Carbon Capture and Storage Activities in JAPAN

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Notes: This report presents mainly ongoing or planned projects supported by METI.

Cost Saving CO_2 Capture System (COCS Project)

New Chemical Absorption System

Project Outline

CO_2 sequestration technologies entailing of CO_2 capture, transport and storage underground or at depth at sea, could be an immediate potent counter measure to global warming issues. Since CO_2 capture of CO_2 sequestration constitutes more than 70% of all the CO_2 sequestration costs, it has to be reduced drastically by near-term adaptation of CO_2 sequestration. As for the capture technologies, chemical absorption processes are promising because they can be easily and practically made for large scale CO_2 point sources. However, to make them practical in the near future, it is essential to reduce the cost of absorbent regeneration that at present occupies more than half of the cost of CO_2 capture.

Based on these circumstances, a new CO_2 capture project by chemical absorption system has been started with collaboration of three Japanese companies since fiscal year 2004 as a five-year project.

Figure 1 shows the concept of COCS project.

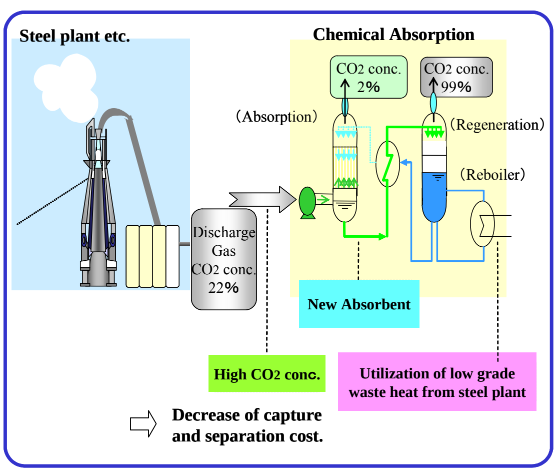

Figure 1: Concept of COCS project

First, we develop amine-complex noble absorbents, which have high absorption rate and low reaction energy, in order to regenerate them with less energy and at lower temperature than present absorbents. If we can regenerate absorbent at lower temperature, we can utilize the low cost waste heat which is presently discharged without recovery at a steel works.

Second, we develop heat recovery technologies for waste heat sources (sensible heat of slag, sensible heat of coke oven gas, etc.) and the heat utilization system by collecting recovered waste heat at a steel works. We estimate that the energy cost for the regeneration can be reduced by almost 50% by the combination of new absorbent and waste heat utilizing system.

Moreover, we plan to construct and operate 20 tons/day of CO2 pilot plant using 22% CO_2 content flue gas from steel works.

Objectives

The major objective of this project is to reduce the CO_2 capture cost by half of that using existing technology.

Major Results

In the first year of the project, 2004, we began to work on some subjects. As for the chemical absorbent, with both experimental and theoretical studies on the reaction characteristics of amine compounds with CO_2, we found a new absorbent which regeneration energy was 30% lower than that of MEA. We also investigated the amount of waste heat in the standard steel works that could be used as regeneration energy for absorbent.

Future Work

We will continue to develop higher-performance absorbent and waste heat utilizing system. We will also prepare the pilot plant study. Figure 2 shows the schedule of this project.

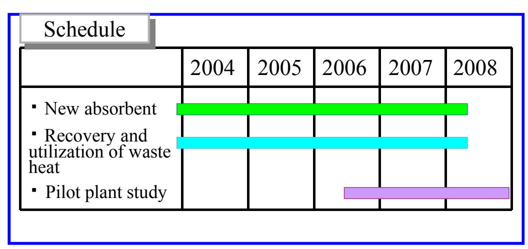

Figure 2: Schedule of COCS project

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Molecular Gate Membrane for CO_2 Capture

Project of CSLF Recognition as CO_2 Separation from Pressurized Gas Stream

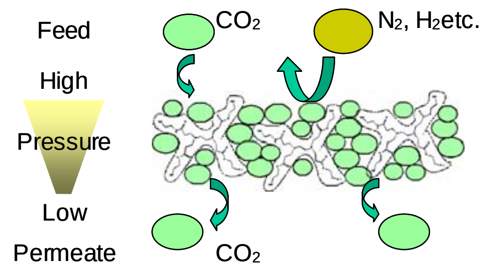

Figure 1: Concept of CO_2 molecular gate membrane

Background: CO_2 capture with existing technology consumes 70-80% of the cost of CO_2 sequestration. In this situation, development of revolutionary CO_2 separation membranes that can greatly reduce the energy requirements and costs of CO_2 separation is the urgent requirements for CO_2 sequestration to progress to practical usage.

RITE is currently developing a CO_2 molecular gate membrane with the goal of producing a new, high-performance separation membrane. The membrane will be preferably applicable to CO_2 capture from pressurized gas streams, such as IGCC process gas and so on.

Primary Project Goal: The purpose of this project is to develop a molecular gate membrane module that can greatly reduce the energy requirements and costs of CO_2 separation.

Objectives: The major objectives of this project are as follows:

1. Development of materials that have molecular gate function, which show excellent selectivity and permeability with high thermal stability.

2. Development of the composite membrane and its module

3. Testing of the module

CO_2 Molecular Gate Function: Figure 1 shows the basic outline of the CO_2 molecular gate function. The separation membrane (separation function layer) has a pathway through which gas molecules pass. In previous macromolecular membranes, nitrogen (N_2) or hydrogen (H_2) was able to negotiate this pathway along with the CO_2. As a result, N_2 or H_2 ended up outside the membrane with the CO_2, making it difficult to obtain a high concentration of CO_2.

In RITE's CO_2 molecular gate membrane, on the other hand, the pathway for gas molecules is occupied solely by CO_2, which acts as a gate to block the passage of other gases. Consequently, the amount of the other gas leaking to the other side of the membrane is greatly limited and high concentrations of CO_2 can be obtained.

Framework: Cooperation in the sharing of knowledge and information across international borders is key to the development and implementation of new, innovative technologies. In developing this CO_2 molecular gate membrane, RITE conducted joint research with the US Department of Energy's National Energy Technology Laboratory (NETL) and the University of Texas at Austin (UTA). NETL will offer a testing information and apparatus. Combining the know-how and information of UTA and RITE will make progress in developing the CO_2 molecular gate membrane possible.

Development of this separation membrane is registered as an international project of the Carbon Sequestration Leadership Forum.

Duration:

First stage: 2003 FY to 2005 FY

Second stage: 2006 FY to 2010 FY

Major Results: At present, RITE has developed novel modified poly(amidoamine) PAMAM dendrimers as CO_2 molecular gate functionalized material. The modified PAMAM dendrimer shows the world largest CO_2 selectivity of more than 1000 and excellent CO_2 permeability, encouraging a great reduction of the energy requirements and costs of CO_2 separation. RITE has also produced a 1 meter long module of PAMAM dendrimer composite membrane.

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Development of High Pressure CO_2 Recovery Process

JGC Corporation is developing a new technology related to CO_2 capture, specifically the High Pressure CO_2 Recovery Process, as a member of an international consortium with BASF Aktiengesellschaft, Germany. The new technology will ensure reliable and economical CCS (CO_2 Capture and Storage).

Natural gas is expected to continue to be used as a major energy source for several decades. Raw natural gas contains CO_2, normally in the range of 5% to 15%, and it is purified by acid gas removal processes in natural gas producing countries. The processes employed to remove CO_2 is solvent absorption in which the CO_2 is removed from the raw natural gas by means of an absorption solvent, and it is then separated from the absorption solvent in a solvent regenerator and finally released into the atmosphere. The amount of CO_2 separated from a large acid gas removal plant is estimated at several million tons per annum.

As interest in reducing the volume of greenhouse gases has increased in recent years, CCS has come to be recognized as one of the most promising technologies. JGC has focused on CCS projects in natural gas producing countries, i.e. the CO_2 separated in acid gas removal units is compressed and injected into underground aquifers. This new technology, the High Pressure CO_2 Recovery Process, can be applied there and lead to more economical CCS operations.

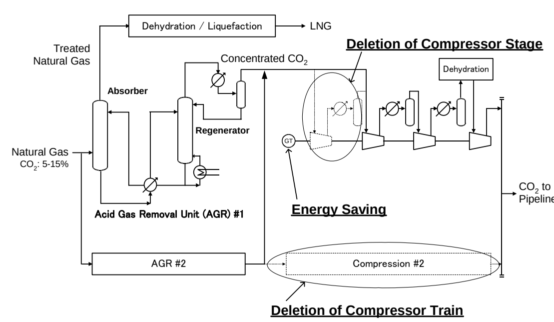
As CO_2 is discharged from conventional acid gas removal units at near atmospheric pressure, the cost and the energy consumption of the compressor for pressurizing it up to the underground aquifer pressure (10-20 MPa) is very large. The new technology enables an increase in the CO_2 discharge pressure, i.e. the suction pressure of compressor is increased. This enables reduction of energy consumption (reduction of OPEX). In addition, the CO_2 volumetric rate at the stage of compressor suction is subsequently reduced and therefore the train number and stages of compressors can also be reduced (reduction of CAPEX). The estimation JGC has conducted so far for a model case shows that the CCS cost ($/ton-$CO_2$) using the new process is as much as 20% less than that using the conventional process.

Development of solvent is one of the important issues. There are no solvents available used for conventional processes which can resist degradation at high temperature caused by saturated conditions of such high pressure regeneration. In addition, developments of process and equipment design for the new technology are also key points for developing economical CCS.

JGC and BASF formed an international consortium and already found a few solvents applicable to the new technology. The consortium can carry out the development effectively and efficiently for early realization of the CCS project.

Under a 2-year subsidy program (2005-2006) sponsored by METI (Ministry of Economy, Trade and Industry), the thermal stability of the solvent under similar conditions to actual plants will be confirmed using a test plant. Basic data regarding solvent properties for modeling the process will also be obtained. The target is to apply the new technology to CCS projects during the First Commitment Period of the Kyoto Protocol.

FIGURE 1: Advantages of High Pressure CO_2 Recovery Process



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Nagaoka Project for CO_2 Geological Storage

Project of CO_2 Geological Storage testing in Japan

Introduction: Time-lapse crosswell seismic tomography is being conducted to monitor the CO_2 at a pilot geological sequestration site in Nagaoka, Japan. The project is supported by the Japanese government (Ministry of Economy, Trade and Industry), as an R&D program of underground storage for carbon dioxide. In comparison to the offshore location of the Saline Aquifer CO_2 Storage project, the Nagaoka project undertaken by Research Institute of Innovative Technology for the Earth (RITE) looks at the geophysical monitoring of CO_2 injection in an onshore saline aquifer. A series of field surveys and measurements consisting of crosswell seismic tomography, well logging, the reservoir formation pressure and temperature measurements, and micro-seismicity monitoring has been conducted jointly with Engineering Advancement Association of Japan (ENAA), to improve understanding of the CO_2 movement in a sandstone reservoir.

There is no any CO_2 leakage from the reservoir, even a huge earthquake (M6.8) hit the Mid-Niigata area on October 23, 2004. Distance between the earthquake epicenter and the CO_2 injection site is about 20 kms.

Geology and CO_2 injection : The pilot CO_2 injection site is located at the Minami-Nagaoka gas and oil field, where Teikoku Oil Co. produces natural gas from the deep reservoir (4700 m). Figure 1 shows the location of the pilot site and the simplified geological setting well studied during oil and gas exploration.

One injection well and three observation wells were drilled at the pilot site (Figure 2). Purchased 99.9% pure CO_2 was injected from CO2-1 at 20-40 tonnes per day. The depth of the reservoir consisting of a 60 m-thick sandstone bed of the Haizume Formation is about 1,100 m below the ground surface. A thin permeable zone confirmed from the well pumping test results, having a thickness of 12 m within the reservoir was selected for injection of CO_2.

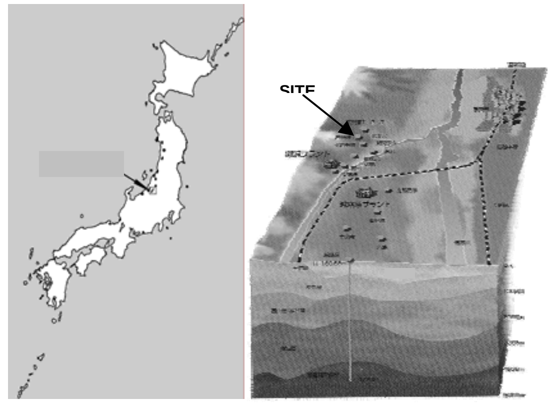

Figure 1: The Location and the simplified geological structure of the CO_2 injection site, Nagaoka, Niigata Prefecture.

The initial temperature and pressure of formation water were 48 °C and 10.8 MPa respectively and the transducers were installed at the reservoir formation depth in CO2-4, to monitor changes of pressure and temperature especially the formation pressure buildup during CO_2 injection. The CO_2 injection started on July 2003 and ended on January 2005. The total amount of injected CO_2 is 10,400 tonnes. Pressure and temperature of injected CO_2 were monitored continuously at CO2-1 throughout the CO_2 injection.

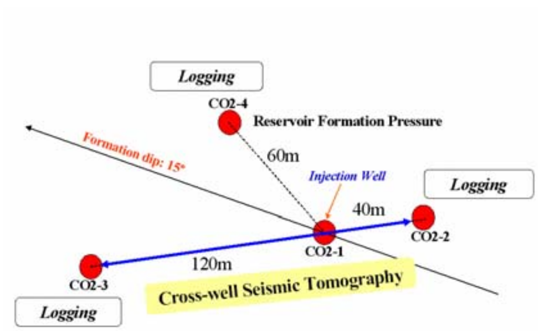

Figure 2: Configuration of the injection well and the three observation wells at the depth of the reservoir formation.

Data acquisition and Results of field surveys: OWS (OYO Wappa Source) was used as the seismic source in the observation well CO2-2, and a 24-level hydrophone tool was deployed down another observation well CO2-3.

Geophysical well logging consisting of induction, gamma ray, neutron and sonic was performed almost once every month at three observation wells of CO2-2, -3 and -4 to detect the CO_2 breakthrough. Such results enable us to modify the numerical model for prediction of the injected CO_2 within the reservoir. The crosswell seismic tomography was conducted to monitor the injected CO_2 between the observation wells of CO2-2 and CO2-3 at a distance of 160 m. The baseline survey was conducted prior to CO_2 injection in February 2003. The monitoring surveys were carried out in January and July 2004, after 3,200 and 6,200 tonnes of CO_2 was injected into the reservoir, respectively.

Difference tomograms were generated from the baseline- and monitor-tomograms as shown in Figure 3. These difference tomograms were obtained by subtracting each monitor velocity from the baseline velocity. Each difference tomogram shows a striking area with velocity anomaly near the injection well CO2-1. The maximum velocity reduction due to CO_2 injection was estimated about 3%. The low velocity zone indicates distribution of injected CO_2 within the reservoir. As increasing CO_2 injection the low velocity zone expanded preferentially along the formation up dip direction.

On October 23, 2004, a huge earthquake with a magnitude of 6.8 in JMA (Japan Meteorological Agency) Magnitude hit the Mid-Niigata area. The earthquake epicenter depth was 14 kms (JMA), and the CO_2 injection site is located about 20 kms away from the earthquake epicenter. The ground motions during the earthquake at 17:56, recorded by the seismicity monitoring system installed at the CO_2 injection site was 705 gal (maximum). There was no any seismicity observed during CO_2 injection before the earthquake. Both crosswell seismic and well logging surveys were repeated after the earthquake to investigate the CO_2 distribution within the reservoir. It is worth to note that there was no any CO_2 leakage from the reservoir according to the survey results.

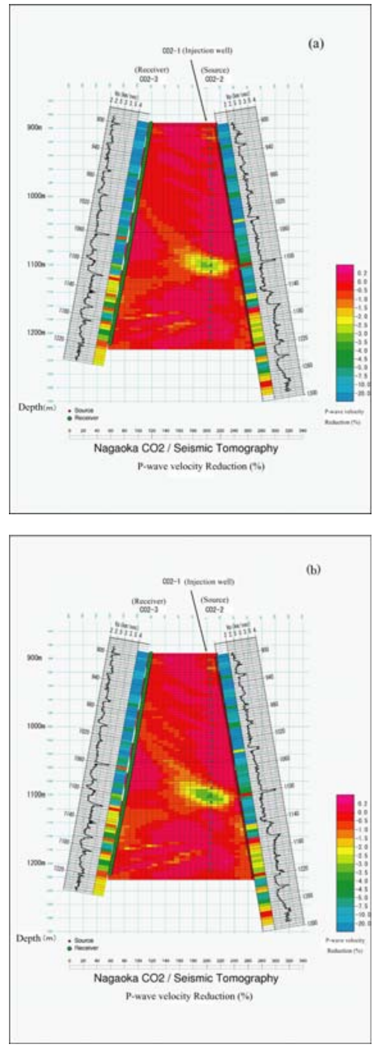

Figure 3: P-wave velocity difference tomograms between observation wells of CO2-2 and -3 at a distance of 160 m. (a) after 3,200 tonne-CO_2 injection, (b) after 6,200 tonne-CO_2 injection. The dashed line indicates the projection of injection well of CO2-1.

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Feasibility Study of CCS Project for Natural Gas Plants

JGC Corporation undertook a feasibility study (FS) for the implementation of CCS (CO_2 Capture and Storage) projects for Natural Gas Plants located in Southeast Asia. The FS was conducted in fiscal year 2004, and sponsored by METI (Ministry of Economy, Trade and Industry).

There are many large Natural Gas Plants (for LNG and Sales Gas production) in this area. The CO_2 content of the feed gas for these plants is in the range of 5-15 mole percent. During processing, the CO_2 is removed by chemical absorption processes and the quantity discharged into the atmosphere annually at each plant is between 1 and 3 million tons.

The CCS project is aimed at recovering highly concentrated CO_2 at the solvent regenerator stage following the chemical absorption process, compressing it up to 20 MPa and injecting it underground. The technology for this process has been proven and the CO_2 recovery cost is lower when compared with that from combustion flue gas in Japan. The Clean Development Mechanism could be applied to the project to cover its operating costs with Certified Emission Reduction credits.

The FS was based on an annual amount of 3 million tons of CO_2 being sequestered into an aquifer located 100 km off-shore and 1500 m underground.

The main topics of the FS are summarized below.

- ✓ Seven (7) large Natural Gas Plants were surveyed and the total CO_2 emissions amounted to 19 million tons per annum.
- ✓ The cost for emission reductions was expected to be around 11 US$/ton-$CO_2$, which was derived by dividing the sum of the capital costs and 10 years of operating costs by the amount of CO_2 to be injected over that period (30 million tons), on the basis of the cost levels existing in 2003. These costs do not include any allowances for profit, interest, or taxes.
- ✓ To promote the project design, preparation tasks need to be conducted for the characterization of the aquifer candidates, such as seismic surveys, the drilling of appraisal wells and the forming of performance predictions. However, it is difficult to invest in those tasks on a private business basis because of the high risks involved due to some uncertainties regarding the realization of the CDM project, such as uncertainties concerning the approval as a CDM project and on marketing of the CER credits. Thus, a subsidy program support sponsored by METI is required for the preparatory tasks.
- ✓ For the preparation tasks, development of safety assessment technologies including remediation technologies, and monitoring and verification technologies, as well as site characterization, should be carried out. The proposed schedule for the performance of the preparation tasks is shown in Figure 1.

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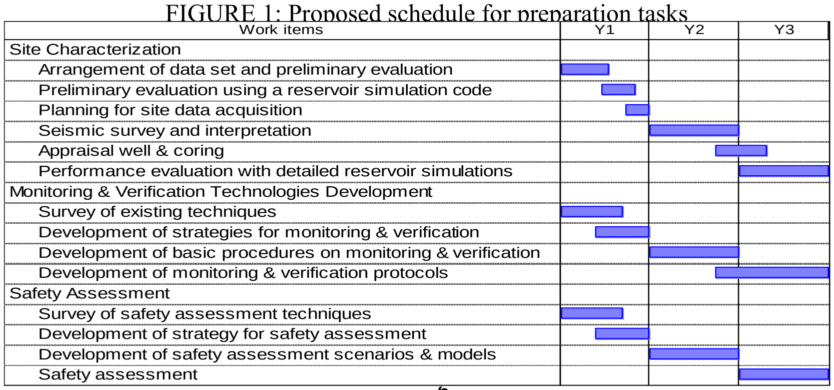
FIGURE 1: Proposed schedule for preparation tasks



Japan CO_2 Geosequestration in Coal Seams Project (JCOP)

Project outline

JCOP has been commenced since JFY2002 with full subsidy from Ministry of Economy, Trade and Industry (METI). The fundamental phase consisting of laboratory experiment and preliminary field test has been designed to investigate technical and economical feasibility of CO_2 sequestration in coal seams. The injection well was completed in Yubari city located in Ishikari Coalfield of Hokkaido. The distance in the coal seam between the vertical injection well and the deviated second well for observation was estimated to allow the breakthrough of CO_2 injected to come up from the observation well during the life of the phase by simulation model. This paper focuses on the multi well CO_2 injection/CH_4 production test which has been conducted using both injection well and observation well. This project is organized by General Environmental Technos Co.,Ltd (KANSO) and field test is undertaken by the Japan Coal Energy Center (JCOAL).

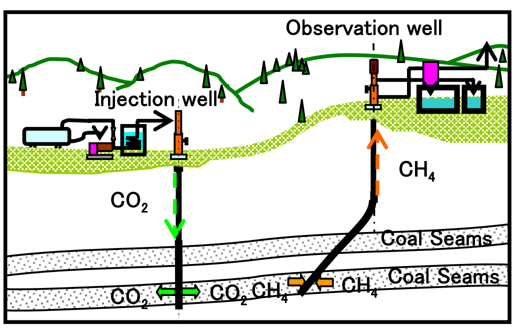


Figure 1: Image of preliminary field test

Object

The purposes of this Project are:

To develop the effective CO_2 injection technology for Japanese coal seams in safe manner,

To produce much more CH_4, and

To pave the way for monitoring the behavior of injected CO_2 in coal seams.

Results

We have obtained the following results from fundamental research : displacement mechanism, CO_2 absorption characteristic, amount of the sequestered CO_2. Injection well was drilled down to 933m in 2003 and encountered three coal seams of which the lowest seam at the depth of 890 to 896m was selected as target coal seam. Cores of the mudstone cap rock and of the coal seams were taken from IW-1 well. The CH_4 gas content data were measured at 22.2 cm^3/g on average, which was excellent for the coal of this rank, high volatile A bituminous. Small amount of CO_2 was injected for preliminary test, while water and gas rates produced from PW-1 well were measured. The numerical simulation model (called the "Ishikari Model") was developed during JFY 2002 to 2003 and well matched with actual measured gas rate as shown in Figure 2. Based on the history matching with Ishikari Model, we verified the CO_2 injection performance and the enhanced effect of CO_2 injection on CH_4 production.

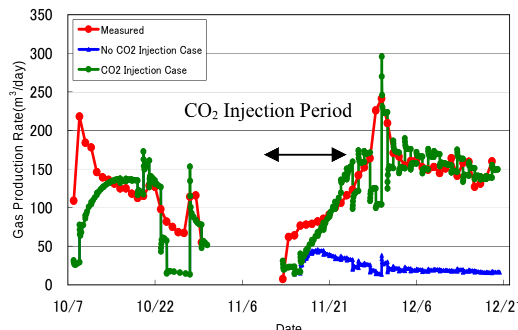


Figure 2: Comparison of gas production rate for CO_2 injection case and no injection case

Issues in the development of technology

As future research tasks, we plan to examine the following aspects:

・CO_2 injection potential and methods to increase CH_4 productivity

・Monitoring of CO_2 behaviour in coal seams

・Economic efficiency of the total system

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Planned submission of a CDM new methodology application for CCS

Mitsubishi Securities (MS), in cooperation with other Japanese companies and a foreign registered oil exploration company, have produced a CDM new baseline and monitoring methodology for a Carbon Capture and Storage (CCS) project. The methodology is titled "Recovery of anthropogenic CO_2 from industrial GHG emission sources and its storage in an oil reservoir.

The methodology is characterized by having a set of detailed applicability conditions with minimum standards for site selection (Pre-Inspection Phase Assessment), monitoring of the oil reservoir for seepage, and abandonment of wells. This is deemed necessary to alleviate public concerns about permanence of storage and safety. Lower quality projects which have little certainty in regards to permanence, are unlike to be applicable to this new methodology.

In order to confirm permanence, the methodology will monitor for significant release (through accidents, earthquakes, well failure, etc.) of stored CO_2 into the atmosphere. CERs equivalent to the estimated amount of CO_2 released (verified by a third party from seismic imaging and other applicable monitored data) will be replaced by the project participant in the event of significant release occurring. A significant release is defined as the release (from the storage structure) of an amount of stored CO_2 equivalent to over 0.7% of the total amount of stored CO_2, in a 7-year crediting period.

The methodology is made up of two parts:

1) An additionality test (Tool for the demonstration and assessment of additionality)

2) Baseline scenario and emission reduction determination

In the baseline scenario anthropogenic CO_2 from the source is vented/emitted into the atmosphere without being captured. Baseline emissions are equivalent to the total amount of CO_2 vented/emitted by the source.

CCS projects utilizing the methodology need to determine project activity emissions due to:

1. CO_2 from the source which was lost during the capture, transfer or recycling processes.

2. GHG from energy used by the project equipment and machinery (both associated with fossil fuel and electricity)

3. Flaring/venting of CH_4 contained in waste gas derived from the CO_2 recycle plant

4. Seepage due to significant release of stored CO_2 from the storage structure

5. Emissions due to CH_4 escaping from the natural gas pipeline (after separation of CH_4 from gas treated in the CO_2 recycle plant)

Leakage and project emissions are deducted from baseline emissions, to determine net emission reductions.

Mitsubishi Securities hopes to submit the new CCS methodology before the cutoff date of October 5 2005 for Round 13 of new methodology submissions. This should mean that the Methodology Panel will consider it at their 19th meeting early next year. CCS technology will be an important tool for fighting global warming in the future. Considering the high costs of CO_2 capture, processing and injection, the incentive provided by income from the sale of CERs will be a critical factor in the dispersion of this technology into developing countries.

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Environmental Assessment of CO_2 Ocean Sequestration for Mitigation of Climate Change

Background:

In order to control global warming, it is necessary to decrease the discharge of CO_2 into the atmosphere. CO_2 ocean sequestration technology is a kind of enhancement technology for the natural process of ocean, which is the absorption of CO_2 in the atmosphere into the mid-depth of ocean. The CO_2 emission over several centuries causes the increase of atmospheric CO_2 concentration, and the pH of surface of the oceans decreases during taking up CO_2, and finally, the atmospheric CO_2 concentration decrease in equilibrium. If captured CO_2 is injected to mid-depth layer without contacting the sea water of surface layer, so, the marine organism of the surface layer is not affected by the injected CO_2. Injected CO_2 to mid-depth is dissolved into the sea water as well as the atmospheric CO_2 is naturally absorbed to the ocean (Fig.1).

Before the implementation of ocean sequestration, the validity of this technology should be evaluated . The biological impact study and the development of the monitoring technology are necessary for CO_2 ocean sequestration. And also, the feasibility study of CO_2 dilution technology should be implemented to confirm the viability of ocean sequestration.

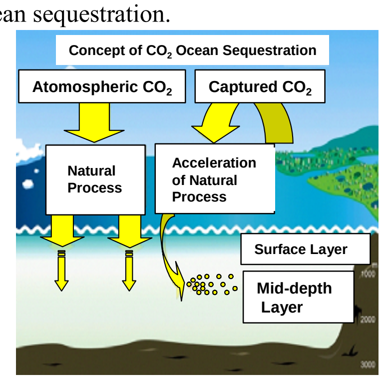

Fig.1 Concept of CO_2 Ocean Sequestration

Primary Project Goal:

Japan is developing environmental assessment technology of CO_2 ocean sequestration using Moving Ship system for the R&D aimed toward a practical system that can make a significant contribution to reducing atmospheric CO_2. The concept of Moving Ship system is shown in Fig. 2.

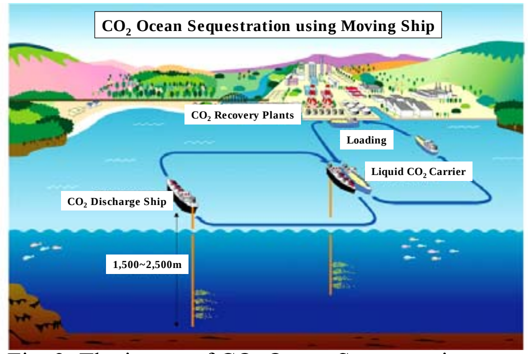

Fig. 2: The image of CO_2 Ocean Sequestration

The liquefied CO_2 injected as droplets into the mid-depths of ocean (1,500-2,500m) is diluted and dissolved in sea water. The project goal of the second phase started in 2002 is the assessment of ocean sequestration validity, the development of environmental impact assessment technology and the development of CO_2 dilution technology.

Objectives:

The major objectives of this project are as follows:

(1) the technological assessment of CO_2 ocean sequestration capability: The effectiveness of ocean sequestration technology must be elucidated by additional investigations using newly developed models based on the accumulated scientific knowledge.

(2) Environmental impact assessment technology: CO_2 impact on ocean environment, especially impact on biota in mid-depth of ocean, must be elucidated before practical implementation of CO_2 ocean sequestration,

(3) CO_2 dilution technology: Development of CO_2 dilution technology is needed to reduce CO_2 impacts on ocean environment as much as possible and its results are applied to the study on the environmental impact assessment technology.

Major Results:

Outline of R&D results in FY-2002 to FY-2004 are followings;

(1) Technological assessment: Consequences of the CO_2 ocean sequestration were simulated

numerically by using global carbon cycle box model, comparing the CO_2 concentration in atmosphere and ocean between the reference case and ocean sequestration (Fig 3). The capability of CO_2 sequestration into the ocean was studied relating to the equilibrium concentration of atmospheric CO_2.

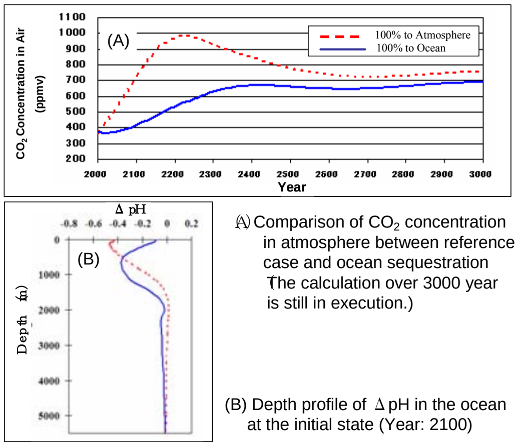

Fig. 3 Simulated atmospheric CO_2 concentration and depth profile of Δ pH in the ocean

(2) Environmental impact assessment technology: The assessment technology of CO_2 injection impacts on environment have been developed on the assumption that applying CO_2 dilution technology developed by this project at suppositional area of CO_2 ocean sequestration near Japan. The physical-, chemical- and biological- environmental surveys have been conducted at the southeast sea area of Okinawa where is a suppositional area of CO_2 ocean sequestration. Biomass, biodiversity, and food web structure of the survey area have been studied year-by-year (Fig. 4). As for predicting acute impacts of high-CO_2 environment on marine organisms, mortality model which could estimate range and degree of impact by means of computational simulation is developed.

Furthermore, laboratory experiments on responses of marine organism to high-CO_2 are carried out to permit more precise prediction of an acute biological impact. As for a first step of a long-term biological impact assessment, deep-sea ecosystem model is attempt to construct based on the biological data derived by surveys at a suppositional area of CO_2 ocean sequestration.

Achievements of the recent studies on the environmental impact assessment technology have been published as the special section in Journal of Oceanography (Volume 60, No.4, August, 2004).

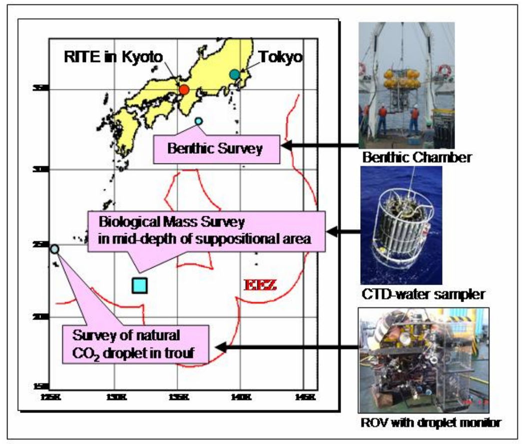

Fig. 4: R&D surveys for the Ocean Sequestration

(3) CO_2 dilution technology: For the prediction of CO_2 distribution, the meso-scale models which were enable to estimate the behavior of CO_2 dilution and diffusion within from 100 m to 1,000 km were developed, and the completion of large-scale models for 1,000s km is in sight by using the computer of the Earth Simulation Center (ESC) (Fig.5). The observation of CO_2 droplet in the Okinawa trough made sure the credibility of CO_2 dilution model. And the feasibility of moving-ship method for CO_2 ocean sequestration was investigated. As for the technology of feeding liquid CO_2 through pipe into sea water, the experiments of the vortex induced vibration (VIV) has been done with a large-scale water tank, and the numerical analysis of flow field were carried out to solve the VIV phenomenon which occurs in towing a long pipe by ship.

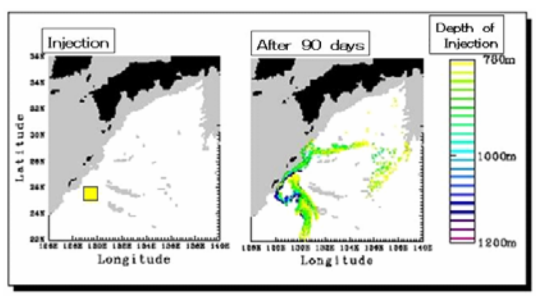

Fig. 5: Simulated CO_2 behavior (Earth Simulator)

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A Research Project on Accounting Rules on CO_2 Sequestration for National GHG Inventories

Project Summary

The long term risk that stored CO_2 could eventually return to the atmosphere through physical leakage in CCS is not ignored. This project has an aim to propose rules for calculating the actual amount of emission reduction by the CCS technologies and how to reflect it within the National Communication (Annual Inventory) under the protocols dictated by the United Nations Framework Convention on Climate Change (UNFCCC).

First, leak estimation models are developed for geological storage and ocean storage. Second, based on the models leak estimation methodology is developed. Third, accounting rules for national inventories and project-based activities are proposed.

Goal

This research project aims to propose transparent and internationally acceptable accounting rules for CCS based on scientific information.

Progress and Achievements

1. Proposal of accounting rules

The summary paper of the accounting rules was presented in GHGT-7 and a detailed paper was prepared as a discussion paper, which was circulated among authors of IPCC 2006 Guideline for National Greenhouse Gas Inventories and used as a reference in the first author meeting of the IPCC 2006 Guideline.

In the proposed accounting rules, a framework of accounting rule of CCS technology is proposed based mainly on leakage estimation using newly developed models. These rules follow identified priority factors with which emphasize estimation and accounting of yearly leakage in the near term as a conservative basis for rule making. In avoided emission estimation methodology, the net stored amount of CO_2 is defined and a three-level-methodology is proposed for estimating yearly physical leakage(see, TABLE1). The proposed accounting rules for CCS consists of avoided emission estimation methodology, accounting rules for national inventories, and accounting rules for project-based activities.

2. A leak estimation methodology for geologic storage

A leak estimation methodology based on quality of cap rocks (seal quality) was developed and were presented in GHGT-7. To quantify quality of cap rocks, Cap-rock Quality Factors (CQF) was also newly developed. CQF is calculated reflecting features of the site, thickness of cap rock, depth of the site and possibility of three types of leakage, leakage via matrix of cap-rock, leakage via fracture of cap-rock, and leakage via wells. We use two different interpretations of CQF, Conduit Model and Membrane Model, to estimate amount of leakage by category of cap-rock (seal) quality.

3. A global ocean system model and a leak estimation methodology for ocean storage

A global ocean system model was developed with the purpose of understanding the physical and biochemical process within ocean system and predicting the effect of ocean storage of CO_2. Based on the simulated storage curves of injected amount of CO_2, a simple formulation for accounting the amount of CO_2 stored in ocean using leakage coefficients was developed. Three papers were presented in GHGT-7.

Future Tasks

Future tasks are re-examination of time frame to apply accounting rules, development of leak estimation methodology using monitoring technology and simulation models and detailed accounting rules for project-based activities.

TABLE1: 3-level-methodologies for estimation of long-term physical leakage

Level	Concept	When apply?	Accuracy	Cost
1	● Simple estimation without detailed evaluation of reservoir. ● The amount of leakage is calculated using leak coefficient or simple formula. ● The resulted values are conservative inevitably	Detailed simulation technologies and physical parameters are not available	Low	Low
2	● Estimation considering the site specificity in detail ● The amount of leakage is calculated by simulation based on the guideline.	Physical and chemical data are available.	Medium	Medium
3	● Measuring of the yearly amount of leakage ● Continuous monitoring is required.	High level technology is available	High	High

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Research and Development of CO2 fixation by large scale plantation in arid area

This project aims at spreading CO2 –sequestration area by afforestation in the semi-arid land. For this purpose, we are improving the physiological performance of trees, especially adding environmental-stress-tolerance as well as high productivity to the tree. The utilization of chloroplast engineering is our approach. Until now, we have developed the gene transfer method to chloroplast genome of poplar. In addition, we have collected several useful genes involved in the environmental-stress-tolerance and high productivity from many organisms. However, the use of genetic modified trees is hard to say quick-acting technology because development of those trees are in research stage and, in addition, social acceptance is required to cultivating them in outdoors even if the genetic modified trees reached a practical-use-stage. Thus we placed this approach as a relatively long one.

Alternatively, the quick-acting method we also use is the application of a non-genetic-modified but a clone of elite trees. We have already prepared a young eucalyptus of 20,000 elite clones containing high growth rate, drought tolerance and salt stress tolerance, respectively. After acclimatization, the plantation has started in July 2005 in about 30 hectares area, approximately 100 km south of Perth, Western Australia where is a semi-dry area of precipitation around 600 mm in a year. We will evaluate these trees in terms of CO2 reduction

FIGURE 1: Elite clone seedlings (the left) and scenery of the planting (the right)

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International Workshop on CO_2 Geological Storage, Japan '06

Introduction: CO2 geological storage is one of key technologies to secure a significant amount of CO2 reduction after Kyoto protocol. As a key part of the Nagaoka Project, 10,000 tons of CO2 was injected into a deep saline aquifer at 1,100m below the ground level between July '03 and January '05. The behavior of injected CO2 is being monitored using a time-lapse geophysical logging and cross-well seismic tomography and the results provide valuable insights into understanding of CO2 behavior in an aquifer.

At the end of this year IPCC Special Report on Carbon Dioxide Capture and Storage will be submitted and CO2 emission reduction actions will be discussed in the first COP after Kyoto protocol launched (COP11) and MOP1.

The international workshop on the geological storage will be held after these key events under the organization by RITE. This workshop provides the result of the Nagaoka Project to the outside including overseas. This workshop would contribute the improvement of CO2 geological storage and be beneficial for all the persons who are interested in global warming mitigation.

Dates: February 20th (Mon) and 21st (Tue) 2006

Venue: The Toranomon Pastoral Hotel in Tokyo

Language: Japanese-English with simultaneous interpretation

Tentative Agenda:

<The 1st day>

Opening remarks Prof. Yoichi Kaya (Director-General, RITE)

Invited Speakers

- Dr. Paul Freund (ex-Manager, IEA GHG)
- Dr. Susan Hovorka (Texas University, US)
- Dr. Don White (Weyburn Project, Canada)
- Dr. Nick Riley (BGS, UK)
- Dr. Makoto Akai (AIST, Japan)

Panel Discussion (joined by Dr. Takashi Ohsumi, Chief Researcher, RITE, A chief examiner of panel is Dr. Makoto Akai)

＜The 2nd day＞

The results of the Nagaoka Project (to be finalized)

a. Overview of the Nagaoka Project (Dr. Ohsumi, Chief Researcher, RITE)
b. Laboratory experiments (acoustic wave and resistivity)
c. Cross-well seismic tomography
d. Geophysical logging and their analyses
e. Reservoir simulation
f. Economical evaluation of the geological storage
g. Risk assessment
h. Public acceptance

Generalization Prof. Shoichi Tanaka, chairperson of the researching committee of the Nagaoka Project

Closing remarks Mr. Masaharu Higuchi, Senior Managing Director, RITE

Official announcement & registration information will be open at RITE web site in the middle of November 2005.

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