Development of Conceptual Hazard Event Tree of \( \text{CO}_2 \) Geological Storage R&D

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Introduction

To maintain sustainable carbon consumption in the world, carbon capture sequestration (CCS) is one of essential technologies to be utilized in near future. The \( \text{CO}_2 \) geological storage technology aims to store Carbon dioxide into underground oil or gas reservoirs, coal beds, or aquifers. To utilize the technology, three categories of research and development issues have to be broken through: (1) monitoring and verification; (2) evaluation capacity of various types of \( \text{CO}_2 \) storage reservoirs capacity; (3) safety and risk assessment for practical realization in near future. In this paper, the authors report about our development of conceptual hazard event tree of \( \text{CO}_2 \) geological storage R&D, as an effort of (3) category of above.

The state of arts of \( \text{CO}_2 \) geological storage R&Ds in Japan

Concerning to R&Ds of \( \text{CO}_2 \) geologic storage, weight has been put on verification of reality of this new technology especially from geosciences and energy- economical side of view. In Japan, under the contract with Ministry of Economy, Trade and Industry, some of institutes are contributing to the project. AIST is in charge of geo-technological side of R&D: evaluation of capacity of \( \text{CO}_2 \) geological storage, laboratory experiments, modeling and simulations, research and evaluation of potential storage capacity of major aquifers. Getting preferable results of a few years in-site experiments and monitoring, the R&D is going to enter verification for realization stage: basic verification test of injection and monitoring, development of advanced model of storage, and preliminary safety evaluation methodology.

Side by side with geo-technological R&D, Japanese legislative sector start to consider on legislations about this new technology. For realization of the \( \text{CO}_2 \) geological storage technology safely and effectively, efforts on preliminary safety and risk evaluation is essential in this stage.

As for safety and risk evaluation of \( \text{CO}_2 \) geological storage, huge contributions have been made with geo-technical perspective. To accomplish total safety and risk evaluation for whole \( \text{CO}_2 \) geological storage technology, considerations from safety engineering side point of view shall contribute in some extent.

Conceptual hazard event tree and scenarios for risk analysis

To utilize the \( \text{CO}_2 \) geological storage technology, there are three categories of research and development issues those have to be verified: (1) monitoring and verification; (2) evaluation capacity of various types of \( \text{CO}_2 \) storage reservoirs capacity; (3) safety and risk assessment. As regard with (3) safety and risk assessment of the \( \text{CO}_2 \) geological storage, those include consideration of operation errors within the geologic storage systems in the future and/ or risks of carbon dioxide release from geologic storage sites. It requires identification of hazards and evaluation of consequences and frequencies of inherent hazards within the new technologies.

In Japan, we do not have legislations that totally cover the new-developing technology of \( \text{CO}_2 \) geological storage. Therefore, for the social realization of the technology, it is immediately needed to process risk identification and evaluation, and to develop and establish concrete risk management system subsequently.

To avoid any oversight in risk assessment framework of the new technology, risk identification should be made from various fields. Nevertheless, risks of all hazard scenarios are not estimated yet in overview. Therefore, estimation of hazard from related fields is essential for advancement of the risk evaluation.

To prepare wide ranged risk assessment framework of \( \text{CO}_2 \) geological storage, we are developing a conceptual hazard event tree of technical problems that should be solved within \( \text{R} & \text{D} \) stage. We constructed the tree using factors that were gathered in interviews to geologists and mining engineers and a survey of the literatures.

Along with the conceptual hazard event tree, we are developing short and long-term hazard preliminary analysis also to prepare total preliminary risk analysis. To accomplish Table 1 and evaluate risks, the authors are extending investigation and gathering data not only hazard scenario but possible mitigating measures. The result of the study is expected to contribute both risk management and legislation in realization stage of this technology in near future.

Conclusion

To prepare wide ranged risk assessment framework of \( \text{CO}_2 \) geological storage, we developed a conceptual hazard event tree of technical problems those have to be solved, based on interviews of geologists and mining engineers and a survey of the literatures. Along with the conceptual hazard event tree, we are developing short and long-term hazard preliminary analysis also to prepare total preliminary risk analysis. The authors are extending investigation and gathering data not only hazard scenario but possible mitigating measures. The result of the study is expected to contribute both risk management and legislation in realization stage of this technology in near future.

Table Extraction of short and long term hazard preliminary analysis

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Likelihood</th>
<th>Frequency</th>
<th>Consequence</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural di s t ers</td>
<td>0.5</td>
<td>Low</td>
<td>High</td>
<td>Address</td>
</tr>
<tr>
<td>Floods</td>
<td>0.2</td>
<td>Medium</td>
<td>High</td>
<td>Address</td>
</tr>
<tr>
<td>Earthquake</td>
<td>0.1</td>
<td>High</td>
<td>Medium</td>
<td>Address</td>
</tr>
<tr>
<td>Geothermal power plant</td>
<td>0.05</td>
<td>Very high</td>
<td>Low</td>
<td>Address</td>
</tr>
<tr>
<td>Oil &amp; natural gas extraction</td>
<td>0.01</td>
<td>Very high</td>
<td>Low</td>
<td>Address</td>
</tr>
<tr>
<td>Underground mining</td>
<td>0.005</td>
<td>Extreme</td>
<td>Low</td>
<td>Address</td>
</tr>
</tbody>
</table>

References

8. Quintessa Ltd., The Generic \( \text{CO}_2 \) Geological Storage FEP Database, http://www.quintessa.co.uk/co2fepdb/
9. Foundation of the European Coal Energy Research Institute (EUREC), Final report of the european research institute of \( \text{CO}_2 \) Geological storage under the seabed in European coal mining area.
14. Foundation of the European Coal Energy Research Institute (EUREC), Final report of the european research institute of \( \text{CO}_2 \) Geological storage under the seabed in European coal mining area.

Figure 1 Areas to be considered and relating Japanese legislations and rights

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