The Mid-to-Long Term Strategy for the Decommissioning of Fukushima Daiichi NPP

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Agency of Natural Resources and Energy (ANRE), Ministry of Economy, Trade and Industry (METI), Japan

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IAEA International Experts’ Meeting on Decommissioning and Remediation after a Nuclear Accident
Outline

1. Mid-to-Long-Term Roadmap for Decommissioning of Fukushima Daiichi NPP

2. Technological Challenges and R&D Program

3. International Cooperation

4. Next Step Forward
1. MID-TO-LONG-TERM ROADMAP FOR DECOMMISSIONING
“Mid-to-Long-Term Roadmap for Decommissioning of TEPCO’s Fukushima Daiichi” was decided in December, 2011.

It defines the decommissioning work into three phases, and sets major milestones of on-site work and R&D projects.

**Phase 1** (with in 2 years):
Commence fuel removal from spent fuel pools

**Phase 2** (with in 10 years):
Commence fuel debris removal from RPVs

**Phase 3** (within 30 to 40 years):
Terminate the decommissioning process
Current Status of Unit 1 -4 (Jan. 28, 2013)

<table>
<thead>
<tr>
<th></th>
<th>Unit #1</th>
<th>Unit #2</th>
<th>Unit #3</th>
<th>Unit #4</th>
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</thead>
<tbody>
<tr>
<td>Core Melt</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
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<tr>
<td>Hydrogen Explosion</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>RPV Temp. (°C)</td>
<td>18</td>
<td>31</td>
<td>31</td>
<td>NA</td>
</tr>
<tr>
<td>PCV Temp. (°C)</td>
<td>20</td>
<td>32</td>
<td>31</td>
<td>NA</td>
</tr>
<tr>
<td>PCV Water level (m)</td>
<td>+2.8</td>
<td>+0.6</td>
<td>Unknown</td>
<td>NA</td>
</tr>
<tr>
<td>Dose rate O.F.(mSv/h)</td>
<td>53.6</td>
<td>880</td>
<td>500</td>
<td>1.3</td>
</tr>
<tr>
<td># of SPF</td>
<td>392</td>
<td>615</td>
<td>568</td>
<td>1,533</td>
</tr>
<tr>
<td>SFP Temp. (°C)</td>
<td>10</td>
<td>12</td>
<td>9</td>
<td>20</td>
</tr>
</tbody>
</table>
Four short-term challenges

Although reactor cores are maintained low temperature, we are now facing at four major challenges:

- Management of accumulated contaminated water
- Reduction of environmental radiation dose
- Improvement of work environment
- Retrieval of spent fuel from spent fuel pool

⇒See P.23-25
Three long-term challenges

Ten years (End of Phase 2) seems far future, but many issues and problems exist to be tackled and solved well before hand.

- Preparation for Fuel debris removal
- Treatment and disposal of radioactive waste
- Development of remote control devices

⇒ See P.21,22
2. TECHNOLOGICAL CHALLENGES AND R&D PROGRAM
Principles for implementing R&D

- Address on-site technological needs
- Government involvement and support
- Open and flexible framework in collaboration with international science and engineering communities
Key Areas of R&D Projects

- Preparation of fuel debris removal
  - Equipment/device development
  - Core status assessment and analysis
  - Fuel debris characterization and management

- Radioactive waste treatment and disposal
  - Processing and Disposal of Secondary Waste
  - Processing and Disposal of Radioactive Waste

- Remote-controlled technologies as a common tool

⇒ See P.27-31

⇒ See P.33-39
3. INTERNATIONAL COOPERATION
Working with the International Community

1) Bilateral dialogue framework with;
   - France, Russia, Ukraine, UK, US

2) Information Portal for Accident Analysis & Decommissioning
   - This information portal provides an easy access to the technical information.

https://fdada.info/
Working with the International Community

3) Cooperation with IAEA

Japan proposed the followings at the Fukushima Ministerial Conference on Nuclear Safety in Dec. 2012.

- **Hosting IAEA peer review missions**
  - Expert’s review for decommissioning program and activities of Fukushima Daiichi NPP.

- **Setting up an international advisory group**
  - Sharing information and data from the accident and decommissioning process.
  - Provide advice and guidance on safety approaches and policies regarding decommission to the international community.
4) International Collaborative Research

- Severe Accident Analysis Benchmark Project
  (NEA / BSAF Project: Phase I –2014, Phase II Planned)
  - Started initial analysis in November 2012 with the participation of 12 institutions from 8 countries
  - Detailed data and boundary conditions are also made available to non-participating organizations through portal site.

- Exploring possibility of international joint research projects such as;
  - Fuel debris sampling and removal,
    - Processing and disposal of radioactive wastes generated from the nuclear accident.
Working with the International Community

5) Enhancing international business and research partnership

- Government-led R&D projects are seeking expertise from the international community, ensuring openness and transparency.

(Example)

- ATOX Co., Ltd., opened a request for proposal on “Integrated Dose Reduction Planning” from Nov 16th to Dec 15th 2012.
- Six out of thirteen companies were selected as advisors.
  - Areva (France)
  - Babcock International Group (UK)
  - CH2M HILL (US)
  - Onet Technologies (France)
  - Perma-Fix Environmental Services (US)
  - Plejades (Germany)
4. NEXT STEPS FORWARD
Next Steps forward

- Commitment of Government
  - Support for establishing R&D institution
  - Strengthen of JAEA’s ability

- Accelerate and revise the Road Map
  - Revise Road Map

- Work and walk with international communities
  - Shear information, elaborate plans and collaborate
  - Contribute to enhance the world nuclear safety

Visit of Prime Minister Abe (Dec. 2012)
Visit of METI's Minister Motegi (Jan. 2013)
THANK YOU VERY MUCH FOR YOUR ATTENTION

Please visit our website:
www.meti.go.jp/english/earthquake/nuclear/decommissioning
### Mid-to-Long Term Road Map

**Dec. 2012 (Reference)**

<table>
<thead>
<tr>
<th>Present (Completion of Step 2)</th>
<th>Within 2 Years</th>
<th>Within 10 Years</th>
<th>After 30-40 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1, 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;Achieved Stable Conditions&gt;</td>
<td><strong>Phase 1</strong></td>
<td><strong>Phase 2</strong></td>
<td><strong>Phase 3</strong></td>
</tr>
<tr>
<td>- Condition equivalent to cold shutdown</td>
<td>- Commence the removal of fuels from the spent fuel pools (Unit 4 in 2 years)</td>
<td>- Complete the fuel removal from the spent fuel pools at all Units</td>
<td>- Complete the fuel debris removal (in 20-25 years)</td>
</tr>
<tr>
<td>- Significant Suppression of Emissions</td>
<td>- Maintain the effective radiation dose to be less than 1 mSv/year at the site boundary caused by additional emission and stored debris.</td>
<td>- Complete preparations for the removal of fuel debris such as decontamination of insides of buildings, restoring PCVs and filling PCVs with water. Then commence the removal of fuel debris (Target: within 10 years)</td>
<td>- Completed decommission (in 30-40 years)</td>
</tr>
<tr>
<td></td>
<td>- Maintain reactor cooling and accumulated water processing and improve their reliability.</td>
<td>- Continue stable reactor cooling</td>
<td>- Implement radioactive waste processing and disposal</td>
</tr>
<tr>
<td></td>
<td>- Start R&amp;D and decontamination towards removal of fuel debris</td>
<td>- Complete the processing of accumulated water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Commence R&amp;D of radioactive waste processing and disposal</td>
<td>- R&amp;D on radioactive waste processing and disposal and on reactor facilities decommission</td>
<td></td>
</tr>
</tbody>
</table>

Actions towards systematic staff training and allocation, motivation improvement, and securing of workers’ safety will be continuously implemented.

Co-Chair: Minister for the Restoration from and Prevention of Nuclear Accident, Cabinet Office
Minister of Economy, Trade and Industry (METI)
Vice-Chair: Parliamentary Secretary of Cabinet Office, Vice Minister of METI, and President of TEPCO
Members: Agency of Natural Resources and Energy (ANRE), TEPCO
Observer: Nuclear Regulatory Agency (NRA)

Management Board

Co-Chair: Parliamentary Secretary of Cabinet Office
Vice Minister of METI
Executive Vice-President of TEPCO
Adviser: Vice Minister of MEXT
Members: METI/ANRE
TEPCO
MEXT
JAEA (Japan Atomic Energy Agency)
Toshiba
Hitachi-GE
Observer: NRA

R&D Management Headquarter

Chair: Vice Minister of METI
Vice-Chair: Parliamentary Secretary of Cabinet Office
Vice Minister of MEXT
Members: METI/ANRE
TEPCO
MEXT
AEC (Atomic Energy Commission)
JAEA, AIST, CRIEPI
Toshiba
Hitachi-GE
and a couple of academic advisors
Main Schedule of Mid-and-long Term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power

<table>
<thead>
<tr>
<th>Phase</th>
<th>Period to the start of fuel removal from the spent fuel pools</th>
<th>Period to the start of fuel debris removal</th>
<th>Period to the end of decommissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FY2012 (Within 2 years) (Early)</td>
<td>FY2013 (Within 2 years) (Mid)</td>
<td>FY2020 (Within 10 years) (Early)</td>
</tr>
<tr>
<td>2</td>
<td>FY2014 (Within 2 years) (Mid)</td>
<td>FY2015 (Within 2 years) (Late)</td>
<td>FY2021 (After 20-25 years) (Late)</td>
</tr>
<tr>
<td>3</td>
<td>FY2016 (Within 2 years) (Mid)</td>
<td>FY2017 (Within 2 years) (Late)</td>
<td>FY2022 (After 30-40 years) (Late)</td>
</tr>
<tr>
<td></td>
<td>FY2018 (Within 2 years) (Late)</td>
<td>FY2019 (Within 2 years)</td>
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**Primary Targets**

- **Step 2 Completed**
- **Spent Fuel Pools**
- **Fuel Debris Removal (Unit 4)**
- **Fuel Debris Removal Completed (All Units)**
- **Determination of Methods for Reprocessing and Storing Spent Fuel**
- **Consider Handling Method of Damaged Fuels from the SFPs**

**Plan for Reactor Cooling**

- Ongoing Monitoring of Reactor Cold Shutdown States (Maintain water injection and monitoring using temperature and pressure parameters etc.)
- Partial Internal PCV Inspection
- Improving the Reliability of Circulating Water Cooling (water withdrawal from turbine
  source)
- **Target:** Complete Switch to Water Withdrawal from Reactor Building (or lower part of PCV)

**Plan for Accumulated Water Processing**

- Accumulated Water Processing via Reliability Improved Water Processing Facilities
- Consideration of Sub-surface Water Processing 
  - **Target:** Accumulated Water Reduction (lower accumulated water level inside buildings according to groundwater level reduction)
- Water Shielding Walls Installation
- **Target:** Reduction of the Risk of Expanded Sea Water Contamination when Contaminated Water Leaks from Reactor Building

**Plan to Mitigate Sea Water Contamination**

- Underwater and Seawater Monitoring (ongoing)
- **Target:** Attainment of Dosage Below 1 mSv/year at Site Boundaries due to Sources such as New Emissions of Radioactive Substances etc. from the Power Station as a Whole

**Plan to Reduce Radiactive Dosage in the Power Station as a Whole, and to Mitigate Sea Water Contamination**

- **Target:** Change Main Area Radiative Building into an Area Phase Radiation Control are not Required
- Land/Sea Area Monitoring (ongoing)

**Plan for Field Test**

- Circulation Cooling of the Pools (Improve Reliability via maintenance and replacement etc.)
- **Target:** Complete Common Pool Modifications for Fuel Storage

**Plan for Fuel Removal From Spent Fuel Pool**

- Storage of Fuel Assemblies Removed from SFP (store/manage)
- **Target:** Complete Common Pool Modifications for Fuel Storage

**Plan for Maintaining Plant in an Ongoing Stable State**

- **Plan to Reduce Radiactive Dosage in the Power Station as a Whole, and to Mitigate Sea Water Contamination**
- **Plan for Field Test**
- **Plan for Fuel Removal From Spent Fuel Pool**

**Plan to Reduce Radiactive Dosage in the Power Station as a Whole, and to Mitigate Sea Water Contamination**

- **Target:** Calculate Radiative Building into an Area Phase Radiation Control are not Required
- Systematic Decontamination (Removal step-by-step from executive and working area in conjunction with efforts to reduce radiation dosage outside of the site)

**Plan for Field Test**

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Main Schedule of Mid-and-long Term Roadmap

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
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<tbody>
<tr>
<td>Period to the start of fuel removal from the unit fuel pool</td>
<td>Period to the start of fuel debris removal</td>
<td>Period to the end of decommissioning</td>
</tr>
<tr>
<td>FY2012</td>
<td>FY2014</td>
<td>FY2016</td>
</tr>
<tr>
<td><strong>Primary Target: Step 2 Completed</strong></td>
<td><strong>SFP Fuel Removal Start</strong></td>
<td><strong>Fuel Debris Removal Start</strong></td>
</tr>
<tr>
<td></td>
<td><strong>(Early)</strong></td>
<td><strong>(Late)</strong></td>
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</table>

**Fuel Debris Removal Plan**
- Section 1: Reactor Building
  - Stage 1: Reactor Building Containment Maintenance
  - Stage 2: Development of Simplification Assessment Technology for RFP/POV Operation

**RFP/POV Integrity Maintenance**
- Repairs / Corrosion Prevention Measures (Taking proper steps to prevent corrosion)

**Reactor Dismantling Plan**
- Investigate and Develop a Database Establishment Plan.
- Establish a Basic Database (containment status, etc.) for Reactor Facility Dismantlement.
- Confirm Applicability of Process Disposal Concept according to Waste Characterization.

**Radioactive Waste Processing/Disposal Plan**
- Development of R&D Plan for Processing/Disposal.
- Establishment of Disposal Outline.

**Organization & Staff Planning**
- Systematic Staff (including senior experts, training, allocation, improving motivation, etc).

**Work Safety Plan**
- Continue to promote safety, maintain, and improve radiation protection measures. Continuously maintain medical care system.

**Determination of Methods to Remove Upper Parts of POV**
- Determination of Methods to Remove Upper Parts of POV.

**Determination of Process Disposal Methods of Fuel Debris**
- Determination of Fuel Debris Removal Method and Confirmation of Principles of Fuel Debris Container, etc.

**Note:** This roadmap will be updated in consideration of the on-site situation and the latest research and development results.
Accumulated water increased by groundwater intrusion

The highly contaminated water accumulated in the building basement is treated to be used for reactor cooling again. And there exists grand water intrusion (400t/day) to basement as well. The contaminated water generated in this process treated and stored in tank.

- **a. Prevent groundwater flow into the building** → **Develop groundwater bypass**
- **b. Remove the radioactive materials in the contaminated water** → **Install multi-nuclide removal equipment** (Tritium cannot be removed)
- **c. Storage of contaminated water** → **Build additional storage tanks in the site**
Plan and progress of fuel removal from the spent fuel pool

- The Circulating Cooling System had started operation. And desalination of the water in Spent Fuel Pool were in operation.
- Confirmed conditions inside the spent fuel pool via an underwater camera, corrosion investigation of removal unused fuel removal.
- Debris removal from the upper part of Units 3-4 Reactor Building is in progress. (to be completed in end of FY 2013 at Unit 3, in Dec, 2012 at Unit 4)
- At Unit 4, cover installation for fuel removal is on going.
- Preparation of Common Pool which stored removal spent fuel and construction of Dry cask temporary storage facility is on going.

Goal of Fuel removal from Unit 4 spent fuel pool (Start by Nov. 2013, Complete by Dec. 2014)

- Debris removal from the upper part of the Reactor Building
- Cover installation for fuel removal
  - Mid 2013
- Cover (or container)
- Overhead traveling crane
- Fuel exchanger
- Transport vessel
- Spent fuel pool
- Rain prevention
- Carry out

Nov. 2013
We confirmed that the building, including the spent fuel pool, has a sufficient margin of seismic resistance even if an earthquake equivalent to the Tohoku-Pacific Ocean Earthquake (JMA Seismic Intensity Scale 6+) occurs in the area.

We installed a support structure at the bottom of the spent fuel pool at the Unit 4. The structural integrity of the spent fuel pool has been confirmed by quarterly checks (building tilt, no more than 1mm crack width, etc).

Illustration of Force Flow and distribution of SFP

Shell wall (Not-damaged)

Outer wall between the first floor and the second floor was not damaged. (Visual inspection)
TECHNOLOGICAL CHALLENGES FOR FUEL DEBRIS REMOVAL
### R&D Roadmap (Fuel Debris Removal)

#### Phase 1
- Period by when fuel removal from SFP started

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</tbody>
</table>

- **Within 2 years**
  - (Prior Period)
- **Within 10 years**
  - (Middle Period)
- **Within 20 years**
  - (Late Period)

### Phase 2
- Period by when fuel debris removal started

### Phase 3
- Period till end of decommissioning

#### Key Activities:

1. **Decontamination of buildings, shielding, etc.**
   - Evaluation of applicability to actual units
   - Development of Technologies for Remote Decontamination of the Reactor Building Interior
   - Estimation of status of contamination / Collection of basic data
   - Organization of decontamination work / Improvement
   - Design, manufacture, and testing of remote decontamination equipment, etc.

2. **Survey of leaks in PCV**
   - Repair the PCV’s Lower Part/Stopping Interbuilding
   - Survey of leaks
   - Technologies for Identifying Leaks

3. **Shutdown of water in buildings**
   - Repair of PCV
   - Determining Repair Method / Determine Water Stop Method
   - Filling water of PCV
   - PCV Leakage Point Investigation

4. **Repair of PCV**
   - Repair the PCV’s Upper Part
   - Determining Repair Method / Determine Upper Part of PCV

5. **Filling water of PCV/pressure vessels**
   - Determining Repair Method / Determine Upper Part of PCV

6. **Survey of PCV / Survey of Interiors of reactors and collection of samples**
   - Survey of existing technologies / Drafting of survey plan
   - Development and manufacture of survey equipment
   - Development and manufacture of equipment for investigation
   - Study of access methods / Development, design, and manufacture of equipment

7. **Removal of fuel debris**
   - Complete Flooding PCV’s Lower Part
   - Determine PCV Internal Inspection Method
   - Complete Flooding PCV’s Upper Part
   - Determine RPV Internal Inspection Method

### Notes:
- **HP**: Holding points
- **FY**: Fiscal Year
- **Years**: Duration of activities
- **Periods**: Prior, Middle, Late

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*The table and diagram provide a detailed roadmap for R&D activities focusing on fuel debris removal, including phases, timelines, and key tasks.*
### R&D Schedule and On-site Needs

- **Debris characterization and treatment study**

<table>
<thead>
<tr>
<th>Item/Year</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(beginning)</td>
<td>(mid)</td>
<td>(end)</td>
</tr>
</tbody>
</table>

#### Needs

1. **Estimation of fuel debris character**
   - (1) Estimation of the condition in which debris generated
   - (2) Characterization using simulated debris
   - (3) Comparison with TMI-2 debris

2. **Analysis of actual 1F debris**

3. **Development of debris treatment technology**
   - (1) Scenarios study
   - (2) Feasibility study of various technologies

**Preparation of sampling tools**

**Debris sample**

**Defueling operation**

**Discussion starts to decide debris treatment after defueling operation**

**Comparative evaluation**

To contribute estimation of the present status in PCV

To contribute sampling and defueling

To contribute handling and storage

To contribute assessment of debris treatment scenarios

To contribute technology development on debris treatment
Challenges for fuel removal:

1) Development of Remote Equipment and Devices

- **Short-term**
  - Monitoring devices for the R/B under high dose environment
    - Remote-controlled UAVs, etc.
  - Sensing devices for water surface in the S/C and PCV to identify location of leaks
  - Remote-controlled robots running in the water to repair leaks
    - Identify self location in the water
    - Automatic treatment of long-length communication cable
    - Sensor for the shape and water-flow

- **Mid-term**
  - PCV repair devices and defueling equipment
Challenges for fuel removal:
2) Accident analysis for evaluating the core status

- Short-term
  - Accident progression analysis and benchmark study, by using existing and improved integral severe accident codes (cf. TMI-2 experience of OECD/NEA joint research)
  - Database/information portal to make accident data readily available to the international community.
  - Assessment on the validity of severe accident codes and leading greater confidence in the code predictive capabilities

- Mid-term
  - Further analysis applying various models and methodologies
  - Collection of physical data during sampling and defueling
Challenges for fuel removal:

3) Characterization and Sampling of Fuel Debris

- **Short-term**
  - Simulated fuel debris for evaluating its characterization
  - Creating and updating database by making use of the experience of the TMI-2 debris study
  - Management and storage of fuel debris, and development of a new accountancy method

- **Mid-term**
  - Sampling and analyzing actual fuel debris
  - Deployment of defueling equipment, devices, and storage.
TECHNOLOGICAL CHALLENGES FOR RADIOACTIVE WASTE PROCESSING AND DISPOSAL
## R&D related to processing and disposal of radioactive waste

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period by when fuel removal from SFP started</td>
<td>Period by when fuel debris removal started</td>
<td>Period till end of decommissioning</td>
</tr>
<tr>
<td>FY 2012</td>
<td>FY 2013</td>
<td>(Late Period)</td>
</tr>
<tr>
<td><strong>Main event</strong></td>
<td><strong>Implementation of measures for long-term stable storage</strong></td>
<td>(Late Period)</td>
</tr>
<tr>
<td>▼ Step 2 Completion</td>
<td>▼ Fuel Debris Removal Start (First unit)</td>
<td>▼ Decommissioning Completed (All units)</td>
</tr>
<tr>
<td>SFP Fuel Removal Start (Unit 4)</td>
<td>Fuel Debris Removal Completed (All units)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decommissioning Completed (All units)</td>
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</tbody>
</table>

### (3-1) Development of Technologies for the Processing and Disposal of Secondary Waste produced by the Processing of Contaminated Water

- Survey of characteristics of secondary waste
- Study of measures for long-term storage
- Study of technologies for manufacture of waste blocks
- Verification of applicability of existing concepts of disposal / Identification of problems

### (3-2) Development of Technologies for the Processing and Disposal of Radioactive Waste

- Survey of characteristics of rubble, etc.
- Verification of applicability of existing concepts of disposal / Identification of problems (Rubble, etc.)
- Study of properties (Dependent on period of occurrence of specific waste product) / Development of technologies for manufacture of waste blocks
- Verification of applicability of existing concepts of disposal / Identification of problems (Waste from disassembly, etc.)
- Solution of problems of existing technologies
- Solution of problems of existing technologies

- HP 8
- HP 9
- HP 10
- HP 11

### Management of radioactive waste

- Storage and management of radioactive waste
- Implementation of measures for long-term stable storage

### Processing and disposal of radioactive waste

- Installation of Waste Form Manufacturing
- Manufacture of Waste Form...
- Plan for Disposal and Installation of the Manufacturing Equipment of the Waste Form
- Study of properties (Dependent on period of occurrence of specific waste product) / Development of technologies for manufacture of waste blocks
R&D Issues for Radioactive Waste Processing and Disposal

1. Properties Investigation and Characterization

- Properties differ from conventional waste, such as rubble, sludge, and decontaminated waste liquid (nuclide composition, chloride content, etc.)
- Basic information needs to be assessed for the development of each technology

Examples of differences with conventional waste
- Main nuclides: Co-60, C-14, etc.
  → Fukushima Daiichi: Cs-137, Sr-90, etc.
- Sodium concentration is 5 times that of the TMI case due to 50-90% contamination by seawater
  → Lower Cesium absorption performance, increased waste generation
- Presence of sludge and other materials of unknown chemical composition
  → Need to identify these materials through analysis

Outputs
- Radioactive concentration of each type of nuclide
- Component content
- Physicochemical characteristics, etc.

The installation of a hot lab near 1F must also be considered, as large volumes of high-dose, untransportable samples are expected to be generated accompanying decontamination and fuel debris removal.
R&D Issues for Radioactive Waste Processing and Disposal

2. Long-term storage technologies

- Impact of chloride (corrosion) and high radioactivity (heat, hydrogen, surface radiation)
- Duration of storage: how long should it be?
- Is treatment necessary before storage?

Facility for secondary waste storage after water treatment (example)

Cross section B, A, C

Water inlet

A-A cross section
Temperature distribution

Temperature of zeolite layer
Approx. 170˚C max.

Evaluation of temperature and hydrogen distribution in a KURION absorption vessel (by JAEA)

Output: Long-term storage method for each type of waste
R&D Issues for Radioactive Waste Processing and Disposal

3. Processing technologies

- Can technologies used for existing processing technologies be applied?

**Examples of waste package**
- Drums
- Square vessels

**Examples of solidification**

**Basic flow in a cementing facility**

**Outputs**
- Treatment methods for storage
- Methods for production of waste packages
- Performance of waste packages

### 4. Disposal technologies

- Fundamental new technologies on the existing disposal concept
- Extract and address issues related to safety evaluation and find a solution

**Existing concept**

- **Low-level radioactive waste**
  - Trench disposal
  - Pit disposal
  - Yoyusindo disposal

- **High-level radioactive waste**
  - Geological disposal

**Example of an engineered barrier (Yoyusindo disposal)**

- Waste package (1.6 x 1.6 x 1.6, metal vessel)
- Concrete pit (0.7m)
- Low diffusion layer (0.6m)
- Low permeability layer (1m)
- Backfill with clay-mixed soil

**Output:** Waste disposal methods (required burial depth, construction of an engineered barrier, etc.)
Challenges for Radioactive Waste Treatment

- **Short-term**
  - Development of analysis techniques and methods for the characterization of accident-origin solid waste
    - Pre-treatment of solid radioactive waste
    - Simplified and standard methodologies
    - Regulatory and institutional framework
  - Management and processing secondary waste storage after water treatment

- **Mid-term**
  - Exploring possibility for building a research center for international collaborative research program
  - Researchers/experts exchanges with international community
Challenges for Improving the Work Environment

■ Short-term
  ✓ Technologies and systems to reduce the doses of workers
    • Dose reduction management, including shielding
    • Improving materials for workers’ suits
  ✓ Studying methodologies for increasing human performance
    • Advancing human health and performance innovations for severely challenging environments
    • Designing a better work environment

■ Mid-term
  ✓ Address human resource needs for the mid-to-long term