NUMO’s Safety Strategy for implementing Geological Disposal Project

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Nuclear fuel cycle

Uranium mine

Fuel fabrication

Recovery of uranium/plutonium (approx. 95%)

Reprocessing

MOX fabrication

Spent fuel

LLW for geological disposal

Nuclear power generation
# Classification of radioactive wastes & disposal methods

<table>
<thead>
<tr>
<th>Generation point</th>
<th>Category</th>
<th>Example of disposal</th>
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<tbody>
<tr>
<td>Nuclear power plant waste</td>
<td>VLLW</td>
<td>Near-surface</td>
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<tr>
<td>Nuclear power plant</td>
<td>LLW</td>
<td></td>
</tr>
<tr>
<td>Uranium enrichment/ fuel fabrication plants</td>
<td>HLLW</td>
<td>Sub-surface</td>
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<tr>
<td>Uranium waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reprocessing/ MOX fabrication plants</td>
<td>TRU waste</td>
<td>Near-surface</td>
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<tr>
<td>Reprocessing plant</td>
<td>HLW</td>
<td>Geological disposal in more than 300m deep underground</td>
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### Disposal method

- **Trench disposal**
- **Pit disposal**
- **Geological disposal in more than 300m deep underground**

<table>
<thead>
<tr>
<th>Radioactivity</th>
<th>Depth [m]</th>
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<tbody>
<tr>
<td>High</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>
|               | 0         | Low
Classification of specified radioactive wastes

Specific 1\textsuperscript{st} radioactive Waste

HLW

Specific 2\textsuperscript{nd} radioactive Waste

Hull, and Ends

TRU

Spent silver adsorbent

Nitric acid drain

Dry and pellet

High concentration radioactive waste
Layout example of disposal facilities

Inland
- Surface facilities
- Shaft
- Disposal panel
- Connecting Tunnel
- Underground Facilities (TRU)
- Underground Facilities (HLW)

Coastal
- Surface facilities
- Ramp
- Disposal panel
- Connecting Tunnel
- Underground Facilities (HLW)
- Underground Facilities (TRU)
Three Stages of the Selection Process

- Preliminary Investigation Areas (PIAs)
  - Selection of PIAs by Literature Surveys

- Detailed Investigation Areas (DIAs)
  - Selection of DIAs by Surface-based Preliminary Investigation
    - Geophysical survey
    - Borehole drilling, etc

- Repository Site (RS)
  - Final Selection of Repository Site by Detailed Investigation including measurements and tests in the underground facility
Stepwise Refinement of the Safety Case

- **Literature Survey**
  - **Design concept**
  - **Supporting Documents**
  - **Siting Factors for PIAs**
  - **Report on the Selection of PIAs**

- **Preliminary Investigation**
  - **Siting Factors for DIAs**
  - **Report on the Selection of DIAs**
  - **Supporting Documents**

- **Detailed Investigation**
  - **Siting Factors for RS**
  - **Supporting Documents**

- **Safety Case 1**
  - **Safety Case 2**
  - **Safety Case 3**

NSC: Nuclear Safety Commission

**Supporting Documents**

**NSC Basic Guidelines for Safety Review**

**NSC Guidelines for Safety Review**

Licensing
NUMO’s R&D Roles

NUMO’s R&D

Improvement of safety and reliability

- Rationalization/efficiency
- Practicality/sophistication
- Application of the fundamental R&D results
- Systematization
- Demonstration

Role allocation of R&D on the geological disposal in line with the Framework for Nuclear Energy Policy

NUMO: R&D for safe implementation of the repository with improved technology from economic and practical perspectives

The Government & relevant organizations including JAEA:
R&D for establishing the safety-regulation framework, other fundamental issues related to safety assessment, geoscientific studies, and improving repository technology from the viewpoint of increasing confidence

Fundamental R&D Coordination Executives

The Government’s fundamental R&D

- JAEA and other R&D organizations

Suggest needs

Utilize results
Close cooperation with R&D organizations

NUMO

Necessary technology based on the progress of repository programme

R&D Planning

R&D Implementation

Evaluation of achievements

The Government’s fundamental R&D

Fundamental R&D Coordination Executives

JAEA and other R&D organizations
Reflection of NUMO needs in Government’s fundamental R&D

**Objective:**

For implementing the geological disposal in line with the recommendation by the Advisory Committee on the Evaluation of Framework for Nuclear Energy Policy of AEC, NUMO develops and reflects its R&D needs to the Government’s fundamental R&D plan, from the perspective of the implementer.

**Basic policy:**

- Develop NUMO’s R&D needs systematically, in particular, focusing on the detailed investigation phase which involves important decision making;
- Cover a wide distribution of geo-environmental conditions, considering the situation where the sites for investigation cannot be identified due to the volunteer siting approach;
- Determine overpack materials, emplacement methods among other important judgments to be made during the detailed investigation period;
- The site-specific needs will be additionally evaluated as appropriate after volunteer applications received.
Important NUMO needs (tentative) – 1/2

- **From viewpoint of “engineering feasibility”**

  - Knowledge accumulation on long-term behaviors/interactions of the engineered barriers
    
    *(e.g. re-establishment of overpack corrosion rate; assessment technology of corrosion resistance of welded parts, etc.)*

  - Alternative technologies of the engineered barrier system
    
    *(e.g. alternative solidification method of TRU waste, etc.)*

  - R&D for improving engineering feasibility of fabrication/transportation/emplacement of the engineered barriers
    
    *(e.g. sophistication of element technologies on transportation/emplacement of engineered barriers using PEM/block/pellet)*

  - Confirmation/demonstration of technologies for investigation/assessment of geological environment
    
    *(e.g. applicability of technologies for deep geological investigation in coastal/marine areas)*
Important NUMO needs (tentative) – 2/2

- **Needs from viewpoint of “safety assessment”**
  - R&D on the performance assessment scenarios based on probability
  - R&D on the performance assessment considering the long-term evolution of geological environment
    
    *(e.g. standardization/validation of conditions for performance assessment)*

- **Needs from viewpoint of “long-term safety assessment of geological environment”**
  - Review on methods/concepts of extremely long-term assessment
    
    *(e.g. more than 100,000 years)*
Overview of R&D system

Atomic Energy Commission (AEC)
- Basic policy
- Information exchange
- Joint research
- Suggest needs
- Confirm outcomes
- Technical support
- Teaching

Utilities
- R&D from waste-producer perspective
- Implementation of repository project
- Implementers (JNFL/NAGRA/SKB/POSIVA, etc.)

Nuclear Safety Commission (NSC)
- Supervision
- Regulation
- Guideline

Agency for Natural Resources and Energy (ANRE)

Nuclear and Industrial Safety Agency (NISA)

R&D organizations (JAEA/CREPI/AIST)

Fundamental R&D
- Suggest needs
- Confirm outcomes
- Fundamental R&D Coordination Executives
- R&D
- Construction orders/implementation

NUMO
- Implementation of these activities
- R&D required for their implementation

Universities
- Fundamental research

Consultants, Engineering and construction companies
- R&D/ design/ construction

National budget

Geological investigation/assessment
Design/production of the engineered barrier system
Design/construction of facilities/installments
Repository operation/closure
Performance/safety assessments

Implementation of these activities
R&D required for their implementation
Evaluations and advices by third-party

Promote the project getting evaluations and advices about the issues such as promotion of public understanding from domestic and international experts.

- NUMO-hosted international meetings
  - ITM (International Tectonics Meeting)
    Example of achievement; Probabilistic assessment of magmatism

- Evaluations and advices for NUMO’s activities by domestic and international experts
  - ITAC (International Technical Advisory Committee)
  - DTAC (Domestic Technical Advisory Committee)
    Example of achievement; Information Package
    「Repository Concepts」, 「Siting Factors for the Selection of Preliminary Investigation Area」
    Technical Reports
    「Technology and Safety of High Level Radioactive Waste Geological Disposal Background and Technical Justification of Siting Factor for the Selection of Preliminary Investigation Area」
## Schedule of implementation and R&D of NUMO

NUMO is driving to implement the deep geological disposal by doing NUMO’s R&D.

<table>
<thead>
<tr>
<th>Year</th>
<th>Implementation</th>
<th>NUMO’s R&amp;D</th>
<th>Fundamental R&amp;D (JAEA)</th>
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</thead>
<tbody>
<tr>
<td>2000</td>
<td>Establishment of NUMO</td>
<td>For open solicitation</td>
<td>Research on the deep geological environment at URLs in Horonobe and Mizunami</td>
</tr>
<tr>
<td>2002</td>
<td>Open solicitation</td>
<td>For LS and selection of PIAs</td>
<td>2nd report (H12)</td>
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<tr>
<td>2004</td>
<td>Selection of PIAs</td>
<td>For PI and selection of DIAs</td>
<td>Improving the reliability of disposal technologies at Tokai R&amp;D center</td>
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<tr>
<td>2020</td>
<td>Selection of DIAs</td>
<td>Selection of a repository site</td>
<td>Detailed investigations in research galleries</td>
</tr>
<tr>
<td>2040</td>
<td>Licensing</td>
<td>Construction, Operation, Closure</td>
<td>Site-specific</td>
</tr>
</tbody>
</table>

### For open solicitation
- Siting factors for PIAs’ selection
- Repository concepts for volunteer siting environment, etc.

### For LS and selection of PIAs
- Software supporting for LS
- Software developing of repository concepts based on literature information, etc.

### For PI and selection of DIAs
- Siting factors for DIAs’ selection
- Systematization of geological environmental investigation and evaluation
- Improvement of repository design and performance assessment, etc.

### For DI and selection of a repository site
- Important issues of construction, operation and closure
- Requirement management system, etc.
Current situation of NUMO’s R&D

On-going R&D activities
Case1: Improvement of assessment technology for seismic/fault activities

Objective: Establish methods for designing seismic-resistant repository; assessing active folds

Characteristics of deep-underground seismic motion

Seismic response identified by 2D dynamic analysis

Model experiment using CT-scanner

Identification of relevant active fold zones
Case2: Improvement of technologies for construction/operation systems

Objective: Review comparison of waste emplacement methods; applicability of low alkaline cement

Assessment of vertical/ horizontal emplacement using the Prefabricated EBS Module (PEM)

Vertical emplacement
- Block type
- Pellets type

Horizontal emplacement

Combination of PEM and the capsule transportation system

Repository construction technology using low alkaline cement

Corrosion test in low alkaline environment, using carbon fiber material – alternative for steel material (photo images: production of test material)

Collaborative research on tunnel support, plug, etc. (e.g. NUMO, CRIEPI)

Collaborative research on applicability to grout (e.g. NUMO, SKB, POSIVA, Nagra)
Case 3: Improvement of repository design by 3D analysis of radionuclide migration

**Objective:** Develop the 3D analysis code of radionuclide migration, which allows simulation of its detailed behaviors, to study their effects on different repository designs.

**Comparison of release between different waste emplacement methods**

**Effect of plug for a fault – groundwater flow analysis**
Case 4: Development of Requirements Management System

Conceptualization of requirements management and engineering works

Works and RM process for the stepwise program.

Preparation of e-contents

- Contents for “repository design at each site-selection stage
- Trial use of the outcomes of the fundamental R&D (e.g. JAEA-KMS)

Developments of NUMO-RMS

- Original system suitable for RM in NUMO and the stepwise program.

Info. exchange with oversea organizations

“RMS2010” held in Tokyo at 26/Jan./2010

NUMO, SKB, POSIVA, ONDRAF/NIRAS, Nagra, domestic organizations

RMS2010
Background of 2010 Technical Report

YR 2000
- Published the JNC 2nd Report
- Establishment of the Final Disposal Act
- Establishment of NUMO

Development of overseas programmes

Amendment of the Final Disposal Act

Progress of overseas/domestic R&D

NUMO became the implementer of the LLW geological disposal

Launch solicitation of nationwide municipalities using volunteer approach

Preparation for the Literature Survey

NUMO
Implementation of the repository project

For siting & PR support

2010 Technical Report (tentative)
Objectives of 2010 Technical Report

For building public confidence in NUMO’s repository project,

- **Clarify NUMO’s safety concepts** (precedent publication in 2009):
  - Specify the safety measures
  - Express NUMO’s policies on its technical activities for ensuring safety

- **Demonstrate Japanese technology advancement, which supports NUMO’s safety concept**
  - Incorporate NUMO’s R&D and the Government’s fundamental R&D activities since 2000
Series of the NUMO 2010 Report group

NUMO manifesto

NUMO’s policy

Leaflet

Transfer technical policies on safety

Technical Reports

PR version of the NUMO 2010 Report

Brochure

Pick-up useful information to support PR activities

2010 Technical Report

Summary

Summary

2010 Technical Report – Main

Main report

Projec

Technologies

Safety Report 2009

Report

FY2009

FY2010
Structure of the Safety Report 2009

Chapter 2: Breakdown of the structure of safety

Global aim

Achievement of safe geological disposal

Aims

Long-term safety

Safety during implementation

Measures

(1) Site selection and confirmation
(2) Engineering measures
(3) Evaluation of long-term safety

(1) Avoid non nuclear accident
(2) Avoid radiation accident
(3) Conservation of natural environment

Chapter 3: Policies and measures for implementation of safety geological disposal project

Policies

Policy 1
Implementation by step-wise decision making based on repetitious confirmation of safety

Policy 2
Implementation by credible (reliable) technologies

Policy 3
Technical works toward public confidence building

Breakdown of policy

Implementation by step-wise decision making based on the advance planning
Repetitious confirmation of safety by coordination between 3 measures
Ensuring safety during implementation

Well planned R&D
QA of technical information
Organizational

Implementation based on understanding of safety by local residence
Information disclosure (e.g. demonstration of technologies)
Consideration for future generation

Chapter 4: Detail descriptions

Section 4.1
Section 4.2
Section 4.3
<table>
<thead>
<tr>
<th></th>
<th>FY 2009</th>
<th>FY 2010</th>
<th>FY 2011</th>
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<tbody>
<tr>
<td>Workshop</td>
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<tr>
<td>Safety Report 2009</td>
<td>Draft production</td>
<td>AESJ review (\downarrow)</td>
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<td>(2009R)</td>
<td>Modifications (\downarrow)</td>
<td>Review report</td>
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<td>Completion of the 2009R</td>
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<tr>
<td></td>
<td></td>
<td>Review by AESJ etc. (\downarrow)</td>
<td>Completion of the 2010R</td>
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<td></td>
<td>Modifications (\downarrow)</td>
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<td></td>
<td></td>
<td>PR version of 2010R</td>
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Summary

- Preparation for the literature survey has completed.
  - Reliability improvement by showing recent findings -

- Develop & publish the 2010 Technical Report for obtaining the public confidence toward NUMO’s repository project and its safety; promoting its project implementation

- In regards to stepwise research & technical development, their comprehensive visions and progress will be laid out to the general public in an easily understood manner;

- For ensuring the transfer of NUMO’s technology, the required human resources will be secured and fostered with the mid and long term vision.
Thank you for your attention

For further information:
www.numo.or.jp/en/index.html