CCS Technical Workshop

– Approaches to Address Concerns over CO_2 Seepage from Reservoirs –

Summary

RITE, in association with the Ministry of Economy, Trade and Industry (METI), hosted a CCS Technical Workshop with a theme, Approaches to Address Concerns over CO_2 Seepage from Reservoirs, in Tokyo on 24 January 2013. There were 137 participants from businesses, universities, research institutes and governments. The attendees discussed how to address concerns of this kind and how to secure the safety of CCS through presentations from four experts, two from overseas and the other two from RITE, moderated by Prof Toru Sato, the University of Tokyo. At the end of the workshop, it was concluded that large projects such as CCS should be discussed from two viewpoints – economic growth and environmental impacts – and that taking environmental impacts into consideration should be recognized as an added value.

1. Background and Objectives

Establishing the safety of CCS has been increasingly recognized as an important part of promoting CCS technologies in the world. Japan launched a large-scale CCS demonstration project in 2012, which is set to start work on safety issues. In the case of offshore CO_2 storage in Japan, measures to secure safety are required by a permitting scheme under the Marine Pollution Protection Act. These activities are also essential for responding to the general public's concerns about safety.

With this background, the workshop was designed to focus on CO_2 seepage from reservoirs. The workshop provided an opportunity to discuss how to address concerns of this kind and how to secure the safety of CCS through presentations on frameworks for environmental impacts assessment, including regulations; an approach to avoid CO_2 seepage; a methodology for assessing potential environmental impacts in the unlikely event of CO_2 leakage based on computational simulations; and a field survey conducted in response to an alleged leakage.

2. Participants

There were 137 participants. Those from universities/ research institutes, engineering businesses and consultant firms/ think tanks accounted for 40%, 41% and 13%, respectively, and there were some from governmental ministries/ agencies.

3. Overview of the Workshop and Conclusions

Aims

The workshop was kicked off with greetings from the host and the co-host. Firstly, Prof Kenji Yamaji, Director General, RITE, began by touching upon the initiation of preparation for Japan's full-chain demonstration in 2012 and then pointed out that CO_2 should not leak but can leak. He asserted that it was therefore necessary to take approaches on the assumption of a CO_2

leak, including the clarification of leak mechanisms, site characterization, the establishment of methodologies for leak detection and environmental impacts assessment. Then he introduced that, under the assumption that CO_2 leakage is possible, monitoring is required under Japan's Marine Pollution Prevention Act.

Following Prof Yamaji's remarks, Mr Koji Hachiyama, Director of the Global Environment Partnership and Technologies Office, METI, said that we are required to secure economic growth by increasing fossil fuel-derived power as an alternative to nuclear and also to reduce CO_2 emissions. He expressed METI's intention to do their best to reduce costs toward CCS commercialization by promoting technology development in the full-chain demonstration; to prepare regulations; and to improve local public perception. In order to present scientific evidence to look into risks, the Director introduced that METI had commissioned various studies to RITE such as developing techniques for geological characterization; CO_2 behavior analyses in reservoirs; and analyses of CO_2 migration from reservoirs. He concluded his remarks by saying that outcomes from RITE studies were well-valued globally and that METI wants to present data to the society to discuss risks openly with a wide range of stakeholders

Before moving on to the presentations, Prof Toru Sato of the University of Tokyo as the moderator briefed the purposes of the workshop. Stating that the purposes had been already mentioned in the previous greetings, Prof Sato proposed that Japan present its CCS technology as a package combined with safety and environmental impacts assessment in promoting it domestically and internationally after the Japan's full-chain CCS demonstration. He concluded his remarks by reemphasizing that it was essential to assess impacts of potential CO_2 leakage and then the first presentation was started.

Frameworks of Environmental Impacts Assessment

As a first presentation, Dr. Jun Kita, a senior researcher from RITE, talked about CCS regulations in Japan and overseas, the outline of environmental impacts assessment, the Australian Gorgon and US FutureGen projects as case studies for such assessment and a UK-Japan joint experiment to improve understanding on potential impacts of CO_2 leakage on the marine environment.

All safety issues to be considered in CCS projects are covered in a guideline released by METI in 2009, "For safe operation of a CCS demonstration project". In Japan, CCS operators are required for damping CO_2 under the seabed to obtain a permit; to assess environmental impacts; and to monitor the marine environment by the Act for the Prevention of Marine Pollution and Maritime Disasters amended to ratify the London Convention in 2007. The requirements should be imposed to Japan's full-chain demonstration planned in Tomakomai, Hokkaido. A discussion raised from the floor was regarding allowable periods and amounts of CO_2 leakage under the Act. Such allowable values are not specified in the law and the Ministry of the Environment (MOE) as a regulator is to judge the results of assessment presented by a

CCS operator. In the UK-Japan joint test, the QICS project, a CO_2 release experiment was conducted in the sea and acquired data have been under analysis and evaluation.

Through the presentation, it was emphasized that environmental impacts assessment before the implementation of CCS projects was essential not only to comply with legal requirements but also to improve public credibility and acceptance for the projects.

Approaches to Avoid CO_2 Leakage

The next presentation was delivered by Prof Robert J. Finley from the University of Illinois, USA. He talked about an approach to avoid leaks of stored CO_2 through introducing site characterization and a plan and results of monitoring in the Illinois Basin Decatur Project (IBDP). IBDP is a CCS project where one million tons of CO_2 is captured in a plant to produce chemicals such as ethanol and stored in a saline aquifer two km deep. Injection was initiated in November 2011 and amounted to 370,000 tons as of 18 January.

Site characterization was conducted with 2D seismic and core sampling and acquired porosity and permeability was used to determine storage capacity, injectivity and containment. After no faults were identified in the vicinity of the site, a geological formation with the porosity of around 20% was selected as a reservoir. Near-surface monitoring in the storage site includes ground water, soil flux, surface elevation and air sampling. In addition, the deep subsurface has been monitored from the viewpoint of CO_2 distribution and saturation, groundwater sampling and induced seismicity. It was pointed out that a monitoring plan should include pre-injection monitoring to define baseline data variation, for example, seasonal variation. It was also introduced that brine in groundwater can be an indicator for a CO_2 leak in this specific site. Data such as pressure variation, CO_2 distribution and surface elevation acquired to date confirm that injected CO_2 has been storage safely and stably.

The presentation was followed by discussions, including the necessity of the diversified monitoring and potential leakage routes. Prof Finley explained several aspects as the background of the comprehensive monitoring implemented: requirements regarding monitoring had not been determined at the beginning as IBDP is one of the first CCS projects in the USA; the nature of the project was scientific research; monitoring was conducted more rigorously than is legally required to contribute to public acceptance. Based on outcomes from the project, optimal monitoring techniques are selected afterwards. One of the few possible leakage routes may be vertical fractures below the limit of seismic resolution, but no evidence for such fractures has yet emerged. Another topic of discussion was the period of post-monitoring. In the project, post-monitoring is planned to last for three years due to restriction of funding. But wells are designed to be durable for 30 years and three to 10 years extension will be required once an application is accepted to change a class of the injection well from Class I to Class VI.

Computational Simulation-base Evaluation of Potential Impacts if CO_2 is leaked

The next speaker was Dr. Keisuke Uchimoto, a Researcher in RITE, who explained the necessity of environmental impacts assessment under the assumption of an unlikely CO_2 leak from a reservoir under the seabed and then introduced an assessment methodology that RITE was developing.

Although stored CO_2 has nearly no chance to escape due to a cap rock and various trapping mechanisms, environmental impacts assessment is still necessary because of a number of reasons: science and technology is not perfect; the probability of leak is not zero; it is mandatory under the regulation; and it plays an great role in the improvement of public acceptance. As an evaluation technique, three models are under development along an escape path from a reservoir to seawater column: geological formations, an unconsolidated sediment and seawater. Each of the models was described in detail mainly from the viewpoint of CO_2 state and dominant parameters. In the formation model, faults and wells can provide leak pathways but it is difficult to determine parameters such as the permeability of faults since there are no faults identified around the site. The sediment model is a layer of only a few 10 cm regardless of the thickness of actual sediment layers. The model scale is much smaller than those of the formation and seawater models but evaluation with the model is important because in the layer various reactions take place that have significant influences on the concentration of dissolved CO_2. A question was raised on the definition of sediments from the floor. Important in the model is a few 10 cm from the sediment surface so that a boundary between sediments and a formation below is insignificant. It was also discussed whether the aim of the sediment model was to see CO_2 behavior or impacts on creatures in sediment. The evaluation with the model has the both aspects and the factors to be evaluated in the CO_2 behavior are changes in the concentration of dissolved CO_2. The model for seawater considers factors such as marine topography and water flow. Accounting for transformation from CO_2 bubbles to dissolved CO_2, it calculates changes due to leak, for example, changes in CO_2 concentration.

Finally, a database under development was introduced, which is on the effects of CO_2 concentration elevation on maritime creatures. Checking with the database, the changes of CO_2 concentration estimated with computational simulations can be assessed as the potential impacts of CO_2 leak on the marine environment.

Case Study for a Field Study in Response to an Alleged CO_2 leak

The final presentation was delivered by Dr. Katherine Romanak from The University of Texas at Austin. She talked about a field study conducted in response to an alleged CO_2 leak at the Weyburn-Midale project and its outcomes. The Weyburn project is an EOR project, using captured CO_2, initiated in 2000 and the world's first project where large-scale long-term monitoring was operated. In the project, injected CO_2 has topped 17 million tons so far.

Soon after the project was started, a suspicion of CO_2 leakage from the project was raised by the Kerr family who lived nearby. Although the project operator had analyzed groundwater, water in pits and soil from an early stage of the project and later the Government had also worked on analyses of water, air and soil gas, the Kerrs' concerns had not been resolved over nine years. The Kerr family consequently commissioned an investigation to a consultant firm and based on its results they alleged that CO_2 was leaked from a reservoir in the Weyburn project and that the leakage resulted in adverse effects on their land. The results from the study were questioned by experts who were involved in monitoring activities in Weyburn and as a result resurveys were carried out by three groups, including a team lead by Dr. Romanak. Romanak's group validated various issues such as the plan and records of background data acquisition and the applicability of CO_2 concentration-based surveys (surveys that rely on comparison with background data) and then decided to employ a process-based soil gas analyses. In the process-based method, background CO_2 measurements are not used but ratios among major gases such as CO_2, CH_4, N_2 and O_2. The analyses led to the following conclusions: CO_2 is from biologic respiration with some dissolution of CO_2 into groundwater; no indication of exogenous gas from depth; and CO_2 derived from oxidation of methane from oil fields is negligible. These outcomes clarified that there had been no CO_2 leak from the reservoirs, a conclusion that was finally accepted by the Kerrs. In parallel with the field survey, an incident response protocol was created. It should be learnt from a series of the events that setting up a protocol of this kind in advance of a project is essential. In a case where CO_2 leak is suspected, tools to be adopted should be inexpensive but adequate it was proved that the process-based approach is effective in this sense. From the floor, a question was raised on the adaptability of C^{13} and C^{14} analyses in the allegation case. Both of them were not used there mainly because it was already known by the initial study that there were no differences in terms of C^{13} between injected CO_2 and natural CO_2 and C^{14} investigation was costly. In response to a question on the applicability of the process-based method to offshore CO_2 storage, it was introduced that application to ground water was under study and that great interest in collaborative research had been expressed by a number of offshore monitoring experts.

Wrap-up

Following the presentations, Moderator Prof Sato summarized the workshop. To begin, he pointed out that although CCS experts can select a site that should not allow CO2 leakage through deliberate examinations, the public who have learned there are no "absolutes" from *Fukushima* could not help but have concerns about leakage. In this context, the moderator presented his understanding that it was necessary to carry out environmental impacts assessment; to implement an incident response protocol ahead of a project; to take measures to detect potential CO_2 leakage; and to develop methodologies to predict potential impacts of CO_2 leakage based on computational simulations. Finally, Prof Sato concluded the workshop by emphasizing that not only in CCS but also in other large developments it was important to

take both the viewpoint of economic development and that of environmental impacts and that countermeasures against environmental impacts should be recognized as an added value.