Recommendations
for
Achievement of Carbon Neutrality by 2050

- Toward Achievement of Net Zero Carbon Dioxide Emissions and Creation of New Businesses by Carbon Recycling -

June, 2021

Carbon Recycling Fund Institute

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1. Outline of Recommendations

As a last resort, looking beyond COVID-19, the carbon neutrality is now an international trend to solve globally shared issues such as the global warming and sustainable procurement of resources and energies. The following are recommendations made, taking this opportunity, by Caron Recycling Fund Institute (CRF) toward the achievement of carbon neutrality through the establishment of "Sustainable Carbon Society" based on the carbon recycling that utilizes carbon dioxide as a resource, and we will, on our own initiative, work with our member companies (hereinafter referred to as "CRF member(s)") for their realization:

Acceleration of Innovation and Development of Human Resources

- Carbon recycling technologies are still at the early stage of full-fledged research and development/demonstration. Japan, as well as U.S., Germany and other countries, remains competitive in development. In order to achieve the carbon neutrality by 2050, CRF members will be actively committed to developing, putting to practical use, and socially implementing carbon recycling technologies and products as well as investing therein. To that end, they will make the best use of inter-industry collaboration and open innovation including collaboration with start-ups and ventures to accelerate the development.
- To help such industrial movement, the national government needs to enhance its measures to accelerate the development and demonstration related to green innovation (such as carbon recycling and improvement of carbon dioxide (including hydrogen and ammonia) supply chains) for strong support for the development and promotion of innovation.
- Also important are measures to develop human resources that will lead the creation and social implementation of innovation.

Improvement of Market Environment

- The significance and role of carbon recycling technologies and products will be established through their social implementation. Thus, CRF members will endeavor to promote their social implementation while utilizing inter-industry and industry-academia-government collaboration for fostering an understanding of, and widespread use of, the carbon recycling technologies and products.

- In alignment with the industrial movement, the national and local governments need to support the enlargement of market for, and cost reduction of, those products through the public procurement. To that end, it is expected to make the best use of EXPO 2025, Osaka, Kansai and other occasions.

- Companies and the national government will collect and accumulate data related to the separation, recovery and use of carbon dioxide through social implementation to proceed with the preparation for quantitative evaluation. In doing so, they should, through objective considerations, focus on the total optimization of impacts associated with the implementation of carbon recycling.

- Japan should lead, and take the initiative in, the evaluation of a carbon dioxide sink such as ocean and plants and the development of international rule.

- In order to maintain and enhance the global competitiveness of Japan through the social implementation of carbon recycling, the national government is required to push forward the review of relevant systems and regimes.

●COVID-19 is changing our values and behaviors. It is also important to take advantage of the ongoing digitization and decentralization to link carbon recycling with measures for regional revitalization.

Development in Global Market

●As a movement toward carbon neutrality spreads internationally, CFR members, seeing it as an opportunity, will actively tap into the global market, including the licensing business.

●To support the movement, the national government is expected to show Japan's presence in international discussions. It is also important to enhance the international collaboration through an industry-academia-government international conference on carbon recycling, conclusion of a memorandum of cooperation with other countries, and/or joint research based on them.

●It is important for the government, industry and academia to work together to enhance the transmission of information to the world on the usability and progress of carbon recycling. As a part of this, Roadmap for Carbon Recycling Technologies developed by the national government is required to be revised as it progresses.

2. Background to Promotion of Carbon Recycling

At the Davos Forum in January, 2019, former Prime Minister Abe said, taking as an example the artificial photosynthesis and methanation[1], "carbon dioxide could well be the best and most affordable resource for multiple use" as we were to be committed to solving globally shared issues such as the global warming and sustainable procurement of resources and energies, and "it is time now to think about CCU, Carbon Capture and Utilization."

This led to the launch of carbon recycling policy in February, 2019. The Carbon Recycling Promotion Office was established in the Ministry of Economy, Trade and Industry, and the Roadmap for Carbon Recycling Technologies was developed in June. In parallel with the action of the national government, Carbon Recycling Innovation Study Group had been formed on a private sector basis that then evolved into Caron Recycling Fund Institute (CRF). CRF aims to solve the global warming issues while improving the access to energies in the world at the same time, with intent to support the creation of innovation that helps the carbon recycling through public relations, sponsorship for research and other activities.

In October, 2020, Prime Minister Suga, in his policy speech, declared that he would aim for achieving the carbon neutrality by 2050, and told that the revolutionary innovation, especially carbon recycling, would be a key to this. Green Growth Strategy through Achieving Carbon Neutrality in 2050 developed in December, 2020 has formulated 14 growth sectors including the carbon recycling and created the Green Innovation Fund of two trillion yen, which has accelerated the efforts for carbon recycling.

Under these circumstances, Japan's new greenhouse gas emissions reduction target of a "46% decline from fiscal 2013 levels" was announced in April, 2021.

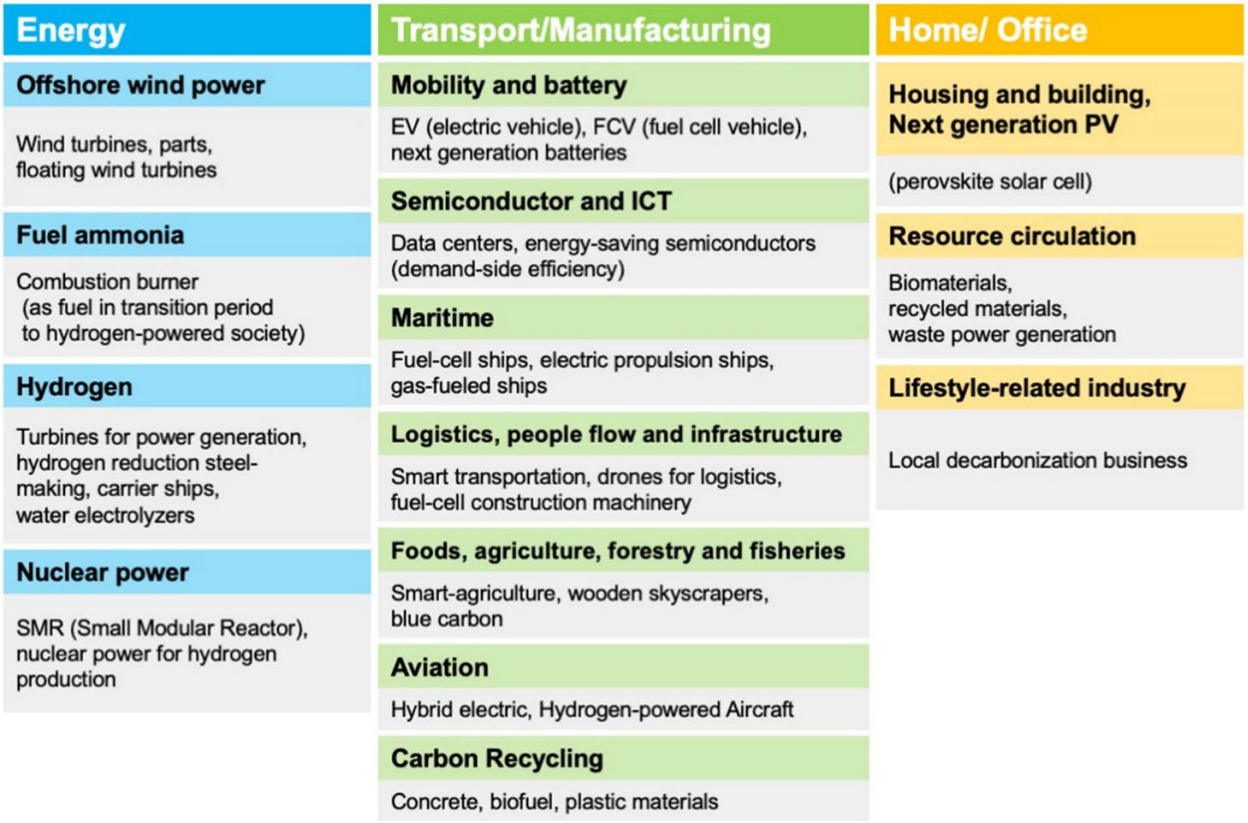

Figure 1: Green Growth Sectors Formulated by Ministry of Economy, Trade and Industry (METI), Source: Website of METI

3. Influence of COVID-19 Pandemic

In 2020, the fast spread of COVID-19 caused the serious economic stagnation due to lockdown in major cities in the world. This led to the reduction of carbon dioxide emissions in the world. However, carbon dioxide emissions derived from energy consumption is said to be reduced by about 6% from the previous year[2], indicating how challenging and difficult it is to achieve zero emissions of carbon dioxide.

On the other hand, there is a huge challenge of improving the energy access as the number of people without access to electricity still amounts to 800 million in the world, which casts a shadow over the achievement of SDGs in 2030.

Under such circumstances, in May, 2020, the European Commission placed the European Green Deal at the center of their economic recovery policy from COVID-19, and clearly stated that EU would focus on the environmental issues such as renewable energy, energy storage technologies, hydrogen, batteries and CCS. China, at the U.N. General Assembly in September, 2020, called for a "green recovery" of the world economy in the post-COVID era, and told that it would achieve a peak in carbon dioxide emissions before 2030 and carbon neutrality by 2060. The United States, which had withdrawn from the Paris Agreement under the former administration, formally rejoined the agreement in April, 2021 under the new administration. The country hosted the Leaders' Summit on Climate in April, 2021 and set a goal of net zero of carbon dioxide emissions by 2050. Thus, it has clearly displayed an attitude of seeking to regain leadership in the international community through measures against global warming.

As mentioned before, Japan's new target for reducing greenhouse gas emissions was publicly announced in April, 2021. From the view point of sustainable corporate value improvement, highly conscious companies, looking at the post-COVID era, have accelerated their activities toward the carbon neutrality while utilizing digital technologies and AI based on the understanding that they should reshape the future in a flexible manner with COVID-19 as a turning point.

The significance of carbon recycling that is a key to those issues will increase its importance.

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[1] Technology to use carbon dioxide and hydrogen to produce methane

[2] Quotation from Global Energy Review 2020, IEA, issued on March 2, 2021

4. Significance of Carbon Recycling

The carbon neutrality means, not the reduction of carbon dioxide emissions caused by human activities to zero, but balancing of "carbon dioxide to be emitted no matter how hard we try after our greatest efforts to reduce emissions" with "carbon dioxide to be immobilized and used as resources with the help of ocean, plants and other power of nature and through the science-and-technology based use and/or storage of them" to add up to net zero.

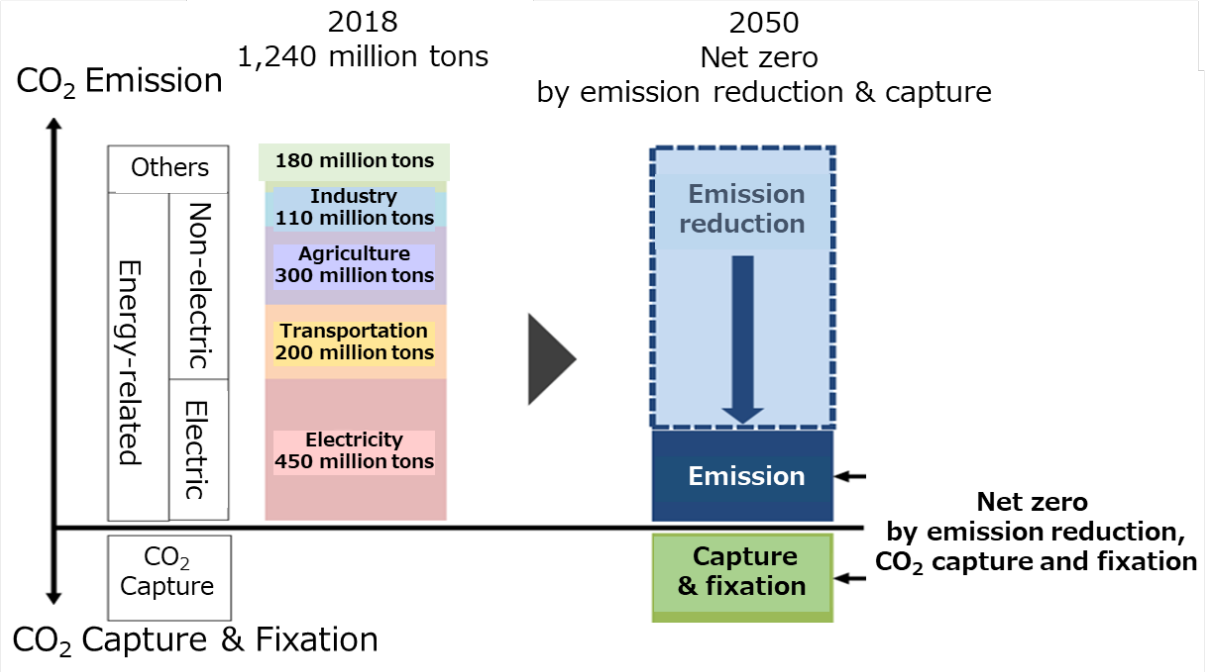


Figure 2: Estimated Carbon Dioxide Emissions Derived from Energy Consumption
Developed by METI, Source: Website of METI

Most carbon compounds containing carbon dioxide are from natural sources and a fundamental substance that is essential to maintain life. For example, plants play a role in using carbon dioxide as raw materials to synthesize carbon compounds to supply them to the natural environment. A body of creatures including human beings is composed of substances with carbon as framework, thus being a part of the carbon cycle on the earth as a whole.

The global warming issues are essentially caused by the increased carbon dioxide in the air above the naturally balanced level due to the use and combustion of fossil fuels by human beings at an extremely rapid pace after the Industrial Revolution. What we human beings should do is to use and recycle as resources by an innovation such excessive carbon dioxide to restore the natural balance. It is also necessary to take steps at the same time with regard to the adaptation to climate change, especially the disaster prevention, given the looming phenomenon such as extreme weather events.

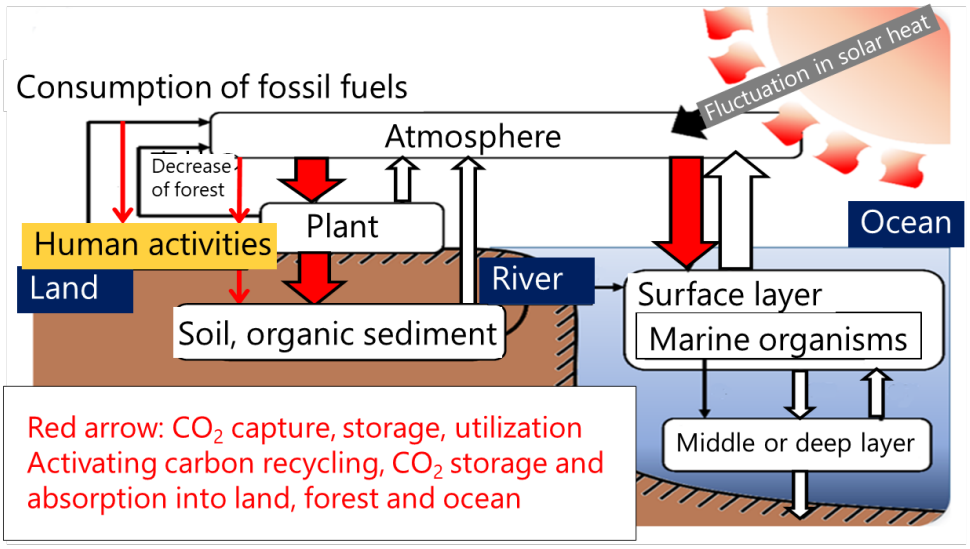


Figure 3: Global Carbon Cycle Model

Source: Prepared based on materials from Center for Global Environmental Research, etc.

Toward the carbon neutrality by 2050, it is indispensable to positively push forward a radical energy transformation including the development and implementation of renewable energy and change in life style. A key to this is to aim to achieve the carbon neutrality through the establishment of "Sustainable Carbon Society" based on a concept of carbon recycling. This will help the adaptation to, and mitigation of, climate change, improvement of access to energies, economic recovery from the COVID-19 pandemic, promotion of circular economy and enhancement of global competitiveness, bringing about the sustainable development of Japan and the rest of the world for a longer term.

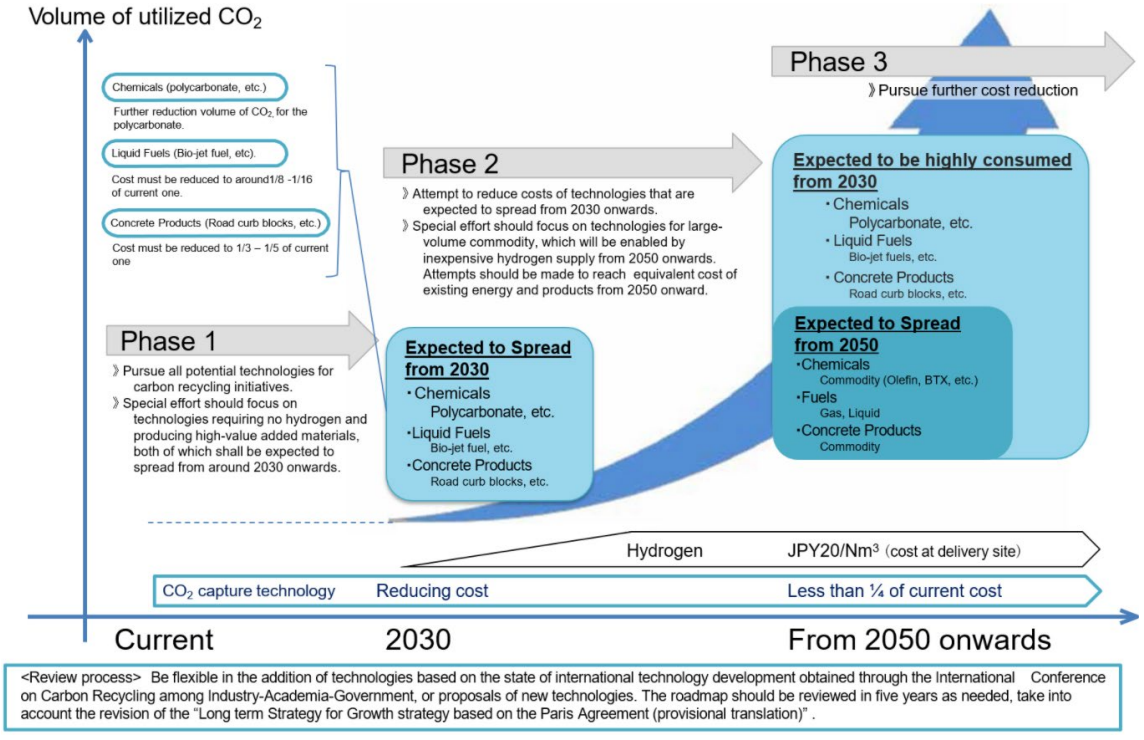


Figure 4: Roadmap for Carbon Recycling Technologies developed by METI

Source: Website of METI

5. Promotion of Public Relations for Carbon Recycling

CRF members will disseminate the significance of carbon recycling mentioned above by delivering science-based information so as to gain an understanding and cooperation of a wide range of stakeholders ranging from specialists to the public. These public relations are expected to dispel misconceptions of "the elimination of carbon dioxide, which allegedly causes the global warming, is the only way to solve the global warming issues" and "the carbon neutrality targets will limit economic activities", and to lead to a positive awareness and behavior on a societal level such as seeing the carbon recycling as a new business opportunity and/or change in life style on a voluntary basis.

■ CRF Activities: Our website provides a content that describes scientific events in a comprehensible way related to the carbon recycling for a proper understanding of carbon dioxide. The public relations include the introduction of CRF members' activities related to the carbon recycling and career seminars held online for students in order to find next-generation industrial leaders.

Figure 5: Online Seminars in FY 2020
Source: Website of CRF

6. Development and Promotion of Innovation and Development of Human Resources

Carbon recycling technologies are still at the early stage of full-fledged research and development/demonstration. As startups with a promising technological seed have attracted capital especially in foreign countries, the research and development has advanced rapidly. Japan, as well as U.S., Germany and other countries, remains competitive in development. So as to keep Japan's research and development abreast, CRF members will be actively committed to developing, putting to practical use, and socially implementing carbon recycling technologies and products as well as investing therein. To that end, they will make the best use of inter-industry collaboration and open innovation including collaboration with start-ups and ventures to accelerate the development.

To help such industrial movement, the national government needs to promote the encouragement of the social implementation in an interdisciplinary manner of a promising technology, and to strongly support the development and promotion of innovation, including the development of human resources taking responsibility for the future and of ventures, through accelerating the development and measures related to green innovation (such as carbon recycling and development of carbon dioxide (including hydrogen and ammonia) supply chain). CRF plans to establish a carbon recycling university as a new venue for developing human resources.

■ CRF Activities: They include the discovery of hidden ideas and talents in companies and universities, and support of a fundamental study with excellence in creativity and/or innovation related to the carbon recycling to help its next step of demonstration test and/or social implementation. Specifically, we conduct sponsorship activities for individual researchers or research teams in the wide range of fields related to the carbon recycling, including energy, chemistry, materials, separation and recovery, hydrogen as well as agriculture, forestry and fisheries.

In fiscal 2020, twelve were chosen among 35 projects applied, with grant of 81.86 million yen in total.

7. Sectors with Potential to Utilize Large Amount of Carbon Dioxide

As the carbon recycling is a concept related to not only the energy industry but also all kinds of industries, it has a potential to utilize a large amount of carbon dioxide for zero emissions. Other sectors with a potential to deploy are as follows:

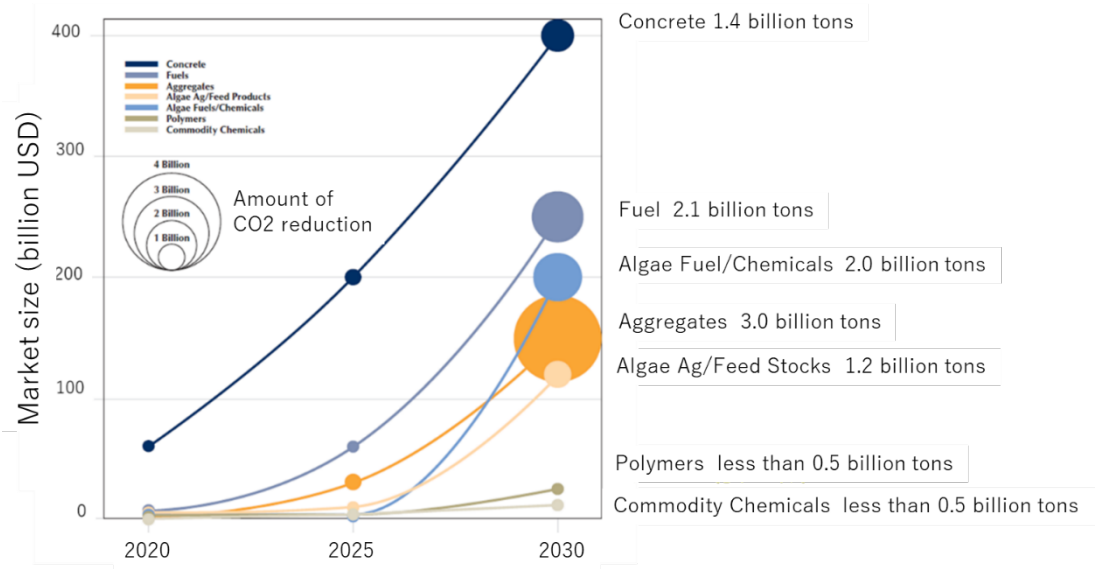


Figure 6: Sectors with Large Potential to Utilize Large Amount of Carbon Dioxide
Source: Prepared based on materials published by U.S. DOE
at 15th Carbon Dioxide Utilization Summit (2020)

(1) Materials Sector

Concrete and aggregate are among first industries listed under the carbon recycling sector in the Green Growth Strategy. In addition, U.S. Department of Energy (DOE) estimates that the concrete will be the largest market, with potential carbon dioxide emissions reduction, if combined with aggregate, being 5 billion tons, the largest in the world. By enhancing the competitiveness through the research and development, demonstration projects and public procurement by the national government, a social implementation and entry into global market is expected to be achieved around 2030. As the offshore wind power generation is to be widely deployed in Japan, the concrete can be used as a foundation block for it.

■ Example of Leading Practice by CRF Members: Taiheiyo Cement Corporation

Taiheiyo Cement Corporation will set up a demonstration facility to separate and recover carbon dioxide in its cement factory with the research grant from NEDO to conduct a demonstration test for the separation and recovery of carbon dioxide of 10 tons a day from exhaust (fiscal 2020/21).

It will be the first demonstration test in Japan to separate and recover carbon dioxide of this amount in the cement factory. In addition, it is developing an elemental technology to immobilize as carbonate the separated and recovered carbon dioxide with using concrete wastes or ready-mixed concrete sludges to recycle it as cement raw materials, base course materials for road paving, and/or other civil work materials.

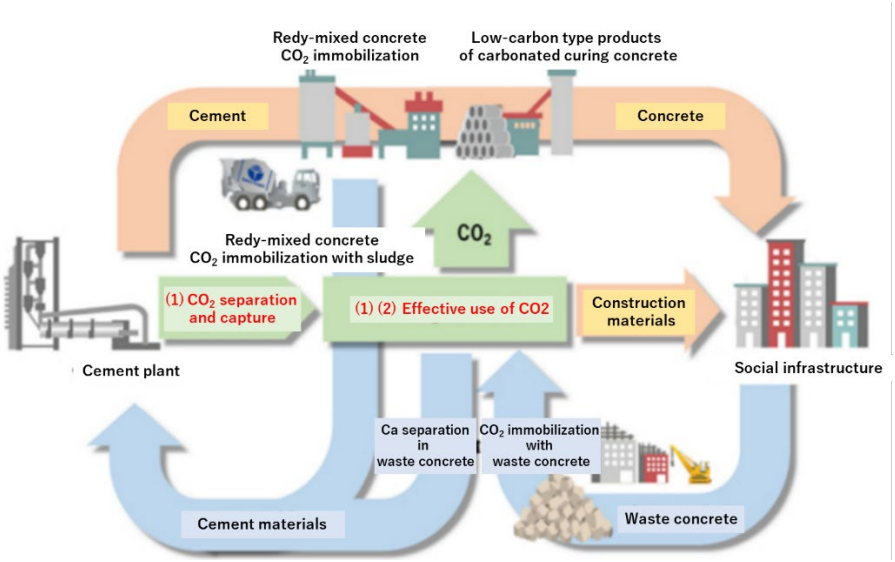


Figure 7: Conceptual Diagram of Carbon Recycling Technology-Enabled Cement Manufacturing Process
Source: Materials from Taiheiyo Cement

(2) Agriculture, Forestry and Fisheries Sector

Promising elements in the agriculture, forestry and fisheries sector include the blue carbon, afforestation and soil fixation. As the carbon recycling in the agriculture sector will lead to the improvement of self-sufficiency in food products, innovative farms are committed to the production management through the carbon density control such as a plant factory. The forestry sector can immobilize a large amount of carbon dioxide by the development of forest as a carbon dioxide sink and logging in a planned manner of trees at their appropriate age through the promotion of robotization on a steep terrain. Moreover, a civil engineering/construction project contributes to the immobilization of carbon dioxide as more woods are used actively for schools, community halls and other public facilities from a stand point of immobilizing carbon dioxide. In the fisheries sector, high expectations are placed on the blue carbon, and there is an initiative to make concrete mainly out of industrial by-products of coal ashes to install it in the sea for an increase in seaweeds attached. Some of those actions have been put into practice as an agro-industrial collaborative project, providing a large potential of carbon dioxide storage.

■ Previous Case by CRF Members: Electric Power Development Co., Ltd.
Osaki CoolGen Corporation, co-founded by Electric Power Development Co., Ltd. and the Chugoku Electric Power Co., Inc., plans to liquefy and transport carbon dioxide recovered from a coal-fired power plant to utilize it as a raw material for photosynthesis at a tomato garden in Kitakyushu that it co-operates with Kagome Co., Ltd. By setting the carbon dioxide density in the greenhouse of the garden higher than that in the air, the growth of plants will be stimulated for increased productivity.

Figure 8: Tomato Garden Co-operated by Electric Power Development and Kagome
Source: Website of Electric Power Development

(3) Chemical Sector

As carbon dioxide is a nonpolar and chemically stable molecule, it is hard to cause its reaction. Therefore, the catalyst development holds the key to the development of technology to make chemicals from carbon dioxide, and high expectations are placed on the improved selectivity and efficiency as well as lower cost of the catalyst. Its effective use is also expected in and out of a chemical complex that emits a high level of carbon dioxide.

■ Previous Case by CRF Members: Mitsubishi Chemical Corporation
Mitsubishi Chemical Corporation, as a member of Japan Technological Research Association of Artificial Photosynthetic Chemical Process (ARPChem), has worked to establish artificial photosynthetic and chemicals manufacturing processes to make chemical materials and plastics from carbon dioxide-free hydrogen derived from water splitting by the sunlight and carbon dioxide emitted from factories. Toward its social implementation around 2040, the company plans to conduct a large-scale demonstration by 2030.

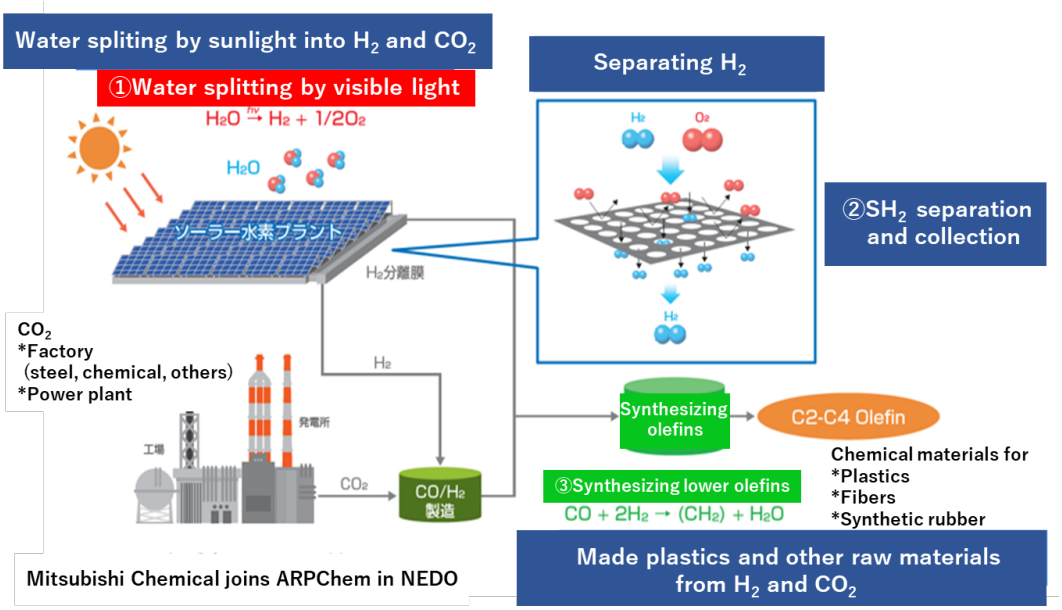


Figure 9: Artificial Photosynthesis; Outline of its Mechanism
Source: Materials from Mitsubishi Chemical

■ Previous Case by CRF Members: Furukawa Electric, Co., Ltd. and Chiyoda Corporation

Furukawa Electric, Co., Ltd. and Chiyoda Corporation are developing a system to directly make, under conditions of low temperature and pressure, basic chemicals (C2 compounds such as ethylene) from carbon dioxide and water (H_2O) that uses as an energy source the electricity, renewable energies in particular, through the development of electrode materials for cathodes. While an existing method emits about 11 tons of carbon dioxide equivalent per 1 ton of ethylene, the reduction by some three tons is expected by combining electricity from thermal power with carbon dioxide as raw materials. It is further estimated that the use of electricity from renewable energy sources will immobilize as ethylene three tons of carbon dioxide equivalent per 1 ton of ethylene, without emitting any carbon dioxide.

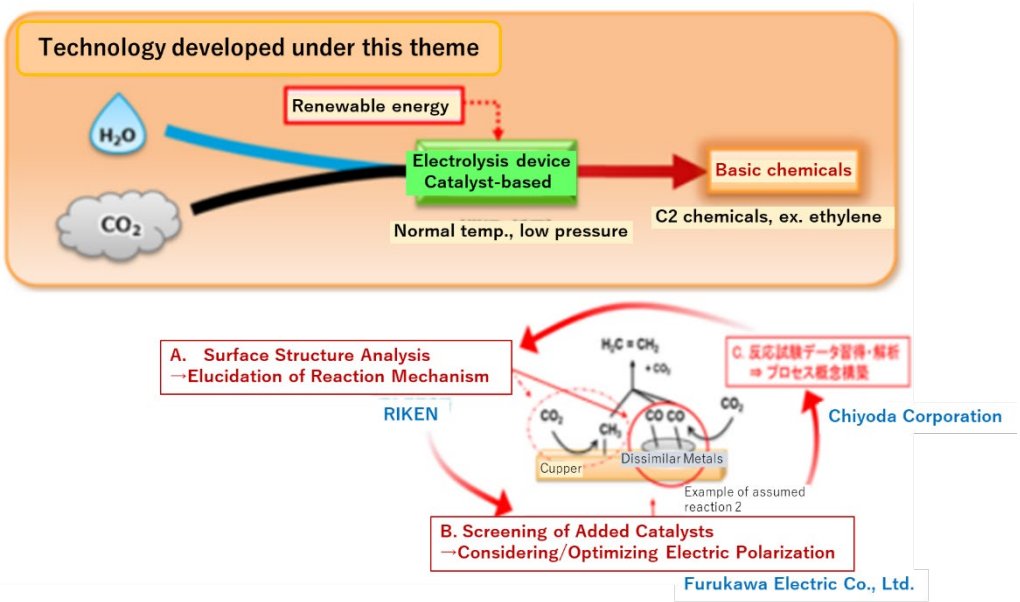


Figure 10: Making Basic Chemicals from CO_2 and H_2O with Catalyst-based Electrolysis Device
Source: Materials from Furukawa Electric

(4) Fuel Sector

Bio-based diesel and jet fuels are under development. Furthermore, with the ongoing methanation technology-enabled development of gas fuels and e-fuels, the fuel sector for automobiles, ships and aircrafts has a high potential for the use of carbon dioxide.

■ Previous Case by CRF Members: euglena Co., Ltd.

euglena Co., Ltd. has been committed to introducing biofuels into the mobility on the land, in the sea and air. In its production and demonstration plant for biofuels established in Tsurumi, Yokohama, the company is making next-generation biodiesel and bio-jet fuels from oils derived from euglena microalgae and used edible oils. It was certified to a new standard of ASTM International in January, 2020, and perfected fuels in conformity to the standard in March, 2021. It looks to achieve the world's first flight of a jet using euglena biofuels during 2021.

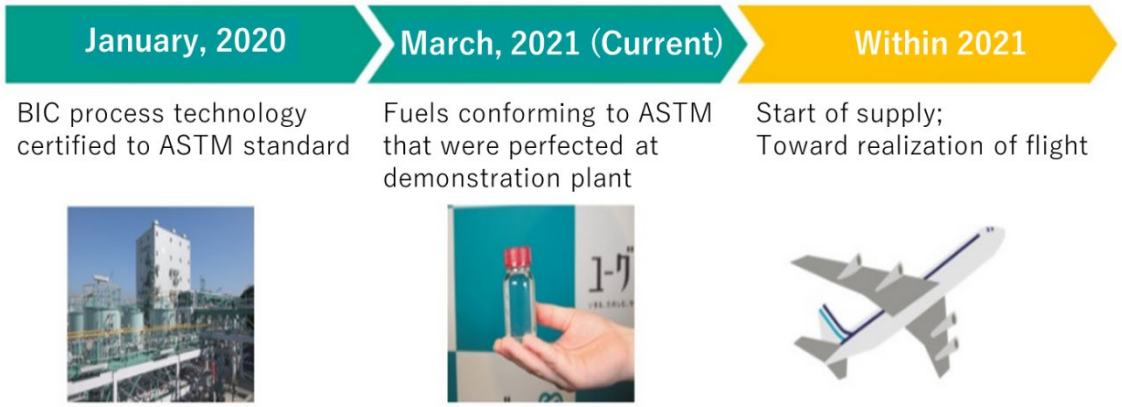


Figure 11: History of Bio-jet Fuels
Source: Website of euglena

(5) Recovery from Air

Direct air capture (DAC) technologies to recover carbon dioxide from the air have started to deploy overseas. While securing and storing carbon dioxide emitted, Japan should examine a way to utilize it as an important carbon source.

8. Improvement of Market Environment

As shown in 7 above, the significance and role of carbon recycling technologies and products will be established through their social implementation. Thus, CRF members will endeavor to promote their social implementation while utilizing inter-industry and industry-academia-government collaboration for fostering an understanding of, and widespread use of, the carbon recycling technologies and products.

In alignment with the industrial movement, the national and local governments need to support the enlargement of market for, and cost reduction of, those products through the public procurement. To that end, it is expected to make the best use of EXPO 2025, Osaka, Kansai and other occasions.

Companies and the national government will collect and accumulate data related to the separation, recovery and use of carbon dioxide through the social implementation to proceed with the preparation for quantitative evaluation. In doing so, they should, through objective considerations, focus on the total optimization of impacts associated with the implementation of carbon recycling.

Japan should also lead, and take the initiative in, the evaluation of a carbon dioxide sink such as ocean and plants and the development of international rule.

In order to maintain and enhance the global competitiveness of Japan through the social implementation of carbon recycling, the national government is required to push forward the review of relevant systems and regimes. For the hydrogen, in particular, as a social system is expected to be created, including lower price and practical use of methanation, toward 2050, the promotion of its heavy use and deregulation needs to be considered. In spite of an idea of classifying hydrogen into colors, including green, blue and gray, according to its manufacturing processes, it is important to drive its use without distinction for the time being. Measures that require urgent considerations include the positioning of carbon dioxide-free hydrogen as non-fossil energies in the sophisticated methods of energy supply structures, and development of guidelines for research and development.

Furthermore, as it is essential to store carbon dioxide internally, the legal system should be improved to promote CCS.

9. Linkage with Regional Revitalization

Efforts to reduce carbon dioxide emissions may unintentionally lead to the overseas drain of an industry. To avoid the overseas drain, it is also important to identify the trend of ongoing digitalization and decentralization through the response to COVID-19 and movement of aiming for the carbon neutralization by local governments, and link the carbon recycling with measures for the regional revitalization while making use of local characteristics and existing infrastructures.

For example, Hiroshima Prefecture has been positive about the carbon recycling since the early stage, and the national government is now developing a center of excellence there to research with utilizing carbon dioxide separated and recovered from a thermal power plant. As the prefecture has shown its enthusiasm by its efforts including the establishment of Hiroshima Global Academy prefectural junior and senior school. Its roles as an international center of excellence for carbon recycling will lead to the education for the coming generation and the international interaction, which would contribute to the local revitalization.

Activities to disseminate “Carbon-neutral LNG” have been set in motion in Japan. “Carbon-neutral LNG” is a concept that LNG, which emits carbon dioxide when mined or burnt, is considered, for the purpose of calculation, to emit no carbon dioxide by combining with afforestation and other commitments. The afforestation activities will further lead to the activation of domestic forestry industry and improvement of forest’s function to recharge water sources.

The national government should encourage the industry-academia-government collaboration to use existing chemical complexes, thermal power plants, cement factories, waste combustors and other infrastructures and launch a new business in a rural area while supporting local governments committed to a carbon recycling project toward the achievement of carbon neutrality.

■ Previous Case by CRF Members: TODA KOGYO CORP.
TODA KOGYO CORP. based in Hiroshima City, Hiroshima developed a technology to recover combustion exhausts containing carbon dioxide from the in-house power generation to obtain soda ash with the same purity as traditional ammonia-soda processes. It realizes the carbon recycling within its manufacturing processes by making its products out of sodium carbonate solution manufactured.

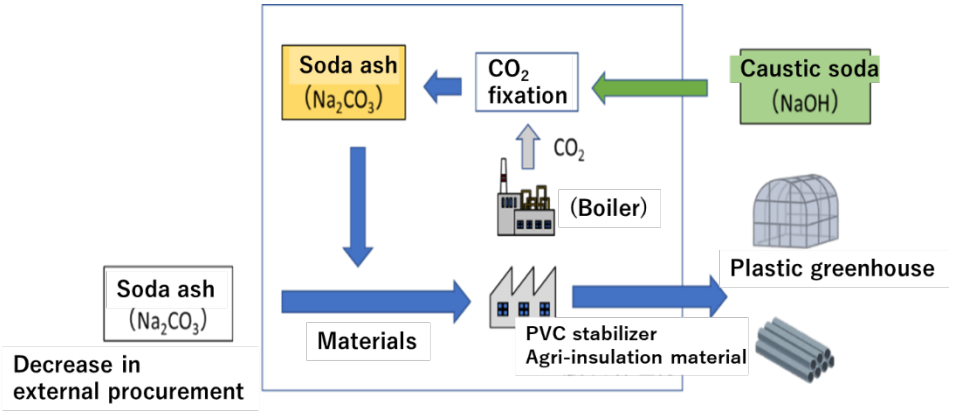


Figure 12: Carbon Recycling Using CO_2 from Boiler Exhaust Gases
Source: Materials from TODA KOGYO

10. Entry into Global Market

As a movement toward carbon neutrality spreads internationally, CFR members, seeing it as an opportunity, will actively enter into the global market, including the licensing business.

To support the movement, the national government is expected to show Japan's presence in international discussions. It is also important to enhance the international collaboration through an industry-academia-government international conference on the carbon recycling, conclusion of a memorandum of cooperation with other countries, and/or joint research based on them.

It is important for the government, industry and academia to work together to enhance the delivery of information to the world on the usability and progress of carbon recycling. As a part of this, Roadmap for Carbon Recycling Technologies developed by the national government is required to be revised as it progresses.

■ Previous Case by CRF Members: JAPAN COAL FRONTIER ORGANIZATION (JCOAL), Kawasaki Heavy Industries, Ltd. and Hitachi Zosen Corporation

One example of the international collaboration to introduce Japanese technologies overseas is a U.S.-Japan international CCUS demonstration project. Specifically, at the Dry Fork coal plant in Wyoming, U.S., JCOAL plans to, with the support of a Ministry of the Environment project, assess environmental impacts of a technology to separate and recover carbon dioxide with solid sorbents. Kawasaki Heavy Industries, Ltd. looks to socially implement the technology. Aside from this, JCOAL has a plan to separate and recover carbon dioxide from exhausts to use it for EOR(Enhanced Oil Recovery) and/or mineralize it with coal ash.

Furthermore, in China, a project has started at the Yulin economic and technological development zone in Shaanxi Province that utilizes carbon dioxide emitted and unused energies used to be discarded (such as by-product hydrogen and surplus electricity), and convert them into natural gases (methane) with a methanation technology of Hitachi Zosen Corporation.

■ Previous Case by CRF Members: Mitsubishi Corporation

Mitsubishi Corporation has pushed forward its sponsorship activities to, and partnership with, startups overseas that are committed to the CCUS. A Canadian business CarbonCure, which the company has invested in and formed a partnership with, developed a method to mix ready-mixed concrete directly with carbon dioxide to produce calcium carbonate. As the method helps to maintain the alkaline property, it can be used for reinforcing steel and has been increasingly implemented mainly in North America. Blue Planet in U.S. concluded a collaboration agreement with it and developed a technology to make gravels (aggregate) out of calcium carbonate that uses carbon dioxide. The technology was employed for a renovation project of San Francisco International Airport.

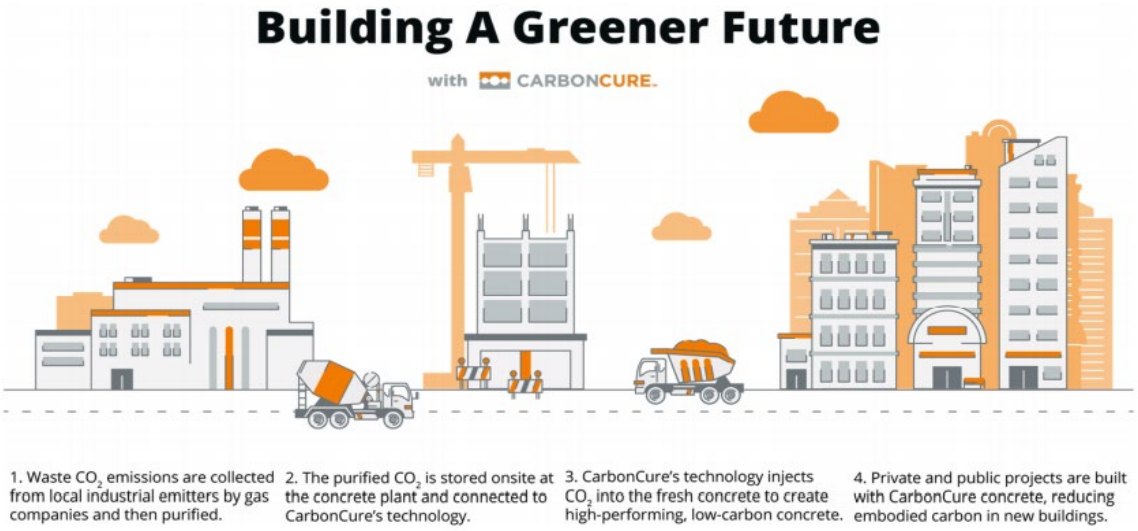


Figure 13: Outline of Processes from Recovery of CO_2 to its Utilization as Construction Materials

Source: Materials from Mitsubishi Corporation

11. Conclusion

The steady implementation of measures toward the achievement of the carbon neutrality by 2050 is required while reviewing the roadmap. It will make no sense, however, if the achievement brings about the overseas transfer of an industry in Japan resulting in hollowing-out. If you seek to realize a decarbonized or low-carbon society only by negating carbon dioxide emissions caused by the use of fossil fuels, etc., it will be difficult to achieve the carbon neutrality.

The sustainable carbon neutrality should be achieved through the carbon recycling, where the value of carbon dioxide is defined to utilize as resources the carbon dioxide and carbon compounds including its absorption and immobilization: that is, co-existence of a wide variety of measures including the establishment of a "Sustainable Carbon Society".

The carbon recycling industry is one of the growth sectors, specifically the 11th sector, in the Green Growth Strategy. Currently, carbon recycling focuses on minerals, fuels, chemicals and separation and recovery, but it is a cross-sectional and cross-cutting field related to all regions. We should aim for the achievement of carbon neutrality not only in Japan, but also around the world under the strong leadership of Japan, through an industry-academia-government collaboration and strong collaboration with foreign countries, let alone the industrial collaboration on a private sector basis.

【Attachment—1】

Overview of Carbon Recycling Fund Institute

（1）Vision

In collaboration with the national government, to support the social implementation of, and commitments at a private sector as a part of their business to, the carbon recycling.

（2）Organizational Structure

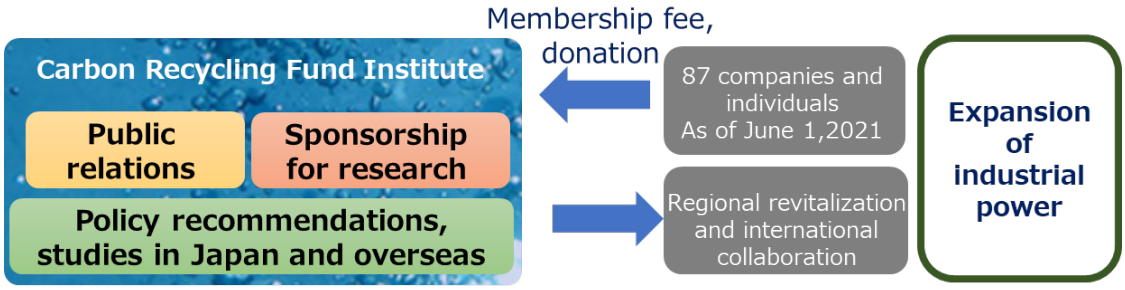
Chairperson: Dr. Yoshimitsu Kobayashi
(Director of the Board, Mitsubishi Chemical Holdings Corporation)
Vice Chairperson: Masayoshi Kitamura
(Special Counselor, Electric Power Development Co., Inc.)

（3）Activities

① Public Relations: Awareness-raising activities related to carbon recycling

② Sponsorship for Research: Grants offered to researchers

③ Others: Including surveys on carbon recycling technologies trends in and out of Japan, development of rules to promote CCUS and policy recommendations



（4）List of Member Companies (as of June 17, 2021)

Corporate members

<Chemicals>
- AGC Inc.
- JSR Corporation
- DIC Corporation
- Denka Co., Ltd.
- TODA KOGYO CORP.
- Toray Industries,Inc.
- BASF Japan Ltd.
- MITSUBISHI GAS CHEMICAL COMPANY, INC.
- Mitsubishi Chemical Corporation

<Electric power>
- Electric Power Development Co.,Ltd. (J-POWER)

<Electric>
- Furukawa Electric Co., Ltd.

<Energy>
- Idemitsu Kosan Co.,Ltd.
- INPEX CORPORATION
- Japan Petroleum Exploration Co.,Ltd.
- Tokyo Eco Service Co.,Ltd.
- TOKYO GAS CO.,LTD.
- NIPPON COKE & ENGINEERING COMPANY, LIMITED

<Renewable energy>
- Geothermal Energy Research and Development Co., Ltd.
- euglena Co., Ltd.

<Iron and cement>
- UBE INDUSTRIES,LTD.
- Kobe Steel, Ltd.
- SUMITOMO OSAKA CEMENT CO.,LTD.
- Nippon Steel Corporation
- Mitsubishi Materials Corporation
- TAIHEIYO CEMENT CORPORATION

<Trading company>
- ITOCHU Corporation
- Cosmos Shoji Co., Ltd.
- JFE Shoji Corporation
- Sumitomo Corporation
- TOKYO SANGYO CO.,LTD
- Marubeni Corporation
- MITSUI & CO., LTD.
- Mitsubishi Corporation

<Heavy industries>
- IHI Corporation
- Kawasaki Heavy Industries, Ltd.
- Sumitomo Heavy Industries, Ltd.
- Mitsubishi Heavy Industries, Ltd.

<Engineering>
- Ebara Corporation
- Chiyoda Corporation
- Toyo Engineering Corporation
- JGC CORPORATION
- NIPPON STEEL ENGINEERING CO., LTD.
- NGK INSULATORS,LTD.
- HITACHI ZOSEN CORPORATION
- Hitachi Power Solutions Co., Ltd
- FUSO Corporation

<Printing>
- Dai Nippon Printing Co., Ltd.
- Toppan Printing CO., LTD.

<Automotive>
- AISAN INDUSTORY., LTD.
- Nissan Motor Co., Ltd.

<Construction>
- Ohmori Construction Co., Ltd
- SHIMIZU CORPORATION
- Shin Nippon Air Technologies Co., Ltd.
- TAISEI CORPORATION
- TAIHEI DENGYO KAISHA, LTD.
- TOA CORPORATION
- Hitachi Plant Services Co.,Ltd.
- Hulic Co.,Ltd.
- FKG Corporation Fukuoka.K.Gouzai.Inc
- Social Welfare Research Corporation, Inc.
- WAKACHIKU CONSTRUCTION CO.,LTD.

<Banks, Financing>
- Daiwa Securities Group Inc.
- Mizuho Financial Group, Inc.
- Sumitomo Mitsui Banking Corporation
- MUFG Bank, Ltd.

<Food>
- ASAHI QUALITY & INNOVATIONS, LTD.

<Others>
- NTT Data Institute of Management Consulting, Inc.
- KANKYOU SYSTEMS, INC.
- SunFlare Co., Ltd.
- Utilization of Carbon Dioxide Institute Co., Ltd.
- JAPAN COAL FRONTIER ORGANIZATION
- Central Research Institute of Electric Power Industry
- Tokyo University of Science Foundation
- FUTURE ESTATE Co., Ltd.
- Dome Gold Mines Ltd.
- The Institue of Energy Economics, Japan
- Mizuho Research & Technologies, Ltd.

Individual members
- Ueno Hiromoto
- Einaga Yasuaki
- Ohno Yotaro
- Katsu Kinichi
- Sakanishi Kinya
- Sakurai Shigetoshi
- Takahashi Tsuneo
- Takeuchi Aya
- Terashima Chiaki
- Yoshihara Tomomichi

Total 77 companies
10 persons

【Attachment—2】

Outline of Members Survey Results

Survey Period: January 26 – February 25, 2021
Respondents: 66 corporate and 11 individual members
Number of Responses: 46

1. The questionnaire survey consisting mostly of closed questions asked about the following:

① Their ongoing national project(s)
② Their commitments to a hydrogen project and its progress
③ Any country or region of their potential international partner
④ Challenges in carrying out research and development
⑤ Supposed supply source of carbon dioxide and associated challenges
⑥ A method to separate and recover carbon dioxide that they are considering and working on, and its associated challenges
⑦ A method to transport carbon dioxide that they are considering and working on, and its associated challenges
⑧ Their view on CCS
⑨ Potential benefits of, and challenges in socially implementing, a promising carbon recycling technology
(Refer to Figures 1 and 2)
⑩ Comparison of technological development between Japan and foreign countries
⑪ What it takes to promote the technological development in Japan
⑫ What it takes to socially implement and bring into business Japanese technologies

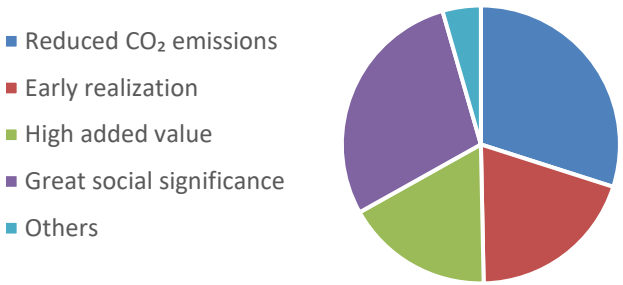


Figure 1 : Potential Benefits of a Promising Carbon Recycling Technology

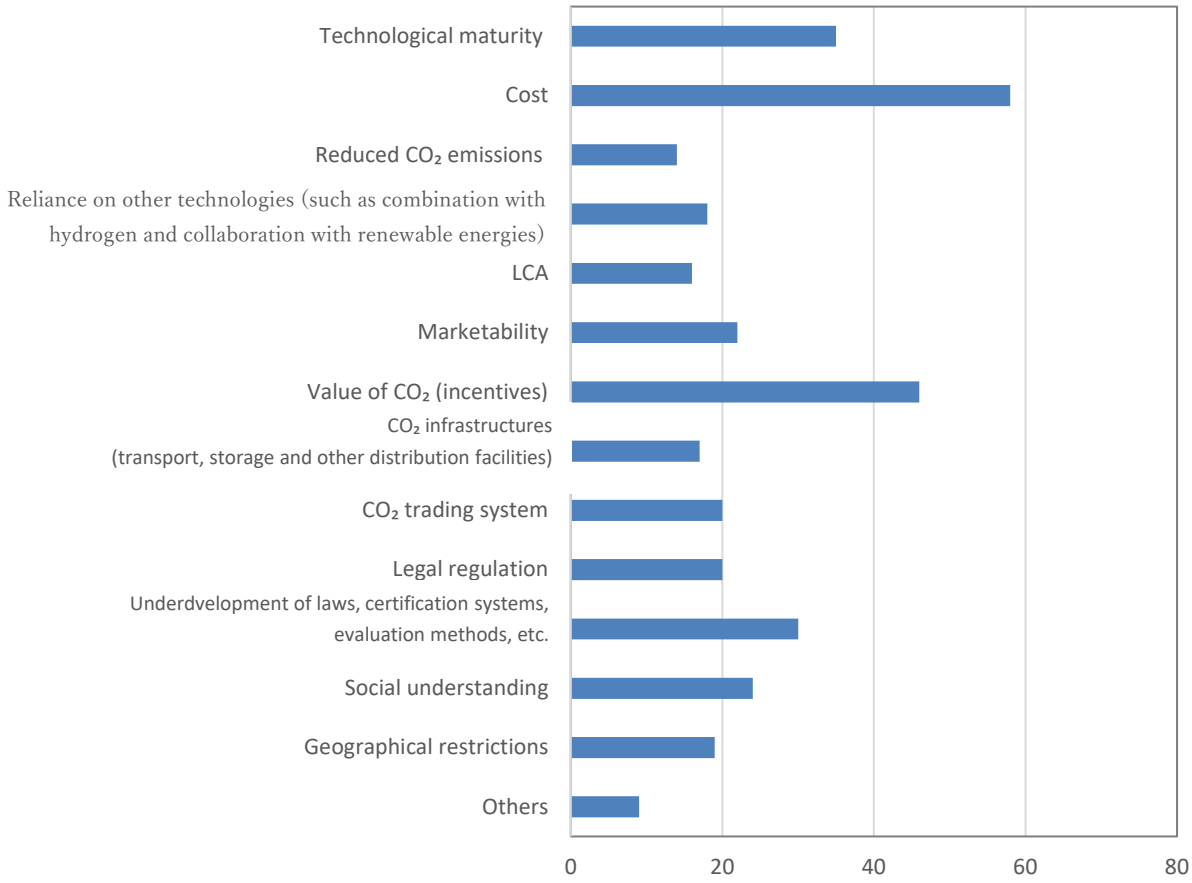


Figure 2 : Challenges in Socially Implementing Carbon Recycling Technologies

2 . The free-format questionnaire survey asked about the following, with the major answers received as follows:

① Expectations for carbon recycling
- ✓ Can be a measure to reduce carbon dioxide emissions for all industries.
- ✓ Will give more choices of energies and more measures to achieve the carbon neutrality.
- ✓ Has a potential to enable the return of valuables.
- ✓ CCS has a potential to drive consumption in terms of quantity, while its storage volume is limited.

② Opinion on a sink such as blue carbon
- ✓ Improvement of environmental assessments, development of a rule to measure carbon dioxide sinks, and encouragement on a global basis is required.
- ✓ Would expect inter-agency initiatives.
- ✓ Scientific and careful examination on a quantitative and multifaceted basis is required for an impact on biodiversity.
- ✓ Enhanced social visibility and development of a certification system is required.

③ Opinion on the regulatory reform (such as deregulation and tighter regulations) related to research & development, manufacturing of products, and other issues

- ✓ Development and/or improvement of a certification system and standards such as adaptation to JIS is required for products that immobilize, or avoid emissions of, carbon dioxide.
- ✓ The evaluation on a lifecycle basis is important.
- ✓ Would expect a mandatory use of, subsidy for, and tax breaks for development and production of, those products.
- ✓ Active utilization by a public agency and tighter regulations to drive widespread use in a private sector is desirable.
- ✓ Development of a system to trade carbon dioxide emissions in and out of Japan

④ Opinion on how a way to add value to carbon dioxide should be institutionalized

- ✓ System to evaluate carbon dioxide emissions reduction properly and quantitatively
- ✓ Institutionalization in a manner that enables the maintenance of global competitiveness
- ✓ Tax credits, like 45Q in U.S., to support carbon dioxide emissions reduction
- ✓ Development of a scheme to share the costs and social significance in an entire society is required.

⑤ Remedies for challenges in socially implementing carbon recycling technologies

[Chemicals/Fuels Issue]

- ✓ Cross-industrial collaboration
- ✓ Scheme to evaluate value of CN and reflect it in price

[Fuels Issue]

- ✓ Being well-positioned to supply a large amount of hydrogen stably and inexpensively
- ✓ Non-EU-driven international standardization
- ✓ Utilization of existing assets

[Mineralization Issue]

- ✓ Standardization of products with CR technologies

[CCS Issue]

- ✓ Improvement of business environment and legislation