Overview and Challenges in Strategy Making for Decommissioning in Japan

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Current Situation in Japan
Restart generating electricity

◆ Sendai Nuclear Power Unit No.1 (Kyusyu Electricity Power Company Inc., PWR, 890MW) had been inspected from May 10th 2011, and been conducted the adjustment operation after restarting power generation on August 14th 2015. It had returned to commercial operation on September 10th 2015.

◆ Sendai Nuclear Power Unit No.2 (PWR, 890MW) restarted the reactor on October 15th 2015 and currently under the adjustment operation.
# Current Status of NPPs in Japan

<table>
<thead>
<tr>
<th>Status</th>
<th>Number of NPPs</th>
<th>Remarks</th>
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</thead>
</table>
| Commercial operation                  | 1              | Sendai-1
Restarted commercial operation    |
| Amendment of the reactor installment license is approved | 5 (including Sendai-1) | Sendai-2 and Takahama-3
Under inspection before commercial operation |
| In the process for restart            | 20             | Tokai No.2 and others                                                  |
| Under consideration                   | 18             | Tsuruga-2 and others                                                   |
| Permanent Shutdown                    | 5              | Shutdown on April 2015
Tsuruga-1 and others                  |
| Decommissioning                       | 4              | Tokai-1, Hamaoka-1,2, Fugen                                           |
| Handling of the accident              | 6              | Fukushima-Daiichi                                                      |
Operational years of commercial NPP in Japan

As of April, 2015

43 LWRs in Operation

Average

40 years limitation

Operational years of commercial NPP in Japan
Amendments to the Nuclear Regulation Act promulgated in June 2012

- **New regulation on severe accidents**  
  Legally-requested measures to prevent and to mitigate severe accidents.

- **Regulation based on the state-of-the-art information**  
  Develop new regulatory standards and apply to existing nuclear facilities (backfitting).  
  Introduce new systems, e.g. design certification.

- **40-years operational limit for NPPs**  
  Legally define the limit to 40 years.  
  NRA can permit a less-than-20-years extension.

- **Special regulation to disaster-experienced NPPs**
From the 1970s, examination of development of the technology relevant to decommissioning is repeated. Dismantling of JPDR of Japan Atomic Energy Research Institute (Current Japan Atomic Energy Agency) was completed in Mar, 1996.

As a commercial nuclear power plant, the JAPC started Tokai Decommissioning project for the first time on Dec, 2001.

Subsequently, JAEA Fugen and the Chubu Electric Power Co. Hamaoka 1, 2 started decommissioning.

Additionally five plants (Tsuruga-1, Mihama-1&2, Shimane-1, Genkai-1) were shutdown in April 2015.
Decommissioning institution in Japan
Institution for decommissioning fund

It is required to accumulate decommissioning cost while plant operation. It is fair that the user of the electricity of the plant absorb the decommissioning cost to prevent from leaving burdens to future generations.

Because,

① Decommissioning cost is large sum, there is a big delay of the timing that required decommissioning cost from electric generating period,

② Decommissioning cost is required as a result of electric generation,

③ It is possible to estimate rational decommissioning cost based on decommissioning standard process shown by Advisory Committee for Natural Resources and Energy
• Estimated total decommissioning cost is 57-77 billion yen (for large scale 1100MWe plant)
• Brief assessment based on linear approximate equation
• Minimum cost because it is duty free
• Directly affect to financial condition of each company because it is internal reserve
Safety regulation on decommissioning in Japan

Continue Construction permit

Plant operation phase

Decommissioning phase

Cessation of operation

Approval

D&D methods, schedule, Radioactive waste treatment, safety analysis etc.

D&D, fuel shipment, decontamination waste disposal etc.

Regulation based on D plan
(Compliance with D plan)

Application for verification of D completion

Confirmation (License Termination)

Approval Criteria

Regulation for plant operation
Regulation for shipment
Tech-spec PP

Gradual regulation
Japanese Standard Scenario for Decommissioning of NPPs

1. Shutdown
2. Defueling
3. System Decontamination
   - (unnecessary for GCR)
4. Safe Store
   - (~ 5-10 years)
5. Dismantling
6. Waste Treatment
7. Waste Disposal
8. Site Release or Reuse

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Waste arose from decommissioning

Low Level Radioactive Waste

NR (Non Radioactive waste)
- No radioactive contamination
- No attached or penetrated contamination

Inside of Control Area

L1: Relatively high radioactive waste
L2: Relatively low radioactive waste
L3: Very low level waste
Clearance material: No necessity to be dealt as radioactive

Outside of Control Area

General Decommissioning Waste

Non Radioactive Waste
### Classification Criteria for LLW Disposal Concept

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Limit Concentration for Intermediate Disposal</th>
<th>Limit Concentration for Near Surface Pit Disposal</th>
<th>Limit Concentration for Near Surface Trench Disposal</th>
<th>Clearance Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>―</td>
<td>―</td>
<td>―</td>
<td>1E+05</td>
</tr>
<tr>
<td>C-14</td>
<td>1E+13</td>
<td>1E+08</td>
<td>―</td>
<td>1E+03</td>
</tr>
<tr>
<td>Cl-36</td>
<td>1E+10</td>
<td>―</td>
<td>―</td>
<td>1E+03</td>
</tr>
<tr>
<td>Mn-54</td>
<td>―</td>
<td>―</td>
<td>―</td>
<td>1E+02</td>
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<tr>
<td>Co-60</td>
<td>―</td>
<td>1E+12</td>
<td>1E+07</td>
<td>1E+02</td>
</tr>
<tr>
<td>Ni-63</td>
<td>―</td>
<td>1E+10</td>
<td>―</td>
<td>1E+05</td>
</tr>
<tr>
<td>Sr-90</td>
<td>―</td>
<td>1E+10</td>
<td>1E+04</td>
<td>1E+03</td>
</tr>
<tr>
<td>Tc-99</td>
<td>1E+11</td>
<td>1E+06</td>
<td>―</td>
<td>1E+03</td>
</tr>
<tr>
<td>I-129</td>
<td>1E+09</td>
<td>―</td>
<td>―</td>
<td>1E+01</td>
</tr>
<tr>
<td>Cs-134</td>
<td>―</td>
<td>―</td>
<td>―</td>
<td>1E+02</td>
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<tr>
<td>Cs-137</td>
<td>―</td>
<td>1E+11</td>
<td>1E+05</td>
<td>1E+02</td>
</tr>
<tr>
<td>Eu-152</td>
<td>―</td>
<td>―</td>
<td>―</td>
<td>1E+02</td>
</tr>
<tr>
<td>Eu-154</td>
<td>―</td>
<td>―</td>
<td>―</td>
<td>1E+02</td>
</tr>
<tr>
<td>α-Nuclide</td>
<td>1E+08</td>
<td>1E+07</td>
<td>―</td>
<td>―</td>
</tr>
</tbody>
</table>
### Decommissioning solid waste treatment & disposal flow

<table>
<thead>
<tr>
<th>Segregation</th>
</tr>
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<tbody>
<tr>
<td><strong>LLW</strong></td>
</tr>
<tr>
<td>Relatively high radioactive waste (L1)</td>
</tr>
<tr>
<td>Relatively Low radioactive waste (L2)</td>
</tr>
<tr>
<td>Very low level waste (L3)</td>
</tr>
<tr>
<td>No necessity to be dealt as radioactive (Clearance material)</td>
</tr>
<tr>
<td>Non Radioactive waste</td>
</tr>
</tbody>
</table>

### Treatment
- **Pre treatment** -> **Packing/temporal storage**
  - Cut, Crush, Compaction: metal, graphite
  - Volume reduction: metal, concrete (include melting, incineration)
  - Decontamination: metal
- **Pre treatment** -> **Packing/temporal storage**
- **Pre treatment** -> **Packing/temporal storage**
  - Decontamination: metal
- **Temporal storage**
- **Temporal storage**

### Disposal
- **Sub-surface disposal with engineered barriers**
- **Near-surface disposal with engineered barriers**
- **Near-surface disposal without engineered barriers**
- **Recycle**
Radioactive Waste Disposal Methodology in Japan

Relatively high radioactive waste
Intermediate depth disposal with artificial structure
Institutions are under consideration
L1 waste

Relatively low radioactive waste
Sub surface disposal with artificial structure
Monitoring 300~400 years
L2 waste

Very low level waste
near surface trench disposal
Monitoring 50 years
L3 waste
**Waste arisen from large scale (1,100MW) PWR Decommissioning**

Non radioactive waste; 500kton (99%)

- **L1; 200t (0.04%)**
- **L2; 1,700t (0.3%)**
- **L3; 3,100t (0.6%)**

- **Core vessel**
- **Pressure vessel**
- **Heat exchanger tube**
- **Steam Generator**
- **Water chamber**
- **Biological shield etc.**
- **Concrete, Metal**
Concept of L1 Waste Disposal Facility

Access tunnel

Connection tunnel

Disposal tunnel

Approx. 100m

Approx. 900m
Existing L2 Waste Disposal Facility (Rokkashio)

① Bird’s eye view of the facility

② Putting drums into concrete pit

③ Cementation

④ Covering with Concrete

No1 Facility
Homogeneous solid waste (drum)

No2 Facility
Miscellaneous solid waste (drum)
L3 disposal facility (Existing JPDR and Tokai-1 plan)

Plan for Tokai-1

- Monitoring hole
- Flood prevention tent
- Partition (Concrete)
- Earth retaining wall (Concrete)

Emplacement stage

Institutional control stage

JAEA JPDR

Emplacement stage

Institutional control stage
Clearance System in Japan

Clearance material is recycled as general material in Japan (free release)

• The final target is free release, however a step by step approach is necessary to obtain public acceptance.

• Clearance criteria is 10μSv/y Base.

• Clearance level for each Nuclide laid down by Ministerial Ordinance based on IAEA RS-G-1.7.
Evaluation and verification procedure for clearance

Arrangement of radioactivity analysis data

- Radiation count rate $\times$ conversion factor (Bq/cps)
- Weight (ton)

Radioactive density (Cs-137)

Total $\gamma$, Gr measurement method

- No correlation
- Correlation

Radioactive density (C-14, Sr-90, total)

Average radioactive density

Nuclide composition ratio (Comparisons with Co-60, Cs-137)

$\Sigma D/C \leq 1$

Criteria for determination

$\frac{\text{Nuclide A density}}{\text{Nuclide A Clearance level}} + \frac{\text{Nuclide B density}}{\text{Nuclide B Clearance level}} + \cdots = \Sigma D/C \leq 1$

※ Cs-137 represent of Mn-54, Co-60, Cs-134, Eu-152, Eu-154

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Treatment of Non Radioactive waste (NR)

- NR is judged by document, not measurement
- Process approval and periodical audit by regulatory body

Flow (sample)

- NR material
- Draw up manifest & Internal approval
- Measurement "for confirmation"
- NR storage area
- Record keeping
- Shipment

Retaining document survey
- Record on radiation
- Work procedure etc.
Challenges and Issues in Decommissioning in Japan
Tasks to be solved in decommissioning in Japan

- Secure facility for SF shipment and waste disposal facility
- Understanding of Stakeholder (local government and regulatory body etc.)
- Revised Funding System
Cultivation of People who will become Leaders in Future D&D business in Japan

- Several universities including Tohoku University and Tokyo Institute of Technology have a short-term seminar dedicated to decommissioning of nuclear power plants (NPPs).
- JAPC dispatches their experts to these seminars as a lecturer.
- JAPC accepts university students to their Education & Training Center and NPPs to teach them outlines of decommission of NPPs.