RITE Today

Research Institute of Innovative Technology for the Earth

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Annual Report

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Transition to Public Interest Incorporated Foundation

Based on a new act enacted in December 2008, Research Institute of Innovative Technology for the Earth (RITE) was granted the public interest corporation authorization by the Prime Minister on November 25, 2011 and made transition to the public interest incorporated foundation on December 1, 2011.

Japan has been recognizing the importance of "business conducted by organizations in private sector for public interest purposes" in a social and economic system and reviewed the public interest corporation system to further promote such activities. As a result of this review, general incorporated associations or general incorporated foundations could be founded only by registration and also, when authorized for their highly public interest services, the general incorporated association or general incorporated foundation could be referred to as the public interest incorporated associations or public interest incorporated foundation.

To implement "New Earth 21" plan announced by the Japanese Government, RITE was launched in July 1990 as a general incorporated foundation based on Civic Code. Since then, focusing on fundamentals of the plan, "developing innovative environmental technologies", RITE has been working as an international center of excellence to accelerate the plan.

In view of the objectives of foundation, the Board of Directors and Councilors of RITE resolved to proceed with the transition to the "public interest incorporated foundation" in June 2009. Since then, amendments of articles of incorporation, renewal of board members, new organizational design of Board of Directors and Councilors and the like have been drafted and discussed.

The drafted amendments and other changes were approved by the Board of Directors and Councilors in March 2011. The Board also adopted application for public interest corporation authorization, which was submitted to the Cabinet Office on May 13, 2011 and successfully paved the way to the transition to the public interest incorporated foundation of RITE.

The changes made along with the transition include: reduction in the number of councilors and directors from dozens of members to about ten members to achieve more mobility as the organization; and establishing a new framework to ensure corporate operations to be sustainably appropriate for the public interest incorporated foundation, that is, granting the Board of Councilors and Directors additional rights to make ultimate decisions on operationally important matters, such as approval of settlement of accounts and amendments of the articles of incorporation, to the existing right of appointment and dismissal of directors.

On the other hand, in view of RITE's history to the foundation, no changes were made with regard to the fundamental sections in the articles of incorporation including "objectives" and "works". (For more information, see RITE's website)

Under the leadership of newly elected president, Prof. Dr. Kaya (former vice director), a successor to Dr. Akiyama the former president, all researchers and officials in new RITE are deeply aware of the meaning of "public interest" and committed to fulfilling our mission on research and development projects for public interest in the field of global environment protection. As always, we appreciate your continuing support and cooperation for our activities.

Promotion of CCS

Yoichi Kaya, President,

Research Institute of Innovative Technology for the Earth

Last year in Japan most focus has been given on the big earthquake in east Japan and the accident of Fukushima Daiichi nuclear plant. It however does not necessarily mean that seriousness of global warming faded out. At COP 17 held in South Africa last December the target of keeping the global temperature rise within 2 or 1.5 degrees was clearly declared. We notice that achievement of this target is a hard task, as factors accelerating emission of CO_2 rather than those reducing it have been increasing. The key factor is economic development of developing countries but another important factor is the barrier set to nuclear expansion since the accident of Fukushima Daiichi. The government of Japan does not make any decision on future energy strategy yet, but often expresses its will of relaxing reliance on nuclear power. It is therefore almost certain that nuclear power will shrink in future in a considerable degree. Although renewables have been promoted all over the world, their development will be limited by several barriers such as present high costs and output variability. Under these conditions we also notice that a new positive factor appeared in the situation of fossil fuels of which resource finiteness has been worried for long; the increase in availability of unconventional gases such as shale gas in the United States.

Taking all these situations into consideration we foresee that fossil fuels will still keep the position of principal actor in energy supply at least for next several decades. Limiting CO_2 emission under these conditions inescapably lead us to use of CCS. However we notice there are a few but serious barriers to development of CCS. The first is the high cost and/or energy required of CO_2 removal, and the second is low public acceptance particularly in Europe where most environmental groups and/or local governments are not in favor of underground storage of carbon oxide. Taking into account that carbon dioxide is, different from ordinary pollutants, harmless and there are many underground sites where carbon dioxide is naturally stored, we may say that CCS is a technology to be safely implemented in practice. We should therefore do a lot of efforts for improving public acceptance of CCS.

Our institute RITE has investigated recovery technology, storing technology and evaluation of safety of CCS and therefore is proud of standing at the top of CCS research in the world. We will do more efforts for developing technologies for mitigating global warming, particularly those of CCS and therefore ask the readers to support our institute conducting R&D along this direction.

Research Planning Group

Recent Activities and Challenges on Innovative Mitigation Technologies to Prevent a Global Warming

1. Introduction

A drastic cut in CO_2 emissions is required to prevent a global warming. According to “Energy Technology Perspective 2010”[1] issued by International Energy Agency (IEA), emissions of CO_2 should be decreased by 14Gt CO_2/yr to achieve 50% reduction in global CO_2 emissions by 2050. Considering economical progress of developing countries, this means that 48GtCO_2 /yr is necessary to reduce from the baseline emissions (Figure 1). Such a drastic reduction cannot be achieved by a sole technology but a combination of many useful technologies is needed. In this context, some innovative mitigation options like “Carbon Dioxide Capture and Storage (CCS)” or “Biomass Utilization” becomes remarkable. Estimated costs of these two technologies are shown in Figure 2. Both are relatively cheep and generated power from these is stable compared to the case of photovoltaic or wind power.

Prior to reports from research groups of RITE, I would like to survey trends in CCS and biomass utilization, on which RITE has been focusing for many years. I would add that some results used in this report were given in NEDO’s research program, “Total System of Zero-emission Coal-fired Power Generation Project”.

2. CCS

2-1. CCS Project

Global CCS Institute (GCCSI) published “The Global Status of CCS: 2011”[2] in autumn, 2011, which summarizes CCS projects activities in the world. There, projects are classified into the following 6 stages based on degree of progress: Identify, Evaluate, Define, Execute, Operate, and Closure. The first “Identify” is the stage of site screening, “Evaluate” is site assessment and pre-feasibility study, “Define” is site selection and feasibility study, “Execute” is project execution, design and installation, and “Operate” means asset operation. The final “Closure” is the stage that injection is completed and asset is decommissioned. Based on the project lists made by GCCSI, I reconfigure the start year of project /capture volume relations by capture options (emission sites and capture technology; Figure 3) and storage options (EOR, EGR, and saline aquifer etc.; Figure 4).

First, Figure 3 shows that emission sites of “Operation” staged projects are mainly a natural gas processing. CCS projects in power generation and synthetic fuel production will start in 2014. Post combustion and pre combustion are appeared in the same proportion but Oxyfuel is low. When synthetic gas production is included, pre combustion becomes the largest.

Next, figure 4 shows that a major storage part of many CCS projects is EOR. Storage projects using sa-

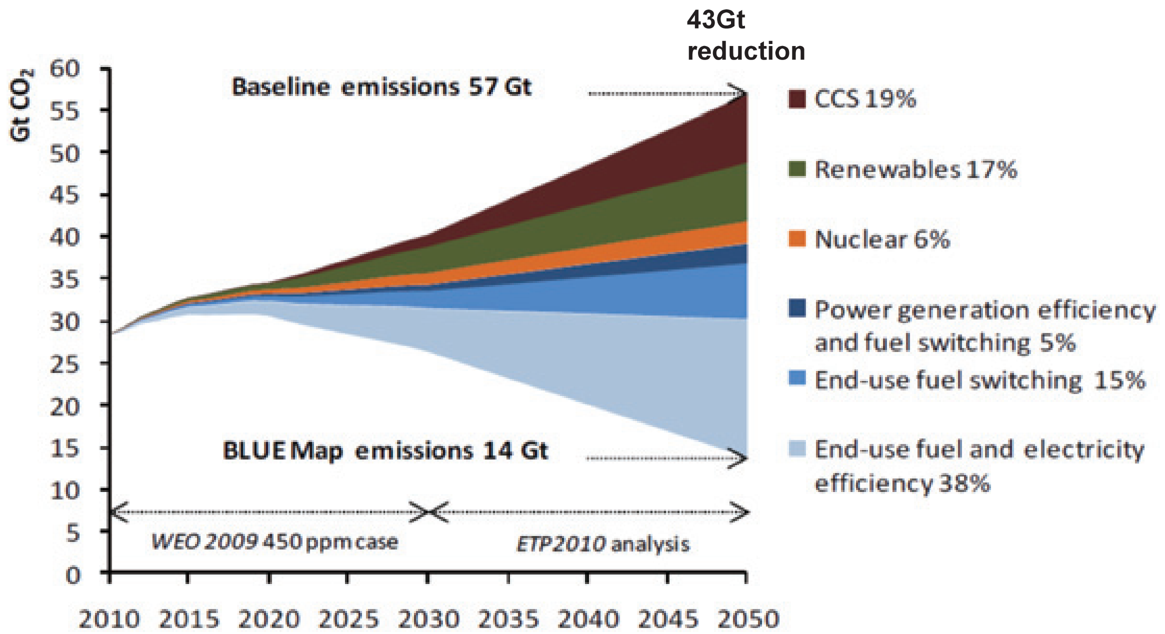


Figure 1 Contribution of mitigation technologies (IEA, Energy Technology Perspective 2010)

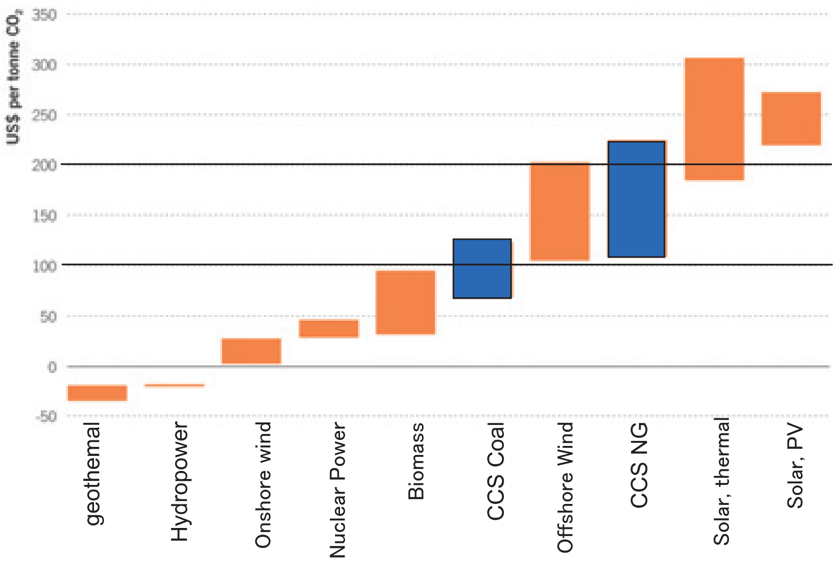


Figure 2 Comparison of CO_2 reduction cost (GCCSI "The Global Status of CCS:2011")

line aquifers like Sleipner, In Salah, and Snohvit are famous but storage amounts of CO_2 are small. In CCS projects in synthetic gas production or power plants which will start from 2014, EOR is also major. Storage projects in depleted gas fields or saline aquifers appear in 2015 and then the proportion of these grows gradually.

Project trends are changeable under the influence of political or economical changes. As already described, earlier CCS projects are combination of capture in natural gas processing and EOR. This is mainly an economical reason. In natural gas processing, CO_2 removal is already included in the process and there is no use to newly build a capture plant. In addition, EOR gains profits derived from increase in oil production. These factors make a project be sustainable without carbon price or governmental subsidies. Expecting a stable carbon market and large monetary support from government, power sector plans CCS projects from 2014. However carbon policy has not been established yet in the world and such large assistances are not promising because of economical crises. Recently Logannet Project in UK was reported to be suspended. Such suspend of project seems to be often occurred in the future. We need to establish worldwide policies for stable CCS implementation. In order to implement CCS sustainably, the following three are necessary; 1) enough, timely and stable support from government (incentives and regulations), 2) R&D to decrease cost, energy penalty, and risks, 3) community engagements in an earlier stage.

2-2. International standardization on CCS

International standardization is also an important factor to expand CCS in the world. For capturing CO_2, three different procedures, Post, Pre and Oxyfuel have been developed and they contain many separation technologies like absorption, adsorption, and membrane etc. Technology comparison is needed to choose the best-matched technology, but there is no common word at present. We also have to answer the following questions to start geological storage: How safely we store CO_2 into underground? How we account amount of reduced CO_2 ? But procedures to answer these questions are not established yet.

In this context, Canada proposed to establish a new Technical Committee (TC) of CCS in International Organization for Standardization (ISO). After voting, Technical Management Board decided to establish the following new TC:

Technical Committee ISO/TC 265 (provisional)

- Title -provisional: Carbon capture and storage (CCS)
- Scope -provisional: Standardization of materials, equipment, environmental planning and management, risk management, quantification and verification, and related activities in the field of carbon dioxide capture and storage (CCS).
  Excluded: equipment and materials used in drilling, production, transport by pipelines already covered by ISO/TC67.
- Central secretary: Canada SCC
- Members (October, 2011)
  - P-members; Australia, Canada, China, France, Germany, Italy, Japan, Korea Republic of, Netherlands, Norway, South Africa, Switzerland, United Kingdom
  - O-members: Argentina, Brazil, Czech Republic, Egypt, Finland, India, Iran, Islamic Republic of , New Zealand, Serbia, Spain, Sweden, USA

Title and Scope are provisional at present and TC is required to decide them and elaborate a draft business plan in 18 months.

In accordance with establishment of new TC, a na-

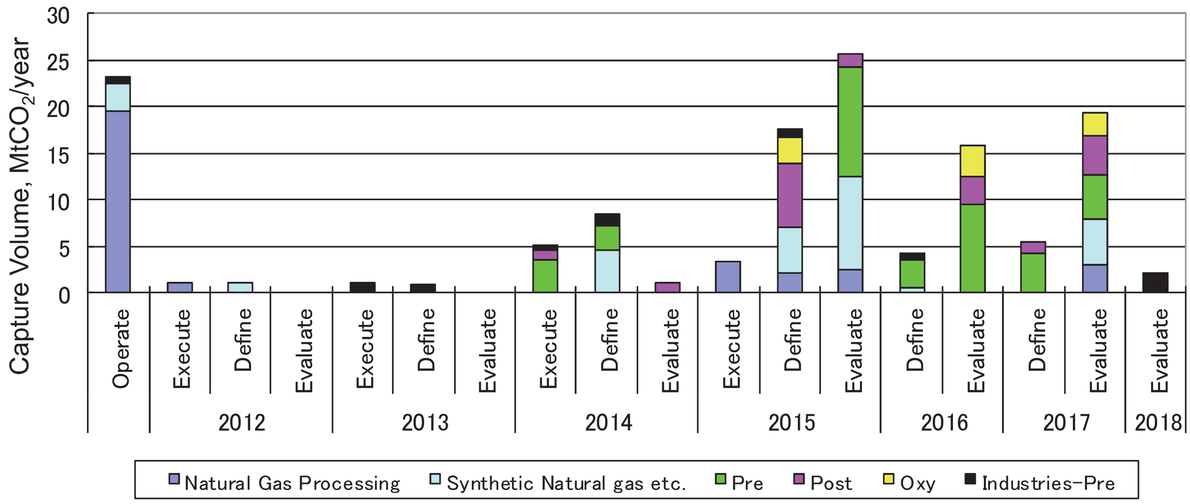


Figure 3 CCS Projects (classified by emission sites and capture technologies)

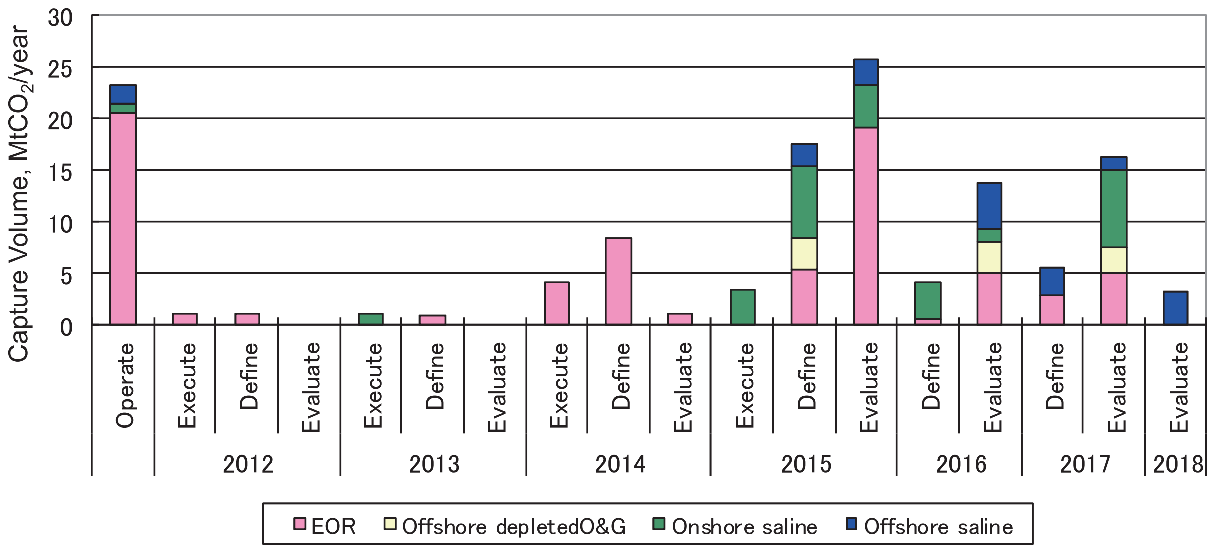


Figure 4 CCS Projects (classified by storage options)

tional mirror committee is required to be established. RITE received a commission of National Committee Secretariate from Japanese Industrial Standard Committee (JISC) in December 2011 and started working for CCS standardization.

3. Biomass utilization

Recent activities in biomass utilization are described in detail in "Special Report on Renewable Energy Sources and Climate Change Mitigation"[3)] published by IPCC in 2011. Figure 5 shows a comparison of lifecycle CO_2 emissions between bioenergies and conventional fossil energies. In many cases bioenergies can reduce CO_2 emissions compared to the case of corresponding fossil energy use. Among bioenergies, use of lignocellulose is attracting a lot of attention from the aspect of non-competitiveness with foods.

Figure 6 shows IEA roadmap of biofuels for transport[4)] to achieve 50% reduction in CO_2 emissions in the world. Advanced bioethanol production and development of BTL becomes a central issue. As aircraft fuels are difficult to be replaced by other technologies, use in this field will be important.

Problems in biomass use are in difficulty in supply of widely-spread biomass, low productivity in conversion processes, and higher cost. The roadmap shows milestones which contains demonstration of reliable, commercial-scale production of cellulosic ethanol, BTL diesel, HVO and bio-SG in 2010-2015 and demonstration of economically feasible production of algae-derived biofuel and other novel biofuel routes in 2020-2030.

4. Conclusion

At the end of 2011, we see slump of nuclear power after accidents of Fukushima nuclear power stations, remarkable progress of shale gas, and expectations on renewable energies. World economy is not good as Euro crisis symbolizes and progress of CCS seems to be slow down. Japanese government plans to present an energy best-mix after 3.11 by this summer. Japan was decided not to join a second round of carbon cuts under the Kyoto Protocol but continues own efforts for reducing CO_2 emissions. It is not easy to forecast the future figure of energy or economy but the only a certain way is to go forward R&D for the future. We are required to develop and use practically innovative technologies described above as soon as possible.

References

1. IEA, "Energy Technology Perspective 2010" (2010)
2. GCCSI, "The Global Status of CCS: 2011" (2011)
3. IPCC, "Special Report on Renewable Energy Sources and Climate Change Mitigation" (2011)
4. IEA, "Technology Roadmap, Biofuels for Transport" (2011)

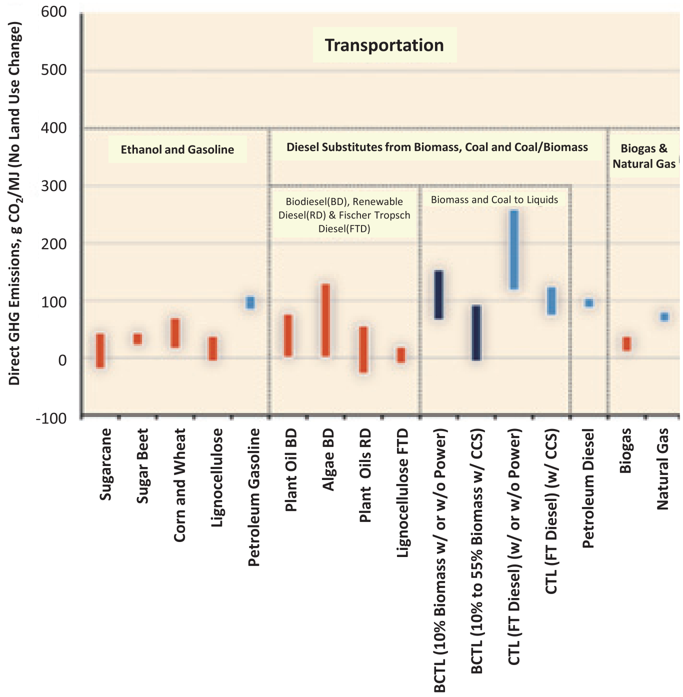
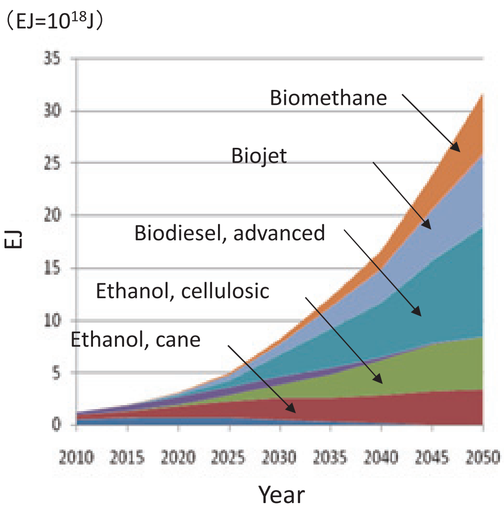


Figure 5 Life-cycle CO_2 emissions of Transport fuels (IPCC, SRREN 2011)



Demand of Biofuels

Milestones for Technical Improvements	Dates
Demonstrate reliable, commercial-scale production of cellulosic-ethanol, BTL-diesel, HVO and bio-SG.	2010-2015
All biofuels to reach >50% life-cycle GHG-emission reductions.	2015-2020
Demonstrate economically feasible production of algae-derived biofuel and other novel biofuel routes.	2020-2030
Integrate biofuel production in innovative biorefinery concepts.	2015-2025

Figure 6 Roadmap of Biofuels (Technology Roadmaps - Biofuels for Transport- 2011)

Systems Analysis Group

Synthetic Scenario Generation for Climate Change and Sustainable Development

1. Introduction

RITE has been working on development of a synthetic scenario for climate change control and sustainable development in a project called "ALternative Pathways toward Sustainable development and climate stabilization (ALPS)" since FY 2007.

As a result of the 17th Conference of the Parties (COP17) to the United Nations Framework Convention on Climate Change (UNFCCC) held in late 2011, global action to tackle climate change is expected to be taken under the Durban Platform for Enhanced Action in a practical sense, bringing all Parties onto one track, although the agreement was made to extend the Kyoto Protocol as a formality.

As observed in the COP17 negotiations and in the domestic policy making process, different actors have different policy priorities based on their economic levels and other inherent challenges, which leads to a difficulty in creating a well-coordinated uniform policy. Climate change is not the only issue on the global agenda, so it should be addressed in a balanced manner under multiple social objectives. Conventional global abatement scenarios may be too simplified to capture richness of detail and context of the real world situation. The results reveal that climate policy with the highly-idealized premises sometimes does not deliver relevant outcomes, or rather causes unduly confusion to the society.

The ALPS project aims at providing alternative plausible future scenarios through quantification of multiple aspects of society on the assumptions that the real-world society consists of a wide range of values. This approach allows us to inform decision makers of more appropriate strategies toward sustainable development and climate stabilization from longer and wider perspectives. This study is expected to make contribution to create a new climate change framework and to set appropriate climate targets in a timely fashion.

2. Scenarios for quantitative analysis

Modeling simulations are powerful tools to support decision making even though they tend to assume perfect information or perfectly rational behavior. At the same time, it is important to bear in mind that the real world is full of variety and complex. The gap between the real world and virtual model world creates a risk of sending a wrong message. Therefore this ALPS project starts from a deep understanding of the current world situation and historical trends in order to avoid such trap. Based on the insights gained from the socio-economic analysis above, narrative storylines with great details are worked out from broader perspectives.

Three different types of qualitative scenarios are developed: 1) Socio-economic scenarios, 2) Climate Change Policy scenarios, and 3) Representative Concentration Pathways (RCP) scenarios. Furthermore sub-scenarios focus on the subject matter of development and diffusion

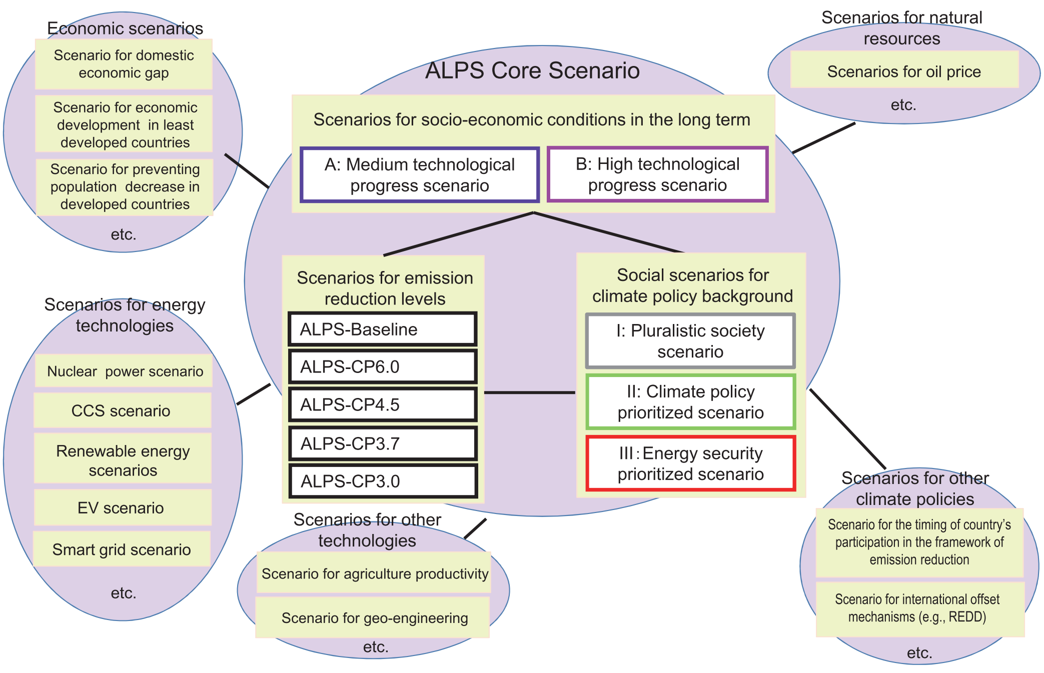


Figure 1 Scenario Groups of the ALPS project

of climate friendly technologies.

With regard to the socio-economic scenarios, a key scenario driver is technological progress, which involves significant uncertainty. Although policy can have a impact on technology progress to some extent, other factors bring larger uncertainty about the future technological change beyond policy impact. It is quite difficult to forecast future innovation and technological progress with high accuracy, so we prepare two discrete scenarios to cover the range of uncertainty. Scenario A (Medium technological progress scenario) illustrates a gradual shift from rapid economic development toward a well matured economy especially in developed countries. Scenario B (High technological progress scenario) describes a future world of very high economic growth with brilliant innovation.

As for scenarios of climate change priority in the broader global agenda, we develop three different narratives. Scenario I named "Pluralistic society scenario" is approximate to the current real world situation with people's diverse values in nature. This scenario is premised on the existence of various barriers to technology diffusion. Scenario II is a "Climate policy prioritized scenario" is a one under which climate change policy is prioritized and people's behavior are rational in the sense that mitigation measures are taken in a cost effective way. This assumption was implicitly adopted by most of the traditional climate change assessment. Scenario III called "Energy security prioritized scenario" in which each nation puts high priority on securing domestic energy resources from energy security perspective.

Our future emissions scenarios are fully harmonized with a set of four RCPs for IPCC AR5. The RCPs have been selecting from existing literature to span the full range of possible trajectories for future greenhouse concentration: a very high emission scenario leading to 8.5 W/m^2, a high stabilization scenario leading to 6 W/m^2, an intermediate stabilization scenario leading to 4.5 W/m^2 and a low mitigation scenario leading to 2.6 W/m^2 (RCP 3-PD). Additionally we go over 3.7 W/m^2 scenario, which comes to five emission pathways in total.

3. Development of models

The ALPS project performs comprehensive modeling scenarios supplemented with the existing models developed by RITE. Scenarios associated with climate change

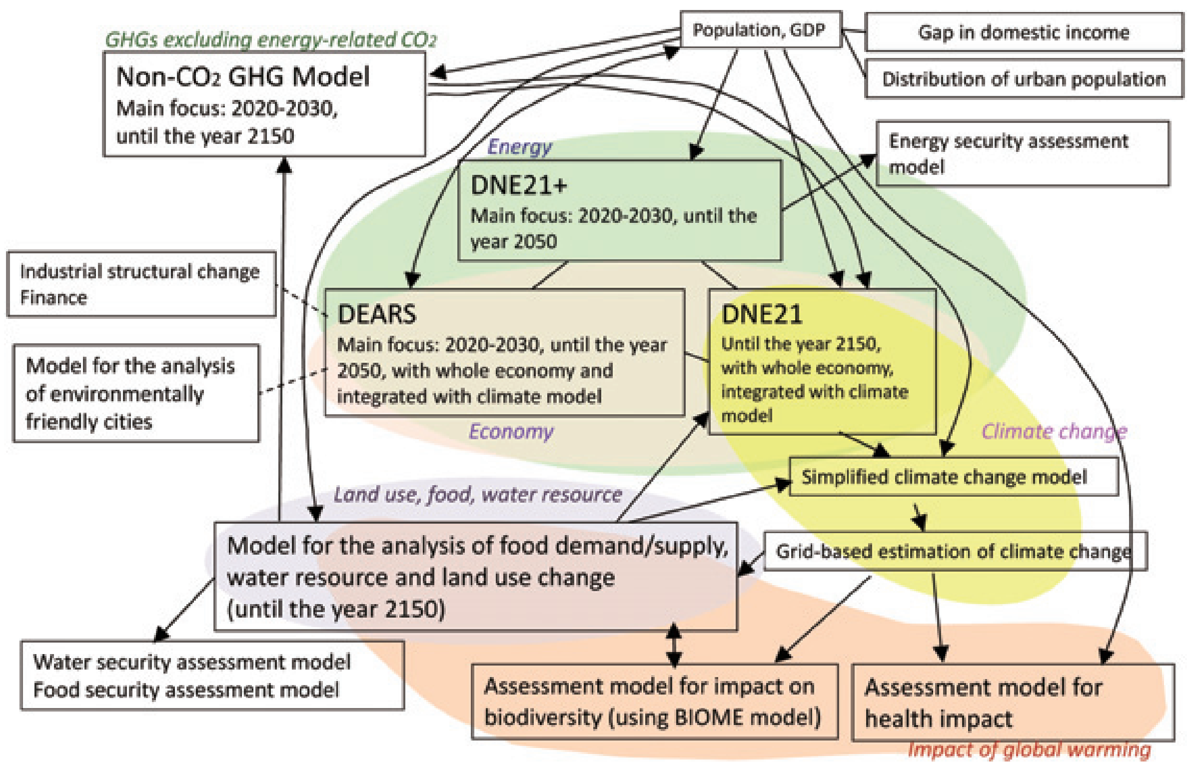


Figure 2 Models for the development of ALPS quantitative scenarios

need to be developed in the context of sustainable development with a wide-ranging set of models to reflect a multifaceted reality. The DNE21+ Model assesses CO_2 emissions from fuel combustion with great details of national, sectoral and technological descriptions. Along with the food demand-supply model, fresh water model, and land use model, a wide variety of plausible future scenarios and narratives are assessed in an integrated and consistent manner.

The models are chosen appropriately in accordance with time frame and objectives of the assessment. For near and medium term analysis, detailed descriptions of the nation, of sector and of technology are highlighted. For longer term analysis, interactions between climate impacts and socio-economic activities are more heavily weighted.

4. Synthetic assessment of socio-economic scenarios for climate change control and sustainable development

Given the diversity in society, a scenario assessment with limited indices related to GHGs emissions and mitigation cost is insufficient. The ALPS project develops quantitative scenarios which are consistent with narrative storylines by using existing models developed by RITE harmonized with data across these models. This enables us to conduct a broad assessment of sustainable development, including a wide variety of socio-economic issues as well as energy and climate change, and to support multi-criteria decision making from broader perspectives.

In accordance with the CO_2 emissions pathways to meet the five specific CO_2 reduction levels as shown figure 3, i.e. ALPS Baseline, CP6.0-stabilization at around 750 ppm-CO_2 eq., CP4.5-stabilization at around 650 ppm-CO_2 eq., CP3.7-stabilization at around 550 ppm-CO_2 eq., and CP3.0-stabilization at around 450 ppm-CO_2 eq., the scenarios are analyzed from multiple aspects respectively. Figure 4 shows the corresponding trajectories of global mean temperature, including estimation of non-CO_2 GHGs emissions that is consistent with each stabilization scenario. In the ALPS CP3.0 scenario, a maximum global mean temperature is expected to increase within 2°C against pre-industrial global mean temperature level. In terms of impacts of climate change, it is desirable to curb GHGs emissions as low as possible, but it is not necessary ideal pathway from multiple criteria because real world trade-offs require us to address a diverse of challenges.

Figure 5 illustrate Marginal abatement cost (MAC) curves. The MAC in 2050 is estimated to amount to 6\$/tCO_2 for CP6.0, 28\$/tCO_2 for CP4.5, 137\$/tCO_2 for CP3.7 and 376\$/tCO_2 for CP3.0 respectively. Compared with the other scenarios, the CP3.0 scenario indicates rapidly growing MAC, implying huge economic burden on society.

Figure 6 shows energy security index associated with ALPS A-Baseline, CP4.5- stabilization at around 650 ppm-CO_2 eq., and CP3.0-stabilization at around 450 ppm-CO_2 eq. It is commonly believed that energy security will be improved by reducing imports of oil as making progress in mitigation efforts. Our quantitative as-

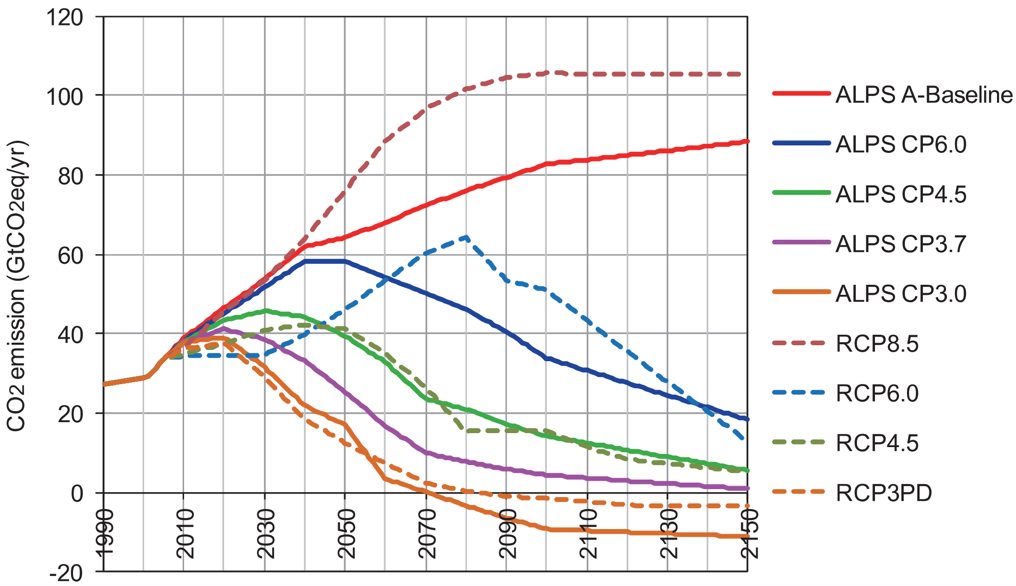


Figure 3 Scenarios of emissions reduction levels in ALPS (Global CO_2 emissions)

Note) The Representative Concentration Pathway (RCPs) are new IPCC emission scenarios to achieve respective four radiative forcing levels.

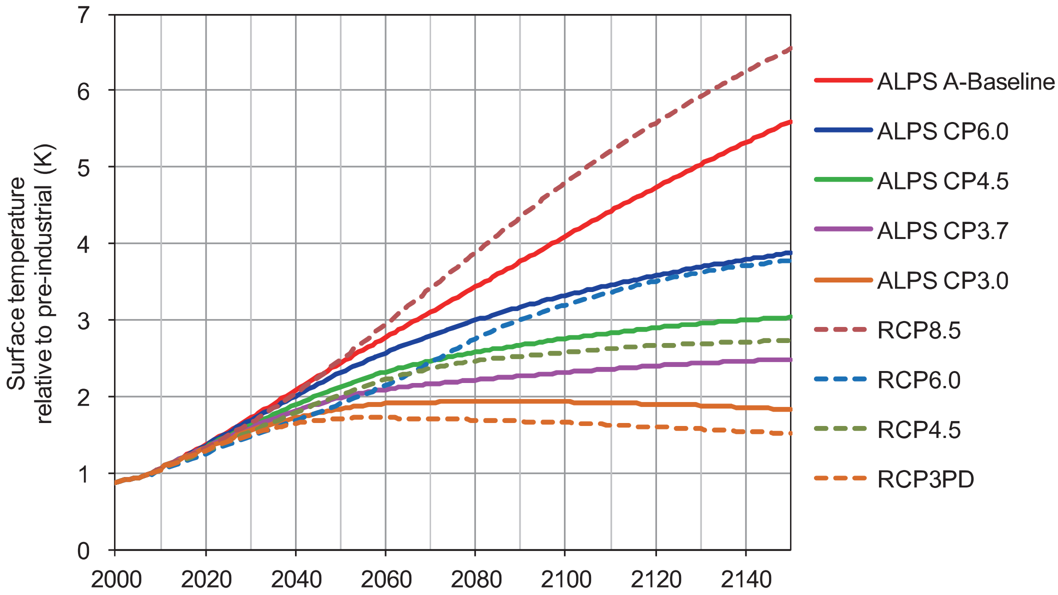


Figure 4 Global-mean temperature change (°C) associated with scenarios

Note) The gap between ALPS scenarios and RCPs mainly comes from the difference in estimation of non CO_2 greenhouse gas emissions.

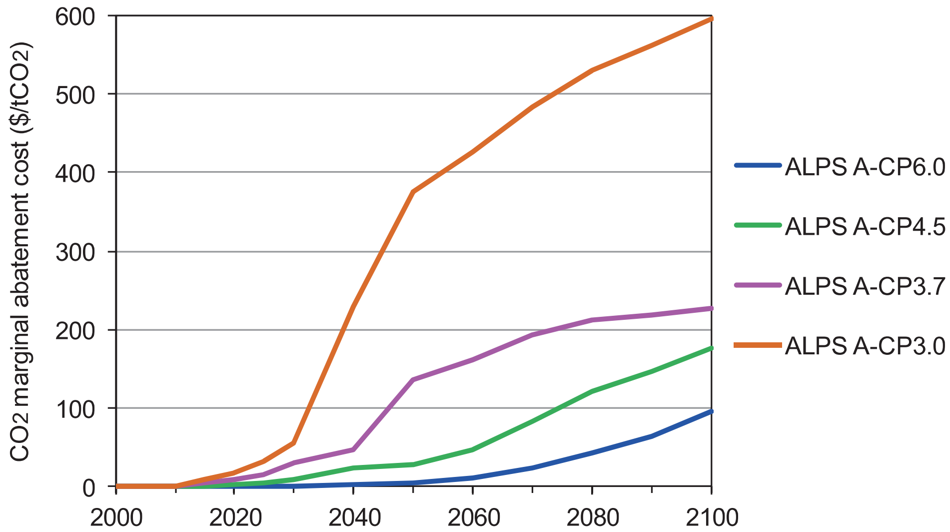


Figure 5 CO_2 marginal abatement cost curves associated with scenarios (Scenario A-I)

sessment, however, shows that energy security can be worsen by reducing domestic coal dependence and by increasing gas utilization in some regions. Energy security can vary across regions depending on emissions reduction levels and other factors.

Figure 7 shows food security index, which is defined as the imports of food in relation to GDP. Given the fact that food is traded globally, it would be appropriate to consider purchasing power for food, rather than degree of self-sufficiency. Food security index will be improved as GDP increase, but it can be fallen when GDP goes down due to excessive mitigation efforts. If food productivity improvement cannot meet the increase of food demand, food security can be degraded due to cropland expansion which potentially pushes up food prices. Climate change has an impact on food production and abrupt climate change can result in adverse effect on the world food supplies and place upward pressure on food prices. Furthermore, growth in the use of food crops for biofuels which compete with them for land resources could potentially exert additional pressure on the food prices. The food security index below takes these factors into account in a consistent and comprehensive manner, and reveals that it is not necessarily improved when significantly reducing CO_2 emissions, which may be counterintuitive results.

We, current generation, need to take appropriate measures for the welfare of future generations in order to realize sustainable development. Without adequate mitigation actions, the wellbeing of the future generation can be

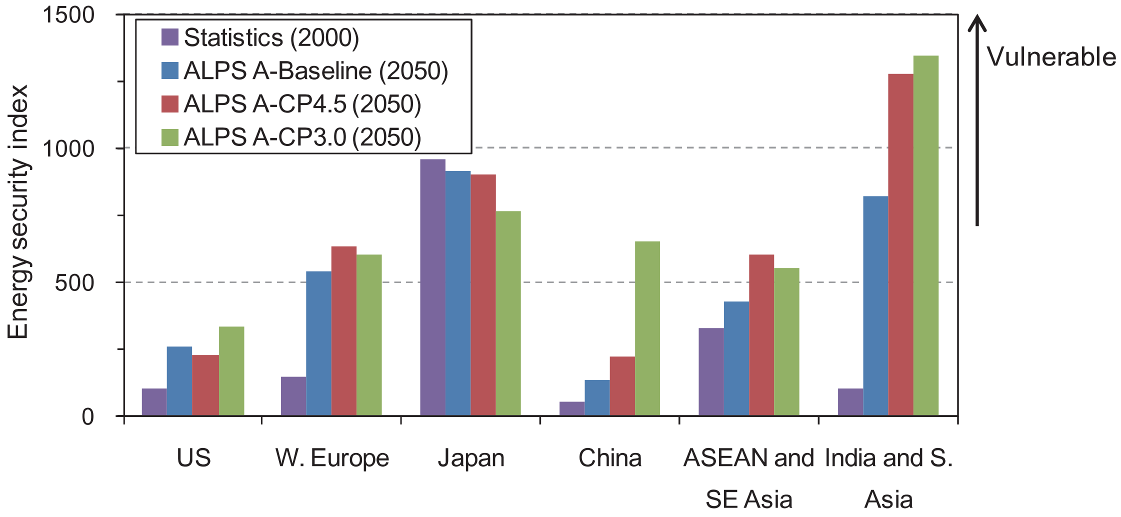


Figure 6 Energy security index across regions
(Scenario A-I, the index is normalized to an US 2000 value of 100)

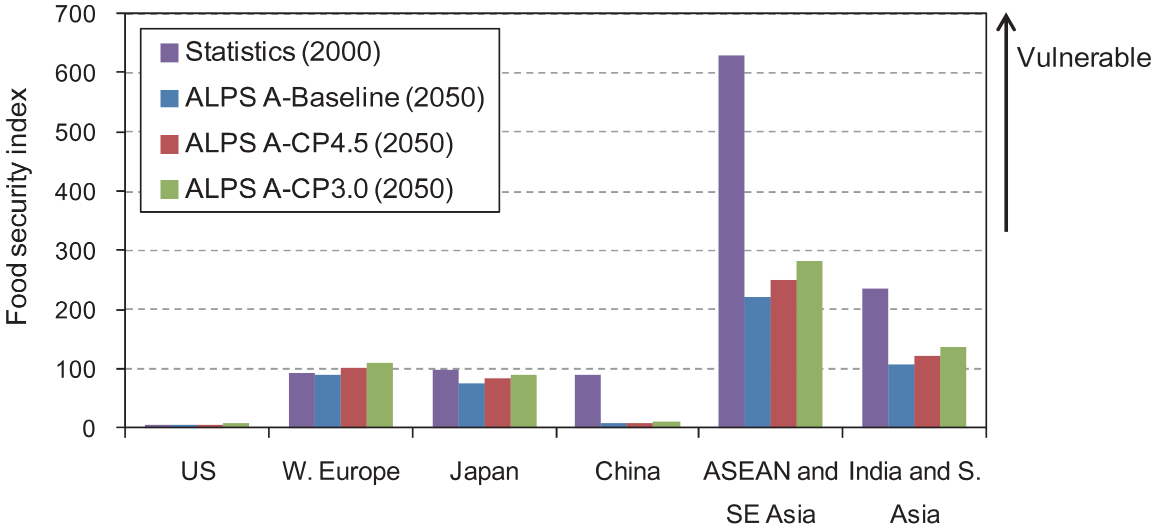


Figure 7 Food security index across regions
(Scenario A-I, the index is normalized to a Japan 2000 value of 100)

damaged. On the other hand, too much burden to the current generation may harm the present economy, debilitating other related activities, and can end up having a negative impact on the future generation. Balancing multiple objectives in society is important to achieve sustainable development, and CO_2 mitigation efforts need to be made in a fair balanced manner as well.

5. Concluding remarks

In the ALPS project, synthetic scenarios toward sustainable development and climate stabilization are generated. For that purpose group of assessment models are developed in order to assess narrative scenarios in a consistent and quantitative manner. The results of this study are expected to not only make scientific contribution to the IPCC but also to serve as fundamental information for decision making in global and domestic climate change policy.

Molecular Microbiology and Biotechnology Group

Global Biorefinery Trends and Research Overview

1. Introduction

The biorefinery is a relatively recent concept proposed by, among others, the U.S. Department of Energy (DOE) to encompass technologies and industries that enable production of chemicals and liquid fuels from biomass instead of from fossil feedstocks (Figure 1). The biomass is of plant origin, enabling a virtuous carbon-neutral cycle of plant growing, processing, harvesting, and burning, meaning that its use does not contribute to net changes in the level of atmospheric CO_2. Since the 1990s, the transition from oil petrorefinery to biorefinery has been one of the key strategic scientific missions of the U. S. Consequently, the advancement of technologies relevant to the implementation of the biorefinery vision is a priority U.S. policy to achieve a sustainable society less dependent on fossil resources in the 21st century. The EU, like the U.S., has recognized the importance of biorefinery, and supported the introduction of biofuels and development of biorefinery using tax incentives, etc. According to a new biofuels roadmap report published last year by the International Energy Agency (IEA), biofuels can provide up to 27% of world transportation fuel by 2050. Biofuel production in 2050 will be 10 times the present production but require only three times the existing area of cultivated land for biofuel plants because future technological improvements are expected to enhance the overall productivity.

Recent trends where competition between biofuel feedstocks and food supply posed a serious downside of the present biorefinery have elevated the shift to non-food-based biomass resources to the status of the most important subject of the biorefinery sector. Agricultural Outlook 2011 report jointly by OECD and FAO (Food and Agriculture Organization of the United Nations), says that higher prices of agriculture commodities such as crops will persist in the 2011-2020 period due to the expanding consumption by an increasing population and economic growth of emerging and developing countries (Figure 2).

2. Biofuels

The 2011 world ethanol production was estimated to be 23.4 billion gallons. This represents more than 20% growth since 2009 and was essentially achieved by converting corn starch or sugarcane-derived sucrose. The production in the U.S. accounts for ca. 60% of the global production and its demand will continue to grow due to the approval of E15 (ethanol-gasoline blends containing up to 15 percent ethanol by volume) in 2010. As much as 40% of the U.S. corn crop is going into ethanol production, therefore material conversion of biofuels into cellulosic biomass from grain is expected without loss of time. The U.S. government has strongly backed biofuel projects which can use agricultural residues such as corn stover or so-called energy grasses such as switchgrass. Cellulosic biofuels are able to eliminate competition with foods, and effectively reduce CO_2 emissions as demonstrated by Life Cycle Assessment (LCA) analyses. At present, the con-

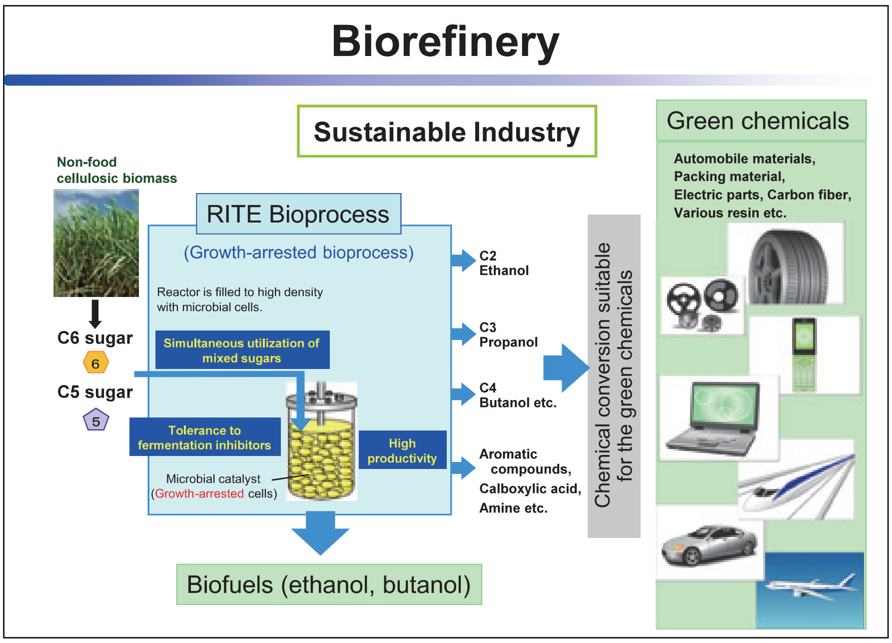


Figure 1 Productions of biofuels and green chemicals from non-food biomass

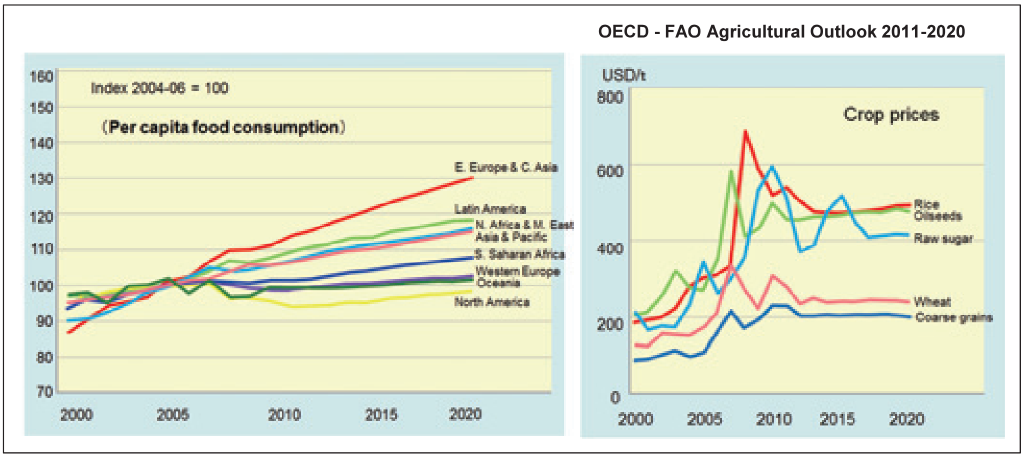


Figure 2 Increase of global food consumption (left) and rising crop prices (right)

struction and operation of large scale cellulosic ethanol plants scheduled earlier in the U.S. seems to be behind schedule due to technological constraints associated with fermentation inhibitors derived from the pre-treatment of lignocellulosic biomass.

The 2011 global production capacity of biofuels, estimated at 44.6 billion gallons, will expand up to 20% by 2015 (Lux Research). In Europe, biofuel consumption in forms such as biodiesel has slowed down due to tax increases on biofuels resulting from concerns of environmental destruction in biofuel production processes etc., or the economic recession of recent years.

However, energy consumption and investment in biofuels sector have continued to expand in emerging countries such as China and India as well as East Asian and South American countries. In Japan, the Basic Energy Plan revised by the Ministry of Economy, Trade and Industry established the promotion of biofuels for transportation in 2010, aiming at a biofuels use of around 3% of the gasoline consumption by 2020.

3. Green chemicals

The growth of green (renewable) chemical production via bioprocessing is expected lead to a sustainable industry. Although more advanced technologies are necessary for the production relative to those for biofuels, a variety of product groups and integrated market size are predicted in the biorefinery sector. The use of non-food feedstocks like corn stover or switchgrass is also an essential requirement. As a target of green products, a new trend puts emphasis on producing commodity chemicals rather than fine chemicals such as 1,3-propanediol, which have been the early focus of biochemical engineering. The green production of acrylic acid and isoprene, products which comprise large industrial markets, as well as carboxylic acids, amines and aromatic compounds have begun to grow. Various joint ventures between companies have been established in these green chemical businesses. The future market size of green chemical is estimated to have the potential to generate $70B at 2015 or $100B at 2020.

4. Technology development: the RITE Bioprocess (Growth-Arrested Bioprocess)

Our group has developed an efficient biomass utilization technology based on intrinsic characteristics of coryneform bacteria. The process was named "RITE Bioprocess" (a growth-arrested bioprocess), and it has so far enabled elevated productivities of organic acids and biofuels. This pioneering technology enables the simultaneous utilization of mixed sugars from cellulosic biomass in biorefinery settings. In collaboration with a private company, we applied it in a cellulosic ethanol production system, earning the Grand Prize at the 18th Nikkei Global Environment Award (see RITE Today 2009). What is more, our process has evoked the interest of international academia and their researchers. Our group leader was awarded the 2011 fellowship award from The Society for Industrial Microbiology (SIM), the first Japanese scientist to receive the award (see Topics). Moreover a German group has been following our footsteps and carried out additional research using coryneform bacteria; they independently confirmed the capabilities and attributes of our innovative bioprocess, which is characterized particularly by a clear separation between product production and the growth phase of the bacteria catalysts. The main technological features of the RITE Bioprocess are given in the following paragraphs.

4-1. Technological attributes of the RITE Bioprocess

In the RITE Bioprocess, coryneform bacteria are engineered to have an optimum metabolic pathway for a particular target chemical. The cells are grown at a large scale and packed to very high densities in a reactor in order to maximize the catalyst/volume ratio at the production stage. Sugars are subsequently added to initiate bioconversion as a substrate under oxygen deprivation; this has the effect to cease the growth of these bacteria while keeping them metabolically active (Figure 3). As a result, the target chemical is produced by growth-arrested cells, with a larger share of the substrate being converted into useful products without any additional natural rich medium or external energy. The key to achieving high efficiency and high productivity is the effective separation of the microbial growth phase from the production phase of the target compound.

This manner of using bacterial cells as if they were simple chemical catalysts enables one to produce large amounts of chemicals in short periods of time, and unlike conventional bioprocesses, the productivities reached, expressed as space-time-yield (STY), are comparable to those of chemical processes.

4-2. Simultaneous utilization of C6 and C5 sugars

Lignocellulosic biomass hydrolysates constitute complex mixtures of different sugars. They composes of pentoses (C5 sugars such as xylose and arabinose) derived from hemicelluloses, as well as hexoses (C6 sugars such as glucose and fructose). By comparison, starch from food grains such as corn, wheat etc. and sugar from sugarcane contain only hexoses. Therefore, for achieving a high yield per substrate, it is essential for microorganisms used in biofuel processes to exhibit the ability to simultaneously utilize both pentoses and hexoses. We introduced several genes involved in the catabolism of C5 sugars into coryneform bacteria, and applied the resultant recombinant bacteria to our bioprocess. These modifications allowed for efficient utilization of cellulosic materials, and faster conversions thus became possible since we could achieve, without any lag phase, the simultaneous utilization of all the sugars present in the reaction medium.

4-3. Tolerance against fermentation inhibitors

Fermentation inhibitors include phenols, furans and organic acids such as acetic acid. These compounds are by-products formed during the pre-treatment of lignocellulosic biomass. As exemplified by hydrothermal treatment, such treatments are typically very harsh but are necessary to break the recalcitrant biomass fiber and thereby facilitate enzymatic hydrolysis. Their strong inhibition has been known for many years to be a cause of

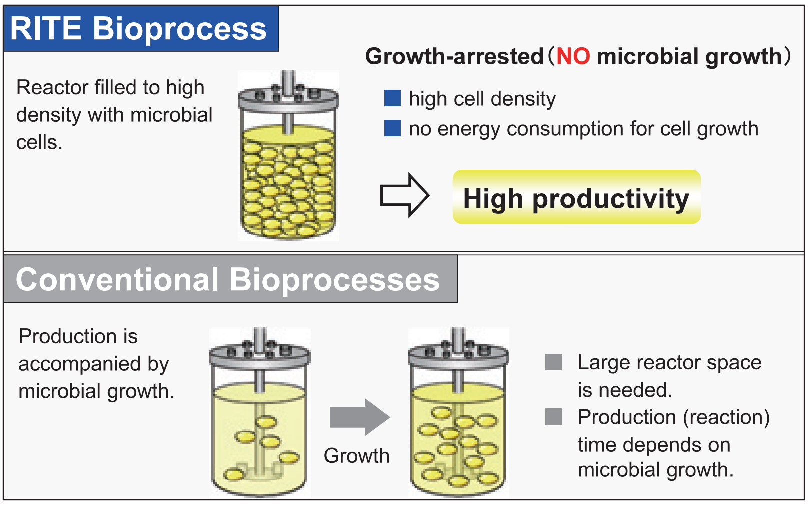


Figure 3 Comparison of RITE Bioprocess with conventional bioprocess

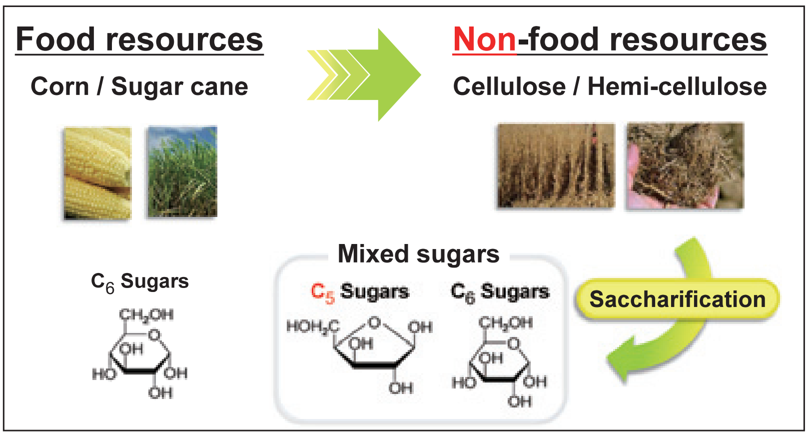


Figure 4 Expanding usage of mixed sugars from non-food biomass

concern to the biofuel manufacturer and they represent one of the biggest problems associated with conventional bioprocesses. However, we demonstrated that these fermentation inhibitors essentially do not affect the RITE Bioprocess, since their action is to inhibit cell growth while our process separates the cell growth phase from the product production phase. Furthermore, we extensively demonstrated that the main metabolic pathways necessary to produce compounds of interest on the one hand remain active under the conditions of the growth arrested RITE Bioprocess and on the other hand are virtually not affected by the presence of fermentation inhibitors in quantities that would hinder conventional processes.

4-4. Future technology development

We are constantly expanding the range of product options that the RITE Bioprocess can support. To this end, we implement global analysis tools including system biology based on metabolome analysis, metabolic pathway design, and genome engineering based on the genome database of coryneform bacteria. In addition to the successful production of ethanol, or L- and D-lactic acids and succinic acid, we are developing a whole range of new targets addressing large market needs or high value added compounds comprising butanol, aromatic compounds, and aminoacids.

Although the economical production of aromatic compounds has been a challenge when using conventional fermentation technologies, their production by industrial biotechnology is still an important aim since these materials, once made from sustainable raw materials such as biomass, are expected by leading Japanese companies to become building blocks for advanced products such as electric devices, hardware, and automobiles. In addition, the RITE Bioprocess shows higher cost performance than conventional fermentation processes such as amino acids manufactured by aerobic fermentation. Because aerobic processes require air compressors and agitation motors to ventilate and mix liquids, respectively, aerobic processes involve additional equipment and expensive operational cost. We have already begun to develop production processes for several amino acids by using the RITE Bioprocess.

4-5. Development for industrialization

In 2009, we established two technology research associations with private companies to accelerate our research and development, in addition to collaborative work for a cellulosic ethanol production system (see RITE Today 2008~2010). The association has corporate status and joint research with private companies and public R&D agencies is now possible. Successful collaborative work is going on under the auspices of "Green Phenol Technology Research Association" and "Bio-Butanol Technology Research Association". For further acceleration towards industrialization, we established "Green Earth Institute Co., Ltd." last year to provide biofuels and green chemicals by using our RITE Bioprocess (see Topics). The concept for its establishment is the industrialization of our RITE-Bioprocess to contribute to the preservation of global environment by employing efforts against global warming and the realization of a post-fossil resources sustainable society.

5. Ending remark

Intense competition in the development of technology which contributes towards global warming prevention and environmental protection at a global scale will persist into the future. To achieve early establishment of commercial-scale biorefinery, we hope to continue our collaborative research development with domestic as well as overseas companies to further expand the RITE Bioprocess platform technology.

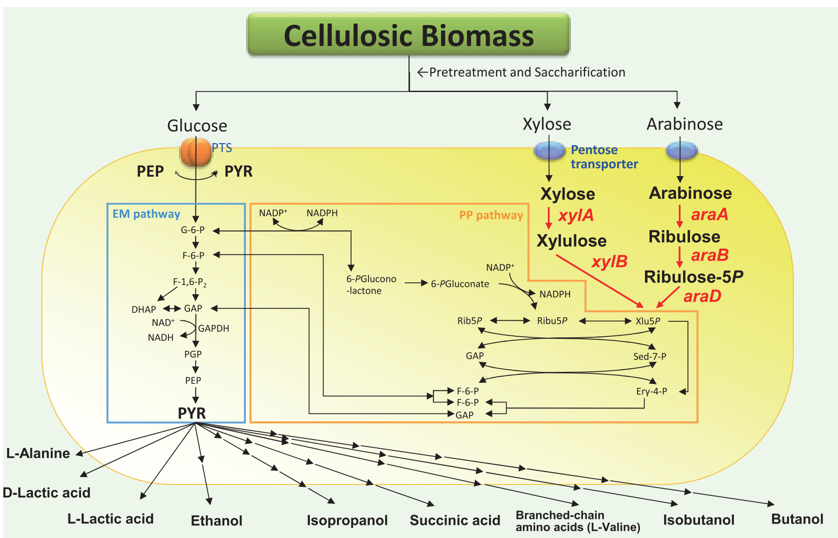


Figure 5 Production pathways of coryneform bacteria designed for acyclic chemicals and biofuels

Chemical Research Group

Challenges for Advanced Industrializing CO_2 Capture Technologies

1. CO_2 capture technologies

CO_2 capture and storage (CCS) is composed of CO_2 capture from fossil fuel combustion gases and its injection into geological formations for storage or sequestration.

The current CO_2 capture cost from emission sources is estimated to be about 60% of CCS costs. Therefore reduction of CO_2 capture costs is important aspect for practical application of CCS.

Our chemical research group studies various CO_2 capture technologies, with a special focus on chemical absorption and membrane separation methods.

We developed a COCS project aimed at reducing the CO_2 capture cost in ironworks by chemical absorption, in which we developed an innovative chemical absorbent that reduced the CO_2 capture cost for flue gas to 3000 JPY/ton-CO_2. We are continuing to develop a chemical absorbent to further reduce this CO_2 capture cost to 2000 JPY/ton-CO_2 (by 2015).

Moreover, we have developed an excellent CO_2 absorbent that is effective for pressurized gas, and are planning to put this into practical use.

By developing molecular gate type membrane technologies to capture CO_2 selectively from H_2-containing pressurized gases such as that in the integrated coal gasification combined cycle (IGCC), we are aiming for a CO_2 capture cost target of 1500 JPY/ton-CO_2 (by 2015).

We have discovered that new types of dendrimer polymers have excellent properties for separating CO_2 from H_2 gas mixtures. RITE and three private companies have established the technology research association, developing membrane modules and separation systems for the practical application.

For CO_2 capture technology using adsorption processes, we have developed new solid adsorbents that do not lose CO_2 capture efficiency even in the presence of water vapor. We are planning to develop a low-cost CO_2 capture process by eliminating the requirement for a dehumidification tower.

Above all, we have begun to develop new solid sorbents, onto which amine is immobilized, for the purpose of developing low-cost CO_2 capture technology.

As mentioned above, we are promoting innovative CO_2 capture technologies, which lay the foundations for the next generation, while developing practical technologies that are acceptable to industries.

Moreover, we have seed technologies such as CO_2 separation by zeolite membranes, H_2 separation by palladium membranes, a hybrid CO_2 capture system that combines membranes with a chemical absorption process, baroplastics that have low temperature flow under high pressure state, etc., to be used for various purposes. Especially the membrane/absorption hybrid CO_2 capture technology has been used practically in a private company.

2. Development of CO_2 capture technology by chemical absorption systems

CO_2 capture by chemical absorption is a prospective technology for separating CO_2 from a CO_2-containing gas by means of thermal dissociation of CO_2 that is chemically absorbed in an amine-based solution. This is suitable for CO_2 separation from the normal pressure gas generated on an industrial scale. Our objective is to develop new, efficient absorbents that will decrease the CO_2 separation cost, which is the main concern for chemical absorption systems.

We planned and coordinated, from FY2004 until FY2008, a "Cost-saving CO_2 Capture System" (COCS) project to capture and separate CO_2 from ironworks blast furnace gas at half the previous cost of a chemical absorption system, and achieved this goal (Figure 1).

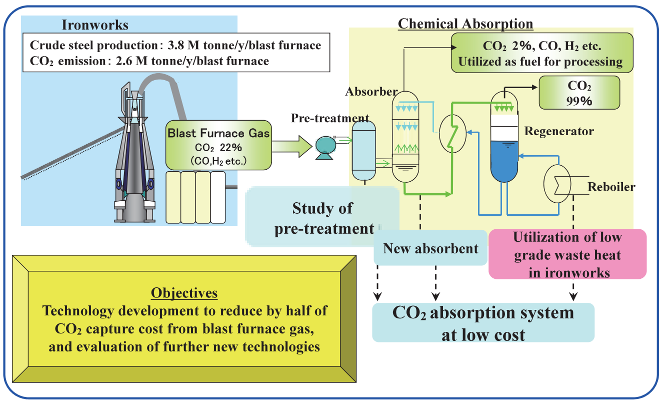


Figure 1 Outline of cost saving CO_2 capture system (COCS project)

In this project, we developed various types of efficient new absorbent. The CO_2 capture energy consumption of the absorbents developed in this project is drastically reduced in comparison with that of MEA (monoethanolamine) used as a standard.

These outcomes were succeeded by another project, "CO_2 Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50" (COURSE50, five years from FY2008), aiming at CO_2 capture from the ironworks process gas.

We are now endeavoring to find more efficiently new absorbents (CO_2 capture energy: 2.0 GJ/ton-CO_2) which

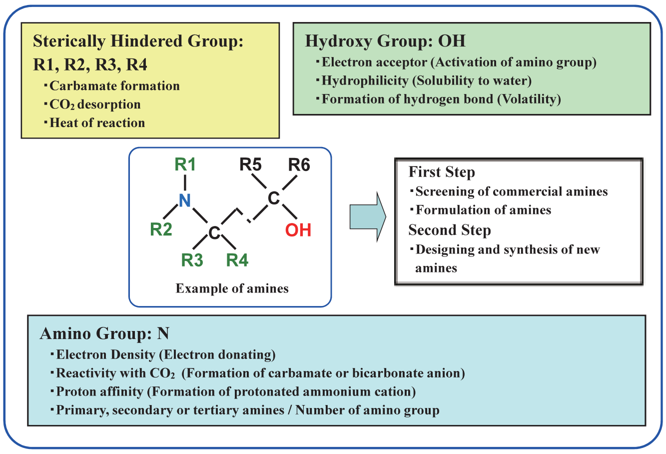


Figure 2 Development of new absorbents

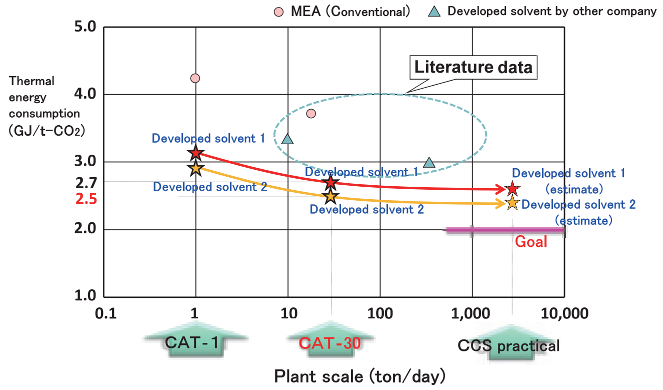


Figure 4 Evaluation of performance (thermal energy consumption)

are appropriate for the COURSE50 project(Figure 2).

In order to minimize CO_2 capture energy, it is necessary to minimize heat of chemical reaction in CO_2 capture and also necessary to maximize CO_2 capture rate in order to minimize plant size. In general, heat of reaction and reaction rate is trade-off, however the development of compatible absorbents is required.

Therefore, we are developing more efficiently new amine absorbents taking advantage of latest computational chemistry and synthetic chemistry with Nippon Steel Corporation and The University of Tokyo, and are evaluating the test results with 1t and 30t-CO_2/day scale pilot equipment(Figure 3) using BFG (blast furnace gas) in cooperation with Nippon Steel Engineering Co., Ltd.

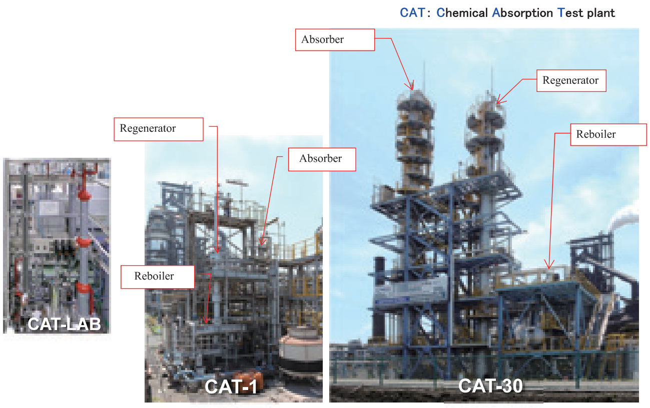


Figure 3 Snapshots of test equipment

To date, we successfully developed a new chemical absorbent (solvent 2) superior to the previously developed chemical absorbent (solvent 1) (Figure 4). The thermal energy consumption of solvent 2 is 2.5GJ/t-CO_2, and furthermore, ca. 0.1GJ/t-CO_2 improvement is expected at actual equipment.

From FY2007 to FY2009, we worked on the research and development of appropriate absorbents for CO_2 capture under high-pressure conditions, based on our accumulated research experience and found amine-based absorbents with excellent CO_2 absorption and dissociation performances. We will propose a chemical absorption system using these amine absorbents as a new technology for CO_2 capture from gases under high pressure.

In addition, we are interested in process development of chemical absorption for CO_2 capture. A new evaluation technique for solvent selection is required to accelerate commercialization of amine solvent methods. Process simulation for advanced amine solvents must be established and improved so as to more accurately estimate the performance of scaled-up processes. The environmental impact of amine-based absorbents is also important in process development and has currently become a crucial issue. In 2010, a pilot plant operation of a RITE-developed solvent at a 10t/d-scale facility was conducted in order to evaluate solvent performance and to gather process data for the process simulation.

3. CO_2 and H_2 separation with a polymeric membrane

Japan's government declared a goal to reduce CO_2 emissions to half of those in 2005 as the objective "Cool Earth 50". One promising means of reducing CO_2 emission is the development of an integrated coal gasification combined cycle with CO_2 capture & storage (IGCC-CCS). In the IGCC-CCS process, CO_2 separation membranes will play an important role for reducing CO_2 capture costs. Estimates indicate that the CO_2 capture cost from a pressurized gas stream using a membrane might be 1500 JPY/ton-CO_2 or less.

We are currently developing a CO_2 molecular gate membrane, with the goal of producing a new, high-performance separation membrane. Figure 5 shows the basic outline of the CO_2 molecular gate function. 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 N_2 or H_2 permeating to the other side of the membrane is greatly limited and high concentrations of CO_2 can be obtained. A RITE's dendrimer, which possesses excellent CO_2/H_2 selectivity, is fixed stably in a cross-linked polymer matrix to form the separation membrane. Figure 6 shows a conceptual diagram of a material incorporating PAMAM dendrimer and its CO_2/H_2 separation properties, along with the data reported in Science and other high-impact journals. Our PAMAM dendrimer/polymer hybrid material shows the world's largest CO_2/H_2 selectivity of 30 or more.

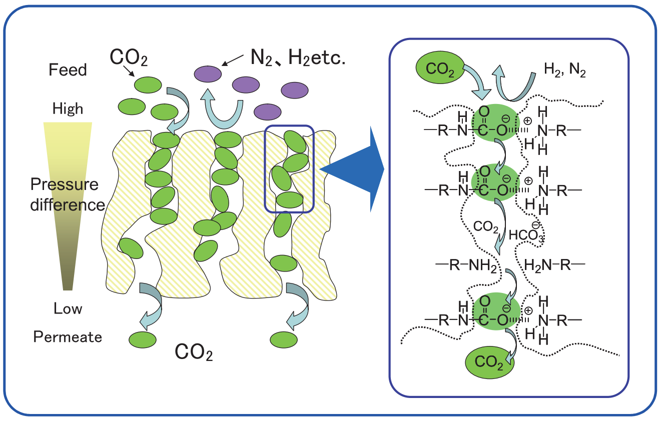


Figure 5 Conceptual diagram of the molecular gate membrane

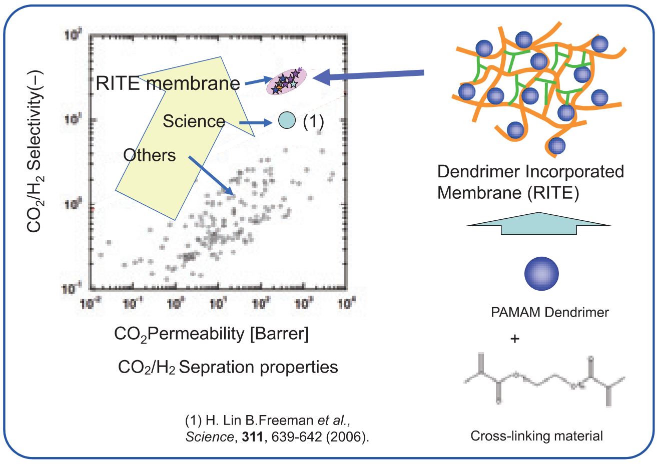


Figure 6 Dendrimer incorporated membrane and its performance

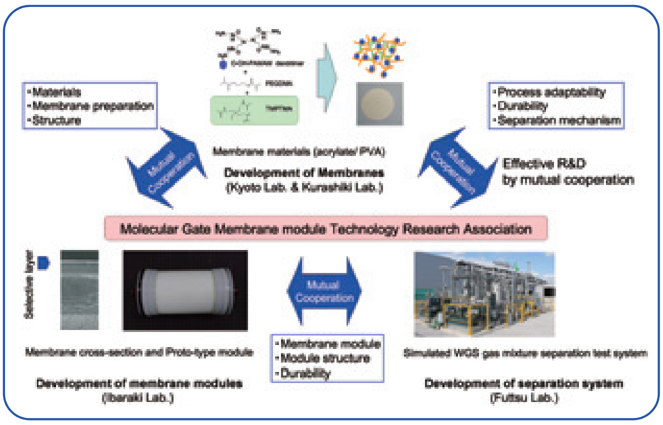


Figure 7 Development of membrane modules in cooperation with private companies

Based on these materials, modification of membrane materials, membrane thickness control etc. are ongoing to improve CO_2 separation performance further.

In the development of a commercial membrane module using the PAMAM dendrimer/polymer hybrid material, RITE, Kuraray Co., Ltd., Nitto Denko Corporation and Nippon Steel Engineering Co., Ltd. established Molecular Gate Membrane module Technology Research Association, and membranes, membrane modules and separation systems are being developed(Figure 7).

In developing this CO_2 molecular gate membrane, RITE conducted joint research with many foreign partners such as the US Department of Energy's National Energy Technology Laboratory (NETL) in a recognized project for the Carbon Sequestration Leadership Forum (CSLF)*, the University of Texas at Austin and the Norwegian University of Science and Technology.

* Ministerial-level international climate change initiative that is focused on the development of improved cost-effective technologies for the separation and capture of carbon dioxide (CO_2) for its transport and long-term safe storage.

4. Development of an energy-saving CO_2-PSA process using hydrophobic adsorbents

Novel hydrophobic adsorbents have been proposed as CO_2 adsorbents for the separation of CO_2 from high-pressure gas. CO_2 adsorption capacities of 13X zeolite and new synthetic adsorbents are shown in Figure 8.

It has been confirmed that the adsorbent synthesized in our study adsorbed considerable amounts of CO_2 at high pressure. It was also confirmed that they adsorbed CO_2 even in the presence of water vapor. From CO_2 separation experiments using CO_2-H_2 mixed gas flows, it was confirmed that the new adsorbent was effective for separating CO_2 from the gas flow in the presence of water vapor. Evaluation of the process cost is now under way.

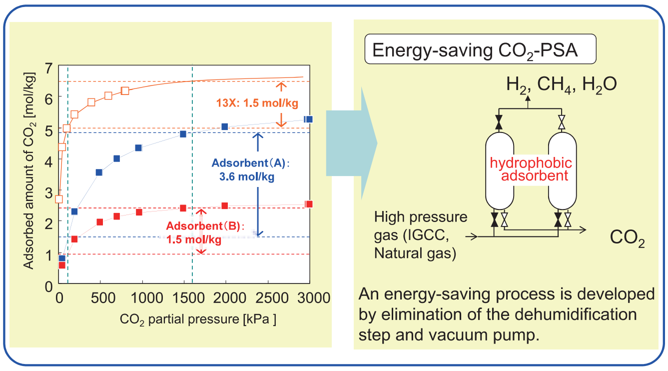


Figure 8 Development of an energy-saving CO_2-PSA process

5. Advanced stage of technology development on CO_2 capture by amine-based absorbents

CCS is a highly viable technology for tackling global warming. It is strongly desirable that this be implemented in the market as soon as possible. Recent R&D on CCS has focused on energy-saving, low-cost CO_2 capture technologies, demonstration and feasibility studies of commercial-scale systems, and so on. RITE began a new project funded by METI in 2010FY, in which the research objectives were to develop novel solid sorbents and to establish evaluation standards CO_2 capture using liquid amine solvents.

With respect to solid sorbents, amines can be immobilized onto a support or encapsulated within a porous substrate (Figure 9). Although solid sorbent techniques use amine-based absorbents, similar to liquid amine solvent methods, it has the advantage of a lower anticipated heat duty for regeneration. RITE investigates novel solid sorbents using RITE-developed solvents through cooperative R&D activities with NETL, from which major research on the solid sorbents has already been presented. It has been confirmed that a new RITE-solvent based solid sorbent synthesized in our study desorbed CO_2 at lower temperature compared with traditional solid amine sorbent. Evaluation for the practical use is now under way.

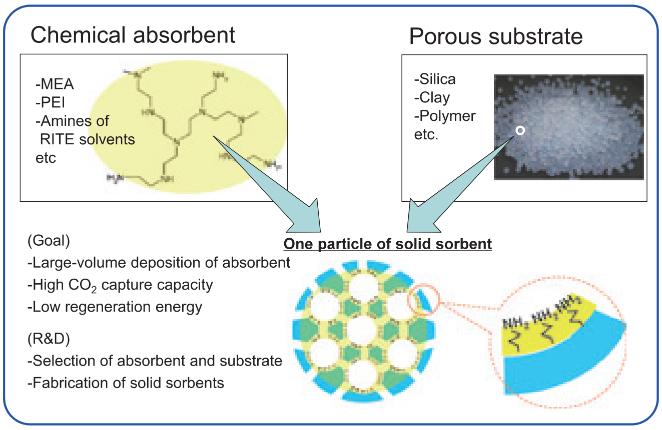


Figure 9 Development of novel solid sorbents

6. Advanced CO_2/H_2 separation materials incorporating active functional agents (GCEP)

RITE has conducted developmental work entitled "Sub-nano structure controlled materials: development of innovative gas separation membranes" as part of the Global Climate and Energy Project (GCEP) of Stanford University, USA.

Under the theme of advanced CO_2/H_2 separation materials incorporating active functional agents, supercritical and subcritical CO_2 acts as a structure-directing agent for CO_2 affinity materials. Figure 10 shows a schematic of the concept. Excellent CO_2 separation membranes will be obtained by strict morphology regulation at the molecular scale. In the figure, supercritical CO_2 regulates the CO_2 affinity membrane materials into a morphology that is preferential for CO_2 permeation (State A). After removing supercritical CO_2, the preferential morphology will be maintained (State B) to form an excellent CO_2 separation membrane.

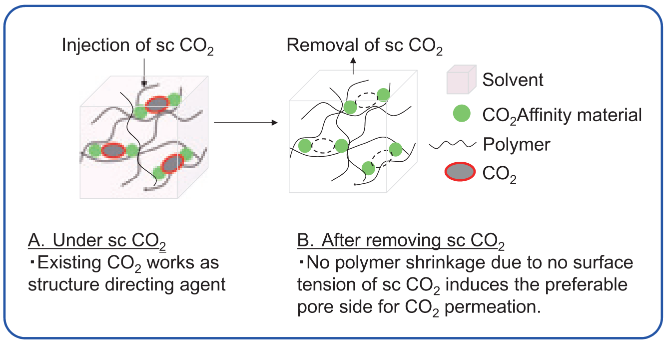


Figure 10 Concept of super critical (sc) CO_2 structure directing method

CO_2 Storage Research Group

Development of CO_2 Geological Storage Technology for Practical Use

1. CO_2 geological storage project

CO_2 geological storage is a technology to safely contain CO_2 into deep underground formations to prevent the greenhouse gas from being released into the atmosphere. The technology involves: enhancing oil recovery (EOR) by injecting CO_2 into oil reservoirs; enhancing coal-bed methane recovery (ECBM) by injecting CO_2 into coal seams; geological sequestration of CO_2 into depleted gas fields; and storing CO_2 in deep saline aquifer. RITE has been working on storing CO_2 in deep saline aquifer, where caprock (mudstone) formation overlies sandstone formation and blocks migration of gases and fluids with high sealing properties, so that CO_2 is safely stored underground for years.

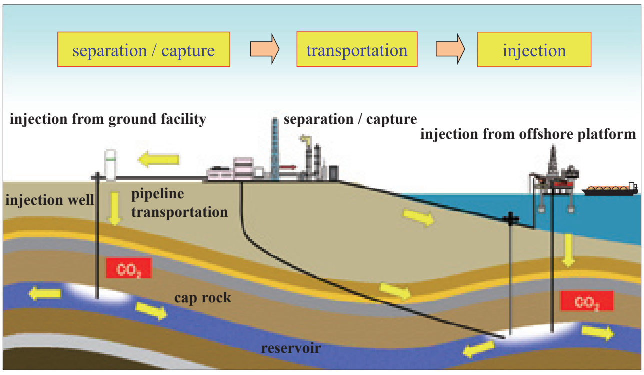


Figure 1 Concept of CO_2 geological storage

RITE has been proceeding with basic research on geological characterization (geological modeling), CO_2 behavior analysis (monitoring and long-term prediction of CO_2 behavior) and CO_2 migration analysis (safety assessment):

(1) Developing techniques of geological characterization

Based on results of cross-hole seismic tomography, physical loggings, physical property measurements of core samples, etc. obtained in the field of Nagaoka demonstration site, RITE closely studies reservoir structures to design better geological modeling that reflects Japan-specific complex geology, such as sand-and-clay formations and gravel formation, and develops methods for geological characterization of reservoir.

(2) CO_2 behavior analysis in reservoir

Through a thorough analysis of physical logging data obtained in Nagaoka demonstration site this year and in the past, RITE further clarifies CO_2 storage mechanism and simulates long-term CO_2 behavior with increased accuracy.

(3) CO_2 migration analysis from reservoir

CO_2 migrates from reservoir mainly through faults and abandoned wells after well or site closure. RITE studies methods of modeling CO_2 migration and develops techniques to monitor and assess environmental impacts on ocean.

RITE applies the above-stated technologies to a proposed CCS large-scale demonstration project and helps accelerate CCS projects in Japan. The CO_2 Storage Research Group achieved the following results in FY2011:

- CO_2 behavior analysis in Nagaoka site

From July 2003 to January 2005, RITE injected about 10,400 tons of CO_2 into saline aquifer 1,000 meters below the ground surface of Iwanohara field, Nagaoka, Niigata Prefecture (owned by Inpex Corporation). To grasp CO_2 behavior after the injection, RITE keeps taking field data regularly by using the wells there. In FY2011, RITE conducted physical well logging, VSP measurement, and analysis of fluids samples of reservoir to study post-injection CO_2 status. Based on the data obtained, RITE carried out history matching and improved long-term simulation analysis of CO_2 behavior. Among many demonstration projects worldwide, only Nagaoka project continues monitoring CO_2 behavior even after the end of injection, thus the observed monitoring results have

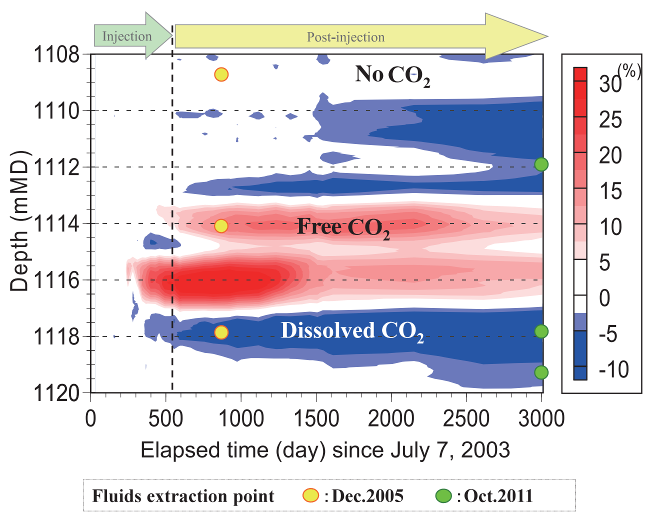


Figure 2 Detection of dissolved CO_2 by resistivity logging (Observation well OB-2)

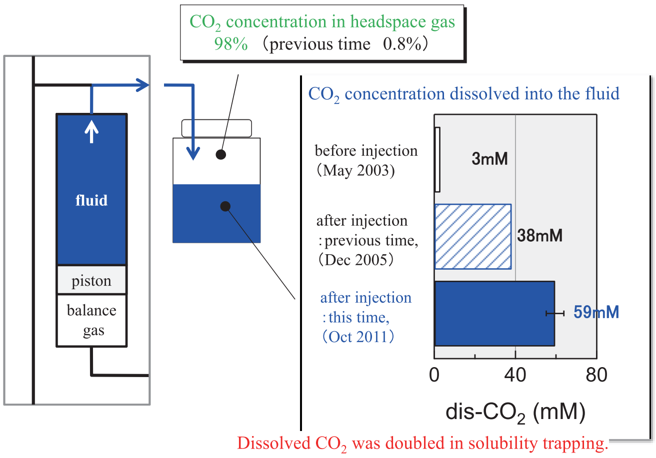


Figure 3 CO_2 concentrations dissolved into formation water

drawn great attention from the world.

- Visualization of CO_2 flow using X-ray CT scanner

RITE introduced a state-of-the-art X-ray CT scanner to understand CO_2 behavior injected into porous sandstone formations of saline aquifer and successfully visualized supercritical CO_2 flows in the pore-space structure of the sandstone. RITE plans to characterize rock porosity and CO_2 saturation in terms of seismic wave velocity and to further advance CO_2 monitoring technology.

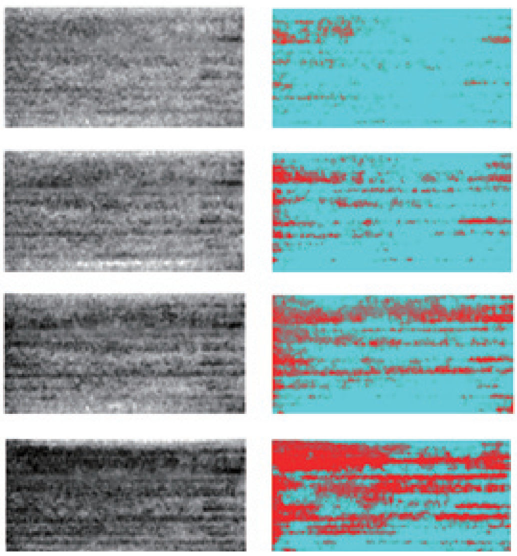


Figure 4 Visualized images of CO_2 flow in sandstone (left: CT images, right: CT images of injected CO_2 (in red))

- Long-term field observation by permanent OBC

As a technique to monitor offshore CO_2 geological storage, RITE adopted a permanent OBC (Ocean Bottom Cable) system and has been evaluating the system since FY2007. First a 16-module (800 meters) OBC was tested in inland water reservoir to evaluate its performance, and then a 24-module (1,200 meters) OBC was tested in real waters for a short time to demonstrate the performance and effectiveness in FY 2010. In FY 2011, RITE further added a 24-module (1,200 meters) OBC to the system and started long-term consecutive observation offshore of Hiratsuka coast in Sagami Bay. In view of application of the system to large-scale CCS demonstration projects, RITE plans to proceed with development of CO_2 monitoring techniques using the permanent OBC.

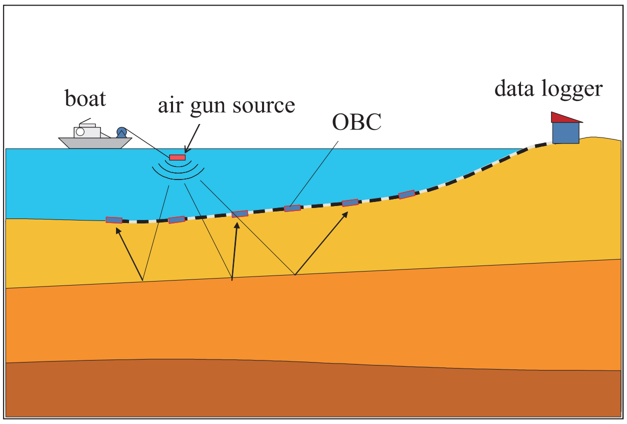


Figure 5 Concept of permanent OBC observation system

Figure 6 Laying permanent OBC observation system

- Research on CO_2 injection impact on geological formation

To observe microseismicities caused by CO_2 injection, RITE installed six 3-C geophones in a CO_2 injection site (Cranfield oil field, Mississippi) of the US carbon sequestration regional partnership under collaboration with the Lawrence Berkeley National Laboratory and the Bureau of Economic Geology of the University of Texas. Observation started in December, 2011. RITE will develop techniques of observing microseismicities to ensure safe injection of CO_2 at the proposed large-scale CCS demonstration project and commercial implementation.

- Environmental impact assessment

Under the project to develop a safety assessment technique of CO_2 migration, RITE selected a baseline model for CO_2 migration simulation in marine sediment and started modeling of CO_2 migration. Under the project to develop a marine environment monitoring, RITE has studied a technique using microbial activity for CO_2 monitoring. Under the project to develop a technique to assess CO_2 impact on benthic ecosystem, RITE started building a database of CO_2 impact on benthic organisms and collecting information on research and development in the UK. RITE is considering: studying survey methods for physical, chemical and biological baselines of marine environment; building a CO_2 behavior prediction model such that CO_2 takes potential migration paths to reach the bottom of ocean and disperse in the ocean water; and developing methods for evaluating CO_2 impact on benthic ecosystem, in future.

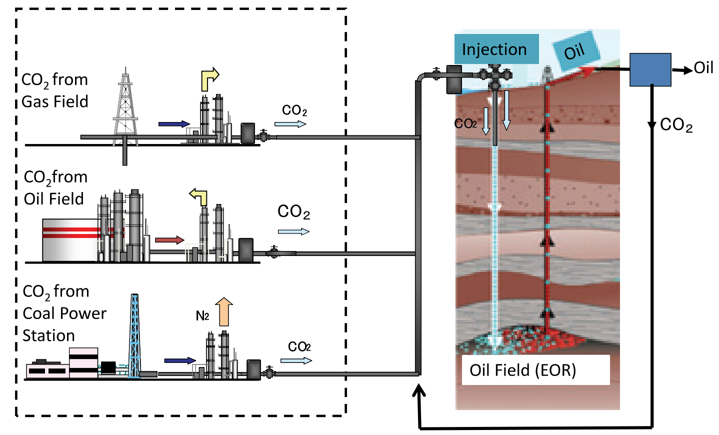
2. Japan-China CCS-EOR project

CCS is a technology to capture and store CO_2 emissions from fossil fuels burning, which is believed to remain essential countermeasures against global warming before 2100. CCS-EOR combining CCS with EOR (Enhanced Oil Recovery) makes profits through the operation so that it is expected to be deployed much earlier. In the United States, CCS-EOR utilizing natural CO_2 has been already implemented in a scale of 60 million tons per year. It is highly expected that the CCS-EOR will move forward to utilizing CO_2 emissions from coal-fired power station in the near future. Its emissions are comparatively large in generating electricity of a specific energy basic unit (1kWh).

Along with the high economic growth in recent years, China increased CO_2 emissions year by year and became the world's largest emitter in 2007. Japan ranks the fifth largest CO_2 emitter in the world. Therefore, CCS-EOR joint study of Japan and China has a significant meaning from the perspective of preventing global warming.

RITE has deepened knowledge sharing on technologies with China National Petroleum Corporation (CNPC) through CCS-EOR workshops (in 2009 and 2010), Saving Energy, Environmental Protection, GHG reduction Workshop (2011) co-organized by RITE and CNPC, and mutual visits to CCS/CCS-EOR related facilities and sites in Japan and China. The technology knowledge sharing resulted in three selected themes for Japan-China collaboration: (1) research on entire CCS-EOR (CCUS) system, (2) research on reservoir characterization techniques, (3) research on microbial restoration of methane deposits with subsurface CO_2 sequestration into depleted oil fields. RITE and CNPC signed "the Memorandum of Understanding on Japan-China collaboration themes" in Beijing on September 28, 2011.

In 2012, the collaboration with CNPC will be focused on "research on reservoir characterization techniques", in which applicability of RITE's reservoir characterization techniques to oil fields in China is scheduled to be studied in detail.



CCS-EOR: Achievement of both Huge CO_2 Storage and Increasing Oil Production

Figure 7 CCS-EOR Overview

Figure 8 Signing ceremony for MoU on CCS-EOR Japan-China collaboration themes

GHGT-11 to be held in Kyoto in November 2012

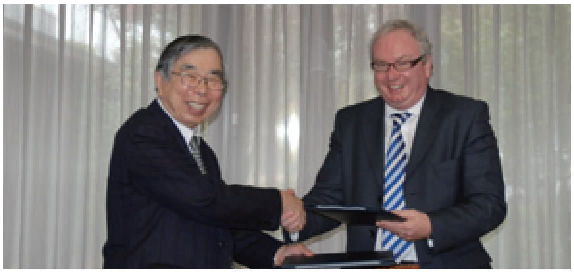
Office for GHGT-11

Research Institute of Innovative Technology for the Earth

GHGT-11

■ Dates: Sunday 18th – Thursday 22nd November, 2012
(Venue: Kyoto International Conference Center and hotels in Kyoto city)

■ Hosted by: RITE & IEAGHG



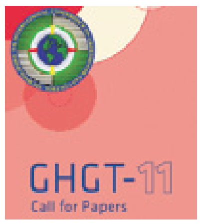
Signing of the Memorandum of Understanding for GHGT-11
Left: Yoichi Kaya (President, RITE), Right: John Gale (General Manager, IEAGHG)

RITE will host the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11) which will be held in Kyoto in November 2012. The GHGT conferences are international conferences guarded by IEA Greenhouse Gas R&D Programme (IEAGHG), which was established as an Implementing Agreement under the International Energy Agency, and of which RITE is a member to represent Japan. The GHGT conferences are held every two years rotating between North America, Europe and Asia. GHGT-11 will mark the 20th year since the first conference of the series (then called ICCDR-1) was held, and the first event of the series held in Japan in the ten years.

<<Programme Overview (Preliminary)>>

	Sun.Nov. 18th	Mon. Nov. 19th	Tues. Nov.20th	Wed. Nov.21st	Thurs. Nov.22nd
AM		Welcome and Keynote Address	Plenary Session	Plenary Session	Plenary Session
			Technical Session 4	Technical Session 7	Technical Session 10
		Technical Session 1	Technical Session 5	Technical Session 8	Technical Session 11
PM		Technical Session 2	Poster Session A	Poster Session B	Final Panel Session
		Technical Session 3	Technical Session 6	Technical Session 9	Closing Session
Night	Registration and Welcome Reception (in Kyoto city)		Networking Reception (TBD)	Conference Dinner (in Kyoto city)	

The GHGT conference series has established itself as the principal international conference on greenhouse gas mitigation technologies especially on CCS (CO_2 Capture and Storage). Abstracts for GHGT-11 submitted during the period from the 26th September 2011 to the 15th February 2012 in response to the Call for Papers are reviewed by the Programme Committee of the conference, and presentations will be made at the technical sessions of the conference, which consist of oral sessions (around 6 parallel sessions) and poster sessions.



<<GHGT-11: Technical Themes>>

	Main themes	Sub themes
1	Capture	pre-combustion; post-combustion; oxyfuel technologies; advanced solvents; membranes; etc.
2	Geo Storage	CO_2 injectivity; storage capacities; monitoring technologies and techniques; wellbore integrity; costs (storage specific); etc.
3	Other Storage	coal beds, mineralisation; basalts and other low permeability reservoirs, ocean storage.
4	CCS for industrial sources (non-power)	iron and steel; cement; refineries; high concentration CO_2 sources; distributed CCS.
5	Transport	pipelines; shipping; hubs and transport networks; CO_2 quality issues; source-sink matching.
6	Negative CO_2	biomass energy use combined with CCS; capturing CO_2 from the air; ocean fertilisation; etc.
7	CO_2 Utilization options	EOR; EGR; ECBM; CO_2 use for production of algae or chemicals; CO_2 for enhanced geothermal; etc.
8	Demonstration	pilot projects; lessons learnt; costs; developments of best practice guidelines; program overviews; etc.
9	Tech Assess & Integration	health and safety issues; whole system LCA studies; CCS and water use; risk assessments; etc.
10	Commercial issues	commercial relationships; value chains; public-private relationships; finance.
11	Public perception	social science research; communication activities and experiences, knowledge sharing.
12	Policies	the role of CCS in furture energy systems, beyond Kyoto:non-CO_2 GHG emission reduction, carbon tax and CCS obligations; etc.
13	Legal & Regulatory	regulatory and legal developments; Requirements; liability transfer and long term liability; emissions accounting, health and safety issues.
14	Education, training and capacity building	needs; experiences; etc.

Technical sessions (oral and poster sessions) of GHGT-11 will serve as platforms to discuss the technical themes related to CCS as show n above. On the other hand keynote speeches and panel discussions at GHGT-11 will take up wider variety of topics like energy policies, solutions for commercializing advanced technologies and international cooperation, and promote Japan's leading edge environmental technologies to the world.

Keynote Speech (GHGT-10)

Poster session (GHGT-10)

Online conference registration will open on the 23rd April and early bird discount will be available until the 23rd July (JST). GHGT-10 held in Netherlands in 2010 was attended by some 1,600 delegates, but only 200 of them were from Asia. In order to increase Asia's presence at GHGT-11 to be held in Japan, we would like to invite all of you working on CCS and other global warming prevention measures to attend the conference to enhance global development of greenhouse gas control technologies.

Online registration, conference programme will be available at **www.ghgt.info**

Early Bird Registration	23rd April – 23rd July 2012 (JST)
Late Registration	24th July 2012 – 15th November 2012 (JST)

Symposium on Innovative Environmental Technologies
–The Realization of Low Carbon and Green Innovation–

Planning, Survey, and Public Relations Group

The symposium entitled "Symposium on Innovative Environmental Technologies –The Realization of Low Carbon and Green Innovation–" was held on December 1, 2011 at Nadao Hall in Tokyo.

The symposium was organized by RITE, and supported by Minister of Economy, Trade and Industry(METI), The Chemical Society of Japan, The Society of Chemical Engineers, Japan, Japan Society for Bioscience, Biotechnology, and Agrochemistry, Japan Society of Energy and Resources, The Japan Institute of Energy, IEAGHG.

We had 348 attendances which emphasizes the great interest in our activities, including participants from METI, Ministry of the Environment and various fields of industry and academia.

The symposium started with Dr. Kenji Yamaji's lecture and then the experts from each research group reported the outcome and outlook of their researches such as scenarios for mitigation global warming, biorefinery technology and CCS technology, with the current trends of the world and Japanese situation. Vigorous questioning and opinions were expressed by the audience.

We received questionnaires from 194 attendances. According to the results, 171 people said that they had been satisfied with the lectures.

ALPS International Symposium 2011

Systems Analysis Group

The ALPS International Symposium 2011 was held at Nadao Hall in Tokyo on February 9th, 2011. This symposium was hosted by the Research Institute of Innovative Technology for the Earth (RITE) with support from the Ministry of Economy, Trade and Industry, Japan (METI).

We are honored to have a variety of leading experts including Prof. Nabojsa Nakicenovic and Dr. Markas Amann from the International Institute Applied Systems Analysis, Dr. Mark Levine from the Lawrence Berkeley National Laboratory, Dr. Leon E. Clarke from the Pacific Northwest National Laboratory, Kejun Jiang from Energy Research Institute National Development and Reform Commission, Kenji Yamaji, a director general of RITE, and Keigo Akimoto from RITE. The symposium was titled "the Frontiers of Scenarios for Climate Change Research and Assessment." We discussed scenario analyses based on a long-term and multiple perspectives.

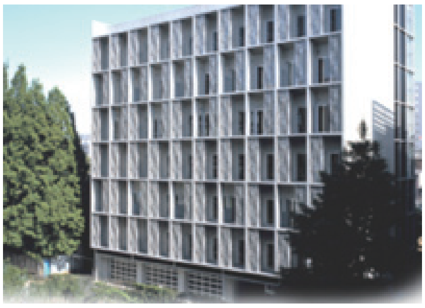
We had an attendance of 230 people from industries, ministries and universities. Their active discussion motivated us to dedicate further efforts to our research and development.

Establishment of Green Earth Institute Co., Ltd. toward the industrialization of biorefinery

Molecular Microbiology and Biotechnology Group

The biorefinery is greatly expected to enable novel technologies or industries that can produce chemicals and liquid fuels from renewable non-food biomass that eschew competition with food resources. Green Earth Institute Co., Ltd. was established to provide biofuels and green chemicals by using a highly efficient process called the RITE Bioprocess which was developed by RITE.

The concept of the establishment is the industrialization of our RITE-Bioprocess to contribute to the conservation of global environment through efforts against global warming and hence the realization of sustainable post-fossil resources society. G.E.I. Co., Ltd. hopes to engage in global business as a leading company in the biorefinery sector.



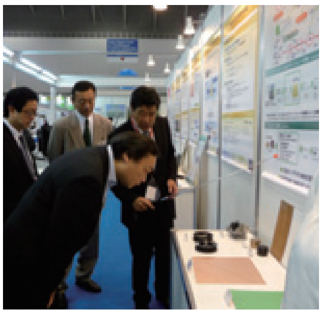
Corporate name: Green Earth Institute Co., Ltd.
Founded: 1st. September 2011
Address: University of Tokyo UCR Plaza 6F,
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, JAPAN

Many visitors attended our seminar and exhibition booth at BioJapan2011 (World Business Forum)

Molecular Microbiology and Biotechnology Group

The World Business Forum organized by the BioJapan Organizing Committee and Nikkei Business Publications Inc. was held at Pacifico Yokohama from 5th to 7th October 2011. This time RITE hosted the forum as a sponsor organization. RITE Director, Dr. Hideaki Yukawa, moderated the seminar on “Green Innovation” following last year.

Our group exhibited the highly efficient bio-conversion technology “RITE-Bioprocess” along with posters and video presentations, which allowed detailed introduction of our activities, and our corporate strategic alliance partners joined the exhibition, with their panels displaying products which were produced using our RITE-Bioprocess. We also introduced our new business arm, the Green Earth Institute Co., Ltd. established this September. We thank very much all those who visited of our booth.



Mr. Takayuki Ueda, front, Director-General, Manufacturing Industries Bureau of Minister of Economy, Trade and Industry, stopped by our booth.

RITE Booth

2011 fellowship award from The Society for Industrial Microbiology

Molecular Microbiology and Biotechnology Group

RITE Director H. Yukawa was awarded the 2011 fellowship award from The Society for Industrial Microbiology (SIM). Founded in 1949 in NY, SIM is an international association dedicated to the advancement of applied microbiology essential for industrial biotechnology. In SIM Meetings, advancement of microbiological sciences which apply to industrial products, biotechnology, materials and processes, are presented and discussed. Global chemical corporations and prominent universities are also on the member list of the association.

This prize was started in 1985 and is given to individuals for their contributions to industrial microbiology. Dr. H. Yukawa is the first Japanese recipient of this prestigious award.

Society for Industrial Microbiology
Dedicated to the Industrial Application of Microbiology and Biotechnology

SIM President Badal Saha and Dr. H. Yukawa

Symposium for Innovative CO_2 Membrane Separation Technology

"Recent trend of membrane separation technology contributing to the prevention of global warming"

Chemical Research Group

On November 4th 2011, Symposium for Innovative CO_2 Membrane Separation Technology "Recent trend of membrane separation technology contributing to the prevention of global warming" was held at Dai-ichi Hotel Tokyo, sponsored by Molecular Gate Membrane Module Technology Research Association, co-sponsored by Ministry of Economy, Trade and Industry (METI) (supported by Japan CCS Co., Ltd.(JCCS), Global CCS Institute, Japan Association for Chemical Innovation (JACI), The Membrane Society of Japan, and The Society of Chemical Engineers, Japan(SCEJ)). 170 related persons attended from companies, universities, research institutes and government agencies.

Molecular Gate Membrane Module Technology Research Association was established by Kuraray Co., Ltd., Nitto Denko Corporation, Nippon Steel Engineering Co., Ltd., and RITE in order to commercialize a molecular gate membrane module, which was pioneered by chemical research group of the RITE.

The purpose of this symposium was to report the recent research trend of CO_2 separation membrane technologies, which the Association have been developing, and the overview of its research and development in overseas, and then widely provide people interested in CO_2 separation with the latest information to help them understand R&D activities for CO_2 reduction required for both public and private sectors.

The speakers ware Yoichi Kaya, Senior Vice President of RITE at that time "Response to Global Warming"; Shin-ichi Nakao, Professor of Kogakuin University "Membrane Separation Technology Status and Future Outlook"; Benny D. Freeman, Professor of University of Texas "Latest trend of membrane technologies in North America"; Tomokazu Ise, Supervisor of Kurashiki lab of the Technology Research Association, "Report of Investigation into Membrane Technologies in Overseas"; Shingo Kazama, Senior Managing Director of the Technology Research Association, "Next-Generation Membrane Module"; Hiroshi Iwahori, Senior Consultant of Ibaraki lab of the Technology Research Association, "Deployment of the Membranes to the World Market".

Membrane modules and posters, etc. were displayed by the Association.

We conducted a survey of visitors. As a result, from 69% of respondents, we received a good response.

CCS Workshop
-Ensuring safety toward public acceptance-

CO_2 Storage research Group

CCS Workshop -Ensuring safety toward public acceptance- was successfully held at Bellesalle Shiodome, Chuo-ku, Tokyo on January 18th, 2012. The workshop was co-organized by the Ministry of Economy, Trade and Industry (METI) and RITE and supported by the National Institute of Advanced Industrial Science and Technology (AIST), the Central Research Institute of Electric Power Industry (CRIEPI), the Global CCS Institute (GCCSI), the IEA Greenhouse Gas R&D Programme (IEAGHG), the Japan Society of Energy and Resources (JSER) and Japan CCS Co., Ltd. (JCCS). We had 386 attendees from governmental organizations, various industries, universities, and research institutes at home and abroad.

Kenji Yamaji, Director General, RITE and John Gale, General Manager, IEAGHG, UK gave keynote speeches on “Role of CCS in Sustainable Energy Future” and “Challenges for practical use and commercialization of CCS”, respectively. Other talks were given by John Bradshaw, CEO, CO_2 Geological Storage Solutions (CGSS),Australia on “Geological storage of CO_2: “Practicalities” - issues, risks and uncertainties associated with site selection”; Sally Benson, GCEP Director, Stanford University, USA on “Monitoring Performance of Geological Storage Projects”; Ziqiu Xue, Associate Chief Researcher, CO_2 Storage Research Group, RITE on “Microseismic Monitoring at the CCS fields”; and Peta Ashworth, Leader of Science into Society Group (SISG), CSIRO, Australia, on “Stakeholder engagement for successful CCS development: Considerations and lessons learned”. Moderator was Kozo Sato, Professor, the Frontier Research Center for Energy and Resources Graduate School of Engineering, the University of Tokyo.

Alongside the workshop, RITE held poster sessions by RITE researchers. The attendees had fruitful discussions on various issues such as stakeholder engagement or public acceptance.

Systems Analysis Group

■2011 Original Paper

	Title	Researchers	Journal
1	Investment for Competitive Power Plants under Uncertainty of Allocation Scheme	Junichiro Oda, Ryuta Takashima	Journal of Real Options and Strategy, Vol.4 No.1 47-60, February 2011
2	GIS-based Estimation of Global Carbon Sequestration Potential through Forest Management	K. Akimoto, T. Tomoda, K. Tahara, T. Kojima	Journal of Chemical Engineering of Japan, Vol.44 No.10 pp.764-773, 2011
3	International Climate Agreements under Induced Technological Change	M. Nagashima, H-P. Weikard, K. Bruin, R. Dellink	Metroeconimica, Vol.62 No.4 pp.612-634, 2011
4	Assessment of Copenhagen Pledges with Long-term Implications	K. Wada, F. Sano, K. Akimoto, T. Homma, K. Tokushige, M. Nagashima, T. Tomoda	Energy Economics, in press

■2011 Other Paper (e.g. Review, Comment)

	Title	Researchers	Journal
1	Verification of Mid-term Emission Reduction Targets - Shared Reductions by Developed and Developing Regions	Keigo Akimoto	Posted on the International Environment and Economy Institute's Website, March 1, 2011
2	Estimate of Power Generation Costs by Energy Source and Issues of Solar Belt Planning	Keigo Akimoto	Monthly Business i. ENECO, Vol.49 No.7, July 2011
3	Insights from Game-Theoretic Analysis on the Design of International Climate Agreements	Miyuki Nagashima	International Public Policy Studies, Vol.16 No.1, September, 2011
4	Proper Understanding of Scenario	Keigo Akimoto	Symposium on IPCC-AR5 (Mitigation Policy and Transformation Pathways), posted on the website September, 2011
5	Importance of Minimizing Social Barriers to Adoption of Energy-efficient Technologies for Realizing Emission Reductions	Miyuki Nagashima	Symposium on IPCC-AR5 (Mitigation Policy and Transformation Pathways), posted on the website, September, 2011
6	Look at the Forest, Roots and Soil	Keigo Akimoto	Daily Global Warming News http://daily-ondanka.com/thoughts/index.html, September, 2011
7	Climate Change Mitigation and Balanced Energy toward Sustainable Development	Keigo Akimoto	Energy for the future, December, 2011

■2011 Oral Presentation (Domestic Conference)

	Title	Researchers	Forum
1	Analyses on Comparability for Mid- and Long-tern GHG Emission Mitigation	Keigo Akimoto, Fuminori Sano, Takashi Honma, Kenichi Wada, Ayami Hayashi, Miyuki Nagashima	27th conference on Energy, Economy and Environment, January 26, 2011
2	Bounded Rationality in Energy-efficiency Investments	Kenichi Wada, Keigo Akimoto, Takashi Honma, Fuminori Sano, Junichiro Oda, Miyuki Nagashima	27th conference on Energy, Economy and Environment, January 26, 2011
3	Analysis of Land Use for Agriculture and CO2 Emissions due to Land-use Change	Ayami Hayashi, Keigo Akimoto, Masanobu Kii	27th conference on Energy, Economy and Environment, January 26, 2011
4	Analysis of Domestic Economic Impacts on Mid-term Targets of CO2 Reductions	Takashi Honma, Keigo Akimoto, Miyuki Nagashima, Kenichi Wada, Fuminori Sano	27th conference on Energy, Economy and Environment, January 26, 2011
5	Development of Socio-economic Scenarios Based on Analysis of Socio-economic Factors	Takashi Honma, Keigo Akimoto, Kohko Tokushige, Kenichi Wada	27th conference on Energy, Economy and Environment, January 26, 2011
6	Analysis of Long-term Climate Change Mitigation in a Transportation Sector by Using a World Energy Systems Model	Fuminori Sano, Keigo Akimoto, Junichiro Oda, Takashi Honma, Kenichi Wada	27th conference on Energy, Economy and Environment, January 26, 2011
7	Analysis of Long-term Climate Change Mitigation in a Power Generation Sector by Using a World Energy Systems Model	Fuminori Sano, Keigo Akimoto, Junichiro Oda, Takashi Honma, Kenichi Wada	27th conference on Energy, Economy and Environment, January 26, 2011
8	Consideration on Evaluation Indicators Concerning Global Warming Measures and Sustainable Development	Kohko Tokushige, Keigo Akimoto, Junichiro Oda, Kenichi Wada, Ayami Hayashi	27th conference on Energy, Economy and Environment, January 26, 2011
9	Study of Global Steel Scenario by Region	Junichiro Oda, Keigo Akimoto, Fuminori Sano, Takashi Honma, Kenichi Wada, Juan Liu	27th conference on Energy, Economy and Environment, January 26, 2011
10	A Study on Discount Rate in Climate Change control	Miyuki Nagashima, Keigo Akimoto	27th conference on Energy, Economy and Environment, January 26, 2011
11	A Study on Historical Transition of Energy Policy in China Based on the Five-year Plans	Juan Liu, Keigo Akimoto	27th conference on Energy, Economy and Environment, January 26, 2011
12	Evaluation of Agro-land Use and Water-use under Climate Change	Ayami Hayashi, Keigo Akimoto, Masanobu Kii	30th Annual Meeting of Japan Society of Energy and Resources, June 2, 2011

	Title	Researchers	Forum
13	Assessing the Benchmark Stringency of EU ETS Phase III in Iron & Steel and Cement Sectors	Junichiro Oda, Keigo Akimoto, Kenichi Wada, Miyuki Nagashima, Fuminori Sano, Takashi Honma,	30th Annual Meeting of Japan Society of Energy and Resources, June 2, 2011
14	An Analysis of Global Food Production under Forest Preservation	Ayami Hayashi, Keigo Akimoto,	2011 Annual Meeting of Society of Environmental Science, Japan, September 8, 2011
15	Mitigation of GHG Emissions	Keigo Akimoto	43rd Fall Symposium of The Society of Chemical Engineers, Japan, September 14, 2011

■2011 Oral Presentation (International Conference)

	Title	Researchers	Forum
1	Balancing Mitigation Efforts from Long-term Perspectives	Kenichi Wada	The Fourth Asian Modeling Exercise Meeting, China, March 31, 2011
2	Toward Effective and Sustainable Global Warming Mitigations	Keigo Akimoto	Hartwell Ⅱ Meeting, United Kingdom, April 8, 2011
3	Scenarios for Sustainable Development and Global Warming Response	Keigo Akimoto	UN Expert Group Meeting on SD21 Sustainable Development Scenarios for Rio-20, Austria, June 27-29, 2011
4	For Rightful Understanding of Scenarios	Keigo Akimoto	Symposium on IPCC-AR5 (Mitigation Policy and Transformation Pathways), Japan, July 5, 2011
5	Importance of Removing Social Barriers for Realizing Emission Reductions	Miyuki Nagashima	Symposium on IPCC-AR5 (Mitigation Policy and Transformation Pathways), Japan, July 5, 2011
6	Energy-efficiency Opportunities in the Residential Sector and their Feasibility	K. Wada, K. Akimoto, F. Sano, J. Oda, T. Homma	The Sixth Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, Croatia, September 8, 2011
7	Overview of ALPS Project and Future Perspectives	Miyuki Nagashima	Seminar on Japan's contribution to IIASA Activities, Austria, September 16, 2011
8	Climate Policies in Japan Update	Kenichi Wada	AMPERE Vienna, Austria, October 3, 2011
9	Energy-efficiency Opportunities in the Residential Sector and their Feasibility	K. Wada, F. Sano	EMF24 Potsdam, Germany, November 7, 2011

■2011 Non-Journal Publication

	Title	Researchers	Magazine, Newspaper, etc.
1	The Ways to Stop Global Warming of our Country - International Contributions of the Low-carbon Technologies	Keigo Akimoto	Environment Strategy Council, Global Environment Forum-Kansai, February 3, 2011
2	Global Warming Suppression and Scenarios for Nuclear Power and Distributed Energy System	Keigo Akimoto	"The Trend of international energy and environmental issues", Symbio Community Forum, March 4, 2011
3	Global Scenarios for Climate Change Response Measures	Keigo Akimoto	CO2 Stabilization Workshop, April 21, 2011
4	Energy and Climate Change Policy Perspectives	Keigo Akimoto	"Japan's strategy of Global Warming", Intellectual Café, Research Center for Advanced Science and Technologies, The University of Tokyo, June 2, 2011
5	Risks and Response Strategies of Global Warming	Keigo Akimoto	"Research Project on Disaster Risk Management that Tackles Global Environmental Change", chaired by Prof. Morimoto, Institute of World Study, Takushoku University, June 21, 2011
6	Towards a New International Post-Kyoto Framework	Keigo Akimoto	Keidanren International Environmental Strategy WG, , July 21, 2011
7	Strategies for Global Warming -Big Picture on Global Warming Issues-	Keigo Akimoto	An intensive course, The University of Tokyo Graduate School of Art and Science, August 1-2, 2011
8	Estimate of Power Generation Costs	Keigo Akimoto	Workshop on Costs, Japan Atomic Energy Commission, September 1, 2011
9	Estimate of Power Generation Costs	Keigo Akimoto	Commissioners' Regular Meeting, Japan Atomic Energy Commission, September 13, 2011
10	Game-theoretic Analysis of International Climate Agreements: Introduction of the Latest Paper and Future Perspectives	Miyuki Nagashima	Workshop on "Economic analysis relating to the environment and energy resources strategy after 2011 Kanto-Tohoku Earthquake", September 22, 2011

	Title	Researchers	Magazine, Newspaper, etc.
11	Estimate of Power Generation Costs	Keigo Akimoto	Keidanren Energy Policy Workshop, October 21, 2011
12	Analysis of Japan's Strategy for Energy and Environment	Keigo Akimoto	Keidanren Global Japan Committee, October 25, 2011
13	Energy and Environmental Policies and Technology Perspectives	Keigo Akimoto	Kagawa Next Generation Manufacturing Study Group, November 9, 2011
14	SSP, RCP, ALPS Scenarios	Keigo Akimoto	The Second Workshop on Scenarios and Climate Change Impact Assessment, November 15, 2011
15	Food Production and Aglo-land Use in the 21st Century -Development of Quantitative Scenarios by Using a Global Model-	A. Hayashi, K. Akimoto	The Second Workshop on Scenarios and Climate Change Impact Assessment, November 15, 2011
16	Overview of the Cost Verification Committee of the Government and Analysis of Power Generation Costs	Keigo Akimoto	Nuclear Energy Study Group, the Japan Chamber of Commerce and Industry, November 28, 2011
17	Impacts of Energy Issues on the Local Economy	Keigo Akimoto	General Policy Committee, the Japan Chamber of Commerce and Industry, December 16

Molecular Microbiology and Biotechnology Group

■2011 Original Paper

	Title	Researchers	Journal
1	Regulation of the nitrate reductase operon *narKGHJI* by the cAMP-dependent regulator GlxR in *Corynebacterium glutamicum*.	T. Nishimura, H. Teramoto, K. Toyoda, M. Inui and H. Yukawa.	Microbiology 157: 21-28. 2011.
2	Translation efficiency of antiterminator proteins is a determinant for the difference in glucose repression of two beta-glucoside phosphotransferase system gene clusters in *Corynebacterium glutamicum* R.	Y. Tanaka, H. Teramoto, M. Inui and H. Yukawa.	J. Bacteriol. 193: 349-357. 2011.
3	Identification of mannose uptake and catabolism genes in *Corynebacterium glutamicum* and genetic engineering for simultaneous utilization of mannose and glucose.	M. Sasaki, H. Teramoto, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 89: 1905-1916. 2011.
4	Gene expression profiling of *Corynebacterium glutamicum* during anaerobic nitrate respiration: induction of the SOS response for cell survival.	T. Nishimura, H. Teramoto, M. Inui and H. Yukawa.	J. Bacteriol. 193: 1327-1333. 2011.
5	Efficient markerless gene replacement in *Corynebacterium glutamicum* using a new temperature-sensitive plasmid.	N. Okibe, N. Suzuki, M. Inui and H. Yukawa.	J. Microbiol. Methods. 85: 155-163. 2011.
6	Diversity of metabolic shift in response to oxygen deprivation in *Corynebacterium glutamicum* and its close relatives.	S. Yamamoto, M. Sakai, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 90: 1051-1061. 2011.
7	Metabolic engineering of 1,2-propanediol pathways in *Corynebacterium glutamicum*.	S. Niimi, N. Suzuki, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 90: 1721-1729. 2011.
8	Transcriptional regulators of multiple genes involved in carbon metabolism in *Corynebacterium glutamicum*.	H. Teramoto, M. Inui and H. Yukawa.	J. Biotechnol. 154: 114-125. 2011.
9	Metabolic engineering of bacteria for utilization of mixed sugar substrates for improved production of chemicals and fuel ethanol.	T. Jojima, M. Inui and H. Yukawa.	Biofuels 2: 303-313. 2011.
10	High yield secretion of heterologous proteins in *Corynebacterium glutamicum* using its own Tat-type signal sequence.	H. Teramoto, K. Watanabe, N. Suzuki, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 91: 677-687. 2011.
11	Genome-wide identification of *in vivo* binding sites of GlxR, a cyclic AMP receptor protein-type regulator in *Corynebacterium glutamicum*.	K. Toyoda, H. Teramoto, M. Inui and H. Yukawa.	J. Bacteriol. 193: 4123-4133. 2011.
12	Characterization of the mannitol catabolic operon of *Corynebacterium glutamicum*.	X. Peng, N. Okai, A.A. Vertès, K. Inatomi, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 91: 1375-1387. 2011.
13	Global transcriptome analysis of the tetrachloroethene dechlorinating bacterium *Desulfitobacterium hafniense* Y51 in the presence of various electron donors and terminal electron acceptors.	X. Peng, S. Yamamoto, A.A. Vertes, G. Keresztes, K. Inatomi, M. Inui and H. Yukawa.	J. Ind. Microbiol. Biotechnol. (in press)
14	Improvement of the redox balance increases L-valine production by *Corynebacterium glutamicum* under oxygen deprivation.	S. Hasegawa, K. Uematsu, Y. Natsuma, M. Suda, K. Hiraga, T. Jojima, M. Inui and H. Yukawa.	Appl. Environ. Microbiol. (in press)

■2011 Oral Presentation

	Title	Researchers	Forum
1	Biorefinery Blue-Print: a Growth-Arrested Bioprocess for Manufacturing a Portfolio of Commodity and Fine Chemicals.	Masayuki Inui, Alain A. Vertès and Hideaki Yukawa	241st American Chemical Society National Meeting & Exposition、31 March 2011
2	Mechanism of The Different Response of Two *bgl*-PTSGene Clusters to Glucose in *Corynebacterium glutamicum* R.	Yuya Tanaka, Haruhiko Teramoto, Masayuki Inui and Hideaki Yukawa.	American Society for Microbiology 111th General Meeting、21-24 May 2011
3	Genome-wide Identification of In Vivo Binding Sites of GlxR, A cAMP Receptor Protein Homolog in *Corynebacterium glutamicum*.	Koichi Toyoda, Haruhiko Teramoto, Masayuki Inui and Hideaki Yukawa.	American Society for Microbiology 111th General Meeting、21-24 May 2011
4	Production of Biofuels/Biochemicals from Non-food Based Biomass by the RITE Bioprocess	Hideaki Yukawa	2nd Annual Future of Biobased Chemicals - Inception to Marketplace Conference、7 July 2011
5	Gene expression profiling of *Corynebacterium glutamicum* under anaerobic nitrate respiration.	Taku Nishimura, Haruhiko Teramoto, Masayuki Inui and Hideaki Yukawa.	SIM Annual Meeting、25 July 2011
6	Regulation of NAD *de novo* biosynthesis genes in *Corynebacterium glutamicum*.	Haruhiko Teramoto, Masako Suda, Masayuki Inui and Hideaki Yukawa.	SIM Annual Meeting、25 July 2011
7	The RITE Bioprocess in Production of Biofuels and Biochemicals from Lignocellulosic Biomass-Derived Mixed Sugars	Masayuki Inui and Hideaki Yukawa.	International Union of Microbiological Societies 2011 Congress (IUMS2011)、8 September 2011
8	Biorefinery: Today and Future	Hideaki Yukawa	BioJapan2011—A Bio Round Table Meeting for Embassies—、7 October 2011
9	Production of Green Chemicals from Non-Food Biomass by a Growth-Arrested Bioprocess Using Corynebacteria	Masayuki Inui	BioJapan2011、7 October 2011
10	Production of Biofuels and Biochemicals from Non-Food Biomass by a Growth-Arrested Bioprocess Using Corynebacteria	Masayuki Inui and Hideaki Yukawa.	UM-BTI/NAIST Joint Symposium、18 October 2011

■2011 Non-Journal Publication

	Title	Researchers	Magazine, Newspaper, etc.
1	High-Throughput Transposon Mutagenesis of *Corynebacterium glutamicum*.	N. Suzuki, M. Inui and H. Yukawa.	Strain Engineering: Methods and Protocols、p.409-417、Humana Press

Chemical Rsearch Group

■2011 Original Paper

	Title	Researchers	Journal
1	Preparation of Pore-fill-type Palladium-Porous Alumina Composite Membrane for Hydrogen Separation	Kensuke Nagata(NAIST), Katsunori Yogo, Tsuyoshi Watabe, Yuichi Fujioka, Manabu Miyamoto	Chemistry Letters 40 (1), 19-21 (2011)
2	Development of a Low Cost CO_2 Capture System with a Novel Absorbent under the COCS Project	Kazuya Goto, Firoz Alam Chowdhury, Hiromichi Okabe, Shinkichi Shimizu, Yuichi Fujioka	Energy Procedia 4, 253-258 (2011)
3	Synthesis and selection of hindered new amine absorbents for CO_2 capture	Firoz Alam Chowdhury, Hiromichi Okabe, Hidetaka Yamada, Masami Onoda, Yuichi Fujioka	Energy Procedia 4, 201-208 (2011)
4	Quantum chemical analysis of carbon dioxide absorption into aqueous solutions of moderately hindered amines	Hidetaka Yamada, Hiromichi Okabe, Shinkichi Shimizu, Yuichi Fujioka, Yoichi Matsuzaki(Nippon Steel Corporation)	Energy Procedia 4, 133-139 (2011)
5	Development of an energy-saving CO_2-PSA process using hydrophobic adsorbents	Katsunori Yogo, Tsuyoshi Watabe, Yuichi Fujioka, Yosuke Matsukuma, Masaki Minemoto (Kyusyu Univ.)	Energy Procedia 4, 803-808 (2011)
6	Effects of membrane properties on CO_2 recovery performance in a gas absorption membrane contactor	Hiroshi Mano, Yuichi Fujioka, Nobuhide Takahashi, Yusuke Furuta, Hiroshi Fukunaga, Toru Takatsuka(Shinshu Univ.)	Energy Procedia 4, 693-698 (2011)
7	Density functional theory study on carbon dioxide absorption into aqueous solutions of 2-amino-2-methyl-1-propanol using a continuum solvation model	Hidetaka Yamada, Takayuki Higashii, Shingo Kazama, Yoichi Matsuzaki(Nippon Steel Corporation)	J. Phys. Chem. A 115 3079-3086 (2011)
8	Development of novel absorbents for CO_2 capture from blast furnace gas	Kazuya Goto, Hiromichi Okabe, Firoz Alam Chowdhury, Shinkichi Shimizu, Yuichi Fujioka Masami Onoda(Nippon Steel Corporation)	International Journal of Greenhouse Gas Control 5 1214-1219 (2011)
9	Gas permeation properties of amine loaded mesoporous silica membranes for CO_2 separation	Katsunori Yogo, Manabu Miyamoto, Ayato Takayama, Shigeyuki Uemiya (Gifu Univ.)	Desalination and Water Treatment 34 266-271 (2011)

■2011 Oral Presentation

	Title	Researchers	Forum
1	CO_2 Membrane Separation	Teruhiko Kai, Shingo Kazama	CCS WORKSHOP(Hotel Sultan in Jakarta,Golden Ballroom,Jakarta(Indonesia)) 22 February 2011
2	Membranes in precombustion	Shingo Kazama	International Symposium on Environment,Energy and Materials(Kanbaikan,Doshisha University,Kyoto) 10 March 2011
3	Synthesis and selection of new amine absorbents for CO_2 capture	Firoz Alam Chowdhury, Takayuki Higashii, Kazuya Goto, Shingo Kazama, Masami Onoda(Nippon Steel Corporation)	1st Post Combustion Capture Conference (PCCC1) (Abu Dhabi, UAE) 17 May 2011
4	Advanced CO_2 Separation Using Molecular Gates	Shingo Kazama	Carbon Capture Workshop (Stanford University, Stanford, California) 27 May 2011
5	Development of Molecular Gate Membrane for CO_2 Capture	Shuhong Duan, Teruhiko Kai, Ikuo Taniguchi, Shingo Kazama	6th Japan-China Symposium on Chemical Engineering(Wuhan, China) 23 June 2011
6	Development of a novel CO_2 capture system with chemical absorption for the integrated steel works	Kazuya Goto, Firoz Alam Chowdhury, Satoshi Kodama, Shin Yamamoto, Takayuki Higashii ,Hiromichi Okabe, Shingo Kazama	1st International Conference on Energy Efficiency and CO2 Reduction in the Steel industry(CCD Congress Center Dusseldorf, Germany) 29 June 2011
7	Experimental study into carbon dioxide solubility and species distribution in aqueous alkanolamine solutions	Hidetaka Yamada, Takayuki Higashii, Firoz A. Chowdhury, Kazuya Goto, Shingo Kazama	Sustainable Chemistry 2011(University of Antwerp, Belgium) 9 July 2011
8	Evaluation of a novel absorbent for CO_2 capture in a pilot plant with coal combustion gas containing high concentration of SO_2	Kazuya Goto, Satoshi Kodama, Yuichi Fujioka, Shingo Kazama, Rei Satoh, Masayuki Iwamura(Chiyoda Corp.), Yuli Artanto, James Jansen, Pauline Pearson, Erik Meuleman(CSIRO)	The 8th Asia Pacific Conference on Sustainable Energy & Environmental Technologies (APCSEET2011)(University of Adelaide, Australia) 12 July 2011
9	Development of poly(amidoamine) dendrimer/polymer hybrid membranes for CO_2/H_2 separation	Teruhiko Kai, Shuhong Duan, Ikuo Taniguchi, Shingo Kazama	ICOM2011(The RAI in Amsterdam) 25 July 2011
10	Development of Novel Absorbents for Energy-Saving CO_2 Capture System	Kazuya Goto, Firoz Alam Chowdhury, Shin Yamamoto, Takayuki Higashii, Shingo Kazama	14th Asian Chemical Congress(14ACC)(Queen Sirikit National Convention Center, Bangkok, Thailand) 6 September 2011
11	Development of Molecular Gate Membrane for CO_2 Capture	Shingo Kazama	The Fourth CSLF Ministerial Meeting(Beijing, China) 20 September 2011
12	Advanced CO_2/H_2 Separation Materials Incorporating Active Functional Agents	Shingo Kazama	GCEP symposium(Stanford University, Stanford, California) 5 October 2011
13	Generation Behavior of Heat-Stable Salt in Novel Chemical Solvent for CO_2 Capture Process from Blast-Furnace Gas	Shin Yamamoto, Takayuki Higashii, Shingo Kazama	2011 AIChE Annual meeting(Minneapolis Convention Center, Minneapolis, MN) 18 October 2011

CO_2 Storage Rsearch Group

■2011 Original Paper

	Title	Researchers	Journal
1	Monitoring and detecting CO2 injected into water-saturated sandstone with joint seismic and resistivity measurements	Jongwook Kim, Toshifumi Matsuoka, Ziqiu Xue	Exploration geophysics, 2011, 42, 1-10
2	Experimental study of electric and seismic monitoring for mobile and residual CO2 in the drainage and imbibition stages	Jongwook Kim, Toshifumi Matsuoka, Ziqiu Xue	Geophysical Journal International, submitted
3	Relative permeability of water and supercritical CO2 under steady-state flow conditions in porous sandstones	Tetsuya Kogure, Keigo Kitamura, Tatsuya Yamada, Osamu Nishizawa, Ziqiu Xue	Journal of the Japanese Association for Petroleum Technology, submitted
4	The effect of lamina on super critical CO2 behaviour in porous sandstone: investigation from elastic wave velocity	Keigo Kitamura, Ziqiu Xue,Tatsuya Yamada, Osamu Nishizawa	Journal of the Mining and Materials Processing Institute of Japan
5	Effect of formation water compositions on predicting CO2 behavior case study at the nagaoka post-injection monitoring site	Saeko Mito, Ziqiu Xue, Tatsuya Sato	Applied Geochemistry,submitted
6	Relative permeability of water and supercritical CO2 under steacy-state flow conditions in porous sandstones	Tetsuya Kogure, Keigo Kitamura, Tatsuya Yamada, Osamu Nishizawa, Ziqiu Xue	Journal of geography,in press

■2011 Oral Presentation

	Title	Researchers	Forum
1	Roles of geophysics and rock physics in geological CO2 sequestration	Ziqiu Xue	12th international congress on rock mechanics, Beijing, China, 2011/10/21
2	Fluid chemistry of the onshore CO2 sequestration formation at nagaoka, japan: 5 years passed since CO2 injection	Saeko Mito, Yuki Asahara, Ziqiu Xue	AGU fall meeting (Invited), San Francisco, USA, 2011/12/5-9
3	Nagaoka 4d seismic revisited	Naoshi Aoki, Akihisa Takahashi, Ziqiu Xue	IEA-GHG 7th monitoring network meeting, Potsdam, Germany, 2011/06/07
4	CO2 saturation from nagaoka wireline measurement	Ziqiu Xue, Takahiro Nakajima, Shun Chiyonobu, Saeko Mito	IEA-GHG 7th monitoring network meeting, Potsdam, Germany, 2011/06/08
5	The rock physical approach to the complex CO2 flow in the bedded Tako sandstone	Keigo Kitamura, Ziqiu Xue, Tatsuya Yamada, Osamu Nishizawa	Japan Geoscience Union meeting 2011, 2011/05/22-27
6	Monitaring subsurface CO2 condition by applying rock physics	Osamu Nishizawa, Tatsuya Yamada, Ziqiu Xue	Japan Geoscience Union meeting 2011, 2011/05/22-27
7	Data analysis of time-lapse well logging results for the monitoring of stored CO2 at the Nagaoka pilot site	Takahiro Nakajima, Ziqiu Xue, Saeko Mito	Japan Geoscience Union meeting 2011, 2011/05/22-27
8	Experimental study for CO2 migration monitoring to estimate P-wave traveltimes and amplitudes by drainage and imbibition	Susumu Sakashita, Keigo Kitamura, Dai Nobuoka, Hiroyuki Azuma, Junya Takeshima, Hideki Saito, Ziqiu Xue	Japan Geoscience Union meeting 2011, 2011/05/22-27
9	Design of experimental facility for steady state relative permeability mesurements in water-supercritical CO2 systems	Tsuya Kogure, Ziqiu Xue	Japan Geoscience Union meeting 2011, 2011/05/22-27
10	Visualization technique of CO2 storage mechanism using X-ray computed tomography	Yukihiro Yazaki, Shun Chiyonobu, Ziqiu Xue	Japan Geoscience Union meeting 2011, 2011/05/22-27
11	Geological features of reservoir formation of Nagaoka CO2 injection Site, based on the sedimentary facies analysis	Shun Chiyonobu, Yukihiro Yazaki, Ziqiu Xue	Japan Geoscience Union meeting 2011, 2011/05/22-27
12	CO2 monitoring by the time-lapse well logging at the pilot-scale injection site, Nagaoka, Japan	Takahiro Nakajima, Ziqiu Xue, Saeko Mito	KACST-JCCP 1st joint international workshop for the Earth's surface and subusurface 4D monitoring in 2012, Rihadh, Saudi Arabia, 2011/1/9
13	Global trends of CO2 geological storage development and approach of RITE	Shigeo Murai	Innovative environmental technology symposium, 2011/12/1
14	current status of CCS technologies	Makoto Nomura	37th Japan Society for Atmospheric Environment symposium in Osaka, 2011
15	Super critical CO2 monitoring in porous sandstone by simultaneous measurement of Vp and resistivity	Ziqiu Xue, Toshifumi Matsuoka	Fall meeting of the Mining and Materials Processing Institute of Japan (invited), 2011/09/28
16	Evidence of Geochemical Trapping at the Pilot-scale CO2 Injection Site, Nagaoka	Saeko Mito, Yuki Asahara, Ziqiu Xue	Annual Meeting of Geochemical Society of Japan (invited), 2011/09/14-16
17	Distributed size of patchy saturated CO2	Hiroyuki Azuma, Chisato Konishi, Ziqiu Xue	Fall meeting of Society of Exploration Geophysicists of Japan Conference (invited), 2011/09/13-15

■2011 Non-Journal Publication

	Title	Researchers	Magazine, Newspaper, etc.
1	Development of CO2 gelogogical storage technologies	Susumu Sakashita, Ziqiu Xue	JCRM News, 2011/4
2	CO2 storage technology in deep saline aquifer	Koichi Takizawa, Ziqiu Xue	Electorical Review, 2011/6
3	Marine environmental assessment for CO2 storage at offshore aquifer	Jun Kita, Ziqiu Xue	Electorical Review, 2011/7
4	Mineral trapping of CO2	Saeko Mito, Ziqiu Xue	Electorical Review, 2011/8
5	Study on monitoring method available for assessing microseismicity in CCS demonstration sites. (Part 1) -A geological survey in the SECARB region, and selection of demonstration site-	Tsutomu Hashimoto, Kinichiro Kusunose, Haruka Kondo, Shigeo Horikawa, Iwao Niinuma, Ziqiu Xue	Japan Society of Engineering Geology 2011/10/27-28
6	Study on monitoring method available for assessing microseismicity in CCS demonstration sites. (Part 2) -Design of microseismic monitoring network and expansion into CCS sites in Japan-	Tsutomu Hashimoto, Kinichiro Kusunose, Shigeo Horikawa, Haruka Kondo, Iwao Niinuma, Ziqiu Xue	Japan Society of Engineering Geology 2011/10/27-28
7	Relative permeability of water and supercritical CO2 under steacy-state flow conditions in porous sandstones	Tetsuya Kogure, Keigo Kitamura, Tatsuya Yamada, Osamu Nishizawa, Ziqiu Xue	International Conference on Flows and Mechanics in Natural Porous Media from Pore to Field Scale- Pore2Field, Rueil-Malmaison, France, 2011/11/16-48
8	Evaluation of a resistivity model derived from the time-lapse well loggings at CO2 injection site, Nagaoka, Japan	Takahiro Nakajima, Ziqiu Xue	KACST-JCCP 1st joint international workshop for the Earth's surface and subusurface 4D monitoring in 2012, Rihadh, Saudi Arabia, 2011/1/9

Notes

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