COE on the Mitigation of Global Warming

RITE is addressing research and development of new technologies for reducing greenhouse gas emissions in collaboration with industry, government and academic institutions around the world.

Development of CO_2 Capture and Utilization Technologies

We are working on developing technology to efficiently capture CO_2 from various sources such as power plant exhaust gases, industrial exhaust gases, and the atmosphere. In addition, we are promoting the development of carbon recycling technology that utilizes CO_2 as a carbon resource.

Development of CO_2 Storage Technologies

We are developing CO_2 geological storage technology. Toward the deployment of CCS technology,the CO_2 Storage Research Group conducts research on safe and stable CO_2 geological storage in deep saline aquifers for a long term and works closely with international organizations.

Development of Biorefinery Technologies

Developing technologies to harness microorganism for efficient production of biofuels and green chemicals based on biomass (renewable resources).

Research on Strategies to Respond to Global Warming

Computer models are developed and optimal scenarios are explored for both economic development and global warming mitigation; both short/mid-term (～2030) and long-term (～2100) scenarios.

Industry Cooperation

CO_2 Separation and Capture･Utilization Technology

- **Development of Chemical solvents:**
  Cooperation with Nippon Steel Corporation
- **Development of CO_2 Separation Membranes:**
  Research promotion with Sumitomo Chemical Co., Ltd.
  via Molecular Gate Membrane module Technology Research Association.
- **Development of Solid sorbent:**
  Cooperation with Kawasaki Heavy Industries, Ltd. (Coal-fired power plant)
  Cooperation with Mitsubishi Heavy Industries, Ltd. (Direct Air Capture)
  Cooperation with CHIYODA CORPORATION and JERA (Natural Gas fired power plant)
- **Development of CO_2 Utilization**
  Cooperation with JFE Steel Corporation
- **Collaboration with companies via the Strategic Council for the Industrialzation**

CO_2 Storage Technologies

Research promotion by the Geological Carbon Dioxide Storage Technology Research Association formed with private companies: Electric Power Development Co., Ltd., ITOCHU Corporation, ITOCHU Oil Exploration Co., Ltd., INPEX Corporation, Japan Petroleum Exploration Co., Ltd., JX Nippon Oil & Gas Exploration Corporation, Mitsubishi Gas Chemical Co., OYO Corporation, TAISEI Corporation, and National Institute of Advanced Industrial Science and Technology and RITE.

Biorefinery Technologies

- **Green Chemicals:**
  Promote the commercialization of green chemicals (aromatic compounds, etc.) through Green Chemicals Co., Ltd., a joint company established by RITE and Sumitomo Bakelite Co., Ltd.
- **Amino Acids, etc.:**
  Promote the commercialization of amino acids, etc. in collaboration with Green Earth Institute Co., Ltd. (GEI), a venture company originating from RITE.

Outreach Activities

Organizing symposiums and exhibitions

Innovative Environmental Technology Symposium
Symposium in Kansai on Global Warming Mitigation Technology for Future Society
RITE Association Meeting　IPCC Symposium　ALPS International Symposium
Symposium for Innovative CO_2 Separation and Utilization Technology
BioJapan (Co-organized)　CCS Technical Workshop

Publication of RITE Today (annual research review)

Others

Public relations through mass media and web site　Facility visit program
Environmental education etc.

International Partners

International

- **ALternative Pathways toward Sustainable development and climate stabilization (ALPS IV)**
  ･International Institute for Applied Systems Analysis (IIASA)
  ･International Energy Agency (IEA)
  ･Resources for the Future (RFF)　･Stanford University
- **Energy Demand change Induced by Technology and Social innovation (EDITS)**
  ･International Institute for Applied Systems Analysis (IIASA)
  ･Lawrence Berkeley National Laboratory (LBNL)
  ･Asian Institute of Technology (AIT)　and others
- **Standardization of CCS (ISO/TC265)**
  Promotion of the activity of Mirror committee in Japan and collaboration to the standardization of ISO/TC265
- **Intergovernmental Panel on Climate Change (IPCC)**
  Data gathering, analysis and recommendation for 6th Assessment Report
- **International Test Center Network (ITCN)**
  Knowledge sharing and collaboration on CO_2 separation & capture technology

United States

- **Japan – US partnership for CCS**
  ･Energy & Environmental Research Center (EERC) in University of North Dakota
  Collaborative project on a field test of fiber optic sensing
- **Lawrence Berkeley National Laboratory (LBNL)**
  Collaborative project on monitoring technology using fiber-optic sensing
- **Illinois State Geological Survey (ISGS)**
  Knowledge sharing on geochemical monitoring at a large-scale test site

Australia

- **Commonwealth Scientific and Industrial Research Organisation (CSIRO), Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)**
  Collaboration on development of technology to monitor fault stability.

Norway

- **Norwegian Geotechnical Institute (NGI)**
  Knowledge sharing on geological deformation measurement and geomechanics analysis

RITE
Research Institute of Innovative Technology for the Earth

Research Institute of Innovative Technology for the Earth (RITE)

https://www.rite.or.jp/

The most updated information on RITE and the research activities are available through e-mail newsletters. Please contact us via our website for any inquiries.

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Keihanna Plaza Laboratory Wing 4F 1-7, Hikaridai, Seika-cho, Souraku-gun, Kyoto, 619-0237
CO_2 Storage Research Group: +81-774-75-2309

- Kyoto Station ----- (Kintetsu Kyoto Line, approx. 30 minutes by express)
  → Shin-Hosono Station ----- (Taxi or Nara Kotsu Bus, approx. 10 minutes) ▶ RITE
- Kintetsu Namba Station ----- (Kintetsu Nara Line, approx. 40 minutes by express)
  → Yamato Saidaiji Station ----- (Kintetsu Kyoto Line, approx. 10 minutes)
  → Yamadagawa/Shin-hosono Station ----- (Taxi or Nara Kotsu Bus, approx. 10 minutes) ▶ RITE
- KIX ----- (Airport Limousine Bus, approx. 100 minutes)
  → Gakken Keihanna Plaza ----- (Taxi, approx. 10 minutes) ▶ RITE

- Approx. 3-minute walk from Uchisaiwaicho Station Exit A3 by Toei Mita Line
- Approx. 5-minute walk from Toranomon Station Exit 1 by Tokyo Metro Ginza Line
- Approx. 7-minute walk from Shimbashi Station Hibiya Exit by JR Yamanote Line, Tokyo Metro Ginza Line

▶ RITE Tokyo Office

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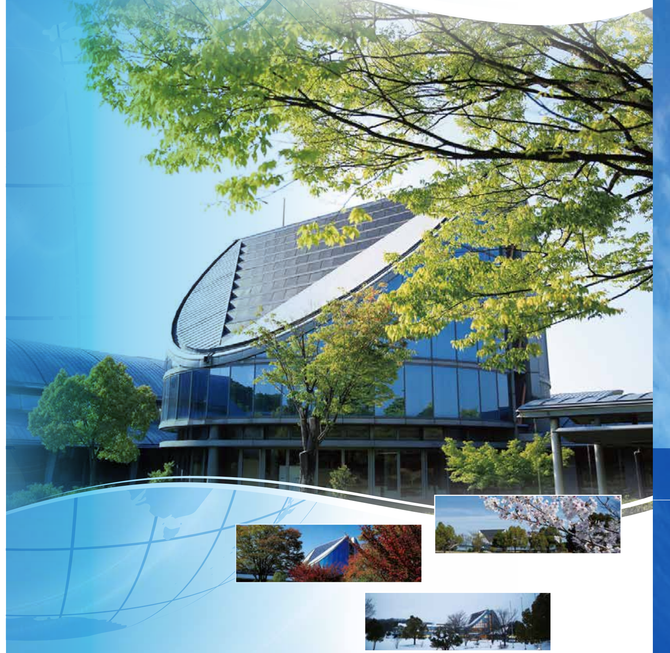
RITE
Research Institute of Innovative Technology for the Earth

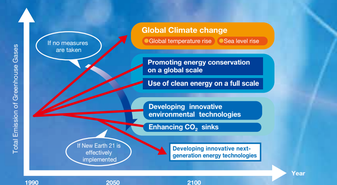


Research Institute of Innovative Technology for the Earth (RITE)

Toward Economic Development and Global Environment Protection

"The NEW EARTH 21": The Earth Regeneration Plan

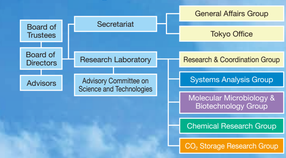
In 1990, the Japanese government proposed the Earth Regeneration Plan, "The NEW EARTH 21", a 100-year plan to clean up our natural environment which has been degraded by human-included activities over the past 200 years.



RITE was established in July 1990 as a center of excellence which would work internationally toward implementing this plan, focusing on the following two measueres;

- **Developing innovative environmental technologies**
- **Enhancing CO_2 sinks**

Organization of RITE



Contributing to the future through our innovative technologies

The Research Institute of Innovative Technology for the Earth (RITE) was established in 1990 as a center of excellence to work internationally toward developing innovative environmental technologies based on the Earth Regeneration Plan "New Earth 21" compiled by the Government of Japan. Since then, we have been carrying out R&D activities particularly for the mitigation of global warming, including R&D on carbon dioxide capture and storage, biorefinery technologies, and integrated analysis on strategies for mitigating global warming. Thanks to these distinctive world-leading research activities, we have become an internationally known institute specializing in technologies for the mitigation of global warming. In recent years, we have been promoting collaborative research with research institutes in the United States and Europe and actively participating in the activities of IPCC. These activities contribute greatly to expanding the international aspects of our research.

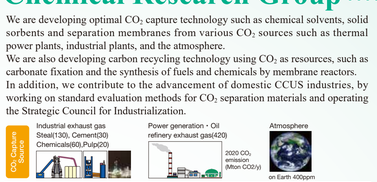
For thirty years, activities for mitigating global warming have been developing worldwide. New Earth 21, the United Nations Framework Convention on Climate Change, the Kyoto Protocol, and the Paris Agreement are representative. Furthermore, Prime Minister Suga declared the goal of "2050 carbon neutral realization" in 2020. It will be necessary to realize the mitigation of global warming under a varied energy supply and demand balanced with the SDGs. Both innovative environmental technologies and digital technologies such as Society 5.0 will be utilized to realize this. We will contribute to the future through our own innovative technology as well.

Finally, we ask for your inspiring advice and continued cooperation for our future activities.

Kenji Yamaji, President
Research Institute of Innovative Technology for the Earth (RITE)

Chemical Research Group

We are developing optimal CO_2 capture technology such as chemical solvents, solid sorbents and separation membranes from various CO_2 sources such as thermal power plants, industrial plants, and the atmosphere.
We are also developing carbon recycling technology using CO_2 as resources, such as carbonate fixation and the synthesis of fuels and chemicals by membrane reactors.
In addition, we contribute to the advancement of domestic CCUS industries, by working on standard evaluation methods for CO_2 separation materials and operating the Strategic Council for Industrialization.



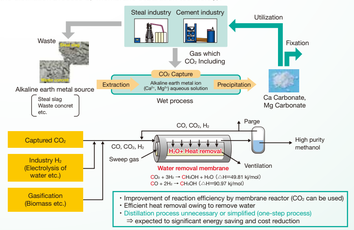
Chemical solvents

We are developing novel amine solvents with energy utilization from low-grade waste heat. We succeeded in the development of amine solvents that can reduce energy consumption by 40%, compared to conventional amine solvents. Some novel amine solvents are in industrial use, and have been adopted in two domestic commercial plants.

■ Industrial use second plant

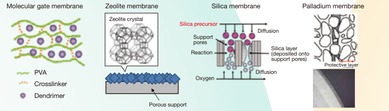
CO_2 utilization

We are developing carbonate fixation using amine compounds and methanol synthesis using inorganic membranes.
For carbonate fixation, we aim to effectively capture calcium and magnesium from solid materials discharged from steel or cement plants.
For methanol synthesis, we aim to enhance the chemical yield of methanol and reduce the load of the distillation process by membrane separation technology.



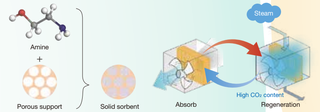
Membranes

We are developing organic membranes such as molecular-gate membranes, and inorganic membranes such as zeolite, silica, and palladium membranes.
For organic membranes, we are working on a molecular-gate membrane module which separates and captures CO_2 from mixed gases including H_2 and CO_2, generated from the production process to obtain H_2 from hydrocarbons.
For inorganic membranes, we are working on the separation between water and alcohol, CO_2 and CH_4 and MCH and H_2.



Solid sorbents

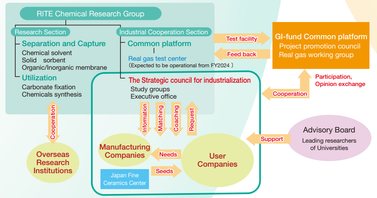
We are developing novel solid sorbents (porous sorbents modified with amines that are used in chemical solvents). The optimal amines and porous supports are chosen depending on the CO_2 concentration. We are working on effective CO_2 separation from coal-fired power plants (CO_2 concentration: around 13%), natural gas power plants (CO_2 concentration: around 4%), the atmosphere (CO_2 concentration: around 0.04%), etc.



■ Development of CO_2 solid sorbent ■ DAC(Direct Air Capture)

The Strategic Council for Industrialization

We are formulating roadmaps for the industrialization of innovative energy and environment technology based on CO_2 separation, capture, and utilization technology.
We are also setting up and collaborating on research with manufacturing and user companies.



Establishment of a common evaluation standard for CO_2 capture materials

We promote efforts to establish a common evaluation standard for CO_2 capture technology. We are developing standard evaluation methods for various CO_2 separation materials, while keeping pace with the international trends in this field. In addition, we will establish a real gas test center in RITE, and support the development of CO_2 separation materials by domestic companies, research institutes, etc.

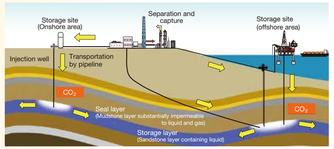
CCUS: Carbon dioxide Capture, Utilization and Storage

CCUS has received increasing attention as an important option to mitigate global warming, and is expected to contribute to approximately 20% of the reduction to be required to achieve carbon neutrality by 2050.

CCUS: Carbon dioxide Capture, Utilization and Storage

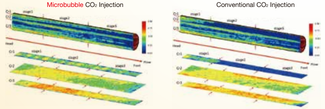
CO_2 Storage Research Group

Toward the deployment of CCS technology, the CO_2 Storage Research Group conducts research on safe and stable CO_2 geological storage in deep saline aquifers for a long term and works closely with international organizations.

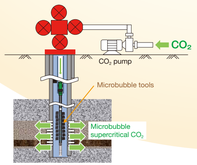


Microbubble CO_2 Injection Technique

In comparison with conventional injection techniques, the microbubble CO_2 injection technique has potentially a high applicability to low-permeable formations. RITE has been developing the technology for years, demonstrating its higher storage efficiency through lab tests.
We have developed tools to generate microbubble CO_2 in a well. The tools have high performance for injection in a deep well at an actual field.



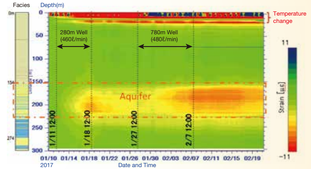
■ CO_2 distributions in sandstone samples by microbubble CO_2 injection and conventional CO_2 Injection (X-ray CT images)



■ Microbubble CO_2 injection test at an actual field

Development of Technique for Monitoring Formation Stability during CO_2 Injection

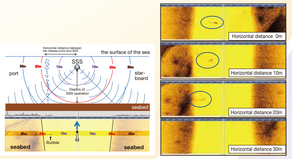
It is desirable to monitor not only the deformations of reservoir and cap rock but those of all formations from reservoir to the surface. RITE has been developing a fiber-optics sensing technique to measure deformations (strains) of formations all along a depth direction. Installing our fiber optic system along a deep water pumping well (300m deep), we have successfully measured deformations of the formations induced by water pumping. We are now trying to improve the installation method.



■ Deformations of formations measured by fiber optics during the water pumping tests

Development of Technique for Detecting CO_2 bubbles by Sonar

For geological CO_2 storage under the seabed in Japan, CO_2 leakage monitoring is mandated by the Act on Prevention of Marine Pollution and Maritime Disaster to demonstrate that CO_2 is not leaking just in case . Aimed at detecting CO_2 bubbles leaked into seawater, RITE have developed a sonar-based technique.



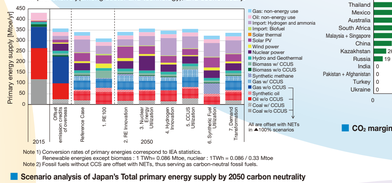
■ Schematic image of sonar bubble detection and images of CO_2 bubbles observed by sonar

Systems Analysis Group

The Systems Analysis Group conducts systematic research regarding policies and measures to mitigate global warming and examinations on the whole system and on scenario development. Also, we make a comprehensive evaluation including synergies and trade-offs between global warming mitigation and sustainable development, and examines more effective measures.

Scenario analysis toward carbon neutrality in 2050

Using a global energy and climate change mitigation model, DNE21+, Rite provides the analyses results for several scenarios for achieving carbon neutrality by 2050. Considering several uncertainties in the outlook of technologies, social constraints, and so on, several scenarios should be assumed and analyzed globally, comprehensively(among sector and technology), and economically.

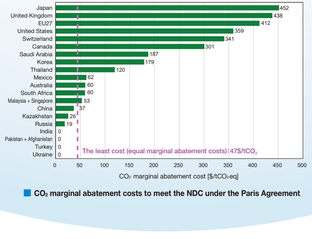


Note 1) Conversion rates of primary energies correspond to IEA statistics.
Renewable energies except biomass : 1 TWh= 0.086 Mtoe, nuclear : 1TWh = 0.086 / 0.33 Mtoe
Note 2) Fossil fuels without CCS are offset with NETs, thus serving as carbon-neutral fossil fuels.

■ Scenario analysis of Japan's Total primary energy supply by 2050 carbon neutrality

Evaluations on NDCs under the Paris Agreement

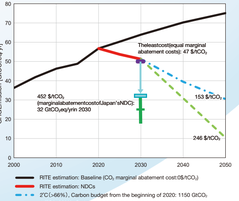
Under the Paris Agreement, as each country voluntarily submits its reduction target, an international review system is important to increase effectiveness. In this regard, we develop evaluation measures of the Nationally Determined Contributions (NDC) which were submitted to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat, and make an assessment by employing multiple indicators enabling to measure the level of efforts.



■ CO_2 marginal abatement costs to meet the NDC under the Paris Agreement

Relationship between NDC in 2030 and long-term scenario

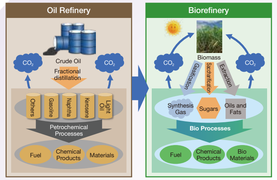
It is difficult to achieve the two degrees Celsius target with high degree of certainty even if countries meet their NDC pledges. Beyond 2050, a further deep emission reduction is required, and the development and diffusion of innovative technologies should be focused on.



■ Interrelationship between the expected global GHG emissions of the aggregated NDCs and long term emission pathways for the 2°C and 1.5°C goals

Molecular Microbiology and Biotechnology Group

Our group is working on biorefinery research and development targeting on social implementation. By harnessing this technology, we are able to produce various valuable fuels and chemicals from biomass rather than petroleum-based resources. Since naturally carbon dioxide is absorbed along plant growth, our biomass utilization substantially contributes to carbon neutrality.



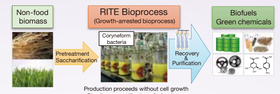
Created by RITE based on Japan Bioindustry Association materials

■ Shift from fossil fuel resources to biomass utilization

Fundamental technology for biorefinery

RITE has established RITE Bioprocess, our biorefinery technology which utilizes coryneform bacteria to produce various biofuels and green chemicals at world's highest level productivity.

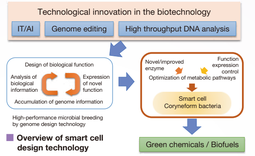
This technology enables bioproduction of the target compounds without competing with food resources by using mixed sugars derived from non-edible biomass (cellulose). Since no petroleum is used as a raw material, it also contributes for reduction of CO_2 emission.



■ Overview of "RITE Bioprocess" for biorefinery

Development of smart cell design technology

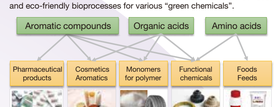
In recent years, rapid technological innovation is progressing in the biotechnology field by fusing information and digital technologies (IT and AI) with cutting-edge technologies including genome editing and high throughput DNA analysis. By incorporating these state-of-the-art technologies, we are working on the development of "smart cells (high-performance microorganisms)" with highly designed functions and utilize them to produce various valuable products.



■ Overview of smart cell design technology

Development of green chemical production technology

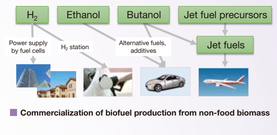
Coryneform bacteria is vastly superior at producing not only amino acids and organic acids, but also aromatic compounds which have been difficult to do with conventional methods. Utilizing this bacterium, we are working on the development and commercialization of low-cost and eco-friendly bioprocesses for various "green chemicals".



■ Commercialization of green chemicals utilizing smart cells

Development of biofuel production technology

High-tolerance against solvent makes coryneform bacteria suitable for production of biofuels, including ethanol and butanol. While also considering novel bio-jet fuel and hydrogen that is expected as the ultimate clean fuel, we are working on the development and commercialization of biofuel production capable of drastically reducing CO_2 emissions.



■ Commercialization of biofuel production from non-food biomass