Technical Strategic Plan 2018 for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.

(Explanatory material)

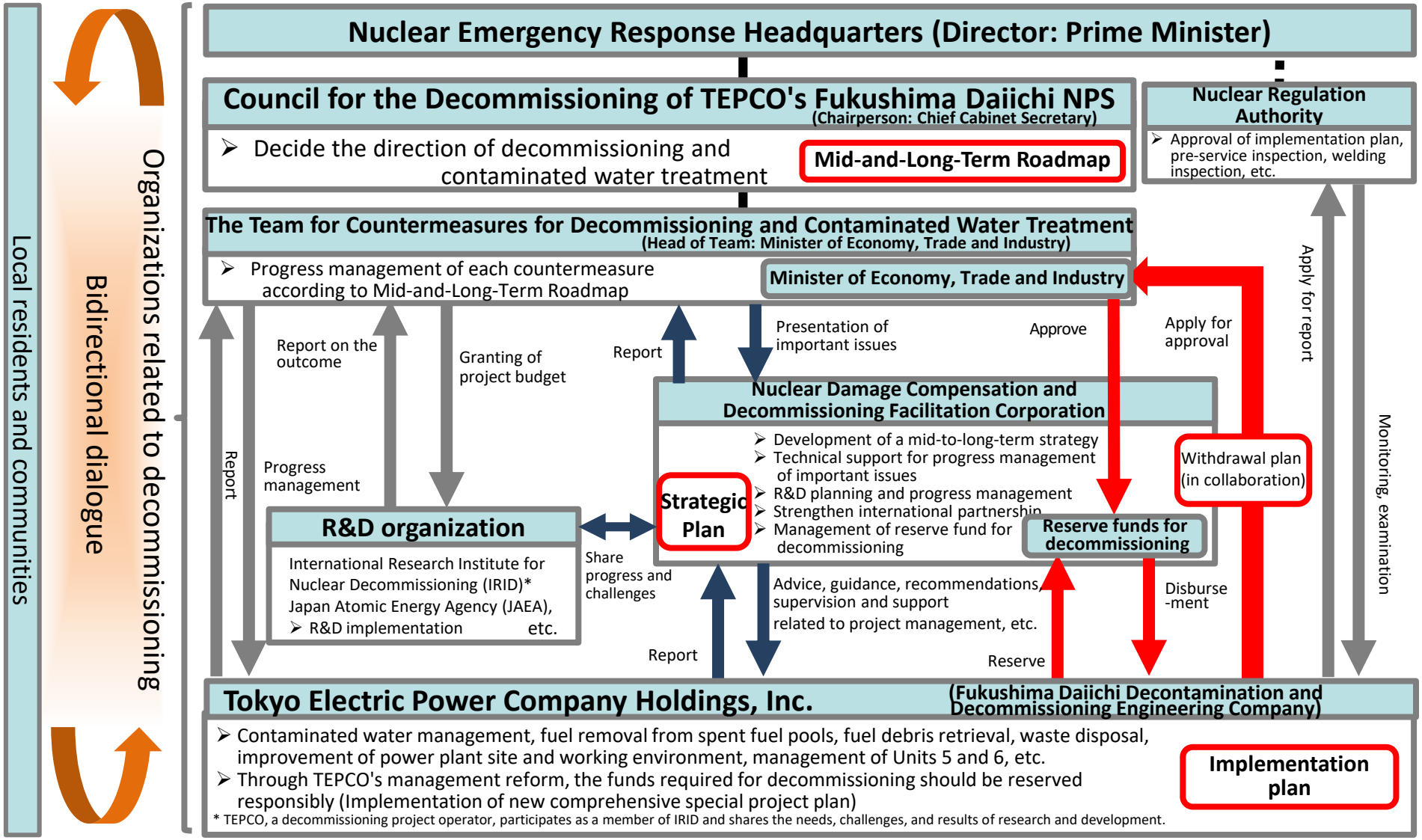
October 2, 2018

Nuclear Damage Compensation and Decommissioning Facilitation Corporation

NDF

Contents

1. Introduction
(Roles & Responsibilities of Organizations Relevant to the Fukushima Daiichi NPS Decommissioning)



1. Introduction (Positioning of the Strategic Plan)

Structure of the Strategic Plan

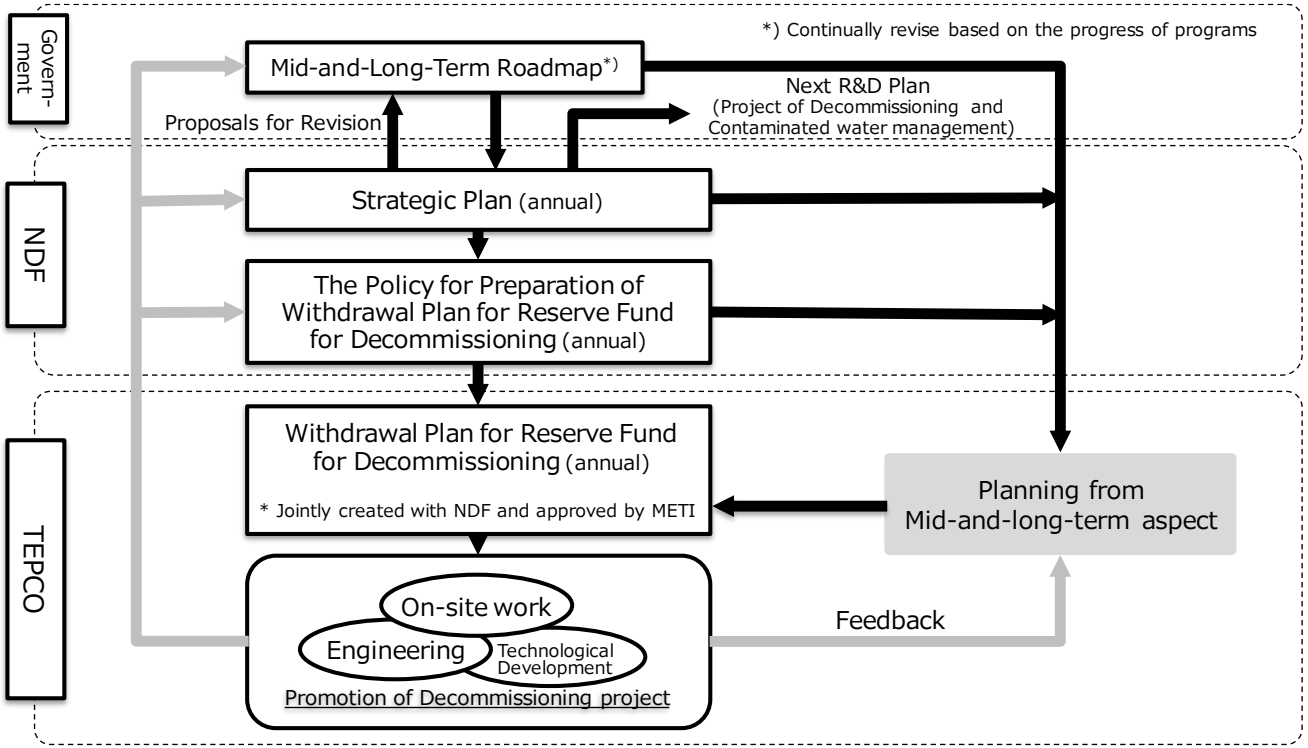
(Strategic Plans to date) Focusing on **Fuel debris retrieval work and Waste management**
as Mid-and-Long-term decommissioning strategies

(Strategic Plan 2018 and later) Adding **Contaminated water treatment** and **Fuel removal from spent fuel pool**

・Providing directions with mid-and-long-term aspect by **overlooking the entire project** from the viewpoint of relevance and consistency with fuel debris retrieval

Positioning of the Strategic Plan based on Reserve Fund for Decommissioning

● Reflecting to "the Policy for Preparation of Withdrawal Plan for Reserve Fund for Decommissioning" through the study for the Strategic Plan



Programs to be included into Withdrawal Plan

- Contaminated water treatment PG
- Pooled fuel retrieval PG
- Fuel debris retrieval PG
- Waste management PG
- Power plan site/Work environment improvements PG
- Management of Unit 5 and 6 Misc. facility/operational management

2.Decommissioning of the Fukushima Daiichi NPS as Risk Reduction Strategies (1/3)

Basic concept of decommissioning

To continuously and quickly reduce the radioactive risk caused by the accident that does not exist in the usual NPS

Progress of decommissioning

Cover for fuel removal was installed (Unit3)
(Photo/video library:TEPCO)

Contaminated water treatment

【Remove】(ongoing) Being purified with multi-nuclide removal equipment
【Redirect】(Mar. 2018) Land-side impermeable wall completed except for deep areas
【Retain from leakage】(ongoing) The concentration of radioactive materials in the surrounding sea area is constantly low
【Stagnant water treatment in the building】
(Dec.2017) In the Unit 2 - 4 turbine building, the level of the stagnant water lowered and the lowest floor's intermediate ceiling was exposed
(Dec.2017) For the condensers in Unit 1-3, draining of highly radioactive stagnant water completed

Fuel removal from spent fuel pool

- Unit 1 (Jan.2018) Rubble removal in the north of the operating floor was started
- Unit 2 (Jun.2018) Opening to provide access to the operating floor was made
  (Jul. 2018) Investigation in the operation floor was started
- Unit 3 (Feb.2018) Installation of a cover for fuel removal was completed, trial operation of fuel handling machine is being performed

Fuel debris retrieval

- Unit 2 (Jan.2018) Internal investigation of PCV was conducted
- Unit 3 Based on the results of investigation in July 2017, 3-D shape restoration of inner pedestal was conducted

Image taken inside the pedestal (Unit2)
3rd International Decommissioning Forum:TEPCO

Waste management

- (ongoing) Sampling/analysis has been made for the purpose of characterization
- (Feb.2018) Operation of solid waste storage building No. 9 started
- (Jun.2018) Storage management plan was revised

2.Decommissioning of the Fukushima Daiichi NPS as Risk Reduction Strategies (2/3)

- Risk level is expressed as the product of “Level of Impact” and “Likelihood of Occurrence” of the event associated with risk source
- The method based on the SED* developed by Nuclear Decommissioning Authority (NDA) is used to express the magnitude of risk in the Strategic Plan

* Safety and Environmental Detriment score

① Hazard Potential

- An index to indicate the level of impact, refers to the definition by SED
- It depends on the inventory(amount of the radioactive material), form of the risk source (gas, liquid, solid, etc.) and time allowable until the manifestation of the risk when loss of safety function occurs
- Examples of reduction measures: Decrease in inventory and decay heat associated with radioactive decay, change of form by treating contaminated water to change into secondary waste

② Safety Management

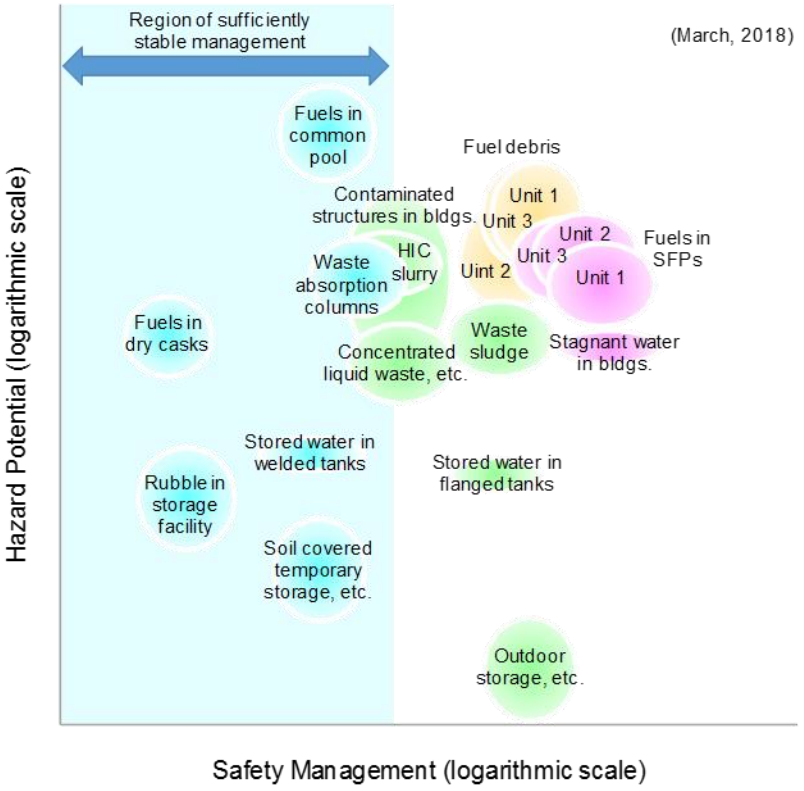
- An index to indicate the likelihood of occurrence of the event, adapted the definition by SED to the Fukushima Daiichi NPS
- It depends on the integrity of the facility and containment and monitoring status of the risk source
- Examples of reduction measures: Transfer of fuel in the pools to the common pool, replacement of rubble stored outside to the storage

Safety Management is generally to be easily achieved

Interim Goal

To bring the risk levels into the “Region of sufficiently stable management” (pale blue area)

Example of risk levels assigned to the risk sources at the Fukushima Daiichi NPS



2.Decommissioning of the Fukushima Daiichi NPS as Risk Reduction Strategies (3/3)

Basic Approach to Risk Reduction

- The decommissioning of the Fukushima Daiichi NPS is **a project with inherent considerable uncertainty**
  - **Placing safety at the top priority, to make integrated decisions taking flexible and prompt approach**, based on the directions determined with previously obtained experience and knowledge.
  - To flexibly address the issues **with experiences**, reflecting the information obtained in advance on the subsequent works.

Viewpoint to make Integrated decisions (Five guiding principles)
◆ **Safe** (Reduction of risks posed by radioactive materials and ensuring work safety)
◆ **Proven** (Highly reliable and flexible technologies)
◆ **Efficient** (Effective utilization of resources (e.g. human, physical, financial and space)
◆ **Timely** (Awareness of time axis)
◆ **Field-Oriented** (Thorough application of Three Actuals (actual field, actual things and actual situation)

Order of Priority

- **TEPCO and NDF have just introduced project management mechanism**
  - Be aware of position of each project and their mutual relationship in managing progress of overall project
  - Aim at choosing the best option, with the viewpoint of the entire site on a long-term basis and considering time axis

Addressing temporary increase of risk level associated with the decommissioning operations

- The decommissioning work is **striving for prompt risk reduction** from the mid/long-term viewpoint
- For possibility of a temporary increase in the risk level and a rise in workers' exposure arising from the decommissioning work, **the risk level during the work must be limited within the permissible range.**
- In case the decommissioning work is delayed excessively, existing risks will remain over the long term and **their risk levels can gradually increase** as the buildings and facilities deteriorate over time. Considering the time needed for associated preparations and work, and many other constraints, **cautious and comprehensive decision making is required for the early implementation** of the decommissioning.

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

Sectoral Target (Fuel debris retrieval)

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

(2) Toward determination of fuel debris retrieval method for the first implementing unit in FY 2019, and start of fuel debris retrieval for the first implementing unit within 2021, **necessary approaches will be taken according to policy on fuel debris retrieval**.

Policy on Fuel Debris Retrieval

① **Step-by-step approach**
- Adjust the direction flexibly as retrieval proceeds

② **Optimization of entire decommissioning work**
- Examine as a comprehensive plan including coordination with other construction work at the site

③ **Combination of multiple methods**
- Combine optimum retrieval methods suitable for the part of each unit where fuel debris is expected to be present

④ **Approach focused on partial submersion method**
- Base the efforts on the partial submersion method that is feasible.

⑤ **Prioritizing fuel debris retrieval by access to the bottom of the PCV from the side**
- Considering accessibility to fuel debris and it could be performed at the same time as spent fuel removal

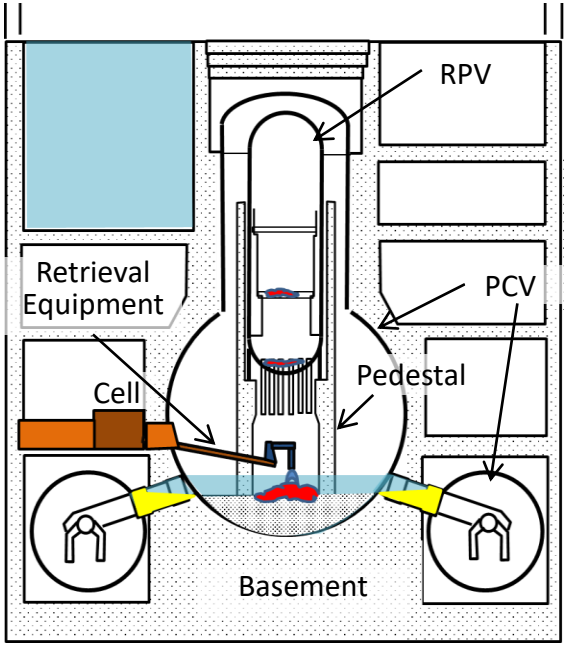
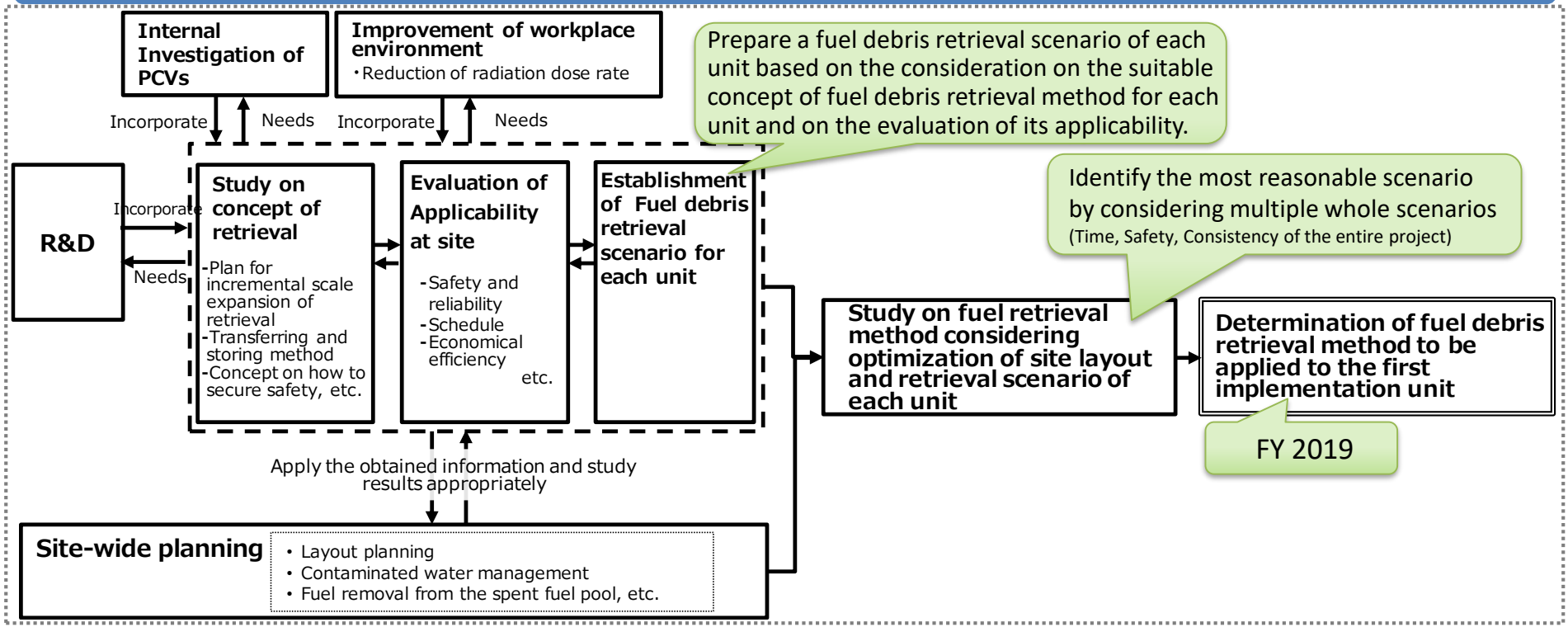


Image of Partial submersion-side access method

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

Sectoral Strategy (Fuel debris Retrieval)

How to proceed discussion toward fuel debris retrieval method for the first implementing unit



First implementation unit will be selected taking reliability of knowledge on inside condition of PCV, environment of working place of necessary preparatory works and risk assessment of each unit into account.

For instance, following must be considered;

- Unprecedented undertaking of fuel debris retrieval in the environment with many uncertainties
- The benefit of getting experiences and information of handling of fuel debris early

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

Sectoral Strategy (Fuel debris Retrieval)

Proceeding method of preliminary engineering

Items to be considered

- **Study on retrieval scenario that includes the whole related operations** ranging from internal investigation, preparations, improvement in the working environment to fuel debris storage.
- **In each step, information to be gained in advance should be organized** in order to secure safety and engineering reliability on the equipment for retrieval.
- **Clarification of prerequisites, evaluation on its uncertainties and forecast** concerning a development of the scenario should be conducted
- Sufficient safety evaluation should be implemented for the major troubles and others assumed at present.

Items to be expected

- **Image of operation process to fuel debris retrieval for each unit** and **identification of technical issues** to be solved
- **Engineering schedule** incorporating the period of solving the technical issues

Continued internal investigation

Accelerated/prioritized R&D

- It is necessary to draw up a roadmap for solving the technical issues extracted so far and identified in the process of implementing preliminary engineering, **through further internal investigation and accelerated/prioritized R&D**.

＜Continued internal investigation＞

- In the future internal investigation, it should be thoroughly identified what kind of data is necessary as part of assembling the whole project, then **implemented for the goal of each phase**.

＜Accelerated/prioritized R&D＞

- Accelerating and prioritizing R&D are to be proceeded including technology to manage the water level in the PCV, according to the fuel debris retrieval policy
- **Identify R&D tasks that their necessities have newly become clear** as a result of preliminary engineering

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

Technical issues and Future Plans (Fuel debris retrieval)

Concept of the step-be-step

	Internal Investigation		Fuel Debris Retrieval	
Image of procedure	Internal investigation (example)	Sampling (examples)	Small-scale Retrieval (examples)	Large-scale Retrieval (Side-access method) (examples)
	Obtain information to identify **distribution of fuel debris and accessibility**, information **to judge ensuring safety** for fuel debris retrieval operation	Obtain information to **improve the accuracy of feasibility of retrieval method** and to **improve the reliability of the protective measures** for ensuring safety	Collect and verify information to identify the work and equipment used for large-scale retrieval (**effectiveness of work/equipment of the fuel debris retrieval, effect on securing safety**, etc.)	Based on the data obtained from the operation until the small-scale fuel debris retrieval, **more efficient retrieval** will be performed

Retrieval Device/ Equipment

Images of fuel debris retrieval (Unit 2)

- Arm type access unit that can be installed **without expanding** X-6 penetration, etc.
- End effector is to be selected depending on internal investigation, sampling or fuel

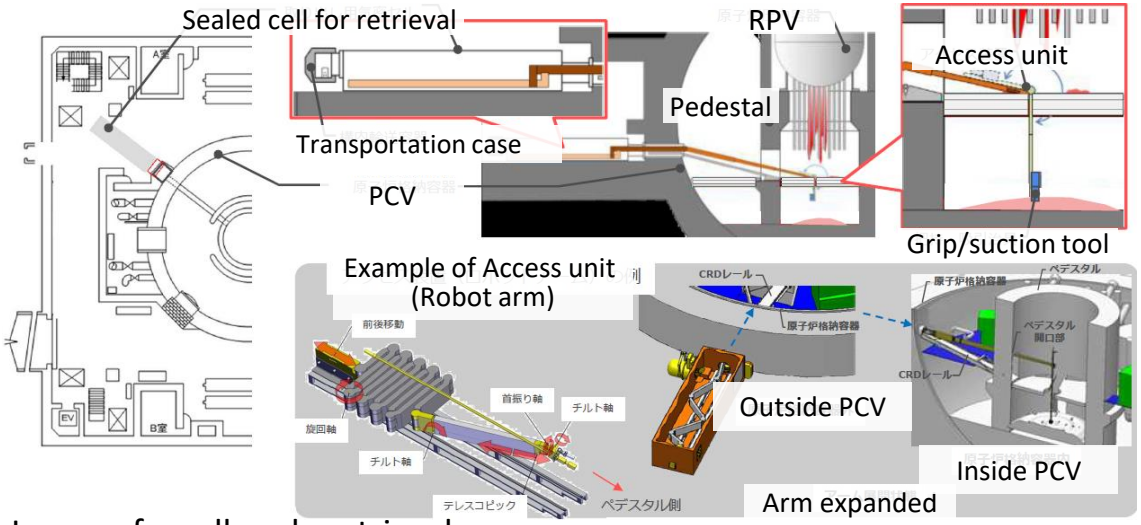


Image of small-scale retrieval

- **Expansion/modification** of X-6 penetration and installation of Arm with rail, etc. that is capable of large-scale operation

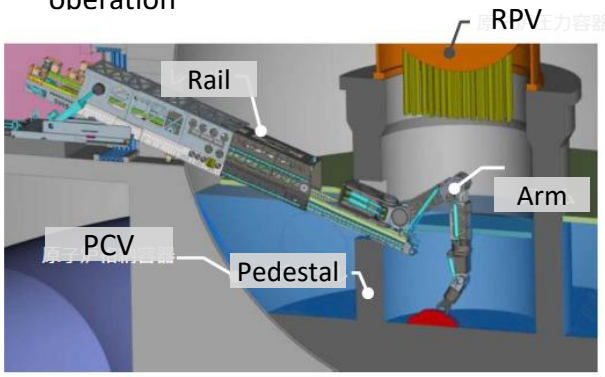


Image of large-scale retrieval
Side-access method (example)

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

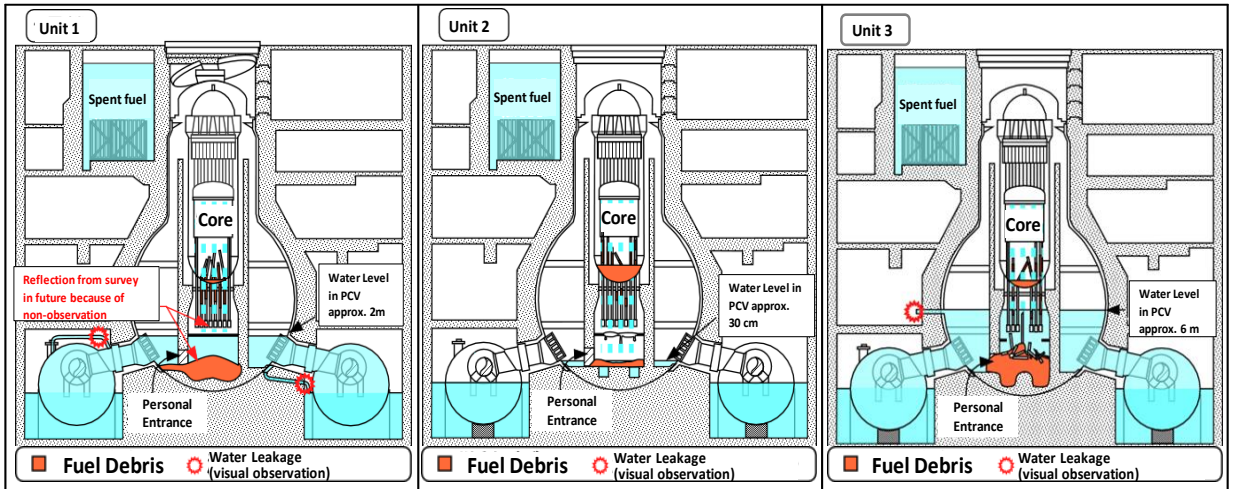
Technical issues and Future Plans (Fuel debris retrieval)

Comprehensive understanding of Reactor Conditions

Comprehensive analysis and evaluation results based on the information obtained so far

- Distribution of fuel debris
- Condition of access route and surrounding structure were analyzed and evaluated based on the following data.
  (The right figure shows distribution of fuel debris.)

- Actual measured value (Plant parameters, etc.)
- Accident progression analysis
- Info from PCV internal investigation, by muon-based detection
- Scientific know-how (experiment, etc.)



	Unit 1	Unit 2	Unit 3
Core Region	• Little fuel debris remains	• Little fuel debris remains • (Stub-shaped fuels might exist in peripheral region)	• Little fuel debris remains
RPV Lower Head	• A small amount of fuel debris is present • A small amount of fuel debris is present in the inside and on the outer surface of the CRD housing	• Large amount of fuel debris is present • A small amount of fuel debris is present in the inside and on the outer surface of the CRD housing	• Fuel debris remains on the RPV lower head party • A small amount of fuel debris is present in the inside and on the outer surface of the CRD housing.
Pedestal Inside	• Most of the fuel debris is present	• A small amount of fuel debris is present	• Amount of fuel debris in Unit 3 is more than that in Unit 2.
Pedestal Outside	• Fuel debris may have spread on the pedestal outside through the personal entrance	• The possibility of fuel debris spreading on the pedestal outside through the personal entrance is low.	• Fuel debris may have spread on the pedestal outside through the personal entrance.

Data based on “Decommissioning and Contaminated Water Treatment Subsidy Project (Advancement of Comprehensive understandings of internal reactor” The Institute of Applied Energy”, IRID, reported in 2017 (Issued in June 2018)

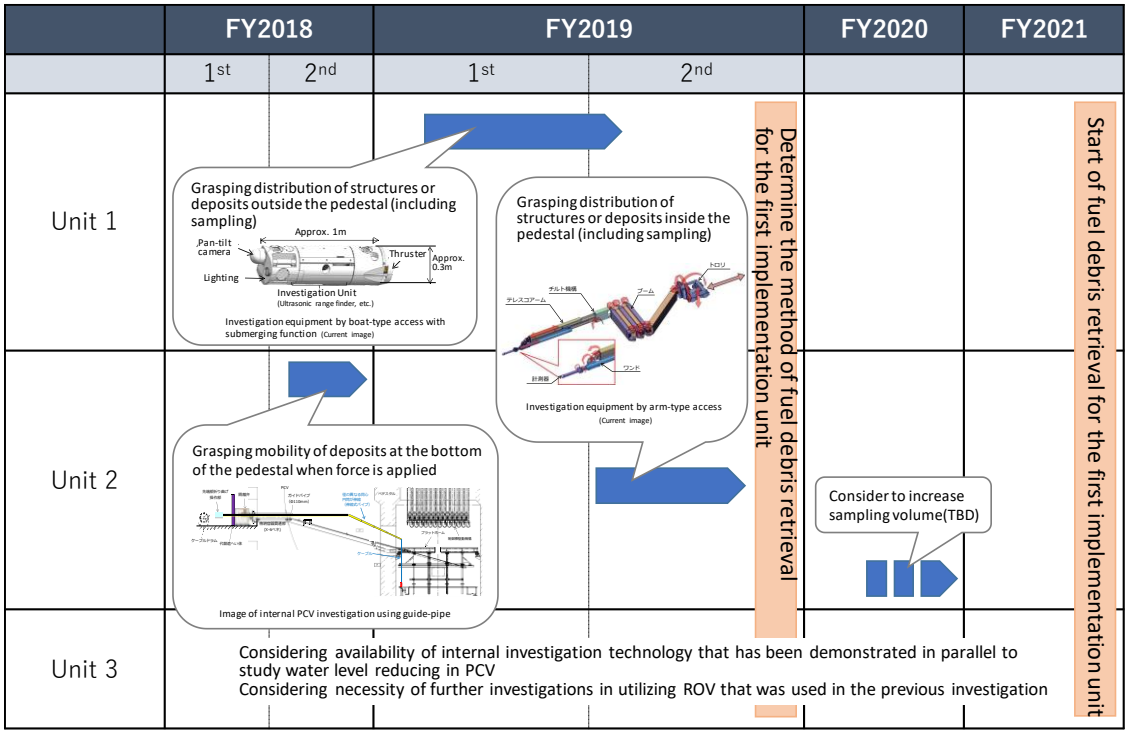
3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

Technical issues and Future Plans (Fuel debris retrieval)

Continuous implementation of internal investigations

- **Following investigation and study should be implemented** steadily to develop scenarios for fuel debris retrieval

Unit 1: Grasping distribution of structures or deposits outside the pedestal (including sampling) [scheduled in 1st half of 2019]
Unit 2: Grasping mobility of deposits at the bottom of the pedestal when force is applied [scheduled in 2nd half of 2018]
Grasping distribution of structures or deposits inside the pedestal (including sampling) [scheduled in 2nd half of 2019]
Consider to increase sampling volume [scheduled in FY2020]
Unit 3: Considering availability of internal investigation technology that was developed and proved by decommissioning and contaminated water treatment project, in parallel to study on water level reducing in PCV
Considering necessity of further investigation in utilizing underwater ROV that was used in the former investigation



3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

Technical Issues and Future Plans (Fuel debris retrieval)

Technical Requirement for ensuring security

It is important to study reasonable protective measures according to the scale of fuel debris retrieval work while taking actions to reduce the uncertainties of the PCVs' internal conditions during the conceptual design phases.

Technical Requirement	Technical Issue	Matters to be Considered
Establishing the containment functions (gas)	• Understanding of dispersion rate of α dust, etc.	• Obtain data while handling fuel debris, dispersion inhibition
	• Determine feasibility of negative pressure control in PCV	• Identify technical feasibility of negative pressure control based on the information that is obtained at each step
	• Exhaust gas management check	• Efficient recovery of dust, etc.
Establishing the containment functions (liquid)	• Inhibition of radioactivity concentration increase in cooling water through fuel debris retrieval	• Obtain data while handling fuel debris • Study on diffusion inhibition by recovering dust
	• PCV water seal feasibility	• Applicability of water seal technology with vent tube to real units
	• Setting of water level in PCV	• Evaluate from the viewpoint of fuel debris cooling and dust dispersion inhibition • Determine the intake site from PCV, monitor and control torus room water level
Maintaining the cooling functions	• Setting of temperature target for operation and countermeasure when abnormality occurs	• Set the PCV internal temperature target to enable implementation of each operation • Consider countermeasures, procedures, etc. at the time of occurrence of abnormality such as recovery of instrument
Criticality control	• Establishment of criticality evaluation method	• Refine criticality information based on the information that is obtained at each step
	• Local neutron measurement around retrieval point	• Select neutron detector and develop operation stop, etc. due to fluctuations in neutron flux
	• Determine the feasibility of measuring non-criticality degree	• Applicability to real units as well as study on retrieval system, examining verification of each technology
	• Detection of criticality by PCV gas management installations	• Acceleration of criticality detection, Possibility of estimation of the level of subcriticality of the entire PCV
Establishing structural integrity of the PCVs /reactor buildings	• Evaluation of Seismic Margin	• Evaluation of seismic margin taking into account the impact of accidents and deterioration • Study of countermeasures in the case of postulated damage to the structures
	• Corrosion mitigation measures during the fuel debris retrieval	• Study of corrosion mitigation measures conforming with the water treatment system
Reduction of radiation exposure	• External and internal exposure control while handling nuclear fuel materials containing α-nuclides	• Dose reduction plan considering contamination condition • Measurement management considering the mixture of alpha nuclides

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

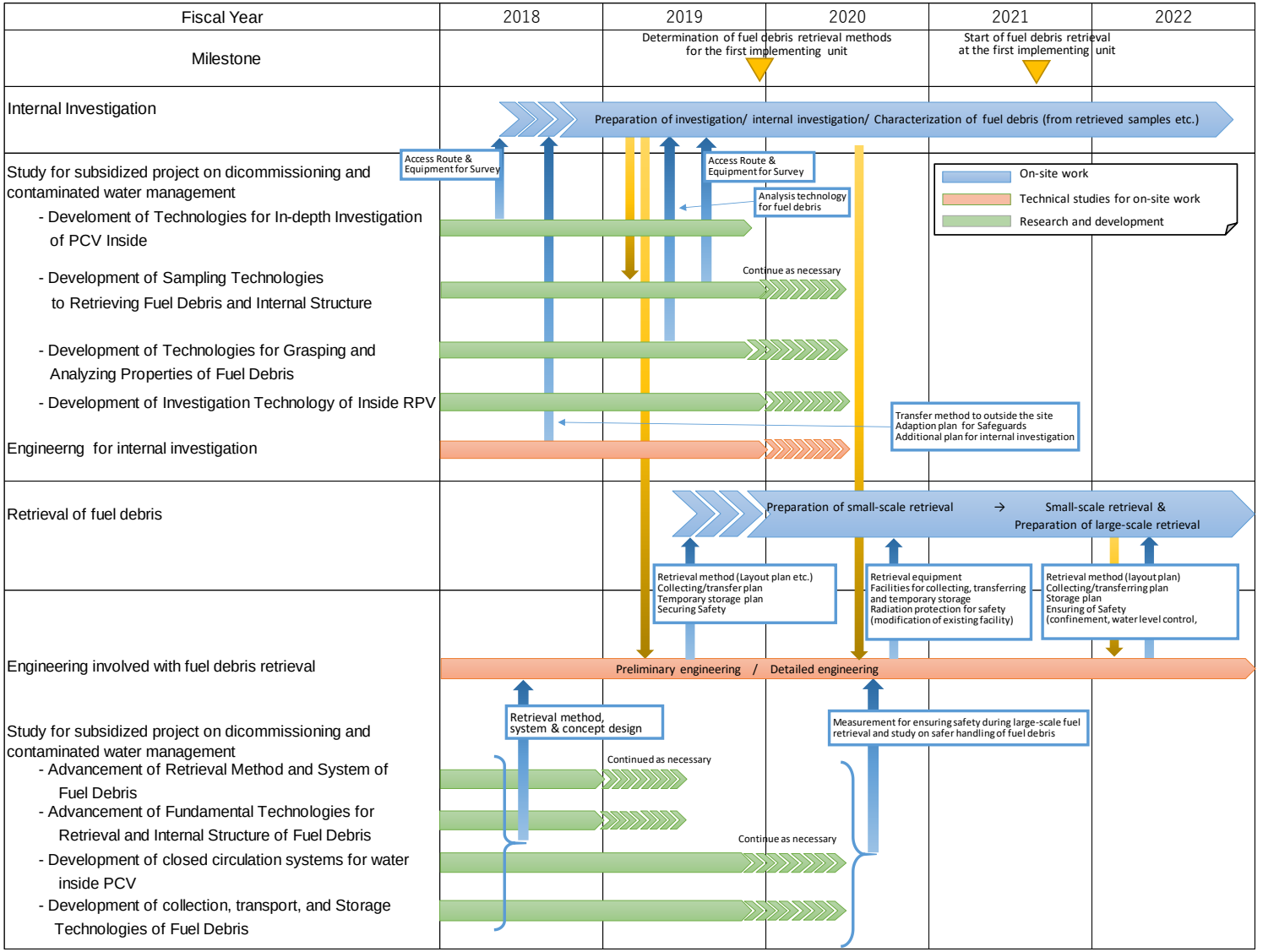
Technical Issues and Future Plans (Fuel debris retrieval)

Fuel debris retrieval method, Technical requirements regard to stable storage

Technical Requirement	Technical Issue	Matters to be Considered
Securing access route	• Establish access route for transporting, installing and unloading the equipment and devices used for fuel debris retrieval, and transporting fuel debris and waste	• Removing obstacles and reducing the dose • When establishing a new opening in the PCV, to suppress the release of radioactive materials and maintain the integrity of existing structures • it is considered on the premise of accessing from the top to the inside of the RPV.
Development of device and equipment	• Develop device and equipment to retrieve fuels debris safely, reliably and efficiently (Considering radiation resistance, remote investigation /maintainability, and a rescue mechanism that does not disturb the subsequent work when trouble occurs)	• The development of a recovery system that can handle various conditions of fuel debris, a fuel debris cutting system and a dust collecting • A technique for installing retrieval equipment • Plan for mock-up tests combining the developed devices and equipment
Establishment of system equipment and working areas	• Install system equipment to establish safety functions	• Actualizing installation method of negative pressure control system, a circulating water cooling/purification system, a criticality control system and a measurement system as a entire system
	• Securing space required for installing the fuel debris retrieval equipment and related system equipment	• Calculating the space required for installing each system • Study on setting up systems outside of the existing buildings
Handling of fuel debris (collecting, transferring and storing)	• Establish a comprehensive fuel debris handling system consisting of collecting, transferring and storing with safety function such as subcritical condition, containment function, countermeasures against hydrogen generation and cooling.	• Details of equipment/systems for collecting, transferring, and storing of the retrieved fuel debris • Storing facility adaptable to the safeguards • Mock-up test plan combined with a fuel debris retrieval device
Treatment of radioactive waste during fuel debris retrieval	• Safe and proper classification and storing of radioactive waste generated during fuel debris retrieval work	• Develop a classification standard in order to judge retrieved material into fuel debris or radioactive waste and actual method of handling
Safeguard measures	• Safeguard measures for fuel debris retrieval	• Proposal of realistic and transparent enough material accountancy and safeguards

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (① Fuel debris retrieval work)

Technical Issues and Future Plans for Fuel debris retrieval (Process chart)



3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (② Waste Management)

Sectoral Target (Waste Management)

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

(2) As the approaches for processing/disposal, **countermeasures integrated from characterization to processing/disposal are studied from the expert point of view**, and the prospects of a processing/disposal method and technology related to its safety should be made clear by around FY2021.

Basic Policies on Solid Waste

(note : Numbers and titles were appended by NDF)

①Thorough containment and isolation
- Containment and isolation of radioactive materials are implemented thoroughly to prevent their dispersion/leakage and human access to them, in order not to cause harmful radiation exposure.

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

③Promotion of characterization
- To proceed with study on processing/disposal method of solid waste, it is necessary to address an increase in the number of analysis samples and proceed their characterization properly.

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

⑤Establishment of selection system of preceding processing methods in consideration of disposal
- Establish selection method of processing for stabilization and immobilization (preceding processing), and selecting the method of the preceding processing, before the technical requirements of disposal are established.

⑥Promotion of effective R&D with a bird's-eye-view of overall solid waste management
- Close cooperation should be realized between R&D fields such as waste characterization, processing/disposal, and necessary R&D issues should be confirmed with a bird's-eye-view of overall solid waste management.

⑦Efficient implementation of R&D projects from the perspective of overall solid waste management
- In order to continue safe and steady solid waste management, the continuous operational framework system including development of adequate facilities and human resources must be undertaken.

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

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (② Waste Management)

Sectoral Target (Waste Management)

The challenge on **solid waste generated by decommissioning** of the Fukushima Daiichi NPS is **the existence of a large volume of waste with various characteristics**.

- It is necessary **to develop a flexible and rational waste stream** as well as improvement of analysis capabilities for characterization.
- **The relevant organizations should proceed with their efforts based on each role** in line with the basic policies of solid waste management that was compiled in the Mid-and Long-term Roadmap

The technical study on the integrated countermeasures from characterization to processing/disposal of solid waste
⇒It should be proceeded with the following policies at the initiative of NDF.

Storage

- The fundamentals of managing solid waste are **to contain not to scatter or leak**.
- It should be kept isolated in a properly storage place, **and managed appropriately by monitoring, etc.**
- It is important to raise awareness **on reducing the volume of solid waste to be generated**.
- **The Storage Management Plan*** released by TEPCO is necessary to be revised the estimated volume once a year and updated as appropriate.

* It estimates the volume of solid waste that will be generated in the next ten years, and shows their policy within it such as on building required waste management facilities, etc

Further safety improvement in waste Storage

- **The secondary waste generated by water treatment with high fluidity**, should be **stored in a more stable and reasonable way**.
- There may be cases where processing for stabilization and immobilization are required although the technical requirements for disposal are not determined (i.e. preceding processing). Study will be continued on **how to select the preceding processing method with disposal in mind**.

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (② Waste Management)

Sectoral Target (Waste Management)

Study on the processing/disposal policy

- **The prospects of a processing/disposal method and technology related to its safety** should be made clear by **around FY2021. (Roadmap)**
- Since the overall picture of solid waste becomes gradually clear as the effort progresses, it will still remain in a stage of accumulating necessary information on its characteristics around FY2021. **The concrete targets are compiled:**

The concrete targets for prospect of a processing/disposal method and technology related its safety

① **Establish safe/rational disposal concept** based on processing technology applicable to solid waste, and **develop safety assessment method** reflecting features of the disposal concept
② **Clarify radiological analysis and evaluation method** for characterization
③ **Clarify processing technology** that would be expected to introduced actual equipment **for stabilization and immobilization** considering disposal
④ **Establish method of rationally selecting preceding processing method**
⑤ **Have prospect of setting processing/disposal measure** for solid waste of which the processing technology considering disposal is not clarified, using a series of method to be developed by 2021
⑥ **Clarify issues and measures concerning storage of solid waste** before conditioning

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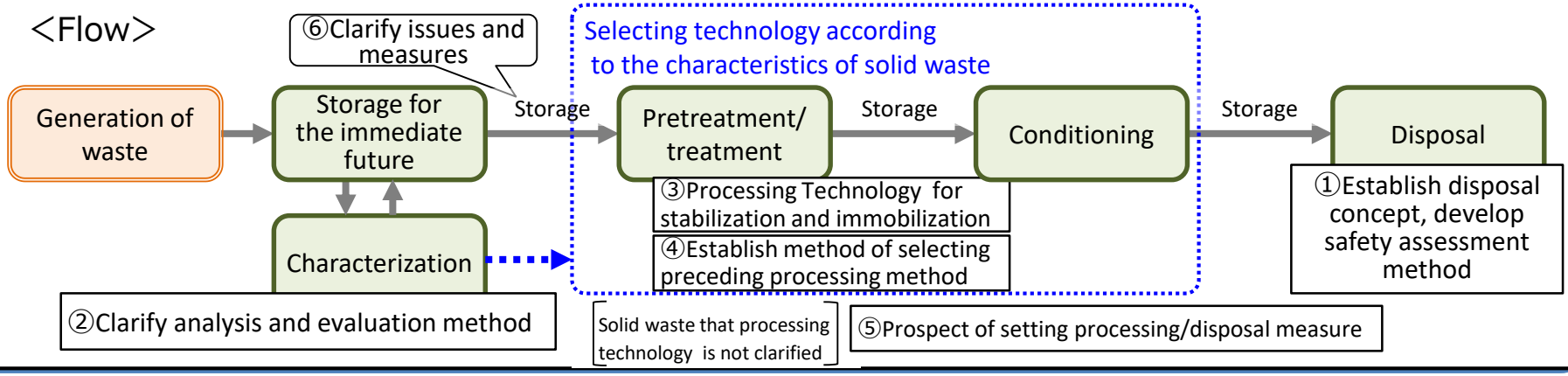


3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (② Waste Management)

Sectoral Target (Waste Management)

Promotion of the characterization

- JAEA Okuma Analysis and Research Center is scheduled to commerce operation at the end of FY2020.
  To improve the accuracy of models to obtain evaluation data based on the limited radiological analysis data
  - The method of reflecting dispersion of radiological analysis data to inventory evaluation using analytical method
  - Study on concept of setting and revising radioactive inventory based on comprehensive evaluation of radiological analysis data and analytical value
- Target of radiological analysis will be mainly on predisposal management, and review target nuclides and to develop efficient analysis method
- **A system, facilities/equipment and technologies** for highly accurate characterization of solid waste will be established by the end of FY 2020

Further improvement of the Safety Storage

- **Selecting processing technology and determining specification of waste package for the secondary waste generated by water treatment** expected to be applicable for actual processing.
- **Regarding the methods of storing high-dose solid waste generated during fuel debris retrieval,** narrow down candidate **methods for storage.**
- For **other solid waste**, study should be proceeded on generation of hydrogen during storage together, with **the timing and content for the case of requiring further measures** to secure safety (reflects to the Storage Management Plan as needed).

Establishing processing/disposal concept and development of safety evaluation method

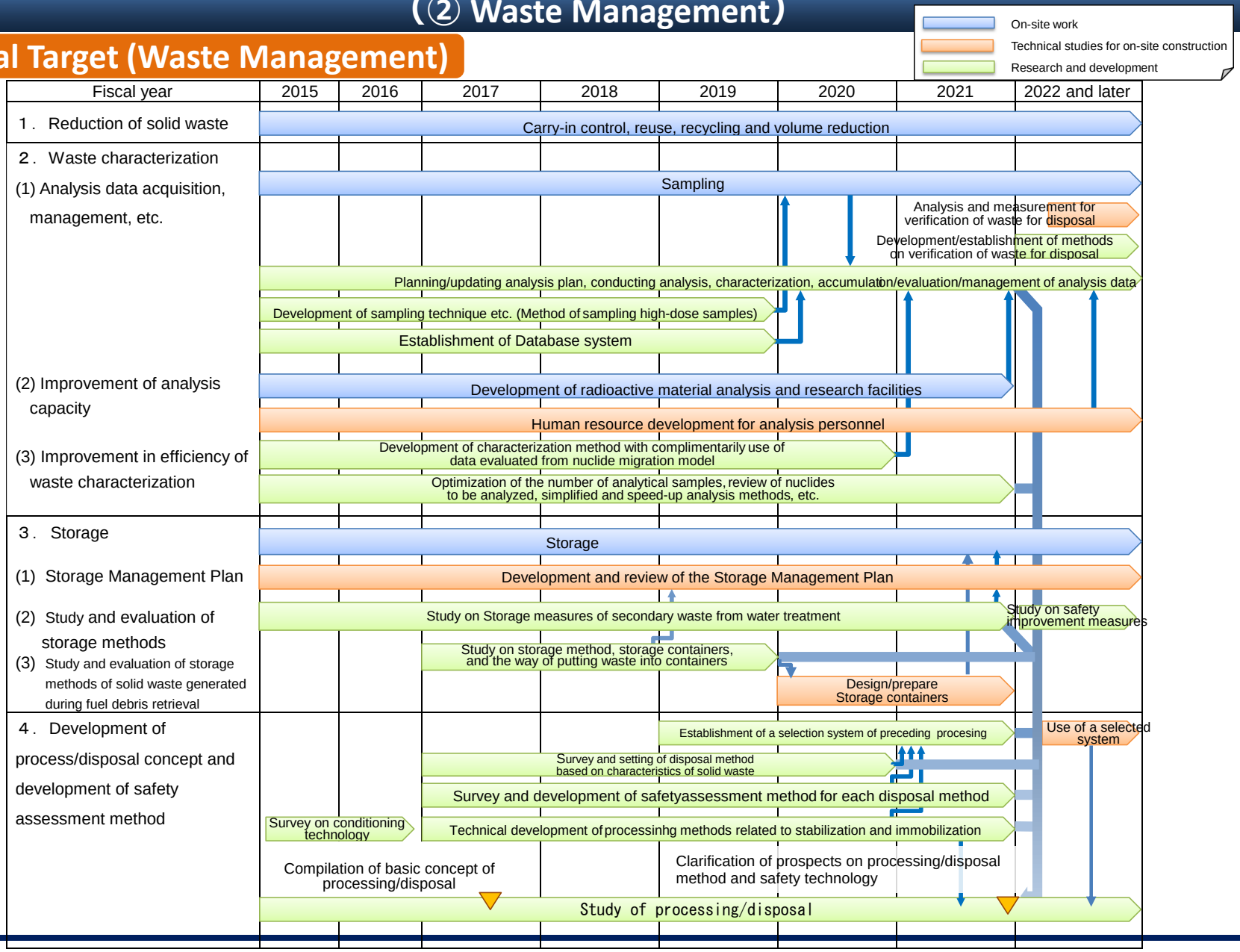
- **In order to select candidate technology as a preceding processing method, selecting** reasonable and feasible candidate technologies and **developing safety assessment methods** will be proceeded.

Other

- **Study on storage method for structures such as core internals and outside of reactors** to be dismantled and removed, and **secondary waste** generated during **duel debris retrieval**

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (② Waste Management)

Sectoral Target (Waste Management)



3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (③ Contaminated Water Management)

Sectoral Target (Contaminated Water Management)

(1) Under the three basic principles concerning contaminated water problems ("Removing" the contamination source, "Redirecting" fresh water from the contamination source, and "Retaining" contaminated water from leakage), **the reinforcement and optimum operation of the water level control system** should be **continued to complete the processing the stagnant water in the buildings by 2020**.

(2) Considering the total **decommissioning process including the full-scale fuel debris retrieval** beginning in near future, **the long term strategy** should be examined for **the measures of the contaminated water**.

Sectoral Strategy

Steady execution of contaminated water management stated in the Roadmap

Preventive and multilayered drastic measures should be continued based on the three principles, it is expected to achieve the milestones stated in the Roadmap.

Preventive Drastic Measures

- Pumping up of high-concentration contaminated water in the **Underground tunnel(trench)** and blockage
- Purification by **multi-nuclide removal equipment (ALPS)**
- Paving (**facing**) in the site to prevent storm sewage osmosis and reduce the amount of groundwater
- Groundwater bypass and pumping up of groundwater in a well (**sub drain**) near the reactor buildings
- Installation of **a land-side impermeable wall** to restrain groundwater inflow into surroundings of the buildings
- Installation of **a sea-side impermeable wall** for suppressing the outflow of groundwater into the ocean and improvement of the ground by the water glass of the seawall side of the building

further measures are taken

Milestone (Major Target Process)

① Reduction of the contaminated water generation to **about 150 m3/day** (by 2020)

② Storing all the water treated by nuclides removal equipment in **the welded type tanks** (FY 2018)

③ For stagnant water in the buildings, **separation of the penetrations** between Units 1 and 2 and between Units 3 and 4, respectively (by 2018)

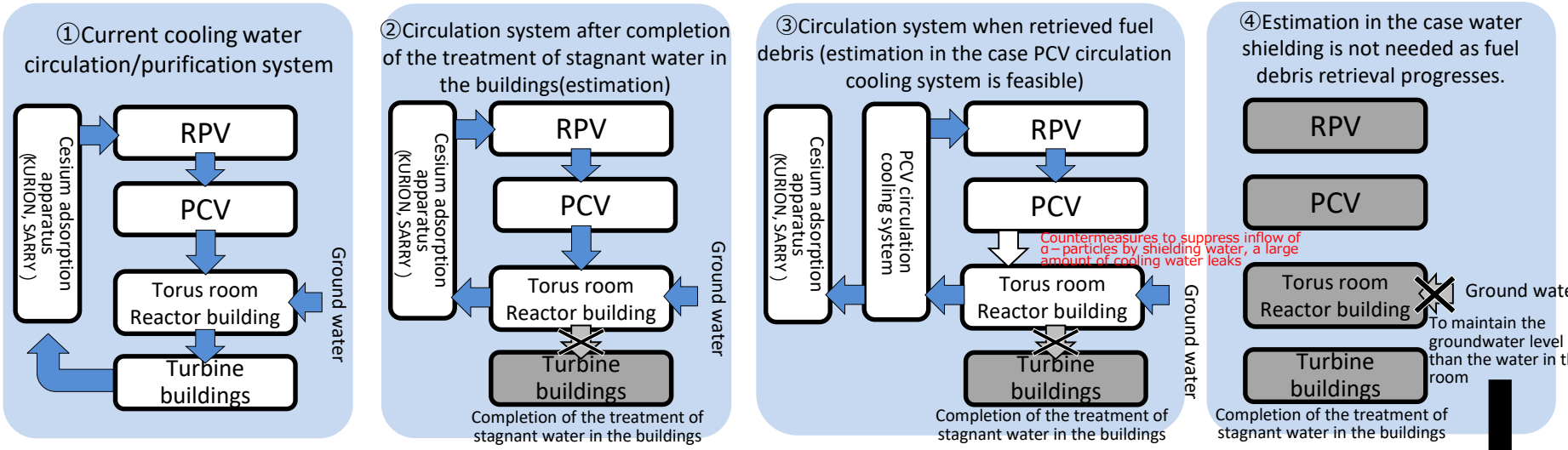
④ **Reduction** of the radioactive materials in the stagnant water in the buildings up to **approximately one tenth** of the amount at the end of FY 2014 (FY 2018)

⑤ **Completion of the treatment of stagnant water in the buildings (by 2020)** (except for reactor buildings)

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (③ Contaminated Water Management)

Sectoral Target (Contaminated Water Management)

Study on contaminated water management based on the relation with fuel debris retrieval



- Because full-scale decommissioning work including fuel debris retrieval will start after a while, it is necessary to discuss the optimal control of contaminated water and groundwater together at each stage of the decommissioning process.

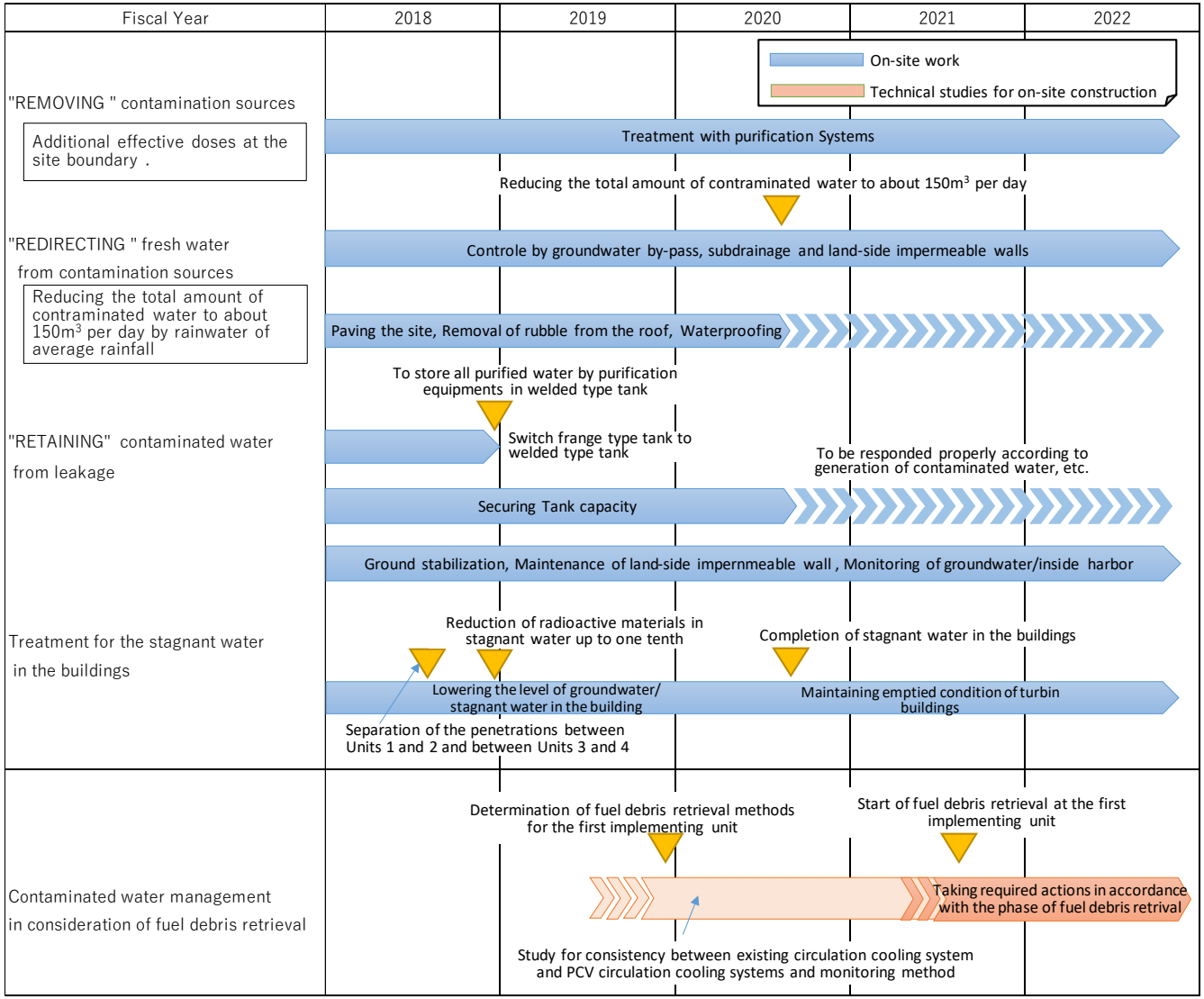
It is important to build a system that can stably control the groundwater level for a long period, such as by combining passive equipment with fewer machine troubles.

Technical Issues

- Reduction of occurrence of stagnant water in buildings, including countermeasures against storm sewage inflow, operation in response to lowering of the water level in the building, enhanced contaminated water management installations
- To properly remove a substance derived from fuel debris containing alpha particle in the PCV circulation cooling system, to set the conditions for receiving a part of water treated by the PCV circulation cooling systems in the existing stagnant water circulation system.

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (③ Contaminated Water Management)

Technical issues and further plan on contaminated water management (Process Chart)



3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (④ Fuel removal from spent fuel pools)

Sectoral Target

(1) **To start removing the fuel from the pool** by around, **1) FY 2023 for Unit 1**, **2) FY 2023 for Unit 2**, **3) Mid FY 2018 for Unit 3**, under the rigorous risk assessment and management and taking measures for safety and security including preventing the disperse of radioactive materials.

(2) By transferring the fuel stored in the Common Spent Fuel Storage Pool to the dry cask at the Temporary Cask Custody Area, the fuel in the spent fuel pools of Units 1 to 4 is **to be stored in the Common Spent Fuel Storage Pool appropriately**.

(3) Based on **the assessment of the long-term integrity and investigation for future treatment of the removed fuel**, **the future treatment and storage methods will be fixed around 2020.**

Progress of Fuel Removal from Spent Fuel Pool

【Unit 1】
- Removed the building cover, installed wind breaking fence
- Removal of a part of rubbles and measure for preventing falling into spent fuel pool are initiated.
- To start removing fuel is targeted for FY2023.

【Unit 2】
- The upper part of the reactor building is to be dismantled to install fuel retrieval facilities.
- Installation of opening to have access to the operating floor and a front chamber to prevent dispersion of radioactive material have been implemented, further surveillance and countermeasures are under way.
- To start removing fuel is targeted for FY2023.

【Unit 3】
- A cover for fuel removal was installed in February 2018.
- Once started the trial operation for fuel handling equipment from March 2018, several troubles have occurred. For fuel removal in the pool which was scheduled in November 2018, it is being examined and reviewed by TEPCO.

【Unit 4】
- Removal completed in December 2014.

【Unit5/6】
- The fuel is also being stored under stable conditions same as a normal nuclear power plant.
- Will be removed when such removal work becomes not to affect fuel removal and fuel debris retrieval work of Units 1 to 3.

Dose measurement of operation floor of Unit 2 by remote robot (Photo/video library:TEPCO)

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (④ Fuel removal from spent fuel pools)

Sectoral Strategy **Technical Issue**

Issues of Fuel removal from spent fuel pool

【Common issues】
- To limit operation exposure during the installation work, it is necessary to determine the final operational dosage at an appropriate time.
- Preparation of **a detail plan for operation space(yard) adjustment and resource management, etc.,** because multiple works would be performed in parallel.

【Unit 1】
- **Rubble** removal on the operation floor, manipulation of the well plugs

【Unit 2】
- Installing a common container for both fuel removal and fuel debris retrieval, and a separate container exclusively for fuel removal on the operating floor were determined **by the proper timing**.
- Before removing the fuel from the pool, the exhaust stuck for **Units 1/2 will be dismantled**.

【Unit 3】
- Appropriate measures to **rubbles** that is fallen into the spent fuel pool

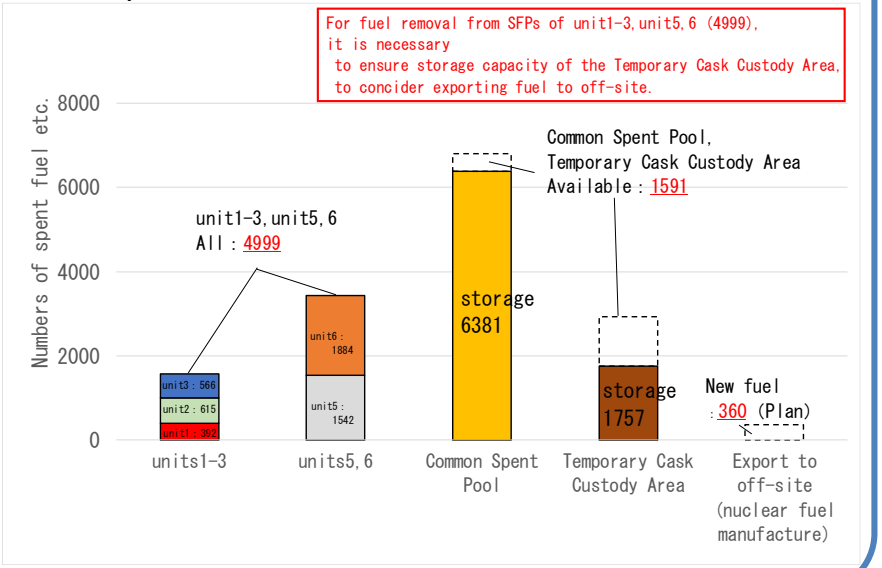
Decision on storage and future treatment methods

- The spent fuel pools is storing flawless spent fuel, damaged one before the accident, and that may be damaged by the rubbles falling into the spent fuel pool.
- Corrosion due to seawater sprayed and injected into the spent fuel pool of Units 2, 3, and 4 at the accident is another concern.
- In the future, necessity of further study on possibility of its long term storage need to be evaluated based on the **inspection results of the fuel taken out from Unit 3**, which is experienced the severe explosion caused by the accident and may be damaged by the fallen rubble.
- Based on the assessment of the long-term integrity and investigation for future treatment of the removed fuel, the future treatment and storage methods of them will be fixed around 2020.

Storage of removal fuel

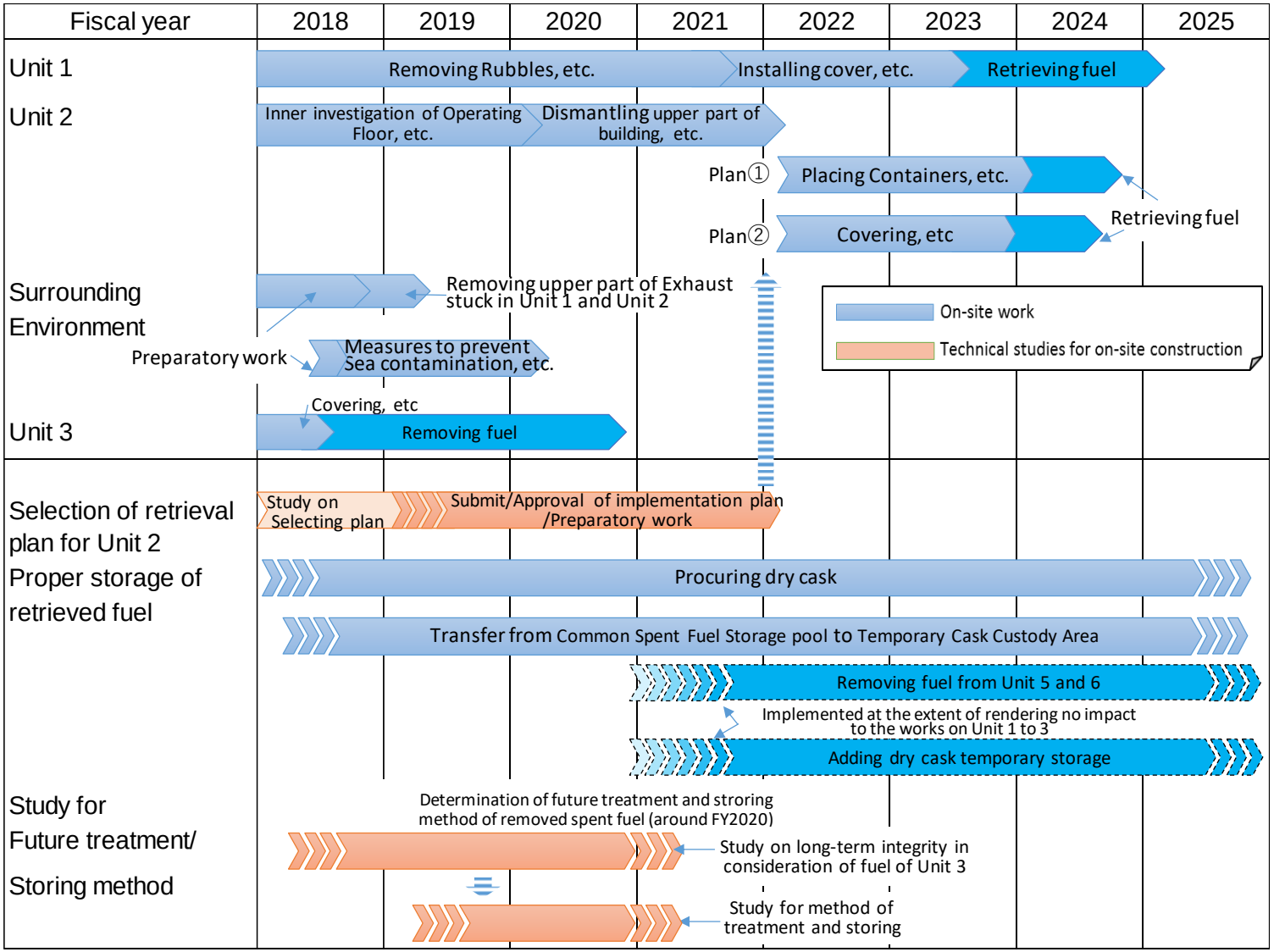
Appropriate capacity for the fuel in the pools of each unit should be reserved both in common spent fuel storage pool and temporary dry cask custody area.

For the deliberate transportation and storage of spent fuel and fresh fuel possessed by the entire site, a fuel transport plan need to be developed taking fuel stored in the Units 5/6 into account. As well, the storage capacity need to be increased and additional facilities are also necessary to be procured according to that plan.



3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (④ Fuel removal from spent fuel pools)

Technical issues and further plan on removing fuel from the spent fuel pool (Process Chart)



3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS (⑤ Other specific measures)

(1) Sustaining of reactor cold shutdown status

- It is judged that a stable state of cold shutdown is maintained based on the internal plant data of Units 1 - 3.
- To maintain the stable state in the future, maintaining and improving reliability through maintenance and management should be continued.

(2) Radiation dose reduction and contamination expansion prevention all over the power station

① Prevention of sea contamination expansion

- The concentration of radioactive materials in the port is below the concentration limit defined in the notification because of the various treatments. Measures to reduce the concentration of radioactive should be continued.
- Regarding contamination of the soil in the vicinity of the harbor, assessing the impact on the ocean from a long-term perspective and future environmental restoration, R&D should be conducted such as to clarify the near-surface nuclide migration mechanism and refine the analytical models.

② Management of gas and liquid waste

- Monitoring of gas and liquid waste should be continued and its emission should be closely controlled to ensure that the concentration limits defined in the Notification is strictly observed. With this view, proper countermeasures should be taken as their concentrations are made as low as possible based on a reasonable methods.

③ Dose reduction through site decontamination

- TEPCO formulated “Implementation Policy of Dose Reduction on the Site” to reduce the dose for each area in the sites. Currently, the area in which it is permitted to work with general work clothes has increased to 96% of the entire sites. The dose rate should be maintained below 5 μSv/h and as close as possible to the situation before the accident ultimately.

④ Reduction of environmental impact

- For the evaluation of the dose at the site boundary including additional emissions from the entire site, reducing the effective dose is continued to address after the goal to reduce the value to less than 1 mSv/year has been achieved at the end of 2015.

⑤ Comprehensive risk review

- TEPCO conducted a comprehensive inspection of risk sources that may affect the outside of the site. The specific measures were discussed while taking priorities into consideration. The Nuclear Regulation Authority created a target map for reducing the mid-term risk.
- It is important to continue to reduce and comprehensively grasp the risk sources like this, while taking the positioning and priority in the entire decommissioning project into consideration for implementing each measure.

(3) Plan for decommissioning measures for nuclear reactor facilities

- TEPCO should formulate a decommissioning plan of the Fukushima Daiichi NPS in phase 3 after commencing fuel debris retrieval.
- NDF should provide multifaceted and expert advice and guidance based on the progress and forecast of the decommissioning, the situation of the reactor buildings, and the trends of R&D with wisdom and knowledge from around the world.

(4) Concrete efforts toward securing safety

①Efforts to ensure work safety

- It is important to evaluate the environment according to input resources from the viewpoint of "justification and optimization," aiming to ensure the safety of the working environment as well as suppressing personal dose.
- It is necessary to formulate a detailed work plan for each work step, to take preventive measures concerning troubles that may occur, and to consider ways to cope with unexpected situations.
- Measures for industrial accident prevention will be taken and reviewed continuously, medical preparedness will be planned in anticipation of industrial accidents, and measures will be taken to reduce occupational risk exposure as much as possible. It is important to ensure a perfect system of work safety by continuing these efforts.

②Efforts for facilities safety

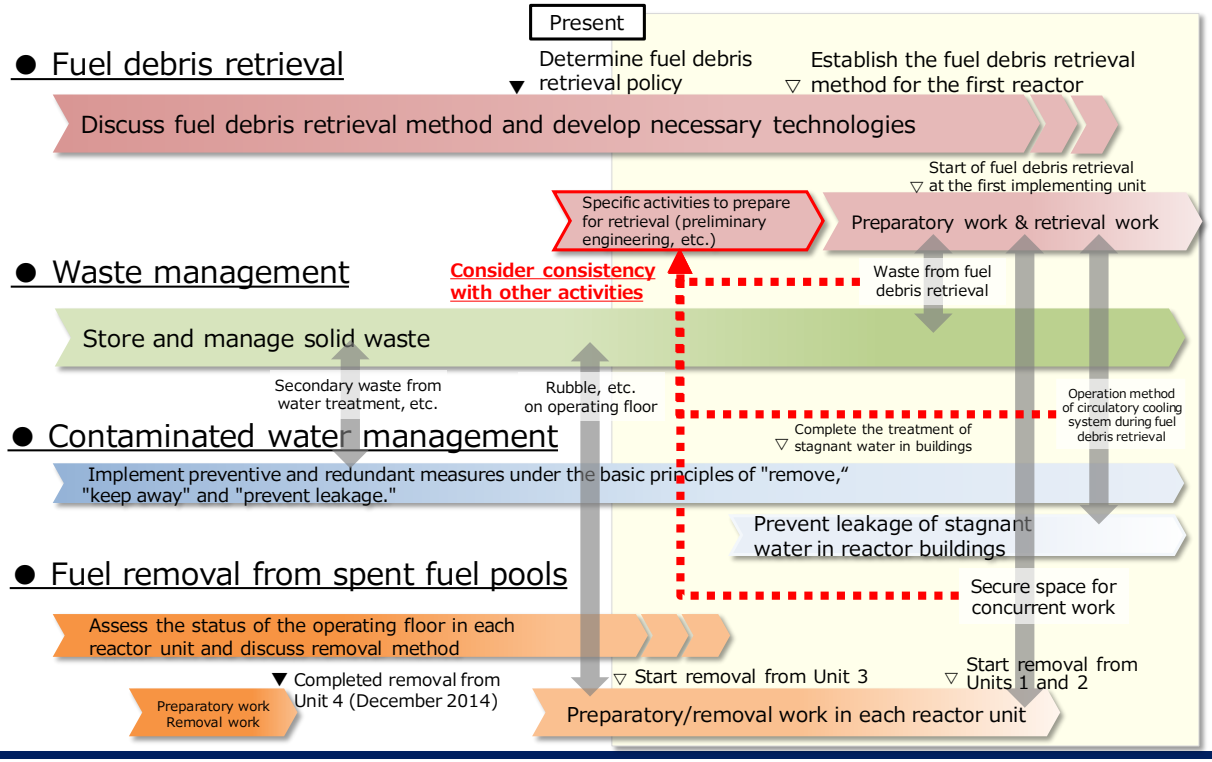
- Measures are implemented to maintain and improve equipment reliability based on the maintenance plan for every piece of equipment.
- Particularly, for equipment vital to securing safety for cooling fuel debris, it is important to continue thorough measures that will be taken to prevent their important function from stopping from management and operation standpoints.
- When installed new equipment or facility, steady quality assurance should be conducted through design reviews and testing and examinations.

③Security enhancement

- As a great quantity of nuclear fuel material is stored, same as a normal nuclear plant, measures to confirm the reliability of each individual, enhance nuclear security training, prevent unauthorized intrusion into the sites, etc. are being implemented.
- Continuing with these efforts, it is implemented appropriate measures for operation to allow accepting the visits of inspectors.

Comprehensive efforts for the decommissioning project of the Fukushima Daiichi NPS

- It is important **to optimize resource allocation and scheduling** while ensuring the consistency and feasibility of the entire efforts to be promoted concurrently while having interrelations.
  - While this complicated and multilayer project should be **controlled based on individual tasks of appropriate scale and control size**, the entire decommissioning project should make progress comprehensively in consideration of **the mutual relationship among the smaller projects**.
  - From a time-based perspective, the overall plan of the decommissioning project should be formulated and discussed while setting reasonable **intermediate targets** from a facility-wide **long-term perspective**.



4. Handling critical enablers for smooth operation of the project (1／3)

Actions toward improvement of working environment and conditions

- A good working environment is the basis for ensuring safe and steady progress of the decommissioning project of the NPS, which will be carried out over the long term.
- TEPCO is improving the working environment infrastructure by consolidating and removing existing rest stations and setting up alternative rest stations, etc. Moreover, variety of measures are taken such as **management for safety and sanitation, preventing heatstroke, exposure management, dose reduction measures in the site**.
- It is necessary to deal with for **improvement in the labor environment and labor conditions properly**.

Cafeteria in a Large rest station
(Photo/video library:TEPCO)

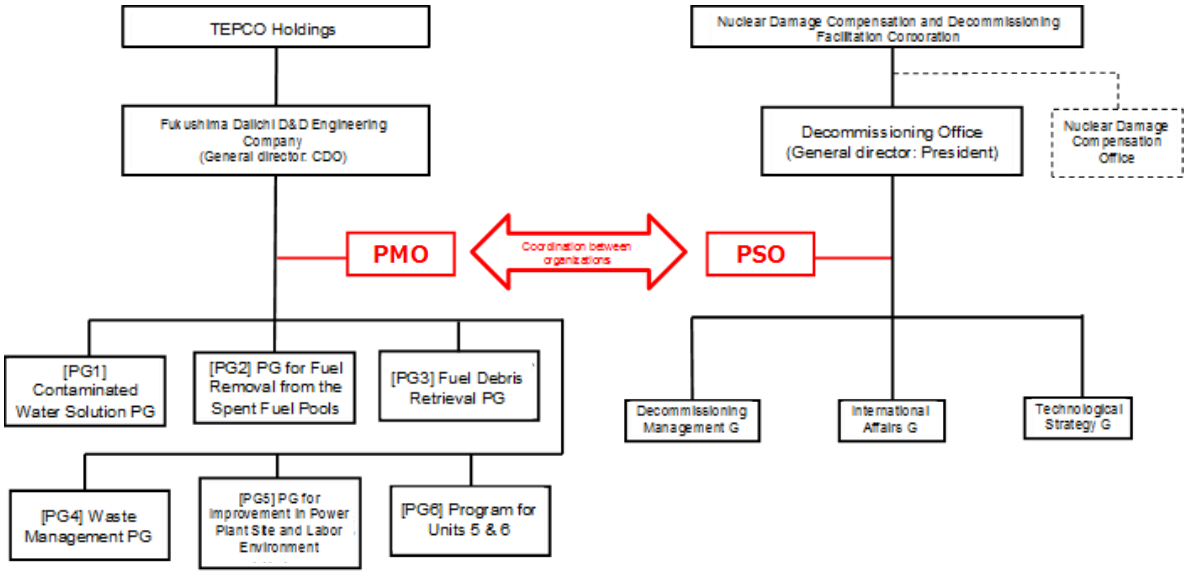
Concept of securing safety and promotion of cooperation

- In conducting tasks for which no preceding experience exists in the world, **principle of securing safety** should be established according to the situation of the Fukushima Daiichi NPS.
- In light of this, **NDF, TEPCO, the Agency for Natural Resources and Energy and other organizations will cooperate with each other, communicate actively with the Nuclear Regulation Authority**, and take appropriate actions such as presenting policies and observation data related to ensuring safety at an early stage.

4. Handling critical enablers for smooth operation of the project (2／3)

Enforced management structure for steady mid-and-long-term decommissioning

- It is necessary to shift the organization management to project-oriented management and reinforce the organization and functions to coordinate the projects.
- Therefore, at **TEPCO**, in addition to the conventionally located Program Manager (PGM) and Project Manager (PJM), a **Program Management Office (PMO)** responsible for project control has been set up. **NDF**, as the supervisory and supporting organization, recently established a **Program Supervision & Support Office (PSO)**
- Withdrawal Plan in the Reserve Fund for the Decommissioning System have been created according to the planning of the project. **It is necessary to enable TEPCO to manage its engineering and make it function**, in order to make a structure of project management work effectively **based on a deep understanding of the technical work** of individual tasks.



4. Handling critical enablers for smooth operation of the project (3／3)

Developing and securing human resources

Developing and securing operators and engineers

- The Decommissioning R&D Partnership Council has prepared **a draft technology map** to grasp the overview of necessary technologies and decommissioning personnel, to utilize it for developing and securing human resources.
- It requires specialized personnel with the ability to manage projects from a comprehensive perspective including the consideration of relationship between the projects based on the overview of the entire decommissioning process. **Companies are expected to improve employees' skills**, such as by encouraging for obtaining related licenses.

Fostering the next generation to play roles in the Decommissioning of the Fukushima Daiichi NPS in the future

- Industry, academia, and the government related to nuclear power should steadily continue efforts for human resources. They should show **a variety of career paths** of researchers and engineering in the Fukushima Daiichi NPS decommissioning.
- "Conference for R&D Initiative on Nuclear Decommissioning Technology by the Next Generation (NDEC)" intended for students, and "Creative Robot Contest for Decommissioning," intended for technical college students are held.

Conference for R&D Initiative on Nuclear Decommissioning Technology by the Next Generation (NDEC)

Award Ceremony

Oral session

Poster session

Creative Robot Contest for Decommissioning

Standard test field

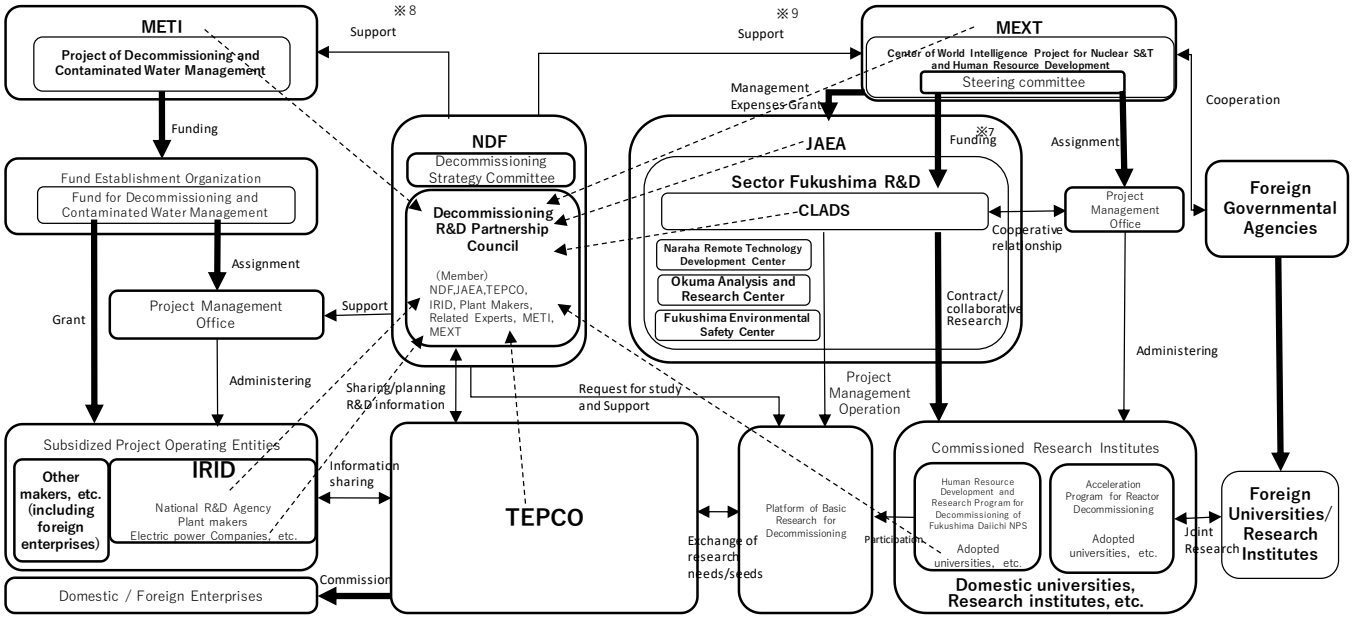
Naraha Summer School

Participants

5．R&D initiatives (1／3)

Entire perspective of R&D

- Various problems exist in the decommissioning of the Fukushima Daiichi NPS, and R&D activities for solving these problems are being conducted by variety of **industrial-academic-governmental institutions engaged through the areas of basic/fundamental research, applied research and development/utilization.**
- To organically link these activities and efficiently solve the on-site problems through R&D, NDF regularly holds meetings of the Decommissioning R&D Partnership Council.

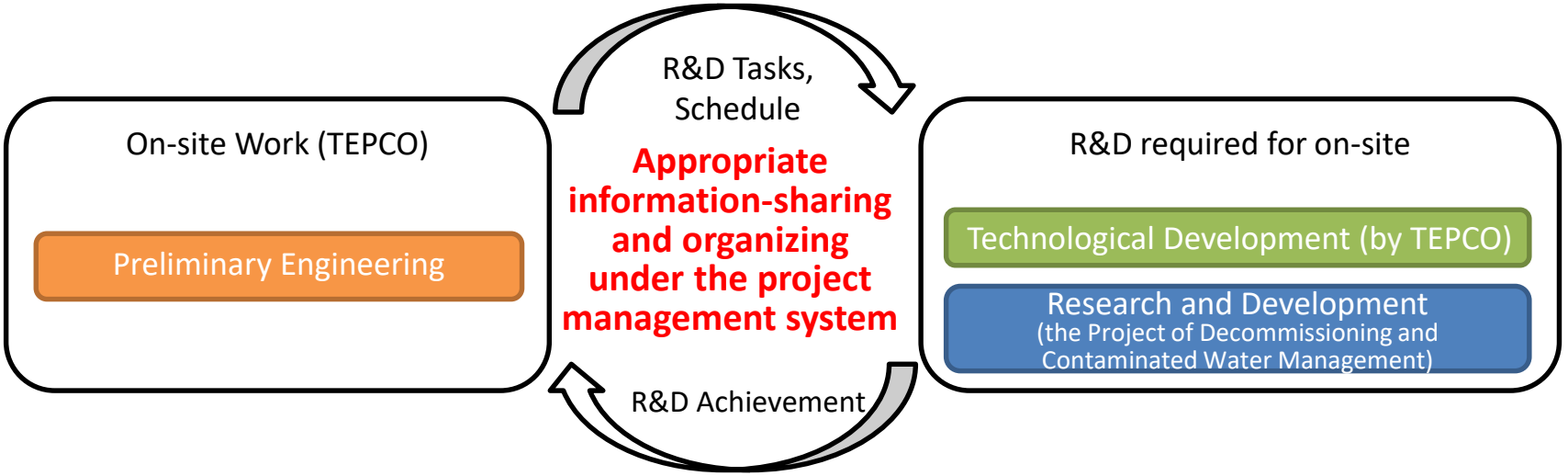


※1 Decommissioning R&D Partnership was established in NDF according to a decision of Team for Countermeasures for Decommissioning and Contaminated Water Treatment.
※2 Bold solid arrow mean supply of R&D and management expenses (except for facilities expense).Light solid arrow means cooperation. Dotted line arrow means participation in Decommissioning R&D Partnership Council.
※3 Some institutions including JAEA are at the multiple positions.
※4 Each institution has their own cooperation with foreign institution based on MOU, etc.
※5 R&D activities by other institutions including Central Research Institute of Electric Power Industry are abbreviated.
※6 Among the promotion projects of nuclear energy science technology/human resource development that require collective know -how, the adopted projects up to 2017 were entrusted by MEXT to the trustee, which are not shown in this figure.
※7 Subsidies for the promotion projects of nuclear energy science technology/human resource development that require collective know-how are delivered to JAEA, but expressed as being delivered to CLADS for the sake of clarity here.
※8 For Decommissioning and Contaminated water treatment subsidy project, NDF drafts the next R&D plan and METI determines it based on the policies on Roadmap and the Strategic Plan and R&D progress.
※9 NDF participates in the steering committee of human resource development promotion project of Nuclear Science Technology that gathers wisdom and intelligence, as a constituent.

5．R&D initiatives (2/3)

R&D of decommissioning required for on-site work/engineering

- R&D tasks that engineering studies clarified its importance should be shared and implemented timely and accurately. **For the time being, R&D tasks are going to be identified according to the progress of the preliminary engineering, and then, it is presumable that the timing to implement such tasks will be determined through the project management process.**
- To realize an R&D management system under such project-based schedule, **appropriate information-sharing should be carried out under the project management system enforced jointly by NDF and TEPCO.** To this end, it is necessary to marshal the details of R&D currently in progress, and R&D tasks required in the future under the project management system clarifying when the problem must be solved and which project needs it.
- As specific processes become apparent, **it will be required for TEPCO to make efforts to raise the ratio of technological development to improve the safety and efficiency of the decommissioning work. Under the Reserve Fund system, it is important for TEPCO to steadily figure out and implement the required technological development.**



5． R&D initiatives (3／3)

Enhancement of basic study and R&D infrastructure for the success of the decommissioning project

- To facilitate the decommissioning project in a safely steady and effective manner, it is essential to develop **mid-and-long-term R&D strategies including scientific and technological investigation based on understandings of the principles and the theories**. For this purpose, NDF has built a "Task Force on Research Collaboration" and specified the 6 **Essential R&D Themes** that should be preferentially and strategically targeted. The Platform of Basic Research for Decommissioning investigated on the themes and compiled R&D strategies for the Themes.
- Also, it is essential to work on developing R&D infrastructure and accumulating technological knowledge.
  - ➢ According to a proposition by NDF, the Center of World Intelligence Project for Nuclear S&T and Human Resource Development by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) is implemented under **the structure centered on JAEA/CLADS** from the newly adopted issues since FY2018.
  - ➢ **R&D infrastructures aiming at mid-and-long-term vision** are being set up mainly in Fukushima Prefecture.
    - JAEA Naraha Remote Technology Development Center (Naraha-machi, in Fukushima prefecture, in service in April 2016)
    - Fukushima Prefectural Centre for Environmental Creation (Miharu-machi, in Fukushima prefecture, opened in July 2016)
    - The building for international research collaboration of JAEA/CLADS (Tomioka-machi, in Fukushima prefecture, opened in April 2017)
    - The facility management building of JAEA Okuma Analysis and Research Center (Okuma-machi, in Fukushima prefecture, opened in march 2018)

Six Essential R&D Themes
① To identify process of characteristic changes in fuel debris over time
② To elucidate corrosion mechanisms under unusual/extreme circumstances
③ Radiation measurement technologies adopting innovative approaches
④ To clarify behavior of radioactive particles generated during decommissioning (incl. alpha dust treatment)
⑤ To understand fundamental mechanisms of radioactive contamination
⑥ Environmental fate studies of radioactive materials generated during decommissioning

The facility management building of JAEA Okuma Analysis and Research Center
(source: JAEA's website)

6．Enhancement of International Cooperation

Significance of international cooperation

- In order to make steady progress on decommissioning of the Fukushima Daiichi NPS, it is important to learn **the lessons of decommission experience from accident reactors and legacy sites in the world** as well as actively utilize the world's best technologies and personnel resources.
- To secure and maintain understanding and support from international communities, it is also important to engage in **decommissioning with open to international societies**. It should strengthen to distribute easily understandable information, for helping accurate comprehension from international society.

Facilitation of international cooperation activities

Enhancement of partnership with overseas decommissioning agency

- It is essential to **strengthen** sustainable **partnership** with overseas decommissioning agencies.

Integrating and utilizing wisdom and knowledge in the world

- In regard to decommissioning of the Fukushima Daiichi NPS, **wisdom and knowledge in the world** that our country should obtain is implemented with a variety of approaches such as system /policy, providing strategy, project plan /operation, ensuring security, regional communications, and so forth, **not only in technical aspect but operational aspect**. In order to use the highest level of technologies and human resources in the world, it should be updated the latest status.

Dissemination to global society

- NDF takes **dissemination of information about the situation of the Fukushima Daiichi NPS** decommissioning globally through holding **side events of IAEA General Meeting** and giving speeches at key international meeting.

Side event of IAEA General Meeting

Close cooperation with relevant domestic organization

- Ensuring consistency of international cooperative activities in Japan from a viewpoint of implementing effective international cooperation, the **close relationship of relevant domestic organizations** should be further enhanced.

7. Local community engagement and further enhancement of communication

Approaches for local community engagement and further enhancement of communication

- In implementing decommissioning of the Fukushima Daiichi NPS steadily, local community engagement is the major premise, and it should be seeking for **decommissioning to contribute to the restoration** in local communities while trying to establish trustful relationships closely with the region.
- It is a starting point to listen to the voice from various standpoints including local communities sincerely. While not only **providing information** but also **communicating interactive** on progresses of approach to safety measures and relevant work and on radioactive safety appropriately, further decommissioning should be proceeded by **establishing common understandings about risk reduction policy.**
- On the foundation of communication like this, it is necessary to initiate specific efforts that decommissioning and its relevant activities become **locally-oriented industries** through in contributing to the restoration and revitalization of the region.

Further spread of communication and measures to reputational damages

- When delays in responding to reputational damages or troubles on decommissioning work occur, it is the most important **to promptly reduce existing risks** while making efforts for proper safety management, in order to prevent from a vicious cycle such as downgrading evaluation from society for addressing decommissioning then it causes the further delay of activities. It is necessary **to enrich communication** with consumers including overseas as well as local residents, media, market participants and distributors.

NDF hosts International Forum on the Decommissioning of the Fukushima Daiichi NPS annually for providing information and vigorous dialogue about decommissioning with the local citizens

The 3rd International Forum on the Decommissioning of the Fukushima Daiichi NPS

“Hairo-no-iroha” a brochure prepared by NDF that disseminates decommissioning in plain words (Cover)