Approach to HLW disposal cost estimation

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IFNEC, RNFSWG WORKSHOP ON APPROACHES TO FINANCING A MULTINATIONAL REPOSITORY – CHALLENGES AND ALTERNATE APPROACHES

11 December 2018
Paris, France
1. Japanese Programme

2. Costing methods and Results
Chronology of Japanese disposal programme

Historical overview

- **1992**: Start of R&D program for geological disposal
- **2000**: Establishment of NUMO (Oct. 2000)
- **2000**: Implementation Organization (NUMO)
  - Site selection and characterization
  - Design, licensing, construction, operation and closure of repository
  - Collection of fund
- **2002**: Start of open solicitation of acceptance of geological survey by literature (Dec. 2002)
- **2005**: Amendment to Final Disposal Act for TRU waste (Jun. 2007)
- **2010**: R&D activities by supporting organizations
- **2020**: 2030
- **2020**: The Great East Japan Earthquake (Mar. 2011)

**No specific site and host rock for DGR**

R&D Organizations (JAEA, CRIEPI etc.)

- R&D  Organizations (JAEA, CRIEPI etc.)
Types of radioactive waste for final Disposal financing

- Nuclear fuel cycle policy
- Reprocessing generates HLW and TRU waste.

Nuclear fuel cycle policy

- Reprocessing generates HLW and TRU waste.

NUMO's responsibility

- Image of disposal
- More than 300m below surface

Geological disposal of high-level & TRU waste

- Vitrified waste
- Canister
- Drum
- Rectangular container

Nuclear fuel cycle

- Uranium mine
- Fuel assembly
- Uranium enrichment & fuel fabrication plant
- Nuclear power plant
- MOX fabrication plant
- Reprocessing plant
- Recovered uranium
- Recovered uranium & plutonium
- Spent fuel
- HLW
- TRU waste

Canister
- Drum
- Rectangular container
Summary of Japanese disposal programme

Site characterization

Municipalities invited by the Government (*)

Preliminary Investigation Areas (PIAs)
- Geophysical surveys
- Boreholes, etc.

Detailed Investigation Areas (DIAs)
- Excavation of test tunnel
- Investigations in the test tunnel

Repository Site (RS)

Selection of PIAs

Selection of DIAs

Selection of RS

(*) This procedure was added in 2007 after Toyo town case
Summary of Japanese disposal programme

Multi barrier system

Deep underground location (deeper than 300 m)

- Isolation from surface perturbations
- Low groundwater flow rate
- Reducing environment

Host rock

Buffer (bentonite + sand)

- Mechanical buffer
- Low permeability hydraulic barrier
- Retardation of radionuclide migration

Overpack (carbon steel)

- Containment for more than 1,000 years
- Extremely low solubility

Vitrified HLW

Natural Barrier

Engineered Barrier System (EBS)
Image of underground facilities

Scale of facilities

Underground facilities: *around 3km by 2km*

Image of surface facilities

Surface facilities: *around 1-2km²*
1. Japanese Programme

2. Costing methods and Results
- In order to implement final disposal of HLW systematically and reliably, nuclear power reactor installation companies and Reprocessing facility installation companies have to pay the necessary expenses (contributions) to NUMO by March 1st every year, in accordance with the "Act on Final Disposal of Specified Radioactive Waste". Note. NUMO, the Nuclear Waste Management Organization of Japan

※1 Updating major of unit price using publication data every year
※2 Required Approval of METI
Estimation of Major of Unit Price for funding

Costing methods of total cost of the final disposal

① Based on the idea accepted at the nuclear energy subcommittee of September 2000 and February 2008.

② Unit price of contributions is calculated by the following method.
   - Dividing the cost, subtracting "Current accumulated fund " from "Total disposal cost for the future", by the amount of waste, subtracting "The amount of radioactive waste for which disposal expenses have been paid" from "Total amount of radioactive waste for the future"

\[
\text{Unit price of Contribution} = \frac{\text{Total disposal cost for the future} - \text{Current accumulated fund} \text{ (including expenses and investment profit)}}{\text{Total amount of radioactive waste for the future} - \text{The amount of radioactive waste for which disposal expenses have been paid}}
\]

Note: Each cost for the future must be reduced present discounted value.
## Reference cases/scenarios

### Terms and conditions for the cost estimation

<table>
<thead>
<tr>
<th></th>
<th>Case A</th>
<th>Case B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Host rock</strong></td>
<td>Soft rock (Sedimentary rock)</td>
<td>Hard rock (Granite)</td>
</tr>
<tr>
<td><strong>Depth of repository</strong></td>
<td>500m</td>
<td>1000m</td>
</tr>
<tr>
<td><strong>Tunnel support</strong></td>
<td>Concrete</td>
<td>Nothing</td>
</tr>
<tr>
<td><strong>Thickness of Buffer material</strong></td>
<td>70cm</td>
<td></td>
</tr>
<tr>
<td><strong>Installation of buffer material</strong></td>
<td>Block installation</td>
<td></td>
</tr>
<tr>
<td><strong>Material of Overpack</strong></td>
<td>Carbon steel</td>
<td></td>
</tr>
<tr>
<td><strong>Thickness of Overpack</strong></td>
<td>19cm</td>
<td></td>
</tr>
<tr>
<td><strong>Access type</strong></td>
<td>1 ramp and 6 shafts</td>
<td></td>
</tr>
<tr>
<td><strong>Siting process</strong></td>
<td>10 sites → 5 sites → 1 sites (LS)</td>
<td>1 sites (PI)</td>
</tr>
</tbody>
</table>
Assumed schedule for the cost estimation

Schedule is based on the amendment of “Plan of Final Disposal” in 2008

- Preliminary Investigation
- Detailed Investigation (I)
- Detailed Investigation (II) at UIF
- Literature Survey

- Site characterization
- Construction
- Operation
- Closure & Decommissioning
- Monitoring (Post Closure)

- Duration:
  - 20 y
  - 8 y
  - 40 y
  - 10 y
  - 300 y

- Duration:
  - 2 y
  - 4 y
  - 14 y
  - 30-40 y

- Duration:
  - 40 y
  - 10 y
  - 300 y
### Result of HLW disposal cost

Adaption of mean value (from 2 reference cases/scenarios)

(Billion JPY)

<table>
<thead>
<tr>
<th></th>
<th>Soft rock</th>
<th>Hard rock</th>
<th>Mean value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD&amp;D</td>
<td>117</td>
<td>117</td>
<td>117</td>
</tr>
<tr>
<td>Site characterization &amp; Land cost</td>
<td>178</td>
<td>199</td>
<td>188</td>
</tr>
<tr>
<td>Repository design &amp; Construction</td>
<td>1,081</td>
<td>903</td>
<td>992</td>
</tr>
<tr>
<td>Operation</td>
<td>767</td>
<td>841</td>
<td>804</td>
</tr>
<tr>
<td>Decommission &amp; Closure</td>
<td>93</td>
<td>100</td>
<td>97</td>
</tr>
<tr>
<td>Monitoring</td>
<td>122</td>
<td>122</td>
<td>122</td>
</tr>
<tr>
<td>Project Management</td>
<td>519</td>
<td>447</td>
<td>483</td>
</tr>
<tr>
<td>Consumption tax</td>
<td>223</td>
<td>215</td>
<td>219</td>
</tr>
<tr>
<td>Sum</td>
<td>3,100</td>
<td>2,944</td>
<td>3,022</td>
</tr>
</tbody>
</table>

*As of FY2017 after annual review*
Result of HLW disposal cost

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>Soft Rock</th>
<th>Hard Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD&amp;D</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Site characterization &amp; Land cost</td>
<td>5%</td>
<td>6%</td>
</tr>
<tr>
<td>Decommission &amp; Closure</td>
<td>25%</td>
<td>30%</td>
</tr>
<tr>
<td>Operation</td>
<td>34%</td>
<td>30%</td>
</tr>
<tr>
<td>Monitoring</td>
<td>17%</td>
<td>16%</td>
</tr>
<tr>
<td>Consumption tax</td>
<td>14%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Soft rock vs. Hard rock comparison.
Results of expenditure and fund

● Total cost
  ➢ Approx. **3,826 billion JPY**
    ✓ **HLW**: approx. **3,022 billion JPY***
    ✓ **TRU**: approx. **804 billion JPY**

*: Number of waste equivalent (as of the end of FY2017)
   -> approx. 24,996 canisters (of the total 40,000 canisters)

● Total of fund from annual contribution (as of the end of FY2017)
  ➢ **HLW**: **944.0 billion JPY**
  ➢ **TRU**: **58.3 billion JPY**
Thank you for your attention