# $CO_2$ Storage Research Group

## $CO_2$ Storage Technology Development for Practical Application

### $CO_2$ Geological Storage Project

$CO_2$ geological storage technology is a technology for safely containing $CO_2$, one of greenhouse gases, underground without releasing them in the air. It includes EOR for enhancing oil recovery by injecting $CO_2$ into oil reservoirs; $CO_2$ sequestration into depleted gas fields; ECBM for enhancing methane recovery by injecting $CO_2$ into coal seams; and storing $CO_2$ in saline aquifer consisting mainly of porous sandstone. RITE has been working on storing $CO_2$ in the saline aquifer, where $CO_2$ could be stably stored for long period of time because of the presence of mudstone layer above the sandstone of the aquifer, which is capable of blocking gas and liquid with high sealing properties.

RITE has been developing basic technologies concerning geological characterization of saline aquifer, monitoring $CO_2$ behavior, and predicting long-term $CO_2$behavior. Partnership with relevant research institutes, such as Japan CCS Co., Ltd (JCCS) and National Institute of Advanced Industrial Science and Technology (AIST) have been further encouraged and this year RITE has also started a joint study with US national research laboratory (on developing technique for predicting $CO_2$ behavior).

Followings are RITE's research results for FY 2010.

• Permanent OBC test study in real waters

RITE conducted performance assessment of permanent OBC (undersea cable) system for seismic wave exploration, which has been developed by RITE for last three years, in real waters off Tomakomai, Hokkaido in July through August, 2010. This test study gave us hands-on experience and know-how about how the cables should be installed and removed and two-month consecutive measurement data, as well as observation data of natural micro-seismicity occurred in near and far areas of the test study site. After taking economic factors into account, RITE will move forward with deployment of the permanent OBC system as a method that is suitable for monitoring $CO_2$ behavior stored in offshore aquifer.

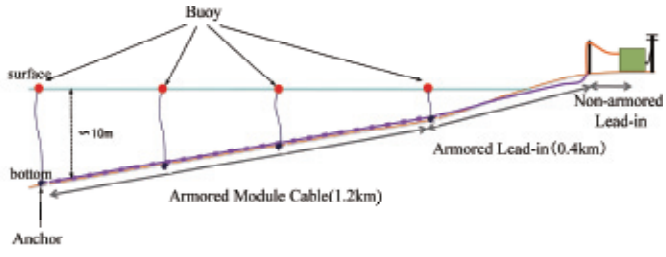



Figure 1 Outline of OBC test study


Figure 2 Photo of OBC

• Monitoring $CO_2$ behavior in Nagaoka site

From July 2003 to January 2005, 10,400 tons of $CO_2$ were injected into saline aquifer 1000 meters below the ground surface of Iwanohara, Nagaoka site, Niigata Prefecture (Inpex Corporation). Even after the end of injection, RITE continues various on-site measurements of wells to grasp $CO_2$ behavior underground. This year, RITE conducted physical logging, cement bond logging and crosshole seismic tomography and confirmed $CO_2$ was safely stored. Among many demonstration projects worldwide, only Nagaoka project keeps monitoring $CO_2$ behavior even after the end of injection and for that reason, its monitoring results have drawn attention from all over the world.

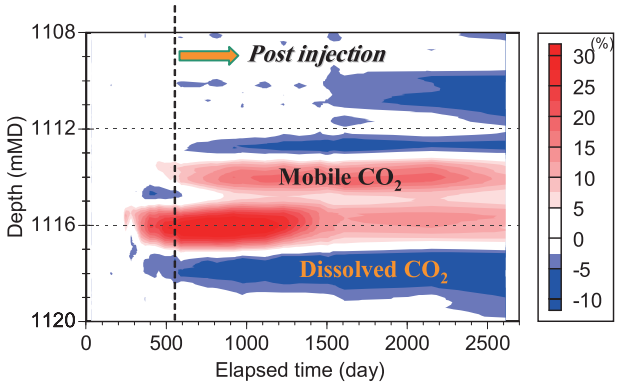
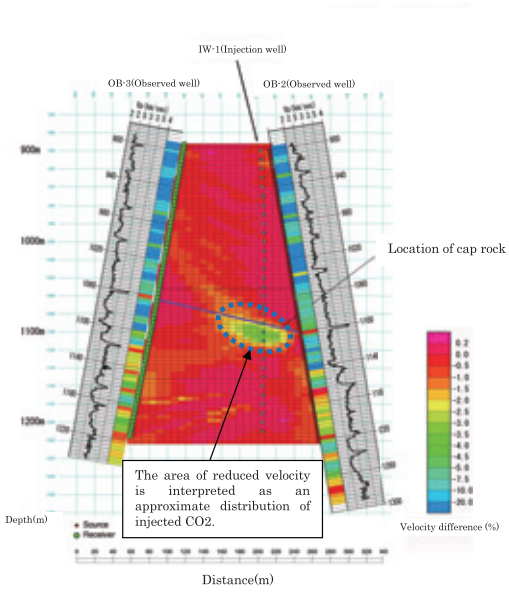



Figure 3 Physical logging




In order to image the distribution of injected CO2, time-lapse croswell tomography was conducted. This figure shows velocity difference tomographs of survey results in the 69th month after the injection ended. The latest survey shows that the velocity difference remain unchanged from just after the injection results. This means injected CO2 is stored safely in the aquifer.

**Figure 4 Crosshole seismic tomography**

• Installation of X-ray CT scanner

To estimate how $CO_2$ is stored after injected into pronouns sandstone formation of saline aquifer, RITE introduced X-ray CT scanner that is capable of visualizing $CO_2$ behavior and distribution in the pronouns structure of sandstone. The state-of-the-art X-ray CT scanner enables us to observe microscopic structure of sandstone in real time, so that we could estimate $CO_2$ behavior into more detail by combining this experiment system with the existing physical measurement techniques RITE has developed.

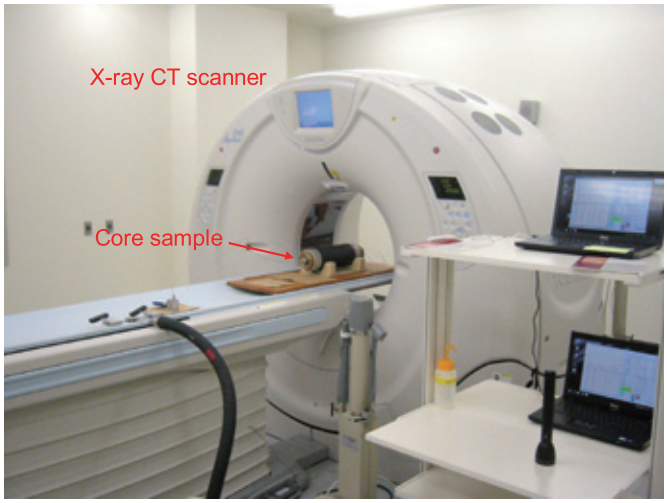



**Figure 5 Photo of X-ray CT scanner**

Based on the research results, RITE will focus on the followings in next fiscal year:

• To address technical issues arising in large-scale demonstration projects (in partnership with Japan CCS Co., Ltd).

RITE has established technical partnership with Japan CCS Co., Ltd, the operator of implementing the large-scale CCS demonstration projects. In this fiscal year, we have started physical measurements of core samples extracted at prospective pilot sites of Japan CCS. Applying this measurement technique to site characterization of possible large-scale demonstration sites, RITE tries to standardize methods for reservoir characterization and physical measurements.

• To promote joint study with research laboratory in the US (US-Japan joint study)

In a joint study with Lawrence Berkeley National Laboratory, RITE has been studying the method for characterizing $CO_2$ long-term behavior and the impact on geological formation at the time of $CO_2$ injection by using data obtained in Nagaoka site or $CO_2$ injection pilot sites in the US. We have started preparatory study and researches for the joint study this year. In the years after the next fiscal year, it is scheduled to conduct physical measurements, including on-site observation of microseismic waves at $CO_2$ injection sites.

## IZEC (International Zero Emission Coal)Project

Combining technology of high-efficiency coal power generation with technology of CCS ($CO_2$ capture and storage), which enables zero emission, has been developed widely in the US, Canada, Europe, Australia, China and others and its large-scale demonstration projects have been planned and implemented in many places. While each technology and its know-hows are accumulated and improved through international partnership, such as CSLF (Carbon Sequestration Leadership Forum), the efforts to demonstrate the technology need to be proceeded. Considering no economic incentives are expected from the CCS technology (except for EOR etc.), it is necessary for the government to support the implementation as a national project, while collaborations between public and private sectors are required to be reviewed for lasting operation of the project in the future.

In view of the situation above, this project is aimed at gathering information on state-of-the-art technology trend of zero-emission coal fired power plant with CCS ($CO_2$ Capture and Storage) projects and at helping making policies for the implementation of technology. RITE has engaged in the following activities as part of FutureGen project since 2009 and IZEC (International Zero Emission Coal) project since 2010.

(1) Gathering and analyzing information on high-efficiency coal fired power plant with CCS projects in the world

(2) Gathering and organizing information on legal

framework, approval criteria and approval authorities in terms of CCS-ready in the world

(3) Hearing and discussion with experts from overseas through the workshop to be held in Japan

As for CCS projects, we have been conducting a survey of current status of more than 60 pilot- and demonstration projects mainly in Europe, the United States and Australia. As for strategies for introducing CCS, we have been conducting research on policies and strategies of the UK, Norway, the Netherland, Germany, the United States, Canada and Australia etc. It is noteworthy that the UK requires a new coal-fired power plant to be CCS-ready when its construction is approved and permitted, and other EU member states need to incorporate requirement of CCS-ready into domestic laws in June, 2011. In Japan, a draft of Strategic Energy Plan of Japan clearly states that coal-fired power plants for future planning are required to review possible equipment of CCS technology by 2030, so we conduct a survey of CCS-ready trend in Europe in that context. Our 2010 research will focus on detailed information on approval criteria and progress toward the implementation, particularly, in the UK and Germany.

"Zero-emission coal-fired plant (IZEC) workshop" is scheduled to be held in February, 2011, where the regulatory authorities in EU member states and operators of large-scale demonstration project are invited to discuss their efforts and update progress toward CCS implementation and exchange opinions on such issues.

## China CCS-EOR Project

CCS, the technology to capture and store $CO_2$ from fossil fuel, is essential as countermeasures against global warming before 2100. In particular, CCS-EOR which can bring commercial advantage by increasing oil recovery is expected to be implemented at early stage.

In the United States, CCS-EOR utilizing natural $CO_2$ has already been developed in a scale of 60 million-tons per year. CCS-EOR is further expected to target $CO_2$ emissions from coal-fired power stations which releases large amount of $CO_2$ emissions for energy unit.

In recent years, China's $CO_2$ emissions have been increasing year by year and become the largest in the world in 2008. Japan also emits a large amount of $CO_2$ which corresponds to the 4th largest one. Therefore, the collaboration between China and Japan in CCS-EOR study has a very significant meaning from the viewpoint of preventing global warming internationally.

As part of technical exchange with China National Petroleum Corporation (CNPC), RITE held the 2nd CCS-EOR workshop in April in Tokyo, following the 1st one in last fiscal year, and discussions and exchange of opinions were made on the technical themes below:

(1) $CO_2$ Storage Basic Research
(2) $CO_2$ Monitoring
(3) $CO_2$ Simulation
(4) $CO_2$ Capture Technology
(5) Progress on EOR development
(6) Case study of demonstration projects
(7) CCUS/System integration

Technical exchange with CNPC has been deepened this year to the extent that RITE conducted research into CCS-EOR pilot sites of CNPC's Jilin oil fields in June. Based on the research results, RITE has chosen the following three themes for China-Japan CCS-EOR collaboration

(1) Research on CCS-EOR (CCUS) whole system
(2) Research on reservoir characterization technique
(3) Research on Microbial Restoration of Methane Deposits with Subsurface $CO_2$ Sequestration into the Depleted Oil Fields

RITE will carefully study each theme to contribute to realizing low-carbon society and ensuring energy security.

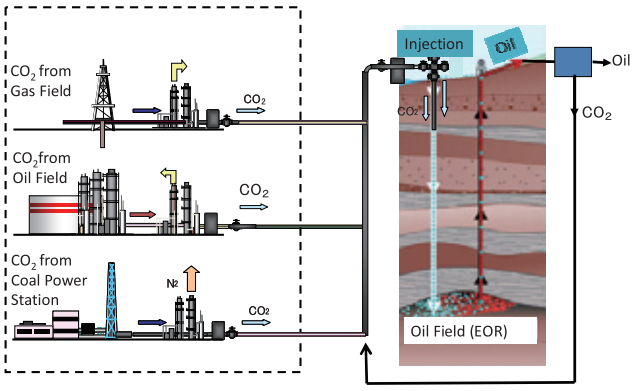



**Figure 6 Outline of CCS-EOR**