Technical Strategic Plan 2019 for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.

(Explanatory Material)

September 9, 2019

Nuclear Damage Compensation and Decommissioning Facilitation Corporation

NDF

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1. Introduction

- Strategic Plan 2019 provides strategic recommendation on how to retrieve fuel debris from the first implementing unit.
- Mid-and-long-term directions that look at the overall efforts of the Fukushima Daiichi NPS, including waste management, are presented.

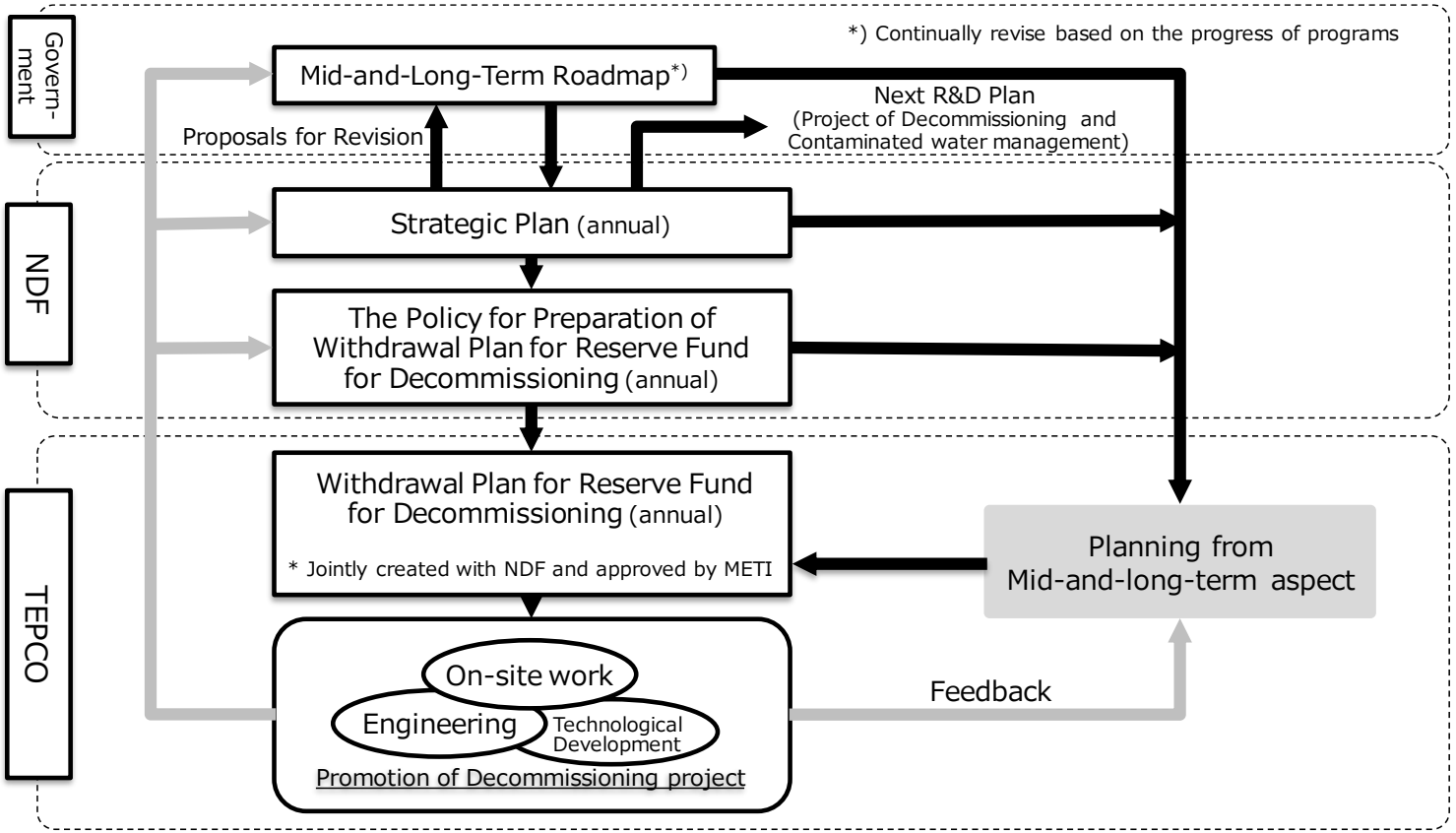


Fig. Positioning of the Strategic Plan based on the system of the Reserve Fund

2. Risk Sources at Fukushima Daiichi NPS and Future Risk Reduction Strategy (1/2)

Basic policy on decommissioning

To continuously and quickly reduce the radioactive risks caused by the accident that do not exist in a normal NPS

Progress in decommissioning

Fuel debris retrieval

- Unit 2 (Feb 2019) Deposit contact investigation in the PCV revealed that the deposits are movable at the bottom of the PCV pedestal and on the platform.

Waste management

- (Jun 2019) Waste storage management plan was revised.

Contaminated water management

【REMOVING】 (continuing) Contaminated water is being purified by multi-nuclide removal equipment, etc.
【REDIRECTING】 (Sep 2018) All areas of the land-side impermeable wall were frozen.
【RETAINING from leakage】(Mar 2019) Transfer of the water purified by the purification equipment to welded tanks was completed.*
【Treatment of stagnant water in buildings】(in 2018) Disconnection of the communication section between Units 1 and 2 was achieved.

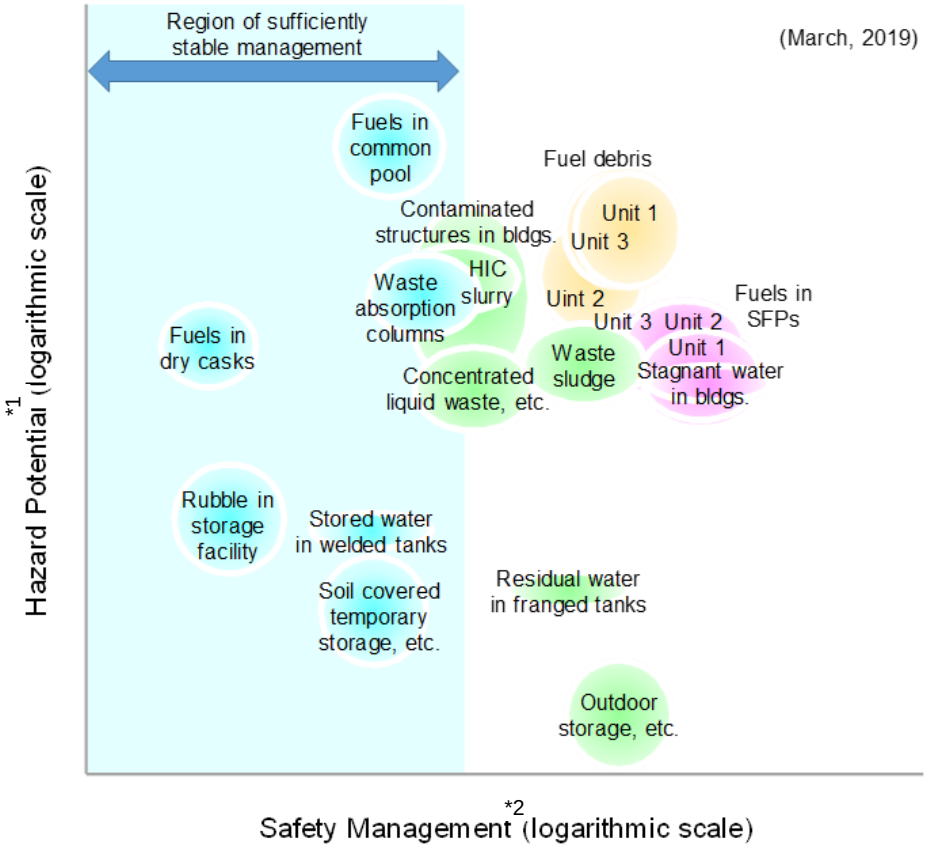
* As for the treatment of the water stored in the welded tanks, comprehensive discussion including social standpoints has been made in the government-led subcommittee

Fuel removal from spent fuel pools

- Unit 1 (continuing) Removal of rubble on the operating floor is ongoing.
- Unit 2 (Nov 2018 to Feb 2019) Investigations were conducted on the contamination state of the operating floor.
- Unit 3 (Apr 2019) fuel removal from SFP was started.

2. Risk Sources at Fukushima Daiichi NPS and Future Risk Reduction Strategy (2/2)

- The interim goal of the risk reduction strategy is to bring the risk levels into the "Region of sufficiently stable management" (areas in pale blue).



Example of Risk Levels for Fukushima Daiichi NPS

*1 : An index of impact of the event, that depends on inventory (radioactive material), form of the risk source and time allowable until the manifestation of risk in case of loss of safety function.

*2 : An index of likelihood that an event will occur, that depends on integrity of facility and on the packaging and monitoring status of risk source.

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

Goals

(1) **Retrieve fuel debris safely after thorough and careful preparations**, including safety measures, and bring them to **the state of stable storage under full management**.

(2) Toward determination of the fuel debris retrieval methods for the first implementing unit in FY 2019, and start of fuel debris retrieval work for the first implementing unit in 2021, **necessary approaches will be taken according to the Policy on Fuel Debris Retrieval**.

Policy on fuel debris retrieval

① **Step-by-step approach**
- Flexibly coordinate the direction while proceeding with the retrieval work

② **Optimization of the overall decommissioning work**
- Examine fuel debris retrieval work as a comprehensive project, including coordination with other works

③ **Combination of multiple methods**
- Combine the optimum retrieval methods for each unit, depending on the locations where fuel debris is considered to be present

④ **Approach focused on partial submersion method**
- Make efforts to focus on a more feasible partial submersion method

⑤ **Prioritizing fuel debris retrieval by access to the bottom of the PCV from the side**
- It should be considered that the accessibility to fuel debris and the removal of spent fuel can be accomplished in parallel

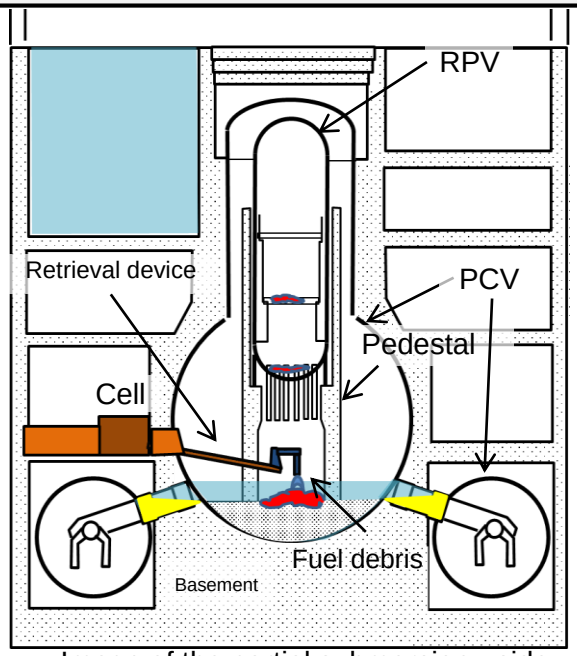


Image of the partial submersion - side access method

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

Strategies

Approach to risk reduction in fuel debris retrieval work

- Since retrieving of fuel debris by partial submersion method is unprecedented project in the world and the information on the condition inside the PCVs is limited, it is important to proceed with operation carefully upon enough and well making preparations.
- By starting with small-scale retrieval basically using existing safety systems such as confinement (hereafter referred to as “existing safety system” without significant modification in the state such like processing PCV wall, a series of operations from retrieval to storage will be performed on a continuous basis, the risk of fuel debris will be reduced and quick effectiveness of the required systems will be ensured.
- Expected effects by small-scale retrieval in the first implementing unit
  - ✓ Equipment, facilities and safety systems, including remote operations, can be verified.
  - ✓ TEPCO can exploit this occasion as a process of mastering fuel debris retrieval operation.
  - ✓ Information helpful to understand the situation inside PCV can be obtained.
- After retrieval in the first implementing unit, the amount of fuel debris to be retrieved will be increased based on the knowledge obtained, or retrieval will be started in units other than the first implementing one.
- To expand the scale of retrieval or perform the retrieval operation in units other than the first implementing unit, it is necessary to examine the actual site applicability based on the concept of safety systems, and further improve the site environment including further radiation dose reduction, lowering of the water levels and securing of the premises, and conduct internal investigations and R&D activities.

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

Strategies

Outline of the strategic recommendation for determining fuel debris retrieval methods for the first implementing unit

Progress of R&D and PVC internal investigations

- Deposits in Unit 2 are movable.
- Development of the arm-type access equipment has been taking form.

Progress of work environment improvement

- Radiation dose in Unit 2 is relatively low.

Progress of site-wide planning

- Spent fuel removal from SFP can be performed in parallel with fuel debris retrieval operation.

Study on the retrieval concept

- Utilize existing safety systems and arm-type access equipment that actual site applicability is getting in sight .
- Start from small-scale retrieval by methods such as gripping and sucking, and also prepare plans for crushing of fuel debris.
- Contain retrieved debris in small containers and transfer them, contain them into canisters, and then store them at the dry temporary storage facility within site .

Study results of the actual site applicability for each unit

- Unit 1: Although the air-tightness of existing safety systems is relatively high, the radiation dose in the work environment is high, and the access route has been unidentified.
- Unit 2: The air-tightness of existing safety systems is high, and the radiation dose in the work environment is relatively low. The access route has been mostly confirmed.
- Unit 3: The access route has been mostly confirmed, but the air-tightness of existing safety systems is lower than other units, and the radiation dose in the work environment is relatively high.

: Preliminary engineering

Comprehensive assessment

- In Unit 2, fuel debris can be retrieved “safely”, “reliably” and “promptly” using an arm-type access equipment, and the risk resulting from all fuel debris in Units 1 to 3 can be “promptly” reduced.

Points to be recommended for determining fuel debris retrieval method for the first implementing unit

[1] Fuel debris retrieval should be started on a small-scale basis by methods such as gripping and sucking.
[2] Next step of fuel debris operation are to be studied using information and experience accumulated through previous operation .
[3] Retrieved fuel debris should be transferred to the on-site temporary dry storage facilities at the Fukushima Daiichi NPS.
[4] Unit 2 is most appropriate as the first implementing unit from the viewpoint of optimization of the overall decommissioning work, and so on .
[5] The method for expanded scale of fuel debris retrieval should be determined by proceeding with engineering including the assessment of safety based on progress of R&D, PCV internal investigation, Improvement of site condition as well as information & experience accumulated through previous operation.

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

Challenges

Comprehensive understanding of PCV conditions by continued internal investigations, etc.

- Internal investigations and sampling must be carefully prepared over a certain period of time.

Unit 1:	Investigations on the distribution of deposits (including a small-amount sampling) are scheduled to begin in the second half of FY 2019.
Unit 2:	Deposit contact investigations were conducted in the second half of FY 2018 (conducted on 2/13). Investigations on the distribution of deposits (including a small-amount sampling) are scheduled to begin in the second half of FY 2019.
Unit 3:	The necessity of further investigations by means of measures for lowering the water levels in PCVs and using an submersible-type access robot are being examined.

Fig. Deposit contact investigations in Unit 2*

* Source: TEPCO

Approach to the commencement of fuel debris retrieval from the first implementing unit (Unit 2)

- The method of retrieving fuel debris from Unit 2 should be determined in line with the recommendations.
- In determining the method of fuel debris retrieval in Unit 2, the following issues need to be considered.
  - ✓ Removal of obstacles in consideration of enhancing the prevention of the scattering of radioactive materials
  - ✓ Reduction of the on-site radiation dose on the 1st floor of the reactor building
  - ✓ Adjustment of work interference in cases where the operations of fuel removal from SFP and fuel debris retrieval are carried out in parallel

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS ([2] Waste management)

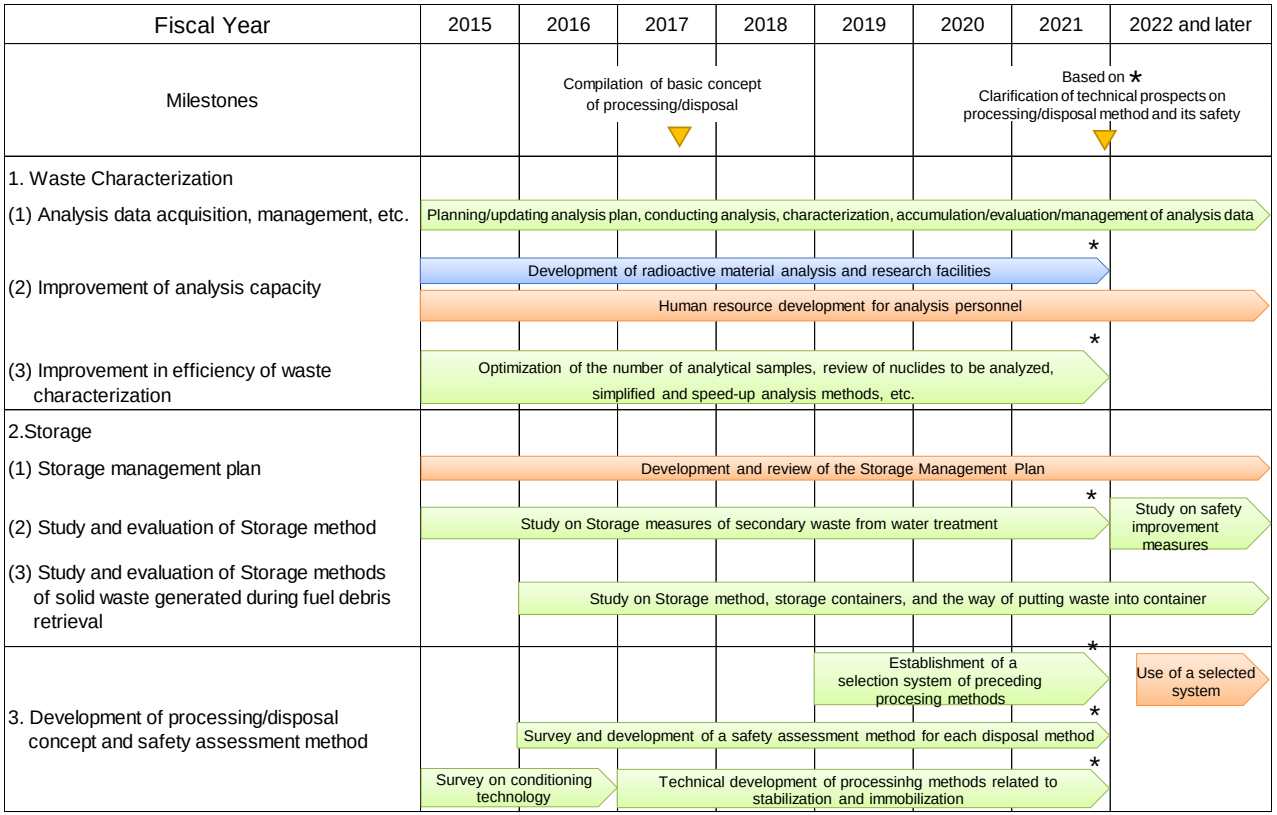
Goals

(1) As the approaches to solid waste storage, **the Solid Waste Storage Management Plan ("Storage Management Plan") is appropriately developed, revised and implemented**, including waste prevention, volume reduction and monitoring, while updating the estimated amount of solid waste to be generated in the next 10 years periodically.

(2) As an approach to processing/disposal, countermeasures integrated from characterization to processing/disposal of solid waste are studied from expert point of view, and. **the prospects of a processing/disposal method and technology related to its safety should be made clear by around FY 2021**

Strategies and Challenges

- Promotion of characterization and enhancement of analysis systems and technical capabilities
  - ✓ Through the development of radioactive material analysis and research facilities and the fostering of analytical human resources, technologies, facilities, and the system should be established to continuously, timely and appropriately carry out the analytical work necessary for decommissioning.
- Development of the processing/disposal concept and safety assessment method
  - ✓ For candidate technologies for preceding processing, reasonable and feasible technologies should be selected, and a safety assessment method should be developed.



On-site work

Technical studies for on-site construction, etc., for each item

Research and development

3. Technological strategies toward decommissioning of the Fukushima Daiichi NPS ([3] Contaminated water management)

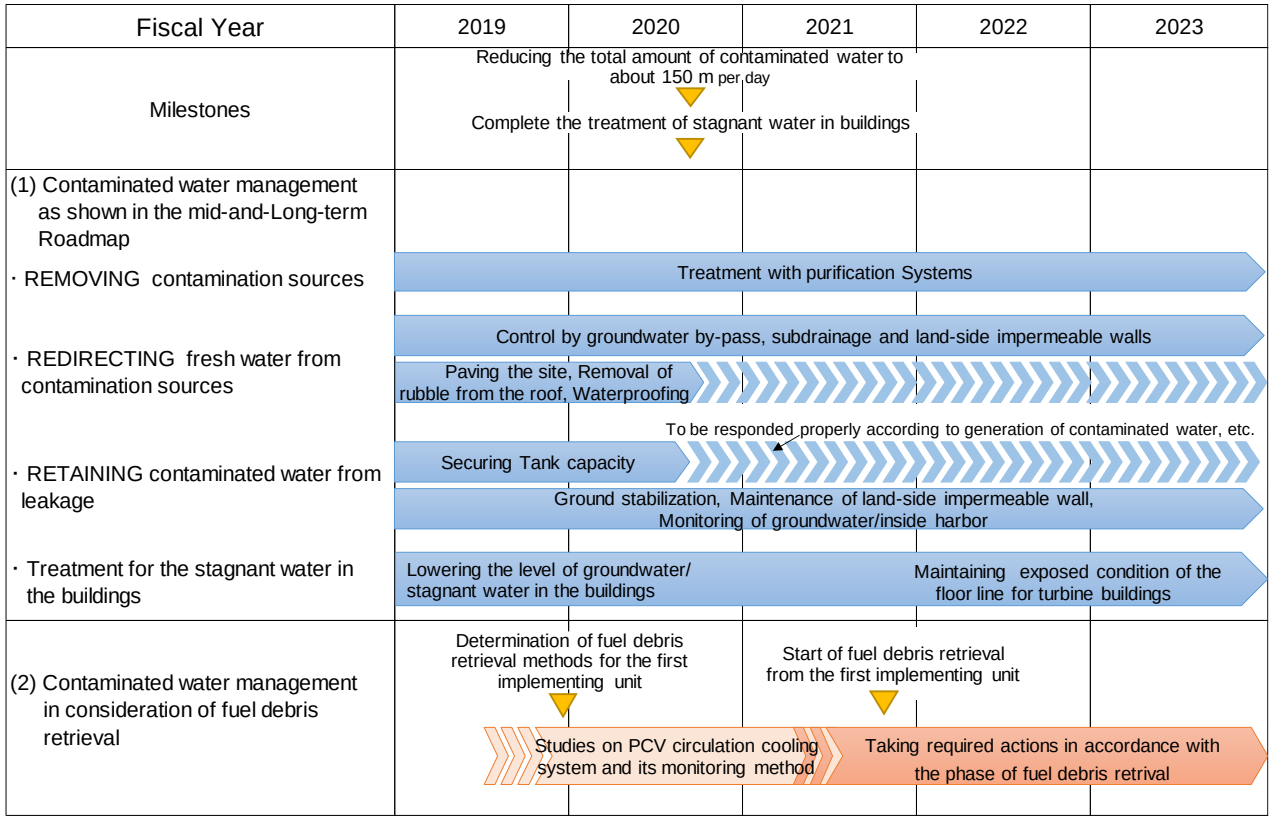
Goals

(1) Under the three basic principles concerning contaminated water issues (“Removing” contamination sources, “Redirecting” fresh water from contamination sources, and “Retaining” contaminated water from leakage), while continuing **reinforced and optimum operations of the water level control system, multilayered measures** should be taken **to complete the processing of the stagnant water in buildings by 2020.**

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

Strategies and Challenges

- Steady execution of contaminated water management indicated in the Mid-and-Long-term Roadmap
- Study on contaminated water management based on the relationship with fuel debris retrieval
  - ✓ It is necessary to proceed with the examination of the entire system, including enhancement of the monitoring to confirm the concentration of radioactive materials at the inlet of the water treatment system.
  - ✓ Further enhancement is needed on monitoring system for water level of groundwater and radioactive materials for the purpose of steadily managing the groundwater surrounding the buildings as well as implementing regular inspections and updates of facilities for sure.



: On-site operation
: Technical reviews for the on-site construction, etc., for each item

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

Goals

(1) Risk assessment and management for the progress of the work will be carried out properly, and measures for safety and security including the prevention of the scattering of radioactive materials will be undertaken thoroughly. **For Units 1 and 2, the removal of fuel in SFP will start by 2023. For Unit 3, the removal is scheduled to be completed in FY 2020.**

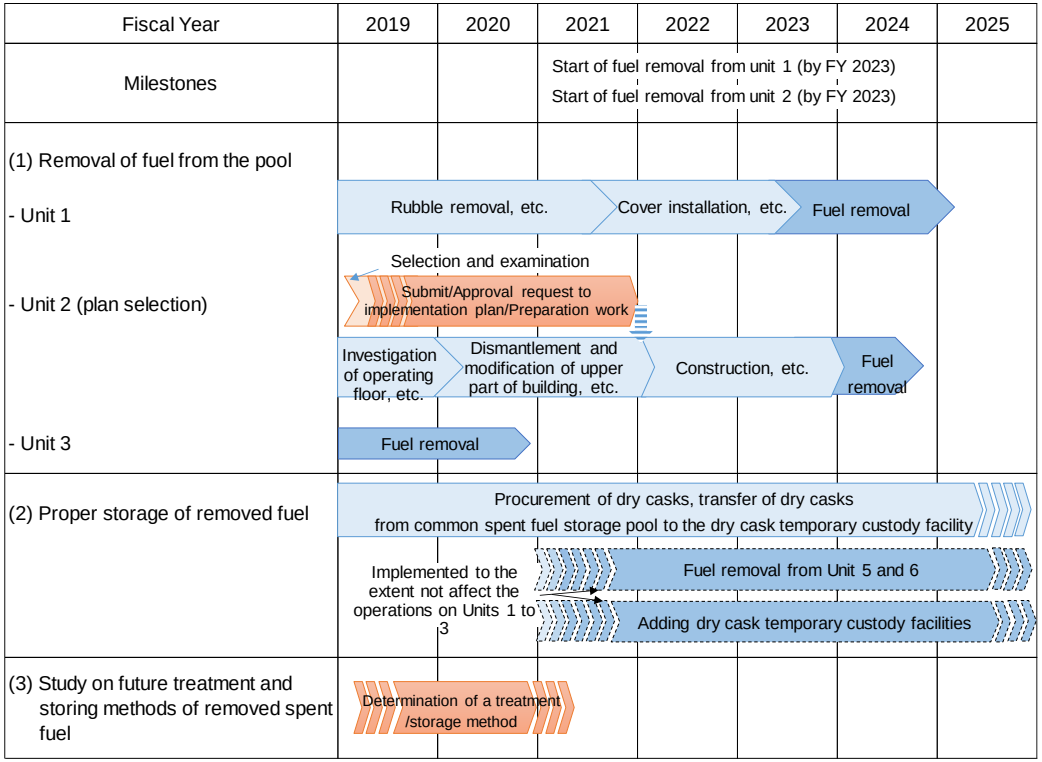
(2) By transferring the fuel stored in the common spent fuel storage pool to dry cask temporary custody facility in order to **secure the capacity** in the common spent fuel storage pool, the fuel removed from the spent fuel pools of Units 1 to 4 is to be **appropriately stored** in the common spent fuel storage pool.

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

Strategies and Challenges

- The evacuation order was lifted in the municipalities where the nuclear power plants is located, and efforts for the return of residents and reconstruction have been started. Careful efforts with more emphasis on safety are required.

- Unit 1: Careful removal of rubble and continued implementation of measures to prevent radioactive dust dispersion during removal
- Unit 2: In addition to the conventional method of completely dismantling the upper part of the operating floor, a method of accessing from the south side of the reactor building without dismantling, to the extent possible, is being considered
- Unit 3: The removal began this April and is expected to be completed by the end of FY 2020



: On-site operation
: Technical reviews for the on-site construction, etc., for each item

4. Handling critical enablers related to the comprehensive approach and smooth promotion of the project

Comprehensive approach to the project

- Formulate a consistent long-term plan for the entire decommissioning process covering from the current status to the short, medium, and long term plans, and comprehensively manage of various efforts in line with this plan
  - Securing the lead time
  - Optimized allocation of limited resources (people, things, money, time, and space)
- In making specific use of the long term plan, set decision points at appropriate times while revising flexibly for effective operation of the plan

Handling critical enablers for smooth operation of the project

- The government, industry and universities associated with the nuclear industry as a whole to make steady efforts to foster and secure future researchers and engineers

R&D initiatives

- TEPCO places much more importance on its own technological development that is directly linked to actual site applicability.
- Management of R&D activities associated with engineering schedule, that the R&D results will be applied to the site in a timely and appropriate manner
- It is also important for universities and public research institutes to share awareness of issues identified at the decommissioning site.

Enhancement of international cooperation

- Learning lessons from the legacy sites and treatment for preceding accident reactors to apply them to decommissioning through utilization of technologies and human resources cultivated in various nations, as a risk reduction strategy
- Establishment and strengthening of a long-term partnership with overseas decommissioning organizations
- NDF proactively participates in international joint activities, such as applying knowledge acquired from accident of Fukushima Daiichi and decommissioning process to other issues in order to respond to new concerns from overseas.

5. Local community engagement

Concept on local community engagement

- “Decommissioning and the reconstruction of Fukushima as an indispensable pair”
- To provide accurate information on decommissioning in a timely and appropriate manner, and to respond to requests from communities through attentive communication.

Actual efforts for better communication

- Providing more in-depth information and developing an interactive communication in progressing decommissioning

The 4th International Forum on the Decommissioning of the Fukushima Daiichi NPS (Aug, 2019)
(Day 1 "Considering the decommissioning of 1F with local residents" in the town of Tomioka)

Decommissioning in line with the reconstruction of affected regions

- Addressing development of local human resources in cooperation with the "Fukushima Innovation Coast Framework".
- Compatibility between the safe and steady decommissioning and giving priority to local communities
- Development of an environment in which more local companies can participate in the decommissioning work through the resources possessed by relevant organizations

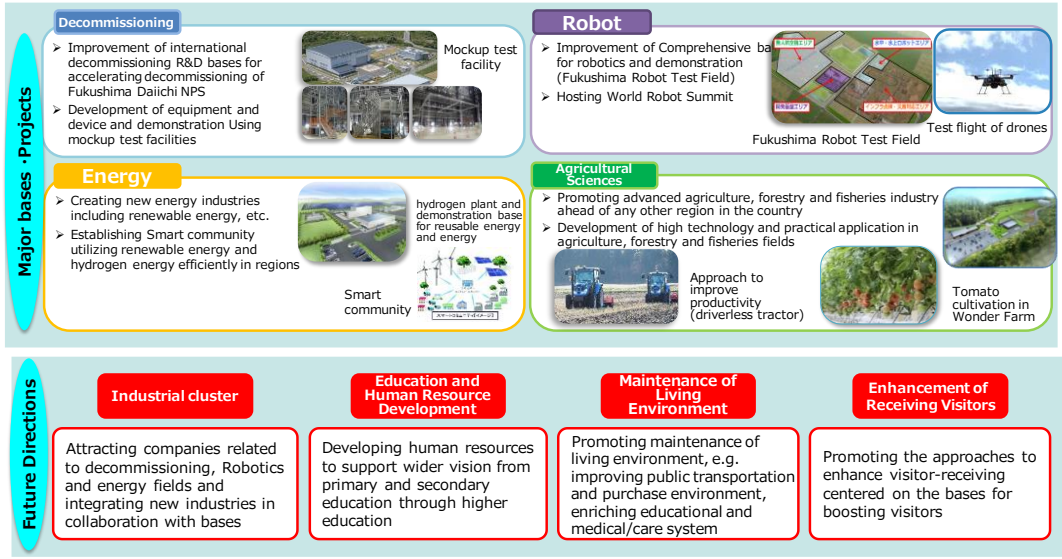


Fig. Overview of Fukushima Innovation Coast Framework*

* Source : Material from Ministry of Economy, Trade and Industry

References

Status of the Estimated Distribution of Fuel Debris

Comprehensive analyses and evaluations will be conducted based on the following information:

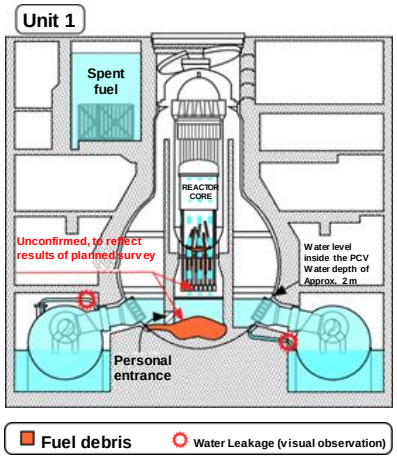
- Distribution of fuel debris
- Access routes and the status of surrounding structures
  (The figures on the right show the distribution of fuel debris.)

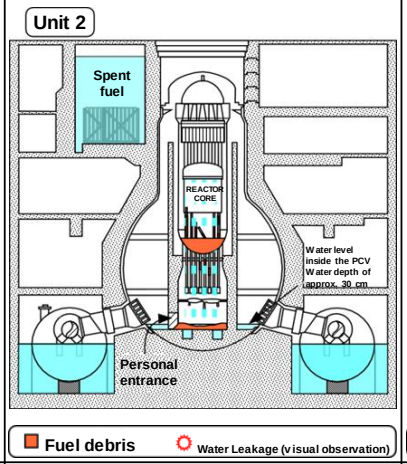
Actual measurements taken during the accident
(Plant parameters, etc.)

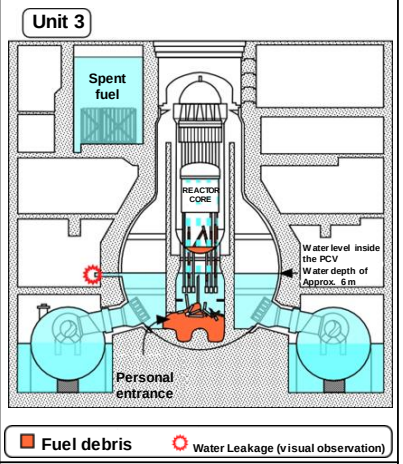
Severe accident progression analysis

PCV internal investigation, muon-based fuel debris detection technology

Scientific knowledge
(Tests, etc.)





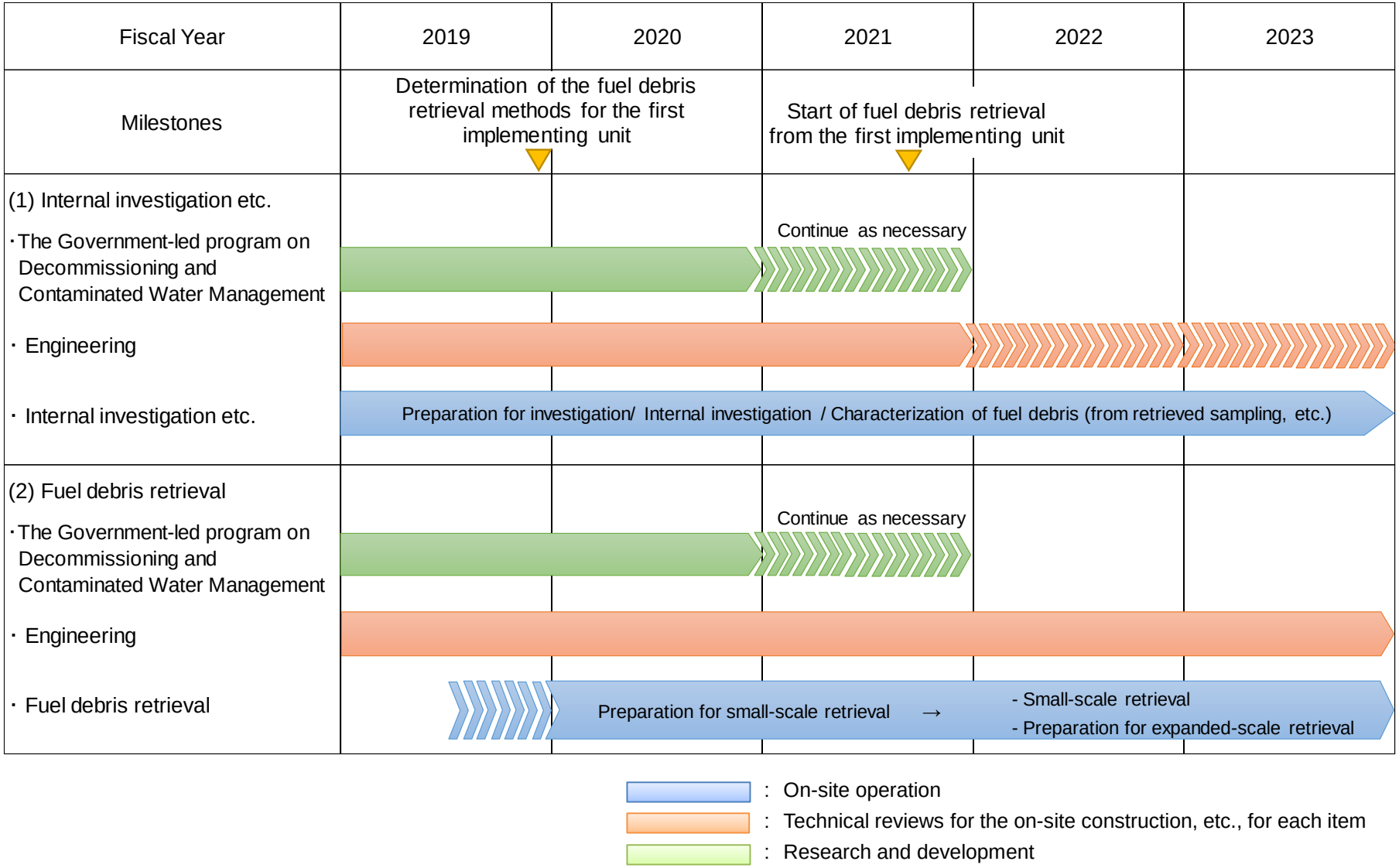


	Unit 1	Unit 2	Unit 3
Core Region	· Little fuel debris remains	· Little fuel debris remains (Stub-shaped fuels might exist in peripheral region)	· Little fuel debris remains
RPV Lower Head	· A small amount of fuel debris is present · A small amount of fuel debris is present in the inside and on the outer 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
Bottom of PCV Pedestal inside	· Most of the fuel debris is present	· A certain amount of fuel debris is present on the floor of the pedestal inside	· Amount of fuel debris in Unit 3 is more than that in Unit 2.
Bottom of PCV 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
Radiation dose in operation site*	· Radiation dose rate around penetration X-6 on the first floor of R/B is high (630mSv/h).	· Radiation dose rate on the first floor of R/B had reduced by about 5mSv/h.	· Radiation dose rate on the first floor of R/B is higher than tens of mSv/h.

* Data provided by TEPCO

Prepared based on the Achievement Report 2017, Subsidy for "The Government-led R&D program on Decommissioning and Contaminated Water Management (Advancement of the comprehensive internal PCV condition analysis)" provided by IRID, The Institute of Applied Energy, June 2018

Key Issues and Future Processes Concerning Fuel Debris Retrieval



Steady execution of contaminated water management indicated in the Mid-and-Long-term Roadmap

It is expected that preventive and multi-layered fundamental measures will be continuously implemented based on the three basic policies, to achieve the milestones indicated in the Mid-and-Long-term Roadmap

Milestones (key target processes) and the status of implementation as of August 2019

[1] Reduction of the amount of contaminated water generated to approximately **150 m^3/day** (in 2020) ⇒ Currently underway

[2] All of the water treated with purification equipment is stored in **welding-type tanks** (FY 2018) ⇒ Completed

[3] **Disconnection of the communication sections** between Units 1 and 2 and between Units 3 and 4 was achieved for the stagnant water in buildings (in 2018) ⇒ Completed

[4] **Reduction** of the amount of radioactive materials contained in the stagnant water in buildings **to approximately 1/10** of the level at the end of FY 2014 (FY 2018) ⇒ Approx. 2/10 of the level at the end of FY 2014 *1

[5] **Completion of treatment of the stagnant water in buildings (In 2020)** *2 ⇒ Currently underway

*1 Calculated amount of radioactive materials as of the end of 2014
(assuming that concentrations of stagnant water in each building are uniform.)

*2 Excluding reactor buildings

Storage Status of Spent Fuels, etc.

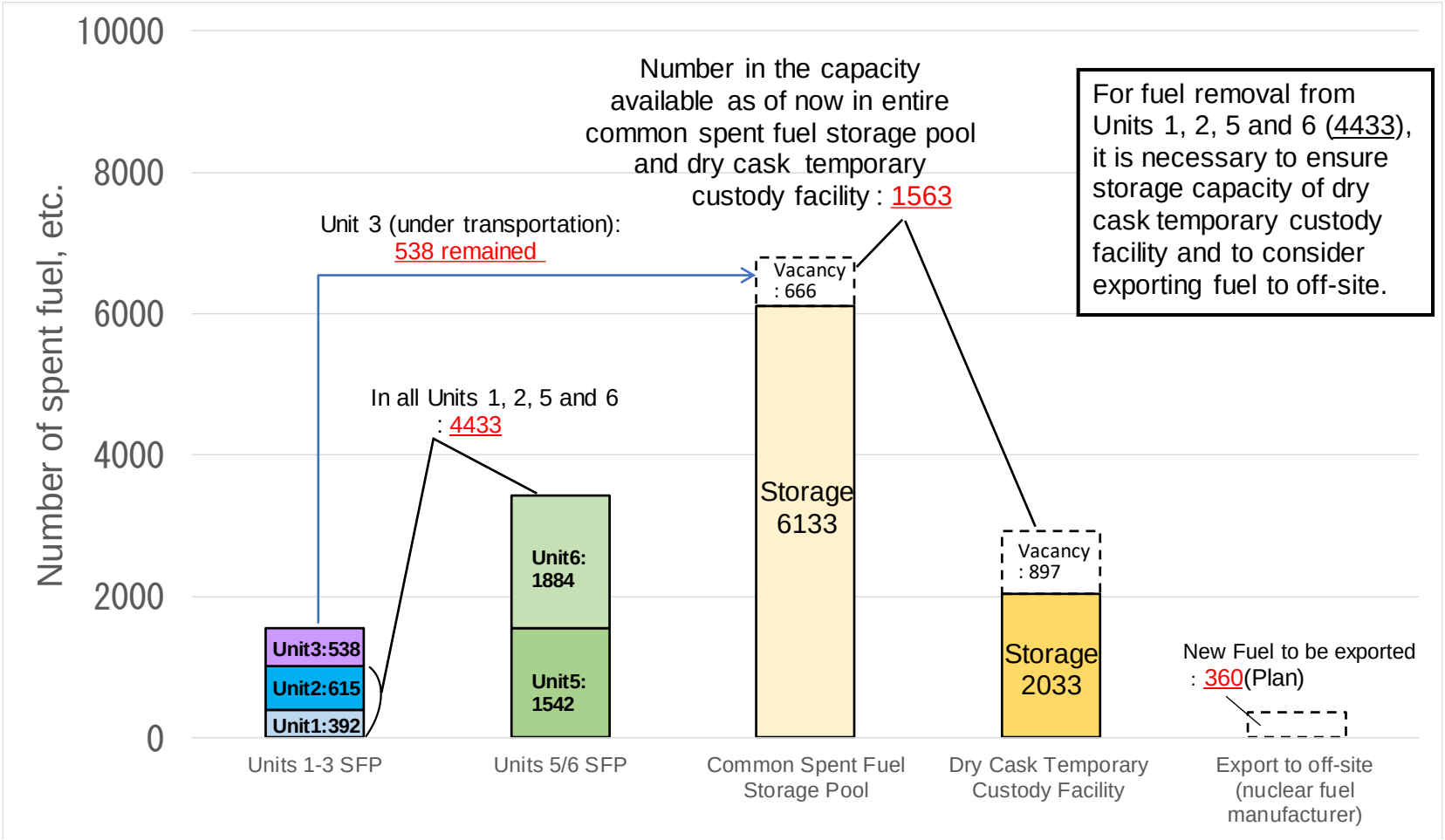


Fig. Storage status of spent fuel, etc. (as of July 25, 2019)

Basic Policies on Solid Waste

(Note) Numbered and titled by NDF for each item.

① **Thorough containment and isolation**

- Containment and isolation shall be thoroughly carried out so that people will not access to radioactive materials to avoid significant radiation exposure.

② **Reduction of solid waste volume**

- The amount of solid waste generated during decommissioning shall be reduced to the extent possible.

③ **Promotion of characterization**

- To promote studies on processing and disposal of solid waste, an appropriate characterization shall be performed in response to the increase in the number of samples for analysis.

④ **Thorough storage**

- Safe and reasonable Storage for generated solid waste according to their characteristics
- Ensuring adequate storage capacity for safe Storage within the site of the Fukushima Daiichi NPS

⑤ **Establishment of selection system of preceding processing methods in consideration of disposal**

- Before the technical requirements for disposal are determined, a method of selecting a processing (preceding processing) for stabilization and immobilization shall be established to select a preceding processing method.

⑥ **Promotion of effective R&D with a bird's-eye-view of overall solid waste management**

- Issues on R&D shall be identified through collaboration among the fields of characterization, treatment and disposal, with a bird's-eye-view on the overall solid waste management.

⑦ **Efficient implementation of R&D projects from the perspective of overall solid waste management**

- For ongoing safe and steady solid waste management, a continuous operational framework including development of adequate facilities and human resources shall be established.

⑧ **Measures to reduce radiation exposure of workers**

- Thorough radiation exposure control, health control, and safety management in accordance with relevant laws and regulations shall be established.