Phase: **Action**

Decommissioning Process **"Processing/Disposal/Environment Remediation (including Wastes containing Alpha Nuclides originating from Fuels)"**
Investigation Subject **"Clearance"**
Issue **"Waste volume reduction by clearance"**

Needs

1. Understanding rational processing and disposing method of waste (concrete and metal) generated from dismantling

Processing/Disposal/Environment Remediation：【Long 2】

Desired state and reasons for it

- In order to reasonably investigate how much dismantling waste can be reduced by clearance, it is necessary to investigate measurement and sorting scenarios of dismantling wastes with radioactive materials attached, such as concrete and metal.
- In order to reasonably investigate how much dismantling waste can be reduced by clearance, it is necessary to have a technology for decontamination of dismantling wastes with radioactive materials attached, such as concrete and metal.

Current state against ideal

- Concrete debris is being crushed and recycled into roadbed material after surface dose rate is confirmed to be equivalent to background dose rate.
- Melting decontamination is being investigated as a decontamination method for recycling metals. In Government-led R&D Program on Decommissioning, Contaminated and Treated Water Management, investigations are underway to elucidation of the nuclide distribution behavior during melting and decontamination, and verification methods after melting treatment.

Issues to be resolved

- Since the amount of waste generated from dismantling is large, it is necessary to have a decontamination technology to reduce the volume of waste through clearance.
- Metal recycling by the molten slag decontamination method is considered a promising candidate technology because it has already been proven in many Western countries. It is necessary to evaluate the applicability of this technology by focusing on the nuclear species and other conditions that differ between Western countries and the Fukushima Daiichi Nuclear Power Plant.
- Since concrete debris will be continuously generated as decommissioning work progresses, it is necessary to appropriately evaluate the balance between the volume of generation and recycling in the future, and if additional measures are required, it is necessary to investigate a measure of the lead time.

2. Developing and rationalizing the analysis method under the unique environment of Fukushima Daiichi NPS, and speeding up the analysis

Desired state and reasons for it

- In order to obtain good analytical results, it is effective to adequately maintain (1) analytical methods and systems, (2) quality of analytical results, and (3) appropriate sample size and quantity.
- There are environmental elements unique to Fukushima Daiichi NPS, such as high background. It is desirable to develop an analysis method under high background.
- A large amount of concrete and metal wastes will be generated from dismantling, etc. in the future. Since rapid clearance of a large amount of waste will lead to smooth decommissioning, it is desirable to streamline the analysis method.
- It is desirable for TEPCO, which will reflect the analysis results in each decommissioning process, to take the lead in establishing and organizing an analysis system, analysis facilities and functions that enable efficient collection and evaluation of analysis results.
- As analytical demand expands in lower concentration areas, such as ALPS treated water and environmental samples, because of the small amount of radioactive elements contained, there will be a need to improve detection accuracy. As demand for analysis of high-dose areas such as fuel debris and high-dose waste expands, it will be necessary to expand radiation protection functions such as shielding and confinement and to diversify analytical items such as elemental distribution and structural analysis.
- In order to make effective use of analytical facilities, it is necessary to balance the information and quantity, detection accuracy, and frequency of analysis etc., to be obtained for analytes, and to develop a plan that takes into account periodic maintenance of analysis equipment and other factors.
- Solid wastes are characterized by a variety of nuclide compositions and radioactivity concentrations and have large quantities. For this reason, unlike the development of waste confirmation methods for ordinary power reactors, development related to the waste confirmation methods specific to the waste of the Fukushima Daiichi Nuclear Power Plant, such as data acquisition, accumulation, organization, and application of statistical methods for setting scaling factor methods and other evaluation methods, is required.
- It is required to consider in advance the qualities expected of each analytical personnel for various analytical tasks, and to systematically develop analytical personnel so that the required roles can be achieved appropriately.

Current state against ideal

- TEPCO identified wastes with high analytical priority based on analytical progress and storage management risks and developed policies and analytical plans for characterizing the properties of each waste based on the characteristics of each waste in 2023. Subsequently, as a reflection of the policies and plans presented at the technical meetings for the review of implementation plans for specific nuclear facilities, etc., analyses were conducted to develop a solidification treatment policy for water treatment secondary waste, etc., to develop a method to control radioactivity concentration of rubbles, to investigate dismantling model cases for building dismantling materials, etc., and review of analysis priority, and updating the number of analyses based on the status of sample collection, etc. are conducted.
- To date, JAEA, together with Nippon Nuclear Fuel Development Co. Ltd. and MHI Nuclear Development Corporation, has conducted analyses of sediments, deposits, solid waste samples,

etc. associated with PCV internal investigations. Based on the experience and achievements to date, JAEA examines the items to be analyzed for fuel debris and the analysis flow required to solve the issues from the viewpoint of the needs for safe and steady progress of decommissioning work.

- The Nuclear Regulation Authority of Japan (NRA) is updating its medium-term risk reduction target map with the aim of clarifying what should be achieved in the medium to long term toward decommissioning and the goals to achieve them. Considering the importance of the transition to stable storing of radioactive materials, the areas for risk reduction where efforts should be prioritized for solid radioactive materials include water treatment waste, etc., rubbles, etc., and building dismantling materials. In addition, it also indicates the analyses that need to be completed in order to achieve the "ideal state to be realized".

Research and facilities

- Development is underway for an analytical methods of simple and rapid data acquisition and an analytical method for various sample forms and difficult-to-measure nuclides, while standardization is underway for an analytical method of rapid analysis through streamlining and automation of sample preparation.
- Efforts are being made in the Project of Decommissioning, Contaminated Water and Treated Water and other related projects to develop methods for understanding the properties of contaminated water with less analytical data, such as a data acquisition planning methods using the DQO process and Bayesian statistics, and the statistical inventory estimation method.
- The waste from fuel debris removal is a mixture of molten fuel and structural materials. If it is possible to quickly confirm whether or not uranium is contained in the adhered materials to damaged supports, pipes, etc., it is expected to improve the workability of the process. Therefore, technological development using laser-induced breakdown spectrometry has been conducted as a simplified (in-situ) analysis technique.
- In addition to the conventional sample analysis, studies were started in FY2020 on the reduction of uncertainty of fuel debris properties by other measurement methods in the Project of Decommissioning, Contaminated Water and Treated Water. Facility management, etc. of JAEA's Radioactive Material Analysis and Research Facilities became operational in 2018; the Laboratory 1 (for the purpose of analysis of solid waste and implementation of third-party analysis of ALPS process water) started analytical work in October 2022; third-party analysis of ALPS process water started in March 2023; and the Laboratory 2 (for the purpose of analysis of solid waste and implementation of third-party analysis of ALPS process water) started in March 2023. The second building (for analysis of fuel debris) is scheduled to be completed in FY2026, while the application for approval of changes to the implementation plan is being reviewed and the project operator is being selected. In addition to the current routine analysis, TEPCO is also considering the construction of an analysis facility (comprehensive analysis facility) based on future analysis needs, such as analysis of fuel debris and solid waste, and aims to complete construction in the late 2020s.

Human resource development

- Exchange of personnel between TEPCO and JAEA and acceptance of personnel from Japan Nuclear Fuel Development Corporation to TEPCO have been ongoing.
- TEPCO estimates that in addition to the current system, about 30 additional personnel will be needed toward the 2030s for waste analysis, and have started training them by having them participate in analysis-related projects to gain practical experience under the Project of Decommissioning, Contaminated Water and Treated Water since FY2023. Since the analysis staff at the Fukushima Daiichi Nuclear Power Plant had only experience in analyzing liquid samples, in preparation for the launch of the comprehensive analysis facility, analysis training for high-dose samples using hot cells and glove boxes is provided in the Building 1, and future candidates for

analysis engineers are dispatched from FY2023 to participate in R&D and are being fostered to become analysis engineers.
- JAEA has formed an analytical technology network utilizing the Ibaraki area and universities, and is working to secure and develop human resources through the implementation of verification of analysis and advancement of analytical technology at the JAEA Okuma Analysis and Research Center.

Issues to be resolved

- The analysis plan will be continuously updated to reflect changes in needs and other factors as decommissioning progresses in the future. In addition, it is necessary to implement the initiatives in the plan and to constantly review necessary measures based on the progress of the plan.

Research and facilities

- The development of analytical methods is planned to be verified at JAEA's Radioactive Material Analysis and Research Facility Laboratory 1 to establish analytical methods and to determine properties based on an analysis plan that takes into account TEPCO's needs.
- It is necessary to develop a technology that enables sufficient analysis even under high background conditions.
- A large amount of concrete and metal waste will be generated in the future due to demolition and other activities. Simplification is required because it takes time to conduct analysis based on clearance criteria,.
- As there are more analysis items for fuel debris than for waste, such as metallographic observation, microstructural observation, and elemental mapping, then there is a concern that the analysis capacity of the Laboratory 2 will be exceeded after the building begins operation. In addition, since the method of treatment and disposal of fuel debris will be determined in the third phase, it is necessary to investigate using the collected fuel debris to obtain data related to treatment and disposal, such as measurements of thermal properties and hydrogen generation by water radiolysis.

Human resource development

- TEPCO have to train personnel in a field in which it has little experience in as short a time as possible, and it is important for TEPCO to make efforts to efficiently train analytical technicians with the cooperation of JAEA and private companies that have sufficient knowledge and experience in the handling of alpha nuclides and fuel analysis technologies.
- It is necessary for TEPCO and JAEA to mutually identify changes in analysis needs and issues over time, and promote human resource development in cooperation, while the Agency for Natural Resources and Energy, NDF, and other related organizations should also provide support for securing analysis personnel.
- With the expected expansion of analytical demand in the future, advanced human resources capable of planning analytical plans will be necessary in anticipation of how to utilize analytical results.

3. Reducing the waste amount by reusing inside the premises

Processing/Disposal/Environment Remediation：【Long 1】

Desired state and reasons for it

- It is desirable to develop specific technologies for reuse of waste inside the premises. For example, wastes can be reused as shielding blocks or as fillers.

Current state against ideal

- Concrete debris is crushed and recycled into roadbed material after surface dose rate is confirmed to be equivalent to background.
- Melting and decontamination are being investigated as decontamination methods for recycling metals. In Government-led R&D Program on Decommissioning, Contaminated and Treated Water Management, investigations are underway to elucidation of nuclide distribution behavior during melting and decontamination, and verification methods after melting and treatment.

Issues to be resolved

- It is necessary to investigate usage and develop a technology for effective utilization of waste with low contamination.
- Metal recycling by the molten slag decontamination method is considered a promising candidate technology because it has already been proven in many Western countries. It is necessary to evaluate the applicability of this technology by focusing on the nuclides and other conditions that differ between Western countries and the Fukushima Daiichi Nuclear Power Plant.
- Since concrete debris will be continuously generated as the decommissioning work progresses, it is necessary to appropriately evaluate the balance between the volume of generation and recycling in the future, and if additional measures are required, it is necessary to investigate a measure considering the lead time.

4. Improving social acceptance of off-premises reuse

Processing/Disposal/Environment Remediation：【Long 1】

Desired state and reasons for it

- In the future, it is desirable to enhance social acceptability so that consensus building with the public can be carried out smoothly when the cleared waste is actually reused outside the premises.

Current state against ideal

- At this stage, the investigation is not well underway.

Issues to be resolved

- For the reuse environment and scientific safety regarding the wastes to be reused, it is necessary to establish an accurate and easy-to-understand explanation method and system.

Relevant Issues

➢ PDR-102 “Waste strategy”