers is a concern, it is necessary to take measures in consideration of the time axis without prolonging the decommissioning activities.

Therefore, in proceeding with decommissioning work, TEPCO, as the decommissioning project executor, needs to consider the following points with particular attention, based on the five guiding principles.

First, with regard to "safe", for the above peculiarities, it is necessary to assume a wide range of possibilities (cases) and to check that it is possible to ensure safety for them as the starting point for all considerations. At the same time, it is important not to prolong the work period considering the risks over the entire work period, and it is necessary to avoid excessive safety measures out of proportion to the risks and to take sensible safety measures (ALARP). It is important that this perspective on “safety” (the safety perspective) is reflected in the consideration of decommissioning work.

Second, with regard to “field-oriented”, it is essential to reflect the information obtained from the actual site in engineering appropriately, because there is a limit to the response by design alone due to large uncertainties. In order to reliably implement unprecedented engineering such as fuel debris retrieval, it is important to value the viewpoints and senses of people and organizations who are directly involved in the actual site work and familiar with the site, and to respect the viewpoints and judgments that are directly addressed at the site (the operator’s perspective). Moreover, in promoting long-term decommissioning, it is necessary to maintain and strengthen the operator's viewpoint and sensibility, TEPCO itself should take over the operator's perspective.

In the actual study of the decommissioning work, TEPCO, as the decommissioning project executor, should define the “requirements” to satisfy regulatory demands for the work, and should consider specific safety measures to achieve them. In doing so, it is essential to apply the safety perspective and the operator’s perspective to handling the characteristics (peculiarities) of decommissioning the Fukushima Daiichi NPS.

In this decommissioning work with significant uncertainties, it is frequently difficult to uniquely define requirements and the equipment/operational specifications that will satisfy those requirements. Even in such cases, the decommissioning work should be carried out flexibly and promptly by verifying and improving the selected, specifical safety measures with the “preliminary implementation and utilization of the obtained information in the latter stages” and “iteration-based[4] engineering”.

2.3.2 Preliminary implementation and utilization of the obtained information in the latter stage

Because of the high uncertainty surrounding the Fukushima Daiichi NPS, it is necessary to assume extremely large safety margins and a wide range of technological options. In addition, considering the further deterioration of containment barriers and other factors, it is necessary to immediately improve the state of risks and reduce uncertainties. Therefore, a “sequential type approach” is important, where “operation at first stage” is implemented for which, practical safety can be ensured, and then the information obtained there is utilized in the next stage, gradually reducing uncertainty in the entire decommissioning process.

[4] A method of gradually increasing the level of completion of engineering by finding the next result based on a certain result and repeating this cycle.

The decommissioning of the Fukushima Daiichi NPS needs to be promoted with the broad understanding of not only the government, NDF, TEPCO, and others, but also of a wide range of people, including local residents. To this end, it is essential for them to fully understand the overall risk reduction efforts described in this chapter and to gain their understanding of the decommissioning project. In particular, it is important to establish a system for continuous risk monitoring that is easy to understand for a wide range of people and to communicate to the public how the decommissioning work will be conducted based on the risk reduction strategy, how the safety of the decommissioning work will be ensured, and how the overall risk reduction of the site is continuously progressing through the decommissioning work, and to disseminate these information to society.

In addition to sharing the status of risks regard to the decommissioning of the Fukushima Daiichi NPS through the Technical Strategic Plan on a constant basis, NDF is considering providing the risk reduction process along with the progress of the decommissioning work. TEPCO also needs to develop a mechanism to identify risks for the entire site and become aware of the need to take action to communicate the status of risk reduction to society in a proactive manner.

3. Technological strategies toward the decommissioning of the Fukushima Daiichi NPS

3.1 Fuel debris retrieval

3.1.1 Target

- Retrieve fuel debris safely after thorough and careful preparations, and bring it to a state of stable storage that is fully managed.
- The trial retrieval process in Unit 2 is under review to improve work safety and reliability during retrieval, and trial retrieval will begin in late FY 2023. Continue the series of operations, including the gradual expansion of fuel debris retrieval, to acquire the knowledge and experience necessary for further expansion of fuel debris retrieval in scale.
- With regard to the further expansion of fuel debris retrieval in scale, consideration will be given to the methods including those for containing, transferring, and storing of fuel debris, through the assessment of fuel debris retrieval in Unit 2, internal investigations, research and development, and the on-site environmental improvement, etc.

3.1.2 Progress

- Unit 1 : In the PCV internal investigation, detailed visual observation, deposit thickness measurement, deposit debris detection and evaluation, and deposit 3D mapping measurement were conducted outside the pedestal from February 2022. In March 2023, using a submersible boat-type access investigation vehicle (submersible ROV), survey inside the pedestal was successfully conducted for the first time. As a result of the series of investigations, a lot of information was obtained such as the distribution status of the deposit outside the pedestal, the neutron flux level, the condition of the deposit and fallen objects at the inner bottom of the pedestal, and the condition of the upper structures such as the control rod drive (CRD) housings. Deposit sampling was also successful, and analysis will be performed in the future. Because the vicinity of the pedestal opening (worker access opening) and almost the entire inner wall of the pedestal have lost their lower concrete, TEPCO is evaluating the impact of external exposure, supposing support function of the reactor pressure vessel (hereinafter referred to as “RPV”) on the pedestal deteriorates to form a large opening in the PCV. As a result of evaluating conditions inside the PCV by setting conservative conditions, TEPCO considers that there is no significant risk of radiation exposure, however, further safety measures such as mobile response and enhancement of PCV containment function are being considered. These evaluations by TEPCO were approved at the NRA Committee.
- Unit 2 : Modification and verification of the control software for the robot arm to be used for trial retrieval and improvement of some devices were implemented, and confirmation of the required functions is in progress. As on-site preparatory work, installation of the isolation chamber was completed in April 2023. Currently, removing the flange bolt, opening the hatch of the penetration X-6, and removing the deposits inside the penetration are in progress.

- Unit 3 : The method for further expansion of fuel debris retrieval in scale is being studied. In FY 2023, evaluation including business continuity is underway, with continued issue studies of each method. In addition, since February 2023, the Sub-Committee for the Evaluation of Fuel Debris Retrieval Methods has been established under the Decommissioning Strategy Committee, a committee of NDF, technical feasibility and business continuity in each of fuel debris retrieval method are being studied and evaluated technically and intensively.

3.1.3 Key issues and technical strategies

3.1.3.1 Fuel debris retrieval strategies in each Unit

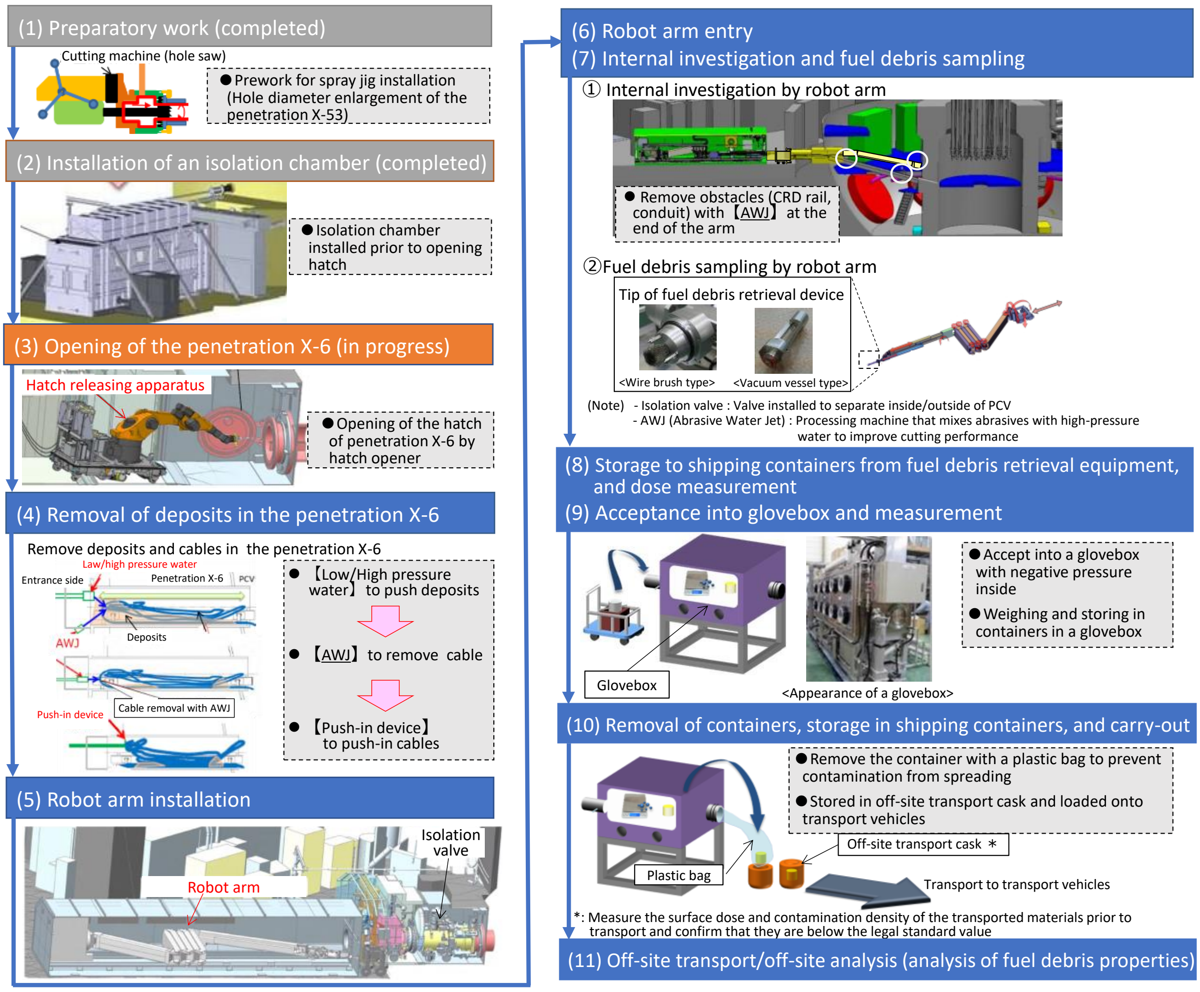
- Common : There are many areas where direct visual information is not available for each Unit, and it is a challenge to promote further internal investigation and obtain various kinds of information. Work will be carried out by formulating/updating the future plan for internal investigation, assuming further expansion of fuel debris retrieval in scale. The direction of the fuel debris retrieval strategy should be ascertained on the basis of the acquired information in order to avoid engineering backsliding and to increase the reliability of the method chosen.
- Common : Regarding field problems experienced so far, measures for preventing recurrence should be reflected in the next work. In addition, methods that can eliminate assumed risks should be developed, and if the risks cannot be eliminated, countermeasures should be prepared in advance.
- Common : With a view to business continuity, methods that enable retrieval even if all on-site conditions cannot be identified, and other methods (robust methods) not easily affected by external events such as earthquakes should be examined while taking into account on-site conditions such as damage to facilities and equipment
- Common : Efforts should be made to prevent the concentration of worker radiation exposure on specific individuals, reduce the exposure of all workers, and secure human resources from a long-term perspective.
- Unit 1 : Toward further expansion of fuel debris retrieval in scale, studies on retrieval methods will be promoted by taking into account the on-site information and the knowledge gained so far and to be gained in the future, such as from the trial retrieval from Unit 2, the gradual expansion of fuel debris retrieval, research and development, the engineering for applying the R&D results on-site, and the results of the PCV/RPV internal investigation.
- Unit 2 : Trial retrieval will be promoted to lead to a gradual expansion of fuel debris retrieval.
- Unit 3 : Considering that the removal of fuel in SFP has been completed and there is little interference with other operations, and working environment of the reactor building will be improved faster than Unit 1, retrieval methods are being examined for further expansion of fuel debris retrieval in scale ahead of other Units.

3.1.3.2 Trial retrieval (internal investigation and fuel debris sampling)

The trial retrieval, which is under preparation at Unit 2, is intended to access the inside of the pedestal from outside the PCV for further internal investigations and collect small amount of fuel debris. This is because the effort is of great significance, entering a new phase, in which containment barrier outside the PCV is extended by opening the hatch of the existing penetration X-6 on the PCV, a series of work tasks should be implemented in a phased manner. (Fig. 5). The information obtained from this efforts will be used for subsequent gradual expansion of fuel debris retrieval and further expansion of fuel debris retrieval in scale. In addition, since this will be the first fuel debris retrieval at the Fukushima Daiichi NPS, the experience gained during the process from the examination to the retrieval operation and the information obtained through the analysis of the retrieved samples will be used in future decommissioning efforts.

It is necessary to proceed with the work safely and carefully, assuming the possibility that the work may not go as planned due to the uncertainty of the conditions inside the PCV. It is important to utilize the valuable information, experience, etc., gained through them in subsequent retrieval operations including for other Units.

Given the adhering condition of the bolts confirmed in the ongoing work to open the penetration X-6 hatch, etc., difficulty in deposits removal may be also a concern inside the penetration X-6, so it is necessary to study in advance a method that enables fuel debris retrieval even if the deposits inside the penetration cannot be completely removed. TEPCO is also considering the use of a telescopic device that has been used in past investigations and confirmed to be accessible to the bottom of the pedestal as a method to complement the internal investigation and trial retrieval by the robot arm.



(TEPCO material edited by NDF)

- The analysis results will be used for subsequent gradual expansion of fuel debris retrieval and further expansion of retrieval in scale.

Fig. 5 Work steps of trial retrieval (internal investigations and fuel debris sampling)

3.1.3.3 Gradual expansion of fuel debris retrieval

The gradual expansion of fuel debris retrieval is being prepared in Unit 2 for the period until further expansion of fuel debris retrieval in scale begins. Its main objectives are to verify the retrieval equipment, acquire data on the environmental impact during the retrieval operation, increase the amount of retrieval, obtain data on fuel debris composition and properties from more samples, and accumulate the retrieval experience of workers.

(1) Retrieval equipment

The retrieval equipment to be used for the gradual expansion of fuel debris retrieval will be improved by increasing the payload and enhancing accessibility, based on the improvements identified during the verification phase of the equipment for trial retrieval. The plan is to expand the range of retrieval while making achievements, starting with retrieval of fuel debris that can be gripped and sucked, and expanding to fuel debris retrieval with cutting. Consideration will also be given to the possibility of cutting platform beams and the range of cutting.

Shielding and preventing the spread of contamination are considered for the enclosure containing the robot arm to take in fuel debris. In addition, because the manipulator to be installed in the enclosure performs various operations and maintenance, it is necessary to ensure the repeatability of tasks and train operators. Moreover, the work period is in the order of several years. Thus, in addition to periodic maintenance, preparation in case of failure is a challenge. Since the radiation dose in the reactor building, where the enclosure will be installed, is high and it is difficult to perform maintenance there. Therefore, the plan is to construct a maintenance building outside the reactor building and equipment and enclosures will be transferred there, then decontamination, dismantling, repair, or replacement will be conducted inside it. The issue is to leverage the experience gained through the maintenance of equipment/devices for further expansion of fuel debris retrieval in scale. Therefore, a system that can reliably preserve maintenance records, including failure histories and corresponding measures, should be established. NDF will continue to grasp and check the status regarding the technological development of retrieval equipment and preparation for field application as needed from the viewpoints of safety assurance and the actual site applicability.

(2) The first storage facility

As to the first storage facility[5], during their designing, there are many points of contact with related facilities such as receiving fuel debris and sending samples for analysis, and when they are installed, there are a lot of interfacing and contacts between various types of work and operation including peripheral work. Therefore, project management by TEPCO is essential for process control and resolution of pending issues. Leveraging the experience and knowledge

[5] As the study progressed, the name was changed because TEPCO decided to store retrieved fuel debris at storage facilities instead of temporarily storing it in temporary storage facilities.

gained from this design and installation work for future projects and construction management is expected. Various remote-control devices are also used for handling fuel debris in the first storage facility. It is necessary to refer to the knowledge related to other remote-control devices and incorporate countermeasures to mitigate potential risks at the design stage into the design.

3.1.3.4 Further expansion of fuel debris retrieval in scale

Further expansion of fuel debris retrieval in scale is an important process in decommissioning, and its reliable implementation will determine the success or failure of the decommissioning project. In light of this, it is necessary to discuss methods with a view to business continuity. Moreover, the Fukushima Daiichi NPS has a unique environment different from a conventional reactor, which requires understanding the following factors that make fuel debris retrieval difficult:

① Extremely high-radiation dose in PCVs and RPVs
② High-radiation dose in reactor buildings
③ Lack of on-site information
④ Building containment barriers
⑤ Criticality control
⑥ Waste management

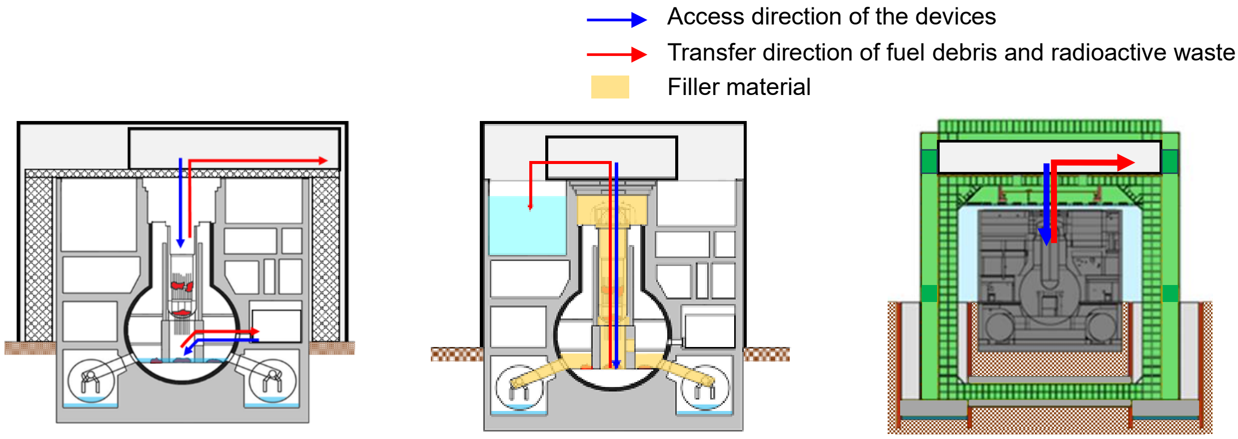
Therefore, the following should be considered when proceeding with examining methods.

- Given an unusual environment different from normal reactors, it is important to consider retrieval method with appropriate requirements for ensuring safety.
- On-site information such as the location, quantity and properties of fuel debris is important to investigate the method, and a comprehensive analysis and evaluation is conducted to estimate the information necessary for the method study, based on previous internal investigations, analytical evaluations, and past finding. Such efforts should be continued in the future, and the accuracy of method investigations should be improved by reflecting the new results obtained through internal investigations, etc., in information for the method study as appropriate.
- When examining retrieval methods, after reviewing the several paths, it is important to combine and narrow down these paths to take according to the on-site information such as internal investigations obtained afterward and the progress of technical studies. In considering several paths, it is necessary to control potential risks in each process from preparatory work to the completion of fuel debris retrieval, and it is also necessary to develop fuel debris retrieval scenario while constantly checking the risk level and risk measures.
- As the scale of work, devices, and facilities will increase and the area of construction will expand, examination should be carried out by setting the requirements (site use area, interfacing with existing systems, groundwater management, waste management, etc.) more clearly in light of the entire power plant, in addition to the requirements for retrieval methods.
- For each task in the work sequence, issues that may significantly affect technological feasibility should be comprehensively identified in order to prevent the issues from being

overlooked. It is necessary to verify that the issues identified can be addressed from the perspective of actual site applicability and technological feasibility.

- In evaluating methods, based on the five guiding principles (safe, proven, efficient, timely, and field-oriented), in addition to the assessment of checking the actual site applicability and technological feasibility, assessment on business continuity also needs to be used as the decision indexes. The criteria to be used in the evaluation should also be clarified from the initial stage of studying the methods.

At present, the conceptual study on the further expansion of fuel debris retrieval in scale for Unit 3 is in progress. Many challenging issues have been identified with respect to methods proposed for discussion by the end of FY 2021. As a result, in FY 2022, the actual site applicability and technical feasibility associated with measures for mitigating these issues were verified. In FY 2023, evaluation including business continuity will be promoted, with continued issue studies of each method. In addition, preparatory works such as yard development, which will be necessary regardless of the retrieval method, are also being identified and organized to specify them as soon as possible. Selecting a specific method is an extremely important decision to determine the success or failure of decommissioning over the medium to long term. Thus, not only TEPCO but also the national government and NDF must cooperate to comprehensively examine and evaluate technological feasibility, with safety as a major prerequisite. To this end, in February 2023, the Sub-Committee for the Evaluation of Fuel Debris Retrieval Methods was established under the Decommissioning Strategy Committee, a committee of the NDF, to conduct technical and intensive study and evaluation on the technical feasibility and business continuity for each method of fuel debris retrieval. The following is an overview of the Partial submersion method (water injection into RPV) (Fig. 6(a-1)), the Partial submersion method option (RPV filling and solidification) (Fig. 6(a-2)) and the Submersion method (shell structure) (Fig. 6 (b)), and their issues. The outline of each method is only an example and is not definitive.



(a-1) Partial submersion method (water injection into RPV) (a-2) Partial submersion method option (RPV filling and solidification) (b) Submersion method (shell structure)

Fig. 6 An example of each retrieval method for further expansion of fuel debris retrieval in scale

(1) -1 Proposed Partial submersion method (water injection to RPV)

The partial submersion method (water injection to RPV) is a method for retrieving debris exposed in the air or immersed at a low water level while pouring water. The main method of access to fuel debris inside the RPV and in the pedestal will be from the top (top-access), while fuel debris outside the pedestal will be accessed from the side (side access). The issues and countermeasures of this method are summarized below according to the aforementioned factors ① to ⑥.

- Factor ① (Extremely high-radiation dose in PCVs and RPVs) : The issue is that all operation inside the PCV/RPV will be conducted using remote control devices. After identifying the required operations including what is expected to be done, the function, structure, and general safety requirements of the remote control device should be established.
- Factor ② (High-radiation dose in reactor buildings) : Some of the work in the buildings can be implemented manually, but in such cases, the issues are careful exposure control as well as environmental improvement. When it is difficult to reduce the radiation dose, operations using remote control devices will be necessary, and the same measures will be required as with factor ①.
- Factor ③ (Insufficient on-site information) : The issue is that the retrieval method must be considered based on the uncertainty of on-site information due to the limited results of the on-site survey. Therefore, in addition to obtaining on-site information through internal investigations, remote control devices and work procedures should be considered to allow for flexible response in cases where the on-site situation still cannot be identified.
- Factor ④ (Building containment barriers) : The issues are seismic feasibility of the top access platform and airtightness of interface with existing structures. As a countermeasure, it is necessary to assess the validity of seismic conditions as well as study measures for reducing the upper load and examination of structure to ensure airtightness. In addition, because existing structures are used as containment barriers facilities, the issue is to examine airtightness and seismic resistance in consideration of the fact that they are damaged by the accident and the aging deterioration. In view of long-term use in the future, it is necessary to monitor, investigate, and assess damage, deterioration, and corrosion conditions, and by taking these into account,

it is also necessary to continuously check the earthquake resistance and structural integrity.

- Factor ⑤ Criticality control : The issue is to have criticality control take shape appropriately for the on-site conditions. Design measures to be considered include the use of multiple monitoring means, setting limits on cutting operations, and installing systems capable of injecting neutron absorbers. Meanwhile, as operational measures, the amount of state change is assessed, and when a condition approaching criticality is detected, criticality is prevented by stopping operations, adding neutron absorbers, and determining whether operations can be resumed.

- Factor ⑥ Waste management : The issue is handling a large amount of waste, such as dismantled buildings and excavated soil in areas that interfere with new structure construction. A plant-wide waste storage plan should be developed to verify that the waste to be generated can all be stored.

(1) -2 Proposed partial submersion method option (RPV filling and solidification)

The partial submersion method option (RPV filling and solidification) is a retrieval method where the pedestal bottom, RPV, reactor well, etc. are physically stabilized by solidifying with fillers, and then excavates, and retrieves fuel debris with fillers. The issues and countermeasures of this method are summarized below according to the aforementioned factors ① to ⑥.

- Factor ① Extremely high-radiation dose in PCVs and RPVs : Because the excavated debris is recovered in a state mixed with water, the issue is to prevent leakage to the outside. It is necessary to examine detection methods in case of leakage, measures to prevent the spread of contamination, and restoration methods after contamination.

- Factor ② High-radiation dose in reactor buildings : The issue is how to lay the filling hose because it is considered that the filler materials are injected into the bottom of the pedestal via side-access. The study is expected to be based on past examples of internal investigations of the Unit 2 PCV.

- Factor ③ Insufficient on-site information : The issue is to achieve a filling condition that ensures excavability by injecting filler materials. Therefore, it is necessary to consider the selection of filler materials and procedures that allow them to be filled appropriately under various conditions. The development should be promoted after clarifying the functions required for fillers. Moreover, since fuel debris is covered with fillers, decay heat removal is also an issue, including whether it is necessary. The possibility that the heat decay removal is inhibited should also be considered.

- Factor ④ Building containment barriers : The issues are the seismic feasibility of the cell to be installed in the reactor building and on the operating floor and securing airtightness. As a countermeasure, seismic assessment should be carried out after specifying the equipment installed on the operating floor, and the structures to ensure airtightness should be examined. Thus, the shielding function required is expected to be reduced compared to proposed partial submersion method (water injection into RPV). On the other hand, because existing structures such as reactor buildings and PCVs are used as containment barriers, the same measures will be required as with proposed partial submersion method (water injection into RPV). If fillers can be used as expected, the impact due to aging degradation is expected to be mitigated.

- Factor ⑤ Criticality control : This has the same issue as with the proposed partial submersion method (water injection to RPV). Measures specific to this option include, for example, limiting the size of the fuel debris recovery line to a size that will not cause criticality and adding neutron absorbers to the filler materials in advance.

- Factor ⑥ : Waste management — The issue is that all filler materials used in large amount must be treated as radioactive waste. For this reason, reducing the filling range should be considered, a plant-wide waste storage plan should be developed to verify that the waste to be generated can all be stored. Since the excavation powder recovered from the vicinity of fuel debris is a mixture of fuel debris, structures, and fillers, the method of sorting fuel debris and waste should also be considered.

(2) Proposed Submersion method (Shell structure)

The submersion method (shell structure) involves enclosing the entire reactor building with a new structure, called a shell structure, as containment barriers, flooding the reactor building, and retrieving fuel debris. Fuel debris inside the RPV and inside/outside the pedestal will be retrieved via top-access. The issues and countermeasures of this method are summarized below according to the aforementioned factors ① to ⑥.

- Factor ① : Extremely high-radiation dose in PCVs and RPVs — Effect of the water shielding by submersion allows a person to approach the middle working framework on which the retrieval work is carried out in the Shell structure. However, since all work inside the PCV/RPV will be performed remotely, it is necessary to take similar measures to the ones in the proposed partial submersion method (RPV water injection).
- Factor ② : High-radiation dose in reactor buildings — In some of the preparatory work prior to the installation of the Shell structure, such as rerouting of RPV injection facilities, work inside the reactor building is required. Thus, it is necessary to take a response similar to that of the proposed partial submersion method (RPV water injection).
- Factor ③ : Insufficient on-site information — To install temporary structures for constructing the shell structure, the issue is that the possibility of soil contamination around the reactor building cannot be completely excluded. It is also necessary to examine construction feasibility, assuming that the excavated soil (including groundwater) is contaminated.。
- Factor ④ : Building containment barriers — In addition to studying the methods based on the uncertainty of on-site information, the issue is to assemble the bottom of the Shell structure into the space inside the shield tunnel with only the side access. The feasibility of welding work and inspection methods should be verified. Another issue is to prevent contaminated water from leaking outside the Shell structure, which has three layers of containment barriers. It is necessary to study measures to detect leakage between the containment barriers and to recover from leakage. For the integrity of the temporary structures, surrounding ground, and shell structure during construction and earthquake, the prospects for feasibility have been confirmed through analysis and evaluation using the finite element method considering water pressure (internal water, ground water), earth pressure, seismic load, etc.
- Factor ⑤ : Criticality control — The issues are the same as for the Partial submersion method (water injection to RPV). In addition, as a countermeasure in case of criticality, the issues are the maintenance/management of boron concentration and the control of the supply of boric acid for a constant boric acid solution environment.
- Factor ⑥ : Waste management — Due to the construction of the Shell structure, the amount of waste such as demolished buildings and excavated soil, which interfere with yard maintenance, will be enormous, and the same measures as those

proposed for the partial submersion method (RPV water injection) will be necessary.

The above describes issues and measures for each method. While technical issues remain with each method, there are also complementary technologies (for example, the shielding effect from using fillers is a common element technology applicable to both the partial submersion and submersion methods).

In the future, it is desirable to extract elements with high technical feasibility, project continuity, and high effectiveness in solving issues out of technologies examined for each retrieval method, and combine them to proceed with examination to establish a more rational and feasible retrieval method.

3.1.3.5 Continuation of accident analysis activities (clarification of events that occurred at the accident)

TEPCO has been conducting estimation of RPV and PCV condition and accident analysis, and is reflecting the results in the examination of fuel debris retrieval method and storage management. On the other hand, since there is still a lack of site information, it is an issue to refine information on the location of fuel debris and dose distribution in buildings by analyzing and understanding accidents. Activities to improve understanding of the events during the accident and incorporate knowledge gained into decommissioning work will continue. Furthermore, the NRA, in cooperation with TEPCO, is reviewing findings from accident analyses to help investigate the causes of the accident and improve nuclear safety in the future. With regard to international cooperation, projects on accident analysis are in progress at the OECD/NEA based on the knowledge of various countries and organizations.

3.1.3.6 Research and development for further expansion of fuel debris retrieval in scale

For issues that are difficult to address in engineering or far-sighted issues, the Project of Decommissioning, Contaminated Water and Treated Water Management has been promoting research and development. This R&D is being carried out in accordance with the R&D medium-and-long-term plan and the next-term R&D plan that are described in Chapter 5.2, and it is important to proceed exhaustively, systematically and efficiently while confirming that it is in line with the needs of TEPCO as the entity responsible for decommissioning. The followings are a list of research and development items being performed. The sections describe research and development that is common to each method, except for (8). Although (8) is research and development relating to partial submersion method only at present, those for other methods will be initiated by identifying research issues as necessary in the future.

(1) Technology for investigation inside the RPV

(5) Analytical and estimation techniques for the characterization of fuel debris

(2) Technology for environmental improvement inside the reactor buildings

(3) Development of analytical technology for radiation exposure dose assessment

(4) Liquid treatment system (α-rays-emitting nuclide removal technology)

(6) Technologies for collecting, transportation and storage of fuel debris

(7) Data acquisition of dust dispersion rate

(8) Fuel debris retrieval method

3.1.3.7 Issues in examining safeguards strategies

Since material accountancy and safeguards for the retrieved fuel debris are unprecedented, TEPCO may face technical issues in examining and applying them to the site. For this reason, NDF will conduct wide-ranging surveys on existing technologies related to material accountancy and safeguards to prepare in case that TEPCO needs technical assistance. NDF will also check the progress of the project from an engineering perspective to confirm that the application of safeguards to systems does not affect the decommissioning process.

3.2 Waste management

3.2.1 Target

- The Solid Waste Storage Management Plan (hereinafter referred to as the "Storage Management Plan") is developed and revised with updating the estimated amount of solid waste to be generated in the next 10 years, as well as appropriate storage/management should be implemented including waste prevention, volume reduction, and monitoring of storage/management conditions based on it.
- Based on the prospects of processing/disposal methods of solid waste and technology related to their safety presented in FY 2021, the creation of options for processing/disposal measures and their comparison and evaluation should be conducted with promoting characterization to establish waste streams that are suitable for the features of solid waste. Proceed study on specific management of the solid waste to present appropriate measures as a whole.
- Develop and update the analysis plan necessary to advance the consideration of storage/management and processing/disposal, and proceed steadily with analysis based on it.

3.2.2 Progress

- Since a large amount of solid waste with various characteristics is generated in association with decommissioning, the efforts based on the following "Basic Policies on Solid Waste" are underway.
- The Storage Management plan published in February 2023 describes that a considerable amount of waste (at least about 300,000 m^3) is expected to be generated in the preparatory works for fuel debris retrieval. This amount of waste generated is estimated based on the assumption of uncertainty due to the fact that the fuel debris retrieval method has not been determined for the dismantling of the buildings around Units 1 to 4 and the resin generated before the earthquake. In the future, the amount of waste generated will be scrutinized in anticipation of the volume reduction effects of incineration, crushing, etc.

< Basic Policies on Solid Waste>

(1) Thorough containment and isolation	(5) Establishment of selection system of preceding processing methods in consideration of disposal
(2) Reduction of solid waste volume	(6) Promotion of effective R&D with an overview of overall solid waste management
(3) Promotion of characterization	(7) Development of continuous operational framework
(4) Thorough storage/management	(8) Measures to reduce radiation exposure of workers

3.2.3 Key issues and technical strategies

In Phase 3, in order to determine the specifications of waste form and their production methods, institutions concerned, led by NDF, are conducting technical studies on integrated measures from characterization to processing/disposal of solid waste, based on their respective roles. The status of each area is shown below.

3.2.3.1 Characterization

While accumulating analytical data, inventory for solid waste will be continuously improved, which is the basic information for solid waste management, including processing/disposal. Although the analysis work itself is not difficult, low-activity waste has the feature of enormous volume. And the limited number of analyses data obtained for high-activity waste due to the difficulty of sampling. Considering their feature, analysis of such waste makes it important to take an approach that ensures the required accuracy efficiently. For these issues, efforts are being made to establish an efficient analysis evaluation method.

Capacity of analysis has been enhanced with the completion of the Japan Atomic Energy Agency (hereinafter referred to as "JAEA")'s Radioactive Material Analysis and Research Facility Laboratory-1 on the premises of the Fukushima Daiichi NPS in June 2022. With that capacity in mind, analyses contributing to solving issues in the decommissioning process will be performed systematically, considering the priority of samples. As acquired data should be used for overall waste management, TEPCO should provide comprehensive management of solid waste characterization, including adjustment of the entire process of collecting samples for analysis, securing analytical facilities, transporting samples, etc. (hereinafter referred to as “analysis supply chain”).

In March 2023, TEPCO developed an analysis plan for the characterization and optimization of storage/management to discuss solid waste processing/disposal methods. Based on this plan, TEPCO and the JAEA will work together to incorporate into specific analysis work, review the analysis plan, Identify the details of necessary technical development tasks, and establish the operational structure of the analysis supply chain early.

3.2.3.2 Storage/management

Storage/management of solid waste should be appropriately implemented for the risk depending on radioactivity concentration and properties, etc. Moreover, it is important to reconsider measurement items and timing, etc., while acquiring necessary information through continuous monitoring of the storage/management status. Though the current storage/management of solid waste is based on the classification by surface radiation dose rate, in preparation for the expected increase in the amount of solid waste generated, it will transit to the management by concentration of radioactivity and examine the rational classification of waste and reuse on-site based on these.

The Mid-and-Long-term Roadmap calls for eliminating temporary outdoor storage of all solid waste, excluding secondary waste generated by water treatment and waste subject to reuse and recycling, by the end of FY 2028. To achieve this goal, it is necessary to develop necessary facilities and installations systematically including incineration/volume reduction facilities and solid waste storage, and promote steadily consolidate storage of solid waste inside buildings. In addition, taking into account the views of the Study group on Monitoring and Assessment of Specified Nuclear Facilities and the Technical Meeting on the Examination of the Implementation Plan of the Measures for the Specified Reactor Facilities, regarding the practicality and rationality of storage of low-level concrete and other waste, an examination will be carried out on storage/management methods which are safe, reasonable and feasible, such as classification according to the characteristics of the main nuclides with a view to long-term processing/disposal.

For ALPS slurry, although there is a delay in installing the ALPS slurry stabilization/treatment system, the immediate storage capacity has been secured. The upper limit of the integrated absorbed dose (5,000 kGy) will be evaluated to exceed before the commencement of the stabilization process, and the HICs that needed to be transferred continuously increased. To ensure storage capacity for HIC and transfer for the time being and to transit to a more stable state, stabilization/treatment system installation and processing will proceed in a planned manner.

Issues and measures for storing/managing high-activity waste to be generated by further expansion of fuel debris retrieval in scale, which were clarified by fiscal 2021, will be reviewed along with examining the fuel debris retrieval methods. Measures will be taken to ensure the storage/management of solid waste expected to be generated during fuel debris retrieval before full-scale retrieval. In preparatory works for the retrieval of fuel debris, it is expected that a large amount of concrete and metal with low radioactivity concentrations will be generated due to the demolition of buildings, etc. Therefore, it is essential to continue the current measures for reducing the amount of materials and to conduct a study on the possibility of further reducing.

3.2.3.3 Processing/disposal

To specify a suitable overall picture covering the entire waste stream, the R&D of processing and disposal technologies required for the series of studies, as shown in Fig.7, will be continued.

Regarding the processing technologies, pending issues in normal-temperature and thermal processing technology, for which research/development is promoted, will continue to be addressed. Although the storage capacity of ALPS slurry has been secured for the time being, it will be a problem to secure storage capacity in the future. Thus, in light of the point at issue regarding slurry dehydration technologies in the Study group on Monitoring and Assessment of Specified Nuclear Facilities and the Technical Meeting on the Examination of the Implementation Plan of the Measures for the Specified Reactor Facilities, the issues related to dehydration should be considered sufficiently to discuss requirements in selecting treatment technologies to be applied, with priority. As a matter of immediate consideration, a study will be conducted on a technology for solidifying a large amount of rubble, which is difficult to separate, in a batch without segregating it, and on a technology for treating slurry dehydrates and their containers integrally.

Concerning disposal technology, to enhance the reliability of the disposal concept, its feasibility will be evaluated based on a study of the long-term evolution behavior of the disposal facilities in light of the characteristics of the waste form to incorporate the results into the discussion of the disposal concept. To appropriately allocate waste to a disposal concept that is shown to be feasible, knowledge of the sensitivity structure of scenarios regarding disposal and parameters to radiation doses will be increased to leverage it for proposing safe and reasonable disposal options. Furthermore, after expanding the target of waste streams incorporating this disposal option, a group of disposal options will be examined with a bird-eye-view of all solid waste at the Fukushima Daiichi NPS. Then, contributions will be made to considering appropriate specific management approaches as a whole in coordination with knowledge gained in areas other than disposal.

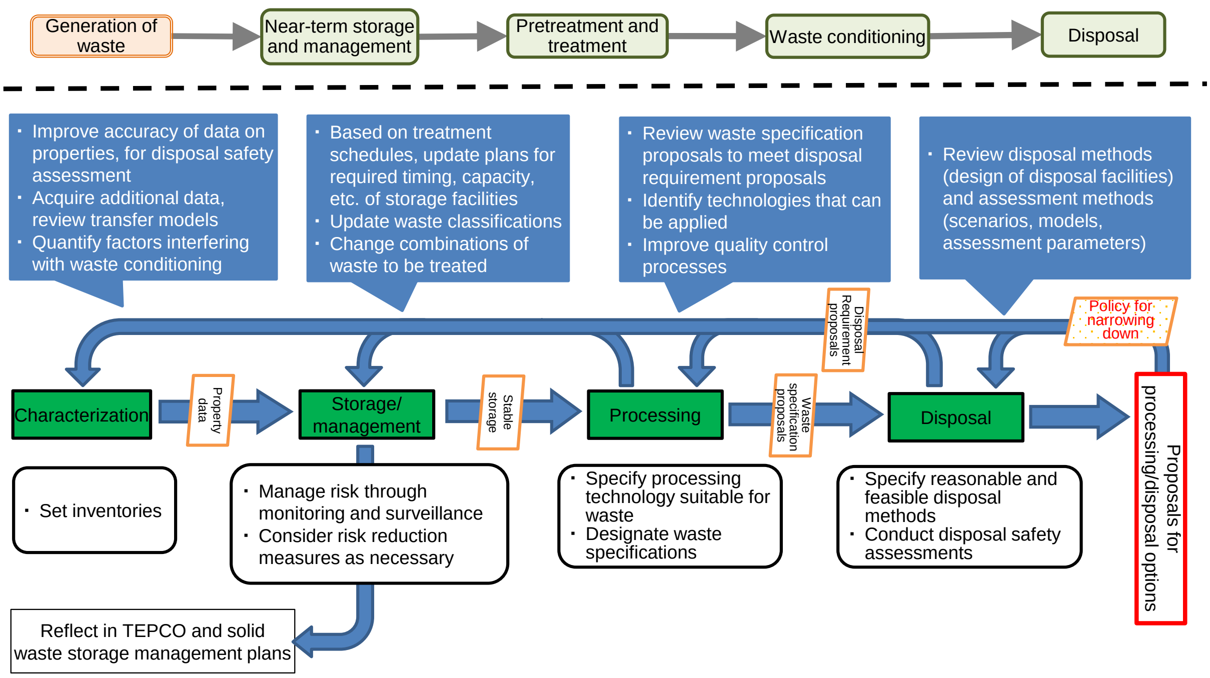


Fig. 7 Procedure to reasonably select safe processing/disposal methods of solid waste

3.3 Contaminated water and treated water management

3.3.1 Target

- Under the three principles concerning the contaminated water issues ("removing" contamination sources, "redirecting" fresh water from contamination sources, and "retaining" contaminated water from leakage), the target is to control the amount of contaminated water generated to less than 100 m3/day or less with the average rainfall by the end of 2025, and about 50 to 70 m3/day by the end of FY 2028, while continuing the operation of the constructed water-level management system. Moreover, to ensure the stable implementation of contaminated water management, measures for mitigating large-scale natural disaster risks, such as tsunamis and storm rainfall, will be implemented in a planned manner.
- To arrange the relationship with a decommissioning process including full-scale fuel debris retrieval beginning in the near future, and to promote examination of the measures of the contaminated water management for medium-and-long term prospects.
- To discharge ALPS-treated water safely and reliably to secure the site and other resources and steadily advance the entire decommissioning process.

3.3.2 Progress

- The amount of contaminated water generated decreased from about 490 m^3/day (FY 2015) before management was in place to about 90 m^3/day (FY 2022). Although the figure fell below the milestone of about 100 m^3/day set out in the Medium-and-Long-term Roadmap, the achievement of the milestone will be evaluated based on data from FY 2023 onward in light of the fact that the amount of rainfall in FY 2022 was less than the average year.
- In FY 2022, a milestone in the Medium-and-Long-term Roadmap was achieved: “to reduce the stagnant water in reactor buildings in FY 2022 to 2024 to about half of the level at the end of 2020”.
- As a countermeasure for heavy rain, a new drainage channel D was installed to contribute to eliminating the risk of inundation in the vicinity of Units 1 to 4. In addition, widening and bypassing of the existing drainage was completed in February 2023.
- Based on the implementation of the basic policy presented at "the sixth meeting of the Inter-Ministerial Council concerning Decommissioning, Contaminated Water, and Treated Water Management" and the " the sixth meeting of the Inter-Ministerial Council concerning the Continuous Implementation of the Basic Policy on Handling of ALPS Treated Water" and future efforts, ALPS treated water was discharged to the sea on 24 August 2023. Communication on various occasions, such as briefings, and information dissemination through various media including the treated water portal site, have been promoted.

3.3.3 Key issues and technical strategies

3.3.3.1 Control of contaminated water generation amount

Toward the goal of limiting the amount of contaminated water generated to about 50 to 70 m^3/day by around the end of FY 2028, local water sealing work in the building will be carried out, in addition to lowering the water level of sub-drains and work of facings around Units 1 to 4.

In the gaps between buildings, which are the main factors of groundwater inflow into buildings, there are nearly 200 sites of penetration at T.P. -0.65 m, the current sub-drain water level (L value). If the water level is lowered to the assumed groundwater level in FY2025 (about T.P. -1 m), the number of penetration sites will be reduced by almost half, which is expected to reduce the inflow to buildings. However, there will still be nearly 100 penetration sites below T.P. -1 m.

To suppress groundwater inflow from the penetration sites of these gaps, the plan is to establish a water seal part by boring holes at the ends of the gaps between buildings and filling them with mortar, etc. As for the water seal at the ends of the gaps, after conducting tests on construction methods and materials using test specimens off-site, and test construction will be carried out at Units 5 and 6, then results will be deployed in Unit 3. In addition, water sealing at penetration sites of the exterior walls of the buildings and facing of the areas around the buildings will be carried out in parallel while coordinating with other decommissioning work, targeting at the end of FY2028 (about 50–70 m^3/day).

3.3.3.2 Treatment of stagnant water in buildings

(1) Further reduction of stagnant water

Due to the presence of high-radiation dose sludge containing cesium and α-nuclides near the floor of the reactor building, lowering the water level of the building too much may lead to reduced water shielding effect and deterioration of the working environment.。Moreover, if contaminated water with a radioactivity concentration several orders of magnitude higher than usual flows into the cesium sorption apparatus, the purification performance may be significantly degraded. Although reducing the amount of stagnant water in the reactor building to about half the level at the end of 2020 has been achieved, setting a new goal to reduce the stagnant water should be considered in integration with the fuel debris retrieval method, and shifted to the steps of stable stagnant water control through decommissioning work.

(2) Stagnant water treatment in the process main building and high-temperature incinerator building

At present, stagnant water in the building is also stored on the basement floors of the process main building and the high-temperature incinerator building, and the plan is to reduce the water level toward the exposure of the floor surface, starting in FY 2024. On the basement floors of these buildings, zeolite sandbags, etc., which were installed immediately after the accident to improve the water quality of the stagnant water, are present in a high dose state, and if the floor surface is exposed on the basement floors, it is expected that the radiation dose on the floors above ground will increase significantly because there will be no water shielding. Therefore, the planned procedure is to first collect as many zeolite sandbags as possible in a submerged environment, then transfer them to the floors above ground using a recovery robot, seal them into storage containers after dehydrating in the building, and transfer them to temporary storage facilities.

In addition, temporary storage facilities for stagnant water are being designed, which will take over the function of a buffer tank that has been performed by the process main building and high-temperature incinerator building. The temporary storage facilities for stagnant water have become much smaller than before, and a plan needs to be developed from an operational perspective to maintain their function even with a smaller capacity.

3.3.3.3 Issues of contaminated water management considering the decommissioning process such as fuel debris retrieval

(1) Examination of water treatment systems for dispersion prevention of α-nuclides and fuel debris retrieval

The relatively high total alpha concentrations have been detected in the stagnant water collected from the bottom of the torus room of the reactor building, and they have been confirmed to exist mainly in the form of granular particles (alpha sludge). As a preparation for increasing the amount of sludge in the contaminated water with the progress of decommissioning, the installation of a filter facility in the latter stage of the cesium sorption apparatus is being examined to prevent the spread of α-nuclides to the downstream side.

With regard to water treatment systems for fuel debris retrieval, it is important to examine the timing and method of retrieval and the performance of the treatment facilities required at that time in a consistent manner. When retrieving fuel debris, contaminated water containing fine particles in large quantity will be generated by processing, such as cutting and other processes, and α-nuclides in fuel debris may transfer to the stagnant water in various forms such as fine particles, ions, and colloids. Therefore, since the water quality of contaminated water depends on the method of cutting and other processing, in the situation where the fuel debris retrieval method is not determined, the challenge is that the water treatment system needs to deal with a wide range of conditions. To establish processing methods for fuel debris, by performing laboratory tests, an examination should be carried out to identify the impact on the water quality of contaminated water. This will allow the establishment of more realistic water quality conditions for contaminated water, leading to streamlining the water treatment systems and improving the reliability.

(2) Medium-and-long term measures for contaminated water management systems

To maintain the effectiveness of contaminated water management over the medium-to-long term, it is necessary to implement periodical inspection and updating of equipment for land-side impermeable walls, sub-drain systems and existing water treatment systems (e.g., SARRY, ALPS) without fail. To this end, it is important to assume various risks such as aging, strengthen the system for monitoring and early recovery measures, arrange procurement of spare and replacement parts for stable operation, and proceed with maintenance and equipment renewal in a planned manner.

In addition, since it will take a long time to complete the retrieval of fuel debris, the challenge is to take a bird's-eye view of contaminated water management in the medium to long term and to establish a more stable contaminated water management and a more appropriate maintenance and management system for each equipment, in conjunction with the selection of methods for further expansion of fuel debris retrieval in scale that is currently underway. With this, these studies should be carried out after considering the interference with the work of fuel debris retrieval.

3.3.3.4 Future efforts for the discharge of ALPS-treated water into the sea

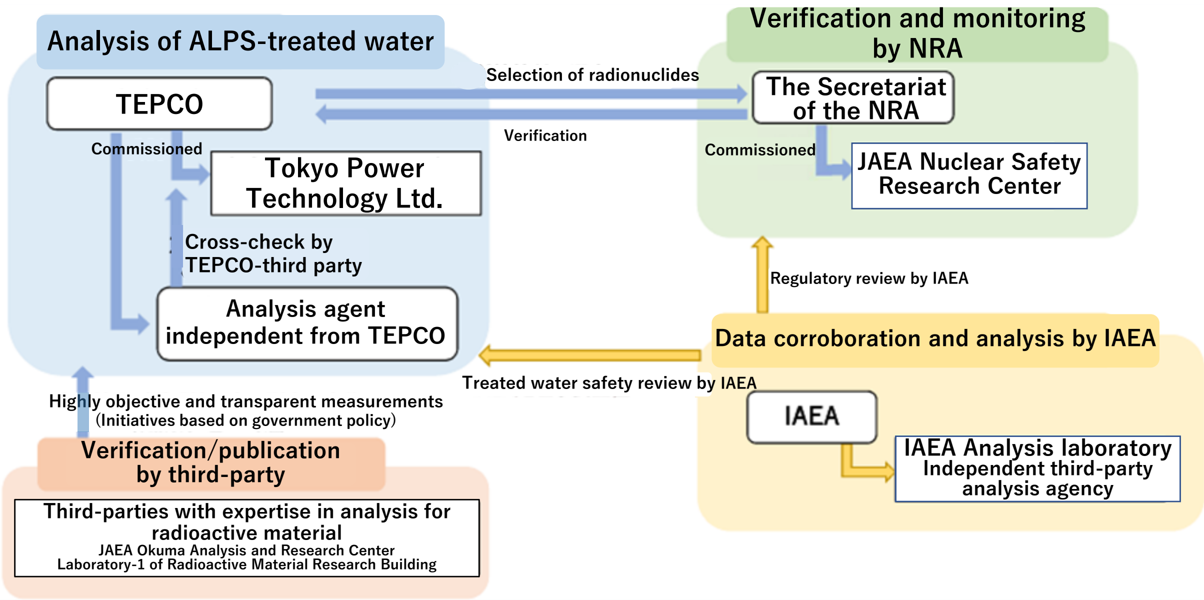
The discharge of liquid waste generated in nuclear facilities into the sea, pursuant to the law, with a sufficiently small radiological impact on the human population and the natural environment is a globally method recognized and is adopted widely in Japan and abroad. The IAEA has published a review finding that activities related to the discharge of ALPS-treated water into the sea are consistent with relevant international safety standards and have a negligible radiological impact on humans and the environment. It is necessary to disseminate highly transparent information based on scientific evidence, including the above, to prevent the impact of reputational damage.

Based on the Action Plan for Steady Implementation of the Basic Policy on the Disposal of ALPS Treated Water formulated by the government, it is essential for TEPCO to reliably operate the facilities in accordance with its own plan for the discharge of ALPS-treated water into the sea and communicate the status with high transparency.

(1) ALPS-treated water analysis and evaluation structure

Fig. 8 shows the analysis and evaluation structure of ALPS-treated water collected at the measurement and confirmation facilities. In addition to its own analysis before the discharge to the sea, TEPCO outsources to independent external organizations and performs analysis every time to determine whether or not to discharge according to regulatory standards. The JAEA Okuma Analysis and Research Center (Radioactive Material Analysis and Research Facility Laboratory-1) also conducts analysis every time before the discharge in accordance with the government’s basic policy. Moreover, the NRA (commissioned to the JAEA Nuclear Safety Research Center) and the IAEA (laboratories belonging to the IAEA and research institutes in third countries) also conduct analysis of ALPS-treated water as appropriate to confirm the analytical quality submitted by TEPCO. In May 2023, the IAEA concluded in its "Report on the results of the first inter-laboratory comparison of radionuclide analysis of ALPS-treated water" that TEPCO has the ability to analyze ALPS-treated water accurately and precisely, and sampling procedures and nuclide analysis methods are appropriate.

In this manner, several institutions are conducting various third-party analyses of pre-discharge ALPS-treated water for comparison with the analysis data disclosed by TEPCO. It is important that those data are made publicly available in a prompt and transparent manner.



(Source: NRA)

Fig. 8 ALPS-treated water analysis and evaluation structure

(2) Periodic verification of nuclides to be measured and evaluated

As the target nuclides to be measured and evaluated before discharge of the ALPS-treated water into the sea, 29 nuclides were selected after re-examining the nuclides that could be contained in the contaminated water before treated by cesium sorption equipment, ALPS and other systems in significant amounts, based on knowledge of decommissioning and buried facilities at nuclear power plants in Japan.

When discharging into the sea, a check is performed to ensure that the sum of the notified concentration limit ratios of the selected nuclides to be measured and evaluated is less than 1. However, it may change depending on the progress of decommissioning work in the future, it is necessary to confirm that there are no significant nuclides other than the selected nuclides to be measured and evaluated (hereafter referred to as “other nuclides”.) If significant amounts of other nuclides are present, the nuclides to be measured and evaluated will be reevaluated, and an environmental impact assessment will be performed as needed.

(3) Strengthening and enhancing marine environmental monitoring

In March 2022, in the Monitoring Coordination Council chaired by the Minister of the Environment, the Comprehensive Monitoring plan was revised based on expert advice, and in April, marine monitoring began before discharge into the sea. In addition to TEPCO, the Ministry of the Environment, the NRA, and Fukushima Prefecture are also supposed to monitor the same marine areas independently in marine areas near the Fukushima Daiichi NPS. A framework has been established for each of them, including TEPCO, to conduct with enhanced objectivity and transparency. Moreover, immediately after the start of the ocean discharge, they are conducting swift analysis and publicizing the results in a preliminary report.

Furthermore, analysis of supporting data and inter-analytical laboratory comparison (ILC) were conducted by the IAEA to ensure the reliability of monitoring. In June 2022, the report of the inter-analytical laboratory comparison was published, and the sampling method of the Japanese analytical institutions were evaluated as adequate, highly accurate, and competent.

To prevent reputational damage, it is important to expedite analysis and disseminate information on monitoring results that is easy to understand in a timely manner. Marine monitoring requires sophisticated analytical techniques and long-time measurements to detect extremely low concentrations of radionuclides. Therefore, to expedite the analysis, in addition to the development of pretreatment technologies for concentrating radionuclides, operational efforts are being made, such as the disclosure of preliminary data from short-time analysis and final data from long-time analysis at different times.

For information dissemination, TEPCO publishes monitoring results on its Treated Water Portal Site and provides the latest information to international audiences in multiple languages. In addition, TEPCO also launched the Overarching Radiation-monitoring data Browsing System in the coastal ocean of Japan (ORBS) website in March 2023.

Since multiple organizations, including TEPCO, the Ministry of the Environment, the NRA, and Fukushima Prefecture, conduct sampling and analysis as marine monitoring, it is important to operate the system continuously so that these pieces of data are disclosed promptly and transparently.

(4) Future operational plans, etc.

TEPCO should continue to conduct checks and reviews on the operational performance of the facilities for the discharge of ALPS-treated water into the sea and the results of marine environmental monitoring, and review and expand the plan flexibly as necessary. Then, toward the prompt and reliable implementation of site usage after the release of treated water, it is necessary to appropriately develop a discharge plan in accordance with the site use plan while considering the concentration/decay of tritium contained in treated water in tanks and attenuation. Moreover, it is essential to provide education and training in a planned manner, including for contractors engaged in system operation and analysis, in order to proceed with decommissioning work safely and steadily.

The IAEA is committed to continuously reviewing the safety assurance measures taken by the government and TEPCO before, during and after the discharge, and a system has been established in which IAEA personnel are stationed at the Fukushima Daiichi NPS before and after the discharge to continue the confirmation. It is important for the government and TEPCO to continue sharing the necessary information with the IAEA, and provide explanations to Japan and the international community based on scientific evidence with a high degree of transparency.

NDF will provide technical and professional support for TEPCO’s planning and operation of countermeasures on contaminated and treated water, while promoting the distribution of accurate information and increasing understanding in line with the interests of those who will receive the information, through meetings and conferences with relevant domestic and overseas organizations. NDF will also ensure that measures to minimize reputational damage are implemented by TEPCO and that action is taken with adequate and sufficient compensation in the event of reputational damage.

3.4 Fuel removal from spent fuel pools

3.4.1 Target

- To complete fuel removal from the spent fuel pools of all Units from 1 to 6 by the end of 2031.
- As the return of residents and reconstruction in the surrounding area gradually advances, to carry out a risk assessment and ensure safety, including preventing the dispersion of radioactive materials, and to start removal of fuel in SFPs in FY 2027 to FY 2028 for Unit 1 and FY 2024 to FY 2026 for Unit 2.
- The fuel in Units 1 to 4, which were affected by seawater and rubble, is retrieved from the SFPs and transferred to the Common Spent Fuel Storage Pool, etc., where it is appropriately stored to be in a stable management state. In order to secure the Common Spent Fuel Storage Pool capacity, the fuel stored there is transferred to and stored in the dry cask at the Temporary Cask Custody Area.
- To perform the evaluation of long-term integrity and the examination for treatment for the retrieved fuel and to decide the future treatment and storage method.

3.4.2 Progress

- Unit 1 : Work is underway to assemble a large cover frame in the off-site yard in parallel to installing a lower frame in the reactor building.
- Unit 2 : The installation of the working platform base mat for fuel removal was completed in November 2022, and erection of steel structure began in January 2023. In addition, the south side of the spent fuel pool was fully cleared of obstacles in March 2023, and decontamination work is underway.
- Unit 3 : Removal of high-radiation dose equipment from the spent fuel pool began in March 2023.
- Unit 6 : The fuel transfer process from the Common Spent Fuel Storage Pool to the dry cask at the Temporary Cask Custody Area has been reconsidered due to the impact of the contamination with foreign substances, causing a delay in the process of transferring spent fuel to the Common Spent Fuel Storage Pool.

3.4.3 Key issues and technical strategies

3.4.3.1 Fuel removal from spent fuel pools

For Units 1 and 2, it is necessary to advance the work steadily to realize the new retrieval method that has been determined.

In promoting the project, it is essential to evaluate safety in association with work, to confirm that necessary and sufficient safety is ensured, and then to comprehensively consider the technical reliability, rationality, the promptness of the work schedule, the actual site applicability, the project risk, etc., in order to address issues.

(1) Unit 1

- Since the overhead crane is unstable on the upper part of the operating floor, removing the it in a safe and reliable way is one of the main issues. Therefore, in the ongoing examination of how to remove the overhead crane, it is assumed that safety assessments will be performed, and it is important to carry out a comprehensive examination in light of rationality and impact on other operations by:

- Formulating specific work procedures and work plans enabling identification of risk items
- Anticipated risk scenarios and countermeasures
- Identifying points to consider, such as exposure of workers, from the operator's perspective

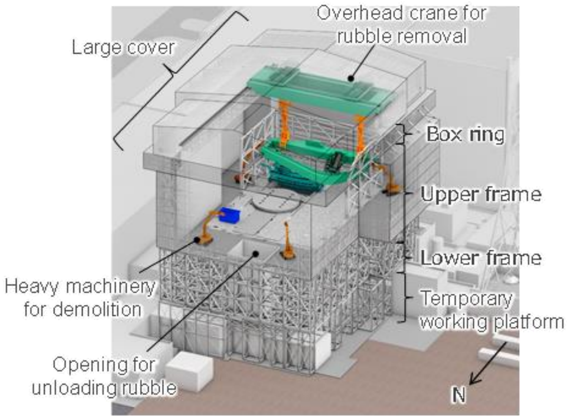


Fig. 9 Overview of the rubble removal from Unit 1 operating floor

The information on the condition of the lower part of the roof slab is limited at present, requiring a detailed investigation after the removal of the slab. Since there is a risk that the crane dismantling process may be delayed depending on the investigation results, investigation should be carried out promptly once it becomes possible, and the results should be incorporated into the safety assessments and rubble removal plans. (Fig. 9)

Regarding the contamination state of the well-plugs of Units 1 to 3, it has been pointed out that the well-plugs have important implications for safety and decommissioning work due to the high level of their contamination. Although the contamination level of the well-plug of Unit 1 is lower than that of Units 2 and 3, it is unstable due to the impact of the accident, and examination is being made on measures to deal with the situation. From now on, a comprehensive decision on how to deal with well-plug should be made based on these examination results and by taking into consideration the impact on fuel removal from SFPs and fuel debris retrieval and performing thorough safety assessments.

A detailed handling plan for 67 fuel assemblies with damaged cladding tubes, which have been stored in the Unit 1 SFP since before the accident, is under development toward the completion of fuel removal in 2031. In particular, efforts should be made to ensure verification of the post-accident condition and risk study associated with handling.

(2) Unit 2

Fuel in FSP will be removed from the opening on the south side of the operating floor using a fuel handling machine composed of a boom-type crane-system that has never been used at nuclear facilities in Japan before (Fig. 10). Since this is a new system, the following measures should be taken without fail.

- Development of appropriate design and production schedules with margin
- Conducting of mock-up tests that sufficiently simulate on-site conditions and operating method, and reliable feedback of these test results into design and production

- Sufficient mastery of system operation and functionality in advance due to the remote-controlled nature of the retrieval work

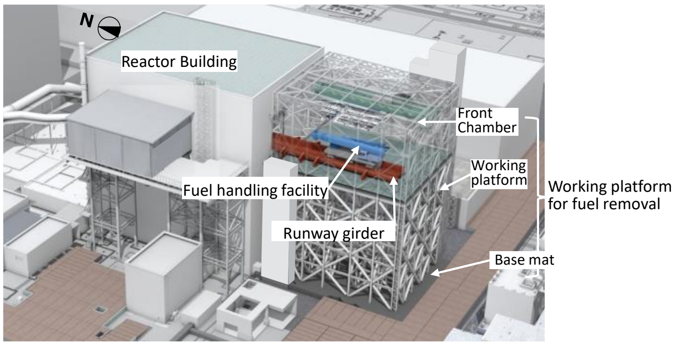


Fig. 10 Fuel removal method in Unit 2 SFP

Fuel removal from pools will be conducted basically by remote-controlled unattended operation, but it is also assumed that some fuel removal will be performed by manned operation. Therefore, it is important to reduce the dose on the operating floor as much as possible, and decontamination and installation of shielding are being carried out. After decontamination, the opening is scheduled to be installed on the south side of the operating floor, and as there is a risk that the work area may be contaminated again, thorough measures to prevent dust dispersion should be taken during installation of the opening.

(3) Removing high-radiation dose equipment

Removal of high-radiation dose equipment is ongoing in light of risk reduction in the event of pool water leakage. It is also possible to exclude pool water from management by draining the pool water after removing the high-radiation dose equipment, leading to smooth fuel debris retrieval operation in the later stages because of the increased flexibility of use of the operating floor. Prior to draining the pool water, the radiation dose and dust dispersion from the pool after drainage should be evaluated to confirm safety in advance.

To remove high-radiation dose equipment, it is effective to utilize the devices used for fuel and rubble removal. The fuel removal system for Unit 1, which will be installed in the future, should also be designed and maintained in anticipation of the removal of high-radiation dose equipment. Moreover, because the capacity of existing site bunkers for storing high-radiation dose equipment is limited, it is important to proceed with constructing new site bunkers.

3.4.3.2 Decision on future treatment and storage methods

The future treatment and storage methods for fuel in SFPs needs to be decided after considering the impact of seawater and rubble at the accident and the damaged fuel stored since before the accident. Future treatment and storage methods should be determined in light of the condition of the fuel to be removed while examining the long-term integrity assessment and treatment. TEPCO plans to transfer fuel in SFPs of all Units to the Common Spent Fuel Storage Pool by the end of 2031. Subsequently, taking into account the tsunami risk, the possibility of dry storage on higher ground has been studied, including existing fuel in the Common Spent Fuel Storage Pool. In addition to the existing metal casks, TEPCO has announced that it will study the application of concrete casks using canisters with proven track records overseas, as dry storage facilities. The dry storage facilities to be applied, including storage of damaged fuel, should be determined based on the advantages and disadvantages of both the casks and the characteristics of the Fukushima Daiichi NPS.

4. Analysis strategy for promoting decommissioning

4.1 Significance of analysis on decommissioning

In the decommissioning of the Fukushima Daiichi NPS, only a few records exist, such as for temperature, and there are many uncertainties regarding the status inside the reactors, the condition of fuel debris, the release path of fission products, and so on. In decommissioning the Fukushima Daiichi NPS, analysis with various analysis targets, purpose of analysis, and radiation dose rates must be performed, as shown in Fig. 11.

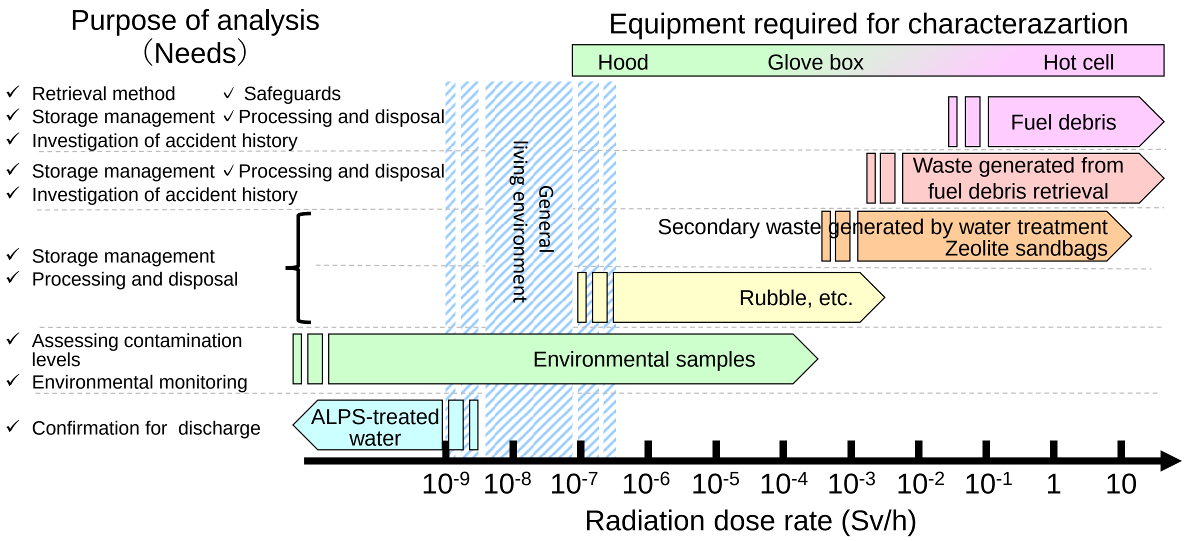


Fig. 11 Relationship between the purpose of the analysis, equipment required for characterization, and radiation dose rates of the analysis targets

If the properties of fuel debris can be ascertained by analysis, an excessive margin in decommissioning work can be eliminated by reducing the uncertainty range, and the rapidity and rationality of decommissioning can be improved. In addition, when considering the processing/disposal measures of solid waste, the property data such as nuclide composition and radioactivity concentration obtained by analysis will serve as basic information. Since ALPS-treated water is assumed to be released to the environment, it should be confirmed that it is sufficiently below the release standard value by analysis. Adequate results obtained from these analyses are indispensable for achieving these conditions and for the safe and steady progress of decommissioning work at the Fukushima Daiichi NPS. In order to obtain the appropriate analysis results, it is effective to improve the three elements of the analysis strategy for fuel debris (Method and system of analysis, quality of analysis results, size and quantity of samples).

4.2 Current status and strategies for analysis

4.2.1 Measures to strengthen analytical method and analysis structure

(1) Measures to strengthen analytical structure

To strengthen the analysis structure necessary for decommissioning the Fukushima Daiichi NPS, TEPCO, the JAEA, NDF, and other related organizations have been working together by studying analysis plans, developing analysis and evaluation methods, securing analysis facilities, and recruiting analysis personnel. In addition, the NRA has also suggested that measures to immediately resolve issues should be examined (such as an all-Japan approach) to strengthen the analysis system, the Agency for Natural Resources and Energy reports on these efforts and the immediate responses. We will continue to steadily implement our immediate efforts and take necessary actions based on the situation.

(2) Discussion on analysis plans

The growing demand for analysis as the decommissioning process progresses must be handled flexibly and systematic preparations must be made so that the decommissioning work does not stagnate due to analysis. TEPCO extracted wastes with high priority for analysis based on the progress of analysis and risks associated with storage management, and reviewed the characterization policy and analysis plan according to the characteristics of each waste. In addition, after integrating and coordinating analysis plans for each type of waste, TEPCO designs the annual development of the necessary analysis capabilities and incorporates them into analysis personnel plans. This analysis plan is continuously updated to reflect changes in needs as decommissioning progresses. Moreover, TEPCO will implement the initiatives in the plan and, based on the progress made, will constantly review the necessary measures.

(3) Development of analysis and evaluation methods

Solid waste has the characteristics of many types of waste in huge amounts. Therefore, efficient characterization is necessary. For this reason, we have developed analytical methods to obtain data easily and quickly, and have established methods of characterization with a small amount of analytical data in the Project of Decommissioning, Contaminated Water and Treated Water Management. As part of this effort, analytical methods that have been accelerated by streamlining and automating pretreatment of sample are being standardized. In addition, efforts are being made to develop analytical methods to deal with various sample forms and the difficult-to-measure nuclides.

(4) Securing facilities for analysis

The JAEA's Radioactive Material Analysis and Research Facility (Laboratories 1 and 2) has the advantage that off-site transportation is not required because the facility is defined as facilities in the peripheral monitoring area of Fukushima Daiichi NPS. For this reason, analyses that require hot cells, such as fuel debris, should be conducted in the Ibaraki area as necessary, and analyses with high promptness should be prioritized on the site of the Fukushima Daiichi NPS and its adjacent areas. It is effective to expand the analysis data under such an assignment of roles according to the characteristics of each facility for analysis.

(5) Securing human resources for analysis

In each facility for analysis, securing and maintaining analytical personnel to continue stable facility operation is a challenge. It is necessary to consider in advance the qualities expected of analytical personnel in various types of analytical work and develop analytical personnel in a planned manner to achieve the required roles appropriately. Because the decommissioning of the Fukushima Daiichi NPS will directly handle unsealed alpha-ray emitters, which are not usually handled by conventional reactors, TEPCO will have to train personnel in fields with little experience in a short period. The development of analytical engineers should be efficiently promoted with the cooperation of relevant organizations with sufficient knowledge and experience in handling alpha-ray emitters. As the demand for analysis is expected to increase in the future, there will be a need for highly skilled personnel capable of analysis planning in anticipation of how the analysis results will be used. Analytical evaluators in charge of this task are required to have the ability to (i) appropriately incorporate the evaluation results into the areas required for the decommissioning process (retrieval method, safeguards, storage/management, and processing/disposal), (ii) provide appropriate instructions for the subsequent sampling, and (iii) logically and accurately understand accident events from analytical results. However, it is difficult for individuals to have all these abilities. Therefore, the Analysis Coordination Meeting and an Analysis Support Team were organized within NDF (Fig. 12). The Analysis Coordination Meeting is responsible for confirming analysis plans and providing advice on problem-solving in response to the increased types and numbers of objects to be analyzed. The Analysis Support Team, consisting of researchers and engineers with extensive experience and knowledge in analytical practice, is to examine and discuss specific R&D approaches and the methods to check reliable analytical techniques in order to solve problems.

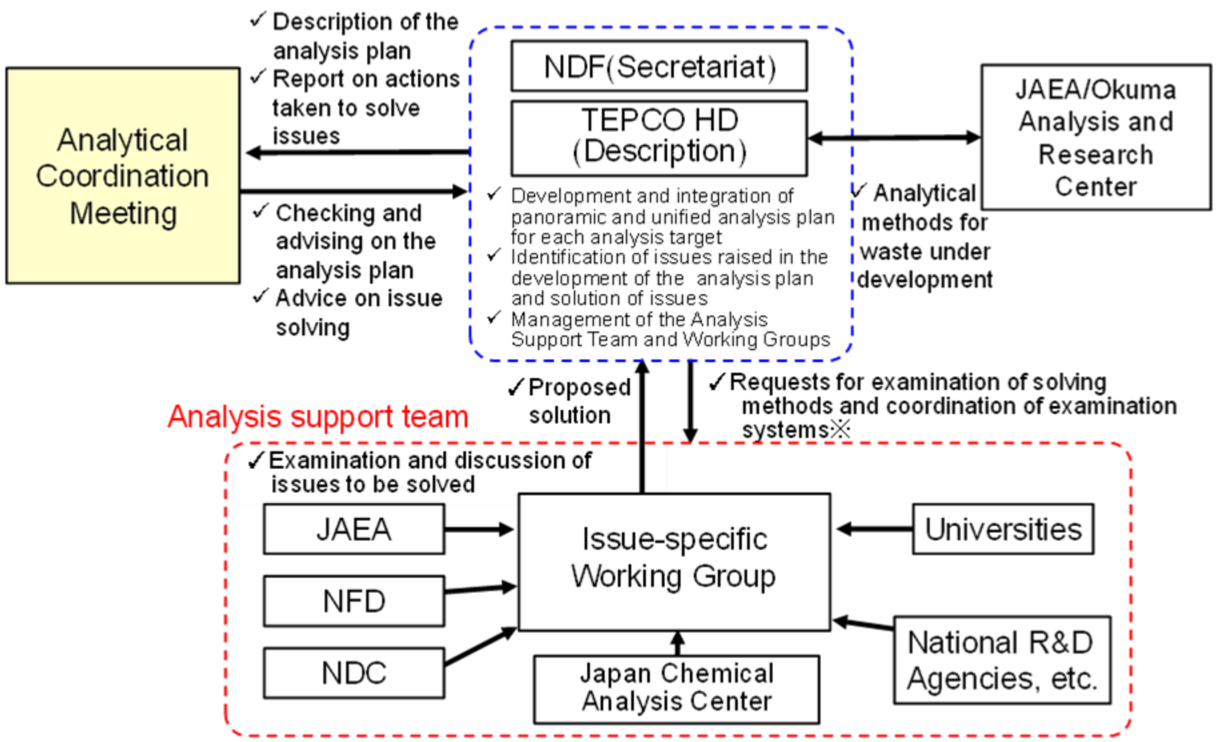


Fig. 12 Role of the Analysis Coordination Meeting and Analysis Support Team

4.2.2 Improvement of the quality of analysis results

It is difficult to accurately identify and quantify all elements and isotopes of fuel debris up to small components by analysis. As such, it is important to have a multifaceted point of view on the analytical results of samples in consideration of the impact of the error factor. As part of the verification of sample analysis results, through studies in light of existing findings, such as results of analysis, investigation and testing, deriving consistent property evaluations will improve the reliability of analysis results, leading to higher quality of the analysis results. To do so, the JAEA, the NFD, MHI Nuclear Development Corporation, and Tohoku University have been cooperating to conduct chemical analysis and structural analysis using the same samples since FY 2020. Currently, Ibaraki area offices are preparing to analyze the Three Mile Island Unit 2 reactor (TMI-2) debris using the latest technologies to expand the fuel debris data.

As for waste, to perform characterization of all solid waste which exists in large amounts using the limited analytical data, an efficient approach to ensure the required accuracy will be essential, and efforts are being made to establish an efficient analytical evaluation method. Accuracy is one of the indicators for the quality of analytical data is the accuracy such as the uncertainty and the lower limit of detection, but accuracy and measurement time are interrelated, and it is expected that increasing the measurement time can improve the accuracy. However, if measurements take weeks or months, it is difficult to keep up with the increasing volume of analysis. Therefore, according to the analytical purpose, objects to be analyzed, and analytical method, it is also important to properly select the accuracy, measurement time, and measurement frequency based on the concerned analysis method.

4.2.3 Diversification of analytical techniques to increase sample size and volume

(1) Comprehensive evaluation by diversified analysis and measurement methods

Since density, hardness, and other items cannot be measured for micro or very small quantity of samples, it is necessary to increase the size and quantity of samples in accordance with the progress of the fuel debris retrieval process. Analysis in hot cells is time-consuming, and the amount of use for each nuclide handled is specified, making it difficult to analyze large quantities. Therefore, it is necessary not only to focus on increasing the quantity of analysis in hot cells but also to diversify analysis and measurement methods. It is effective to assess the analysis items obtained by other methods, consider complementing analysis items depending on the use of the analysis results, and make comprehensive evaluation.

(2) Use of sample analysis and non-destructive assays

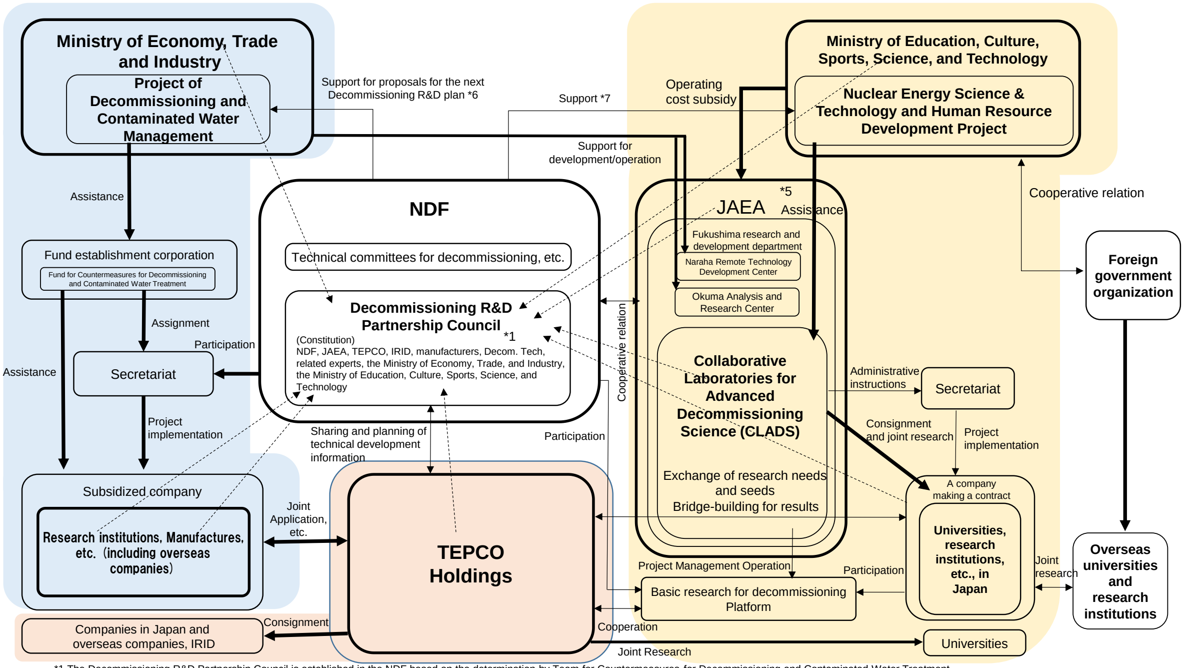
One method is to evaluate the amount of nuclear fuel or radioactivity without destroying the sample (hereinafter referred to as "non-destructive assay"). Although non-destructive assays can measure fewer items, the measurement time is shorter than that of sample analysis, and a larger quantity can be measured per measurement. Moreover, measurement can be performed with the object stored in a sealed container to prevent the spread of contamination, which has the advantage of no radioactive liquid waste generated. However, since fuel debris has impediments to nondestructive assays, such as neutron absorbers, it is necessary to verify the extent to which these impediments affect measurements. Therefore, technology development aiming at on-site application is underway through simulation analysis and actual measurement tests. If this nondestructive assay can quantify the nuclear fuel of the fuel debris in the container, prompt analyses can compensate for the small number of analyses. When increasing the number of analyses, it is desirable to keep the range of uncertainty in the properties of fuel debris as small as possible while increasing information about the samples, including the coordinate information at sample collection, to improve the reliability of the data.

5. Efforts to facilitate research and development for decommissioning of the Fukushima Daiichi NPS

5.1 Significance and the current status of research and development

At present, as trial retrieval of fuel debris is about to begin, it is necessary to accelerate research and development in consideration of the practical application on site for a gradual expansion of the retrieval scale and further expansion of fuel debris retrieval in scale. Under these circumstances, various industrial-academic-governmental institutions, including overseas enterprises, are engaged in basic/fundamental research and applied research by researching institutions, practical application research by manufacturers, and field demonstrations. For application research and practical application research for decommissioning, the Government provides support to the R&D carried out by each organization to solve highly-difficult issues through the “Project of Decommissioning, Contaminated and Treated Water Management” and to promote basic/fundamental research and human resource development by universities and researching institutions in Japan and overseas through the “Nuclear Energy Science & Technology and Human Resource Development Project” (hereinafter referred to as the “World Intelligence Project”). In addition to discussing R&D medium-and-long-term planning and next fiscal year R&D planning and supporting the World Intelligence Project, NDF has also established the Decommissioning R&D Partnership Council to strengthen coordination between the Project of Decommissioning, Contaminated and Treated Water Management and the World Intelligence Project (Fig. 13).

Given that the progress of investigation inside the reactors has clarified on-site needs in decommissioning and TEPCO has begun full-scale engineering work for fuel debris retrieval, the leading players in the Project of Decommissioning, Contaminated Water and Treated Water Management have shifted from the current International Research Institute for Nuclear Decommissioning (IRID)-centered structure to a new R&D structure comprised of researching institutions and manufacturers as key implementers based on TEPCO’s needs, requiring smooth coordination between the R&D implementers and TEPCO. In addition, the Fukushima Institute for Research, Education and Innovation (F-REI) was established by the Government in April 2023 to contribute to the reconstruction and revitalization of Fukushima. NDF will continue to gather information on research and development and human resource development in F-REI and work together on the basis of its implementation.



*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 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.
*6 With regard to the 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.
*7 NDF participates as a member in a steering committee of the World Intelligence Project for Nuclear S&T and Human Resource Development.

Fig. 13 Overview of the R&D structure of the decommissioning of Fukushima Daiichi NPS

5.2 Key issues and strategies

5.2.1 R&D medium-and-long-term plan

NDF and TEPCO have been preparing the R&D Medium-to-Long-term Plan for the decommissioning of the Fukushima Daiichi NPS. The plan overlooks the overall research and development in the next 10 years for decommissioning, so that R&D activities for decommissioning of Fukushima Daiichi NPS can be promoted comprehensively, systematically, and efficiently. Based on the engineering schedule of TEPCO, the R&D medium-and-long-term plan is developed to identify the required R&D and appropriately incorporate R&D results when needed. The plan has also included basic/fundamental research since FY 2022.

In FY 2023, the R&D Medium-to-Long-term Plan was revised in light of the medium-to long-term technical issues that are being discussed by four parties, including TEPCO, Tousou Mirai Technology Co. Ltd., Sector of Fukushima Research and Development, Fukushima Research Institute, Collaborative Laboratories for Advanced Decommissioning Science of the JAEA, (hereafter referred to as “JAEA/CLADS”), and NDF.

5.2.2 Initiatives for the Project of Decommissioning, Contaminated Water and Treated Water Management

NDF has been supporting the Project of Decommissioning, Contaminated Water and Treated Water Management each fiscal year by developing the Next-fiscal year R&D plan over the next two years. When identifying issues in the Next fiscal year Decommissioning R&D plan, it is important to identify them exhaustively, confirm whether it is in line with the needs of TEPCO, and aim for the R&D results to be utilized for TEPCO's engineering.

Furthermore, given that the progress of investigation inside the reactors has clarified on-site needs in decommissioning and TEPCO has begun full-scale engineering for fuel debris retrieval, the main operator of the Project of Decommissioning, Contaminated water and Treated water Management was shifted from the IRID to a framework in which researching institutions and manufacturers are the main operators from FY2023. Along with these matters, NDF undertakes the following two initiatives to secure cooperation between R&D implementers and TEPCO, as well as to further strengthen its functions in planning and proposing R&D and ensuring the actual site applicability of research results. Continual improvement will be made on these initiatives.

- Request for Information (RFI) : Initiative to widely solicit research and development to be addressed in the Project of Decommissioning, Contaminated water and Treated water Management and to unearth the seeds of new ideas of development (started in fiscal 2022)
- Business Review : Initiative to set appropriate milestones for subsidized projects, then evaluate the activities of operators in terms of actual machine engineering and actual site applicability at appropriate times, and provide necessary guidance and advice (to be launched in fiscal 2023)

5.2.3 Promotion of cooperation between decommissioning sites and universities/researching institutions

MEXT has been promoting basic/fundamental research and human resource development activities, which contribute to problem-solving including decommissioning of the Fukushima Daiichi NPS, in the World Intelligence Project led by JAEA/CLADS targeting universities/researching institutions.

To deepen the matching between needs and seeds and ensure consistency from basic/fundamental research to applied practical application research, collaboration has been made between the Project of Decommissioning, Contaminated Water and Treated Water Management and the World Intelligence Project so far. Further collaboration with TEPCO is required to apply the research results on-site. To further develop decommissioning R&D in the future, NDF and the organizations concerned should collaborate to actively share information on their respective projects using the Decommissioning R&D Partnership Council and other opportunities.

In order to make the long-term decommissioning of the Fukushima Daiichi NPS proceed steadier in technical aspects, it is essential to work on developing R&D infrastructure and accumulate technological knowledge, develop fundamental technologies and collect basic data, building up research centers, facilities and equipment, and human resource development. The JAEA, with JAEA/CLADS as its core, is working to enhance its base functions by conducting research and development based further on decommissioning needs, and is developing the Naraha Center for Remote Control Technology Development and the Okuma Analysis and Research Center as hardware.

6. Activities to support our technical strategy

6.1 Capabilities, organization, and personnel to proceed with decommissioning

6.1.1 Ensuring the capability, organization and personnel that TEPCO should possess as the owner of the Fukushima Daiichi Nuclear Power Station

6.1.1.1 Significance and current status of decommissioning project management

In project-type work, such as decommissioning work at the Fukushima Daiichi Nuclear Power Station, the series of tasks consists of clarifying the objectives (i.e., what to do by when for what), determining the specific work content as a means to achieve the objectives, checking the safety and efficiency of the work, designing/manufacturing/building necessary equipment, ensuring the necessary personnel, and using them to achieve the objectives. Thus, the significance of the project management is to clarify the objectives, means, required resources and timelines, and then, to systematically manage project execution in order to accomplish the objectives.

TEPCO has been working to build and strengthen its project management system, which was reorganized in April 2020. Project-based organization management has been almost established through three years of operation. Tousou Mirai Technology Co., Ltd. was established to undertake the basic design required for further expansion of fuel debris retrieval in scale. By seconding its employees to this company, TEPCO is working to acquire cost and process management capabilities, risk management capabilities for uncertain elements, and design know-how, which have been dependent on manufacturers. Now that it is in phase 3-[1], the decommissioning work becomes more difficult and uncertain, and in order to smoothly coordinate and align the entire project with a view to the medium- to long-term, it will be more important than ever that the relevant organizations will further strengthen a management framework in cooperation with each other towards the goal to be achieved, and increase the collective strength.

Examples of main initiatives undertaken by TEPCO up to FY2022 include enhancing the authority of project managers through reorganization, building and operating a risk monitoring system, improving safety and quality levels, and preparing a forward-looking plan (Mid-and-Long-term Decommissioning Action Plan).

6.1.1.2 Capability an owner should possess

As stated in the Fourth Special Business Plan, TEPCO should acquire an owner's engineering capabilities. Additionally, in view of the peculiarities of the Fukushima Daiichi NPS, there are required abilities for upgrading the overall decommissioning strategy to advance coexistence of reconstruction and decommissioning.

In the following paragraphs, the capabilities that should be strategically enhanced by TEPCO in the future, as NDF believes, are described. Instead of addressing only the issues pointed out, regarding the capabilities required for all activities from the development of the decommissioning project strategy and plan to its implementation, TEPCO should consider what should be acquired in priority among such capabilities and continue taking a proactive approach for the acquisition.

(1) Establishment of safety first and engineering based on safety and operator's perspectives

In view of the peculiarities of the Fukushima Daiichi NPS, TEPCO needs to continue instilling the safety-first approach. Then, it is necessary to establish a process in which operators who are familiar with the site should be based on the actual situation of the site, check the safety comprehensively, determine the appropriate general safety requirements for the site, and work on it. The overall capability required for this purpose, including field capabilities, is engineering based on safety and operator's perspectives, and it goes without saying that TEPCO is required to further enhance this capability.

(2) Investigation capability at the upstream side of the project

In decommissioning work at the Fukushima Daiichi NPS, which does not have the upstream design concepts and standards, unlike conventional nuclear power plants, the cases have been accepted, where the project is allowed to return to the process that reexamines what functions should be achieved and what general safety requirements need to be satisfied for that after the project is launched and proceeded with.

In the future, TEPCO should clarify the significance and objectives of the project (what to do by when and for what), specify general safety requirements, develop a comprehensive waste-related plan covering its generation control, reuse, etc., and ensure the feasibility of the project. To this end, in the decommissioning process from its planning to implementation, enhancing the investigation capability is needed, especially at the upstream side.

However, due to the extremely high uncertainty particular to decommissioning at the Fukushima Daiichi NPS, it should also be noted that even if the investigation at the upstream side is enhanced, it does not necessarily mean that everything will proceed according to the result of the investigation. TEPCO, based on the assumption that iteration-based engineering is inevitable to some degree in the future, should aim to optimize its research capability in the upstream of the project by adding the latest knowledge from research and development.

(3) Capability to upgrade project management

Larger, more complex, and highly uncertain high-difficulty projects are expected in the future, and in such situations, it will be difficult for TEPCO to proceed with work only by simple buying (buying), which is to say, by just deciding specifications, prices, and schedules, and procuring goods and services. To adapt to this situation, TEPCO should upgrade its project management, including the relationship with the contractor and the manner of the contract in the case of making a new product (making).

(4) Nuclear security management capability

With regard to improvement actions in response to the physical protection incidents that occurred at the Kashiwazaki-Kariwa, although the situation is different from that of the Fukushima

Daiichi NPS in many ways, it is necessary to ensure that the same measures are taken to the aspects in common to make improvements.

NDF will continue to pay close attention to TEPCO's efforts to enhance its nuclear security management capabilities.

6.1.1.3 Initiatives related to organization

In order for TEPCO to further promote "coexistence of reconstruction and decommissioning", all employees, both inside and outside the Fukushima Daiichi NPS, must share the same aspirations and sense of responsibility regarding how TEPCO can contribute to this region, and must do their best to transcend organizational barriers.

In order to achieve this, TEPCO decided to consider integrating and reorganizing the head office of Fukushima Daini NPS, which currently belong to the Nuclear Power and Site Headquarters, into Fukushima Daiichi Decontamination and Decommissioning Engineering Company, and in July this year, the Office of Organizational Restructuring Preparation was established as the umbrella organization for this. NDF also regards these TEPCO efforts positively, and intends to confirm the activities so that TEPCO will step up progress to achieve coexistence of reconstruction and decommissioning as the integration and reorganization advance.

6.1.1.4 Initiatives to recruit and develop personnel

(1) Short-term efforts

The decommissioning work at the Fukushima Daiichi NPS is at the phase of starting the most critical milestone in recent years, the trial retrieval of fuel debris. To be in line with the gradual expansion of fuel debris retrieval, the entire workload of the plant is also increasing.

Although TEPCO is actively recruiting to meet such strong demand for personnel on-site, in addition to that, it is essential that its leaders clarify work priorities and promote resources allocation according to the priorities, and development of human resources should be promoted to enhance versatility and productivity of existing personnel. TEPCO has been conducting kaizen activities for a long time, and it is an initiative that incorporates the methods of Toyota's kaizen/continuous improvement method with the aim of improving quality and safety. As this is also useful for solving secondary resource issues, the activities should be continued vigorously. Other than that, it is also indispensable to provide education and training, conduct digital transformation (DX), and obtain the necessary outputs with limited resources through efforts.

(2) Medium- and long-term initiatives

The integration of the Fukushima Daiichi Decontamination and Decommissioning Engineering Company and the Fukushima Daini NPS, which TEPCO has been working on, is also crucial in the sense that it aims to optimize the use of personnel beyond the boundaries of business sites through organizational restructuring. The consolidation should be accompanied by the diversification of personnel, standardization and streamlining of business operations, and efforts to ensure the necessary personnel.

In decommissioning work where the workloads are expected to increase from now on, it will require personnel for ever-changing project-based work as well as personnel for operation and maintenance of the new facilities that will be installed as a result of the execution of projects. To ensure such personnel, TEPCO itself should determine what type of and when personnel will be needed in the medium- to long-term, and clearly present the necessity at an early stage so that the company can carry out the activities to recruit personnel from inside and outside the company widely through various channels. This is necessary for hiring, reskilling employees with a view to the medium- to long-term, personnel management including attractive career path design for young employees, enhancing the understanding of the community, and making up for personnel shortages through collaboration with external organizations.

In view of the fact that decommissioning is a long-term activity, TEPCO needs to work to cultivate leaders who will be responsible for decommissioning in a planned and systematic manner from a medium- to long-term standpoint. It is undeniable that leaders in charge of unprecedented and difficult decommissioning projects require a higher level of courage and people skills compared to other projects, in particular. In addition, they need to possess a keen sense of perception that anticipates the changing business environment as well as the ability to adapt to change, and the ability to learn. Furthermore, if other people in the organization are influenced by the leaders who are working on decommissioning as a national challenge as well as by the leadership group following those leaders, and become aware of their own potential and motivated to grow, this will also lead to the recruitment and development of decommissioning personnel over the medium to long-term.

6.1.2 Fostering the next generation responsible for the decommissioning and promoting public understanding

(1) Fostering the next generation who will be responsible for the future decommissioning of Fukushima Daiichi NPS

In order to continue decommissioning of the Fukushima Daiichi NPS over a long period and to continue the R&D activities necessary to that end, it is essential to train and secure future researchers and engineers and to ensure the inheritance of technological skills. It is necessary for industrial-academic-governmental institutions overall to move steadily ahead with efforts according to each level of the secondary and higher education stages.

In decommissioning the Fukushima Daiichi NPS, it is necessary to recruit and develop personnel with expertise in nuclear power as well as personnel specialized in science and technology in other fields. The challenge is how to continuously open up opportunities for promoting excellent personnel with expertise in various fields. In order to achieve this, it is necessary for higher and secondary educational institutions to create opportunities for learning and acquiring peripheral knowledge in addition to expertise, and to maintain associated systems and structures so that they can function as a whole, including teachers. For this reason, the World Intelligence Project has introduced a mechanism for students and young researchers to engage in decommissioning research. Further, to students in secondary education, it is important that efforts are made to ensure that involvement in the nuclear power field, including the decommissioning, will appeal to them.

(2) Dissemination of basic knowledge and promoting people's understanding of decommissioning and the radiation safety involved in decommissioning

Acquiring a basic knowledge of the Fukushima Daiichi NPS is fundamental to promoting public understanding of decommissioning. In particular, from the perspective of enhancing resilience to various disasters in the future, the challenge is to ensure that children, who are the pillar of the future, have opportunities to learn according to their developmental stage. For this reason, the government has been promoting the continuation and expansion of on-site classes and the use of radiological supplementary readers.

6.2 Strengthening international cooperation

6.2.1 Significance and the current status of international cooperation

In order to steadily proceed with the decommissioning of the Fukushima Daiichi NPS, which deals with highly difficult engineering issues, it is important to utilize the experience gained through preceding decommissioning activities of past nuclear facilities (hereinafter referred to as "legacy site".) located overseas. Therefore, it is necessary to promote bilateral cooperation in line with the circumstances of each country and to incorporate the experience of decommissioning activities around the world by utilizing the framework of multilateral cooperation through international organizations such as the IAEA and the OECD/NEA. These international organizations play an important role in developing international standards for decommissioning, and Japan's participation in such efforts is meaningful in promoting the decommissioning of Fukushima Daiichi NPS in an open manner to the international community. In addition, Japan is expected to fulfill part of its responsibility to the international community by sharing the experiences gained through the decommissioning with other countries. From these perspectives, Japan has been making efforts to strengthen international cooperation by concluding cooperation agreements with relevant overseas organizations. It is important to gain international understanding as our country moves forward with the decommissioning of Fukushima Daiichi NPS. To this end, in addition to gathering of wisdom and sharing of experience, it is necessary to disseminate transparent information to the international community and to engage in continuous dialogue.

The Japanese government, TEPCO, and NDF are each working with their counterparts to share technical cooperation, information, experience, lessons learned, etc., with the aim of building a strong cooperative relationship for long-term decommissioning in the future. Moreover, from the viewpoint of maintaining a foundation for utilizing and collecting the knowledge of experts from around the world, NDF annually holds the International Forum on the Decommissioning of the Fukushima Daiichi NPS (hereinafter referred to as the “International Forum”), continuously disseminates information on the current status of and issues related to decommissioning.

6.2.2 Key issues and strategies

(1) Integrating and giving back the wisdom and knowledge from around the world

To ensure the decommissioning of Fukushima Daiichi NPS, it is necessary to learn lessons from the decommissioning activity examples of experienced legacy sites and apply them to decommissioning, and to utilize world-class technologies and human resources, in other words, to mobilize and utilize the world's wisdom. TEPCO has stationed staff at legacy sites to obtain technical knowledge of decommissioning and operational know-how through practical experience, and regularly conducts visits of legacy sites and information exchanges with decommissioning-related organizations and companies. NDF is committed to bringing together the wisdom of the world through regular exchange of information with the public decommissioning implementation entities with a central role in each country. Japan has received a variety of support from overseas through the dissemination of information to the international community, participation in international joint activities, etc. It is necessary to continue to gather world wisdom in technical and operational aspects. Therefore, it is expected that the decommissioning will be undertaken with the following three strategies into consideration.

① Strengthening cooperation with counterparts

TEPCO, as an entity that implements decommissioning steadily, and NDF, as an organization that provides advice and guidance to ensure proper and steady implementation of decommissioning from a mid-to-long-term perspective, will maintain a high level of relationship with their respective counterparts and continue to regularly exchange information, which will be reflected and utilized to the maximum extent possible to solve the required issues.

② Expanding the scope of information collection

It is desirable to explore the possibility of applying general-purpose technologies from more countries to decommissioning and collect technical information, including countries that do not use nuclear technology.

③ Return of results

The project will continue these mutually beneficial relationships while being conscious of returning the expertise and results accumulated domestically so far to the international community. It is also effective to maintain interest in decommissioning technology by responding not only to accidents or decommissioning, but also to aspects such as applications to issues other than nuclear power.

(2) Maintaining and developing the international community’s understanding, interest and cooperation in decommissioning

The challenge is to maintain and develop the international community’s understanding, interest and cooperation in order to bring together the world’s wisdom in the decommissioning of Fukushima Daiichi NPS and to limit the risk of confrontational structures to the implementation of decommissioning as far as possible.

International opinion can considerably impact the progress and success of decommissioning. Therefore, it is necessary to define a policy for international cooperation, taking into account the impact that the spread of misperceptions regarding the decommissioning of the Fukushima Daiichi NPS overseas affects the decommissioning progress. The strategy for gaining international understanding needs to be divided into ① an approach for experts and ② an approach for the general public.

① Approach to experts

It is fundamental for the international community to understand that the efforts toward the decommissioning of the Fukushima Daiichi NPS are scientifically and technically valid and accurately understood by experts abroad. Approximately 12 years have passed since the accident, and there are signs of a decline in international interest in decommissioning technology and progress, as seen in the decreasing number of papers on decommissioning of the Fukushima Daiichi NPS presented at recent international conferences. In order to maintain interest outside Japan, dialogue and exchange with foreign counterparts should be activated outside Japan among technology implementers, technology developers, and researchers involved in the practical implementation of the technology, beyond the public and private sectors.

Until now, based on the framework for cooperation in decommissioning technology, information has been disseminated and exchanged mainly with advanced nuclear power countries that own legacy sites. These activities are significant in complementing the international publicity and are important in gaining international understanding in that they can directly communicate the latest technical information to foreign experts. Furthermore, with regard to unprecedented efforts being made in a peculiar environment of the Fukushima Daiichi NPS, such as fuel debris retrieval and waste management, it is also important to incorporate opinions from new perspectives as well as gain an accurate understanding of the efforts being made through dialogue with many experts from neighboring countries and countries that do not use nuclear technology. It is also expected that the understanding of these experts can be used as a springboard for the spread of correct understanding in their countries. Japan should also support socially influential experts to speak out based on correct knowledge in their own countries and ultimately have a positive impact on international public opinion.

In order to contribute to the formation of international public opinion based on scientific and accurate information, the world's experts must first be correctly understood. Recognizing this, Japan should work also with national government agencies and international organizations to disseminate information and engage in ongoing dialogue with relevant parties on the achievements of its efforts towards decommissioning.

② **Approaches to the general public**

The interests of the recipients of the information have changed since the time of the accident, and there are some gaps between countries in the amount of knowledge and information that are the basis of understanding. Moreover, it is desirable for Japan to actively provide information on the accident at the Fukushima Daiichi NPS, and activities and achievements toward decommissioning to countries other than advanced nuclear nations in cooperation with international organizations.

Regarding the discharge of ALPS-treated water into the sea, the Ministry of Foreign Affairs of Japan (MOFA) and the Ministry of Economy, Trade and Industry (METI) are taking the lead in actively publicizing the issue, based on scientific perspectives. In addition, the Japanese government has implemented concerted measures, such as responding to IAEA reviews by METI and the NRA.

It is difficult to proceed with the decommissioning of the Fukushima Daiichi NPS without global understanding. We will endeavor to build trust by actively and strategically returning to the international community the knowledge, etc. obtained in the course of conducting research on the accident at the Fukushima Daiichi NPS and the decommissioning of the plant. Furthermore, as a responsibility of Japan, which caused the accident, the government and other domestic organizations concerned must continue to provide highly transparent and accurate information on decommissioning of nuclear power stations, which should be strategically addressed in the future.

6.3 Local community engagement

6.3.1 Significance and the current status of local community engagement

The fundamental principle for the decommissioning of the Fukushima Daiichi NPS is “coexistence of reconstruction and decommission”. While progress in reconstruction is being made gradually, decommissioning should never become an obstacle to the reconstruction process. It is important to sincerely listen to local residents’ concerns and questions, and to deepen their understanding and reassure them about the decommissioning process through two-way communication. To this end, the government is exchanging views with concerned local organizations at The Fukushima Advisory Board on Decommissioning, Contaminated Water and Treated Water, and other organized meetings; disseminating information through videos, websites, brochures, and other media summarizing the current status of decommissioning; and holding information meetings and roundtable discussions for local residents and relevant local governments. NDF also holds international forums where local residents and other participants exchange frank opinions on decommissioning with related organizations. TEPCO actively disseminates information utilizing its website and brochures, and accepts visitors to the Fukushima Daiichi NPS.

In order to carry through the decommissioning of the plant over a long period of time, the continued cooperation of local and other companies is essential. Moreover, inviting local companies to participate in the decommissioning project and revitalizing decommissioning-related industries in this region will be an important pillar in contributing to Fukushima's reconstruction. Therefore, based on the "Commitment to the people of Fukushima to achieve both reconstruction and decommissioning" formulated at the end of March 2020, TEPCO has organized its initiatives for the industrial cluster for decommissioning into three major categories: (1) increasing participation of local companies, (2) supporting local companies to step up, and (3) creating new industries locally, and phased in the initiatives. With regard to (1) and (2), TEPCO has promoted these initiatives in cooperation with the Fukushima Innovation Coast Framework Promotion Organization and the Fukushima Sousou Reconstruction Promotion Organization, and from FY2022, has provided information to help local companies consider participation by clearly indicate more specific tasks that are candidates for participation by those companies in the "Medium-to-Long-term Ordering Outlook in the Decommissioning" prepared since September 2020. This information is provided. With regard to (3), in order to build a system for integrated implementation of decommissioning projects locally in the 2020s, "Tousou Mirai Manufacturing Corporation" to establish a plant to manufacture core products necessary for decommissioning, and "Tousou Mirai Technology Co. Ltd." to conduct basic design necessary to further expand of fuel debris retrieval in scale in October 2022.

6.3.2 Key issues and strategies

(1) Communication issues and strategies

Since misunderstandings, concerns, and rumors caused by inappropriate dissemination of information regarding decommissioning will not only delay decommissioning but also hinder the reconstruction of Fukushima, TEPCO will continue to face the issue of communicating the current status of decommissioning in a timely and easy-to-understand manner. Therefore, along with efforts involving direct participation such as face-to-face meetings and inspection tours, TEPCO will strengthen communication that can be conducted in a non-face-to-face and non-contact manner.

Another issue will be to ensure that the government, NDF, and TEPCO work together appropriately, provide information more carefully, and work to build trust with the community. For this purpose, while proactively working in cooperation with related organizations, accurate information should be provided in an easy-to-understand and courteous manner by communicating in both directions through dialogue. In particular, with regard to the disposal of ALPS-treated water, the government and TEPCO are taking measures to disseminate information and suppress reputational impact, as dissemination of accurate information and measures against reputational damages will continue to be issues.

(2) Issues and strategies related to the creation of a regional industrial and economic base through decommissioning

As the initiative for "(3) creating new industries locally" is relatively large-scale investment, and it is required to steadily promote and strengthen the initiative. On the other hand, since manufacture of highly-functional products requires advanced technology, the issue is whether this will lead to the active participation of local companies. For the time being, the current initiatives including “(1) increasing participation of local companies” and “(2) supporting local companies to step up” should be continued and strengthened, while carefully explaining the study status of new decommissioning-related facilities to the local governments, commercial and industrial organizations, etc., to gain their understanding and cooperation. Furthermore, with the cooperation of prime contractors, it is also necessary to consider and implement on a trial basis various approaches, including ordering and contracting, that will make it easier for local companies to receive orders. Moreover, by clearly indicating candidate tasks for participation by local companies in the “Medium-and-Long-Term Ordering Outlook of Decommissioning” in FY2022, it is important to continue to conduct initiatives to increase participation. It is therefore necessary to continue to promote initiatives to facilitate participation by local companies and initiatives that enable local companies to continue to foresee orders of a certain size.

To steadily promote efforts of coexistence with local community, TEPCO needs to further strengthen its partnership and collaboration with local governments and relevant local organizations, along with close internal cooperation. NDF will support TEPCO's efforts to promote regional coexistence, and will work to strengthen coordination and collaboration with local governments and relevant local organizations.