

## **Current status of research and development related to clean energy at RIKEN**

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### **1. Introduction**

RIKEN is Japan's largest comprehensive research institution renowned for high-quality research in a wide array of scientific areas spanning physics, engineering, chemistry, computational science, biology, and medicine. Founded in 1917 as a private research foundation, RIKEN has grown rapidly in size and scope, today encompassing a network of world-class research centers and institutes across Japan.

Now, as a national research and development institute, RIKEN's mission is to maximize research and development outcomes effectively and efficiently. We must at all times remain keenly aware of our responsibility to society, while at the same time ensuring the autonomy and creativity of our scientists. We will link our discoveries in science and technology to the creation of new value, integrate the synergies that distinguish RIKEN, and strengthen our collaborations with partners inside and outside Japan. We will do this by continuing with basic research, which is the source of knowledge, and by developing outstanding technologies. As a world leader in science, RIKEN will strive to create a better life for the Japanese people and contribute to the global community.

In 2015, two historic proposals—the Paris Agreement on global warming (COP21) and the United Nations 2030 Agenda for Sustainable Development—were supported by more than 190 countries. Japan promised to work on realizing the Agenda's 17 sustainable development goals (SDGs) and to move toward a 26 per cent reduction of greenhouse gases from 2013 levels by 2030. To fulfill Goal 7 (affordable and clean energy) of the SDGs and to achieve the greenhouse gas emissions reduction target, Japan has undertaken and expanded scientific initiatives in clean energy technology research and development as a part of its national science policy. As one of RIKEN's missions is to advance R&D based on national strategies, we have also strategically engaged in R&D in this field.

### **2. R&D activities related to clean energy technology**

The RIKEN Center for Sustainable Resource Science (CSRS) plays a major role in research and development for clean energy technologies within RIKEN. Since its establishment in 2013, CSRS has been a leader in creating a sustainable society through transdisciplinary integration of plant science, chemical biology, and catalytic chemistry. Using as guides the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 and the agreement of the COP21 on achieving zero greenhouse gas emissions, we are promoting five flagship projects. Each of these projects aims to further advance basic research in the efficient creation, exploration, and use of beneficial substances from natural resources, sustainable food production, and bioproduction that CSRS has been undertaking in the past. In addition, the projects will move beyond the boundaries of research fields and develop manufacturing methods with less impact on the environment. In particular, advances made in recent years in AI and data science can bring about a significant step forward. While actively nurturing the next-generation of scientists with a strong background in information science, CSRS will lead in creating a future world where people can live healthy and prosperous lives.

In addition to CSRS, other research centers are also involved in research and development for element technologies that can help advance clean energy technologies. Research and development is conducted through the integration of research fields, the promotion of joint

research inside and outside of RIKEN, and the effective use of large-scale facilities such as supercomputers and synchrotron radiation facilities.

### **3. Specific Research activities in hydrogen, CCUS, and related technologies**

Carbon dioxide capture, utilization (CCU) is a technological solution that aims to use CO<sub>2</sub> as a source to produce useful substances, such as chemicals and fuels, by capturing and compressing CO<sub>2</sub> via chemical reactions (by using catalysts), biological reactions (by using plants and algae), or a hybrid of the two.

To reduce greenhouse gas emissions and develop alternative means to create energy, RIKEN is currently advancing R&D projects related to hydrogen, CCU, and other relevant technologies. Research topics include artificial photosynthesis, converting CO<sub>2</sub> and H<sub>2</sub>O into chemical fuels, and biological approaches that help plants and algae absorb CO<sub>2</sub> and/or produce useful substances. Supported by the New Energy and Industrial Technology Development Organization (NEDO), the RIKEN Center for Advanced Photonics (RAP) collaborate with CSRS and they jointly focus on hydrogen production by water electrolysis, a candidate technology to master the use of natural energy sources that, while carbon-free, experience substantial fluctuations. Specifically, this technology R&D project is working to design and control a hydrogen production system that uses a non-noble metal catalyst with an incorporated photosynthesis mechanism so that H<sub>2</sub> can be produced efficiently from H<sub>2</sub>O at a low cost.

RIKEN is also involved in a development project for a system that uses electricity obtained from renewable energy and a non-noble metal catalyst to directly and efficiently produce basic chemical compounds such as ethylene from CO<sub>2</sub> and H<sub>2</sub>O under ordinary temperatures and normal pressures.

Furthermore, we are conducting research on alternatives for fossil fuels, focusing on algae that can produce an abundant amount of oil. Using microalgae analysis and metabolic analysis techniques, CSRS is working on research to discover a metabolic pathway related to the amount of fat and oil production through the analysis of metabolic products and gene expressions of microalgae beneficial to industry. Using matching funds from a corporation that aims to develop microalgae biofuels for practical application, RIKEN has also established a joint research team engaged in developing techniques to mass-produce these biofuels through gene search and gene modification techniques.

*Related programs/projects conducted by the institute (further information on programs/projects are found in the template)*

- Degradation analysis and stabilization improvement of polymer membrane water electrolyzer with non-precious metal catalyst under fluctuating power source (NEDO FY2018-FY2020)
- Hybrid Electrocatalysts for C<sub>2</sub> Production from CO<sub>2</sub> and the Appropriate System (NEDO FY2018-FY2019)
- Development of innovative technology to increase biofuel of microalgae(2018-2023)

### **4. International collaboration**

#### **4-1 International alliance/networking development**

RIKEN is not yet involved in such activities.

#### **4-2 International joint R&D activities**

Concerning the research activities on hydrogen and CCU by RAP and CSRS, RIKEN has collaboration with Lawrence Berkeley National Laboratory (US), National University of

Singapore, Nanyang Technological University (Singapore), Korea Institute for Advancement of Technology, Chonnam National University (Korea), Strasbourg University (France) and Dalian National Laboratory for Clean Energy (China),

- Program/Project name and the topic

## **5. Future perspectives**

To address global issues, including SDGs, not only science and technology but also collaboration among all governments, private sectors, and societies is important. Especially when implementing large-scale clean energy projects, we must unify element technologies, including conversion, transportation and storage, into one system, and collaboration with a variety of sectors is essential for this unification. We will endeavor to engage in collaborative research with other sectors to create problem-solving models as we continue to drive innovation in the development of technology that can produce game-changing outcomes.

(Please attach the CV of participant (with photo))



Hiroshi Matsumoto  
President of RIKEN

### **Career**

- 2015 President, RIKEN
- 2008 President, Kyoto University (–2014)
- 2007 Professor Emeritus, Kyoto University
- 2005 Executive Vice-President (Research and Finance), Kyoto University
- 2004 Director, Professor, Research Institute for Sustainable Humanosphere, Kyoto University
- 2002 Director, Radio Science Center for Space and Atmosphere, Kyoto University
- 2000 Professor, Radio Science Center for Space and Atmosphere, Kyoto University
- 1992 Director, Radio Atmospheric Science Center, Kyoto University
- 1987 Professor, Radio Atmospheric Science Center, Kyoto University
- 1981 Assistant Professor, Radio Atmospheric Science Center, Kyoto University
- 1980 Visiting Researcher, Stanford University
- 1975 Visiting Researcher, NASA Ames Research Center
- 1974 Assistant Professor, Kyoto University
- 1967 Lecturer, Kyoto University

### **Awards and Honors**

- 2017 Honorary Officer of the Most Excellent Order of the British Empire
- 2015 Chevalier in the French Legion of Honor
- 2014 Japan Geoscience Union Fellow
- 2014 Honorary Doctor of Engineering, University of Bristol
- 2008 Hasegawa Nagata Award, SGEPPS, Japan
- 2008 URSI Gold Booker Medal
- 2007 Medal with Purple Ribbon
- 2006 Ministers' Award, Science and Technology Division, The Ministry of Education, Culture, Sports, Science and Technology
- 2006 Russian Federation of Cosmonautics Gagarin Medal
- 2004 Associate Award of the Royal Astronomical Society
- 2003 IEEE Fellow Award
- 1999 AGU Fellow Award for Space Plasma Physics
- 1998 NASA Group Achievement Award (GEOTAIL)
- 1993 NASA Group Achievement Award (GEOTAIL)