経済産業省
Ministry of Economy, Trade and Industry

Special Session
Japan CCS Forum 2019

Initiatives for Carbon Recycling

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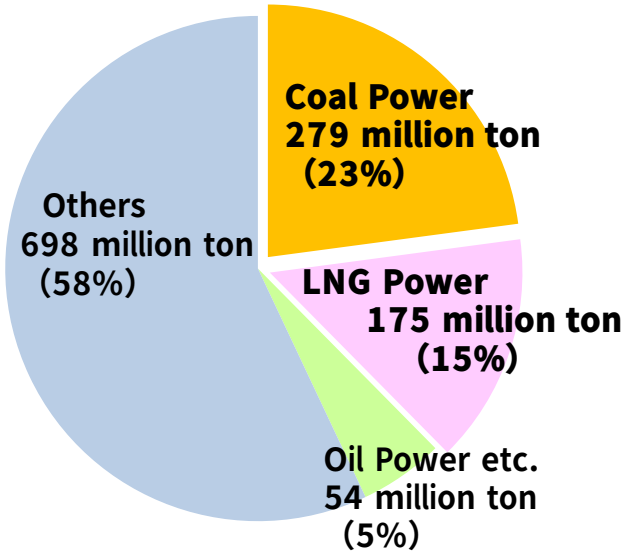
- **Background**
- **What is Carbon Recycling?**
- **Roadmap for Carbon Recycling Technologies**
- **Next steps!**

Background

CO2 emissions from thermal power

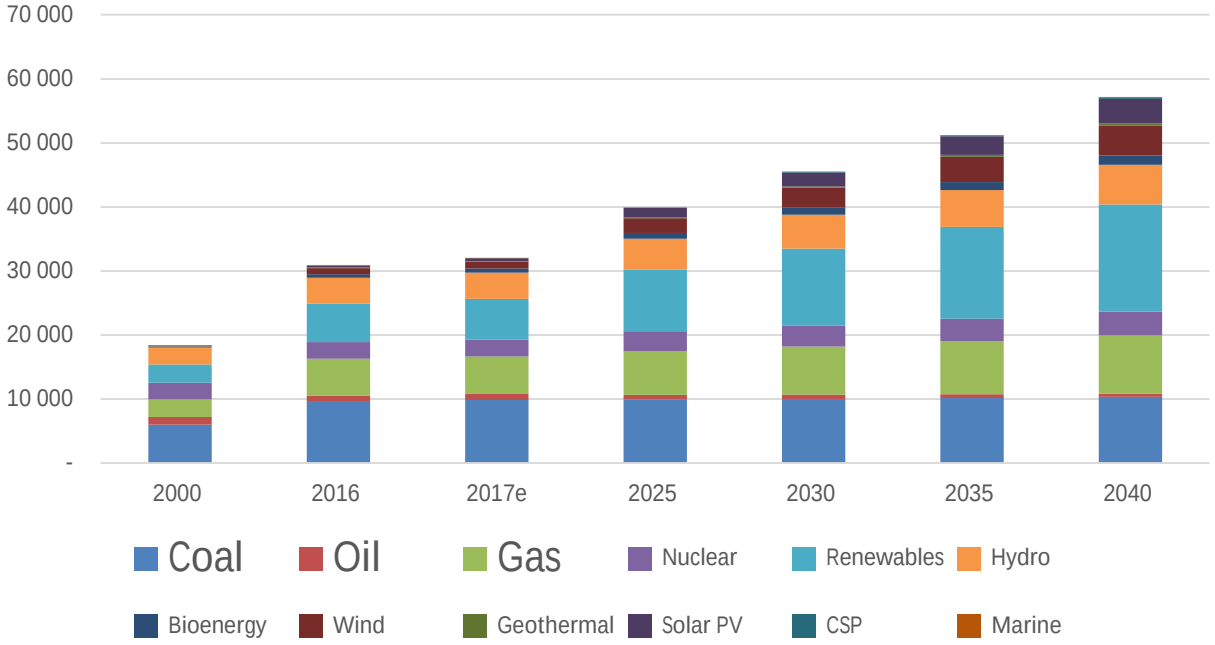
- Around 40% CO2 emissions are produced from thermal power plants in Japan. Around 6.5million ton/year of CO2 will be reduced if the efficiency of the coal thermal power plants improve by an average of 1%.
- Around 3.4million tons/year of CO2 will be reduced if the efficiency of the LNG thermal power plants improve by the average 1%.

CO2 emissions from thermal power plants account for total emissions (2016)



Source：GHG Emissions(2016) by Ministry of the Environment

World Electricity Generation (New Policies Scenario)



Extracted from IEA World Energy Outlook 2018

Background

- 5th Strategic Energy Plan: approved by Cabinet in July 2018
- Towards 2050, reducing GHGs by 80%, challenges towards energy transitions and decarbonization

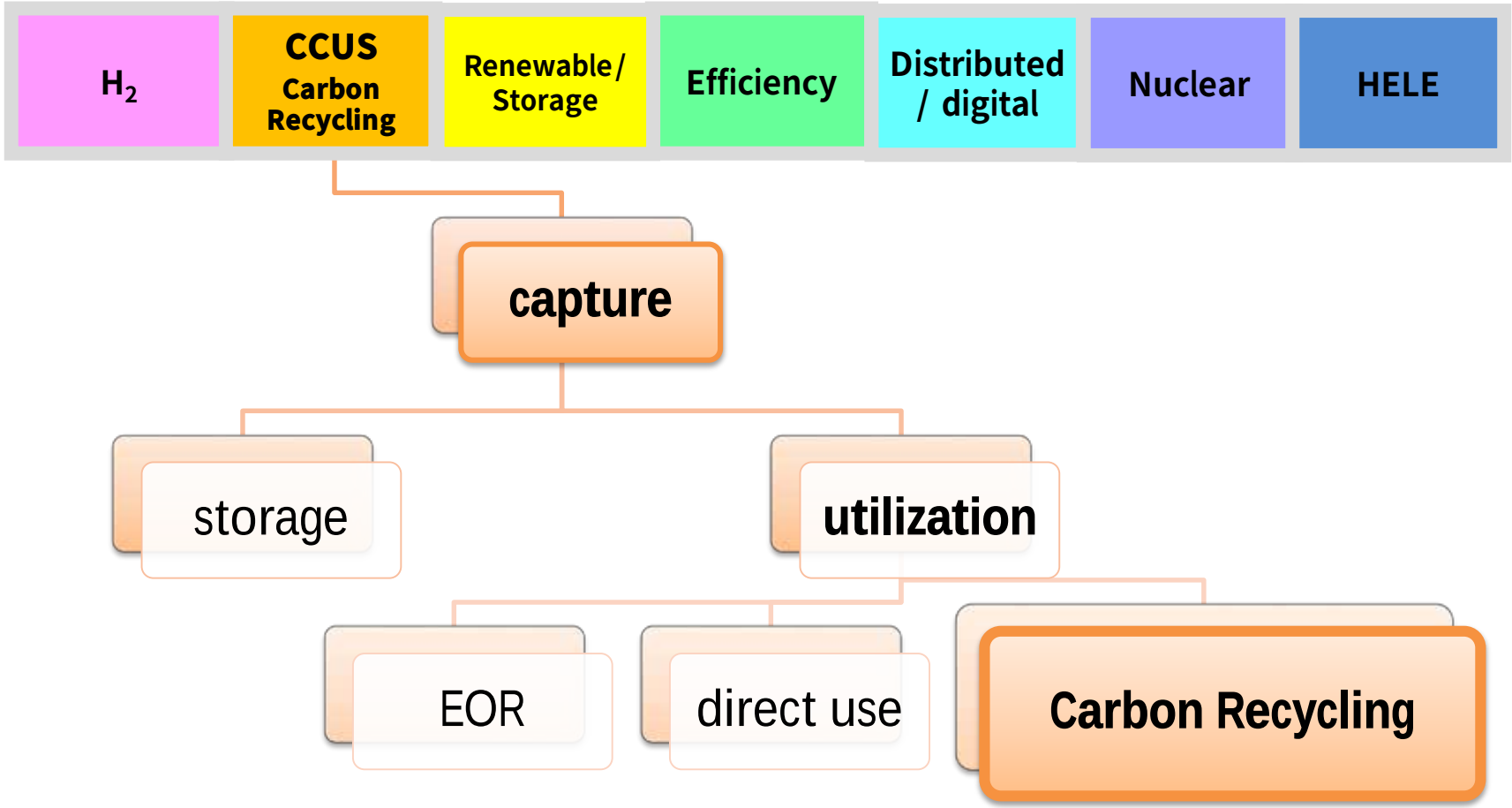
decarbonization — Need to reduce CO2 originally from fossil fuel → **Pursue every option**

- Still many countries have to use fossil fuel as energy sources due to energy security and economic efficiency point of view <energy access>

energy access — Coexistence of energy access in developing countries and solving climate change in the world → **Challenge by innovation**

Challenge every option

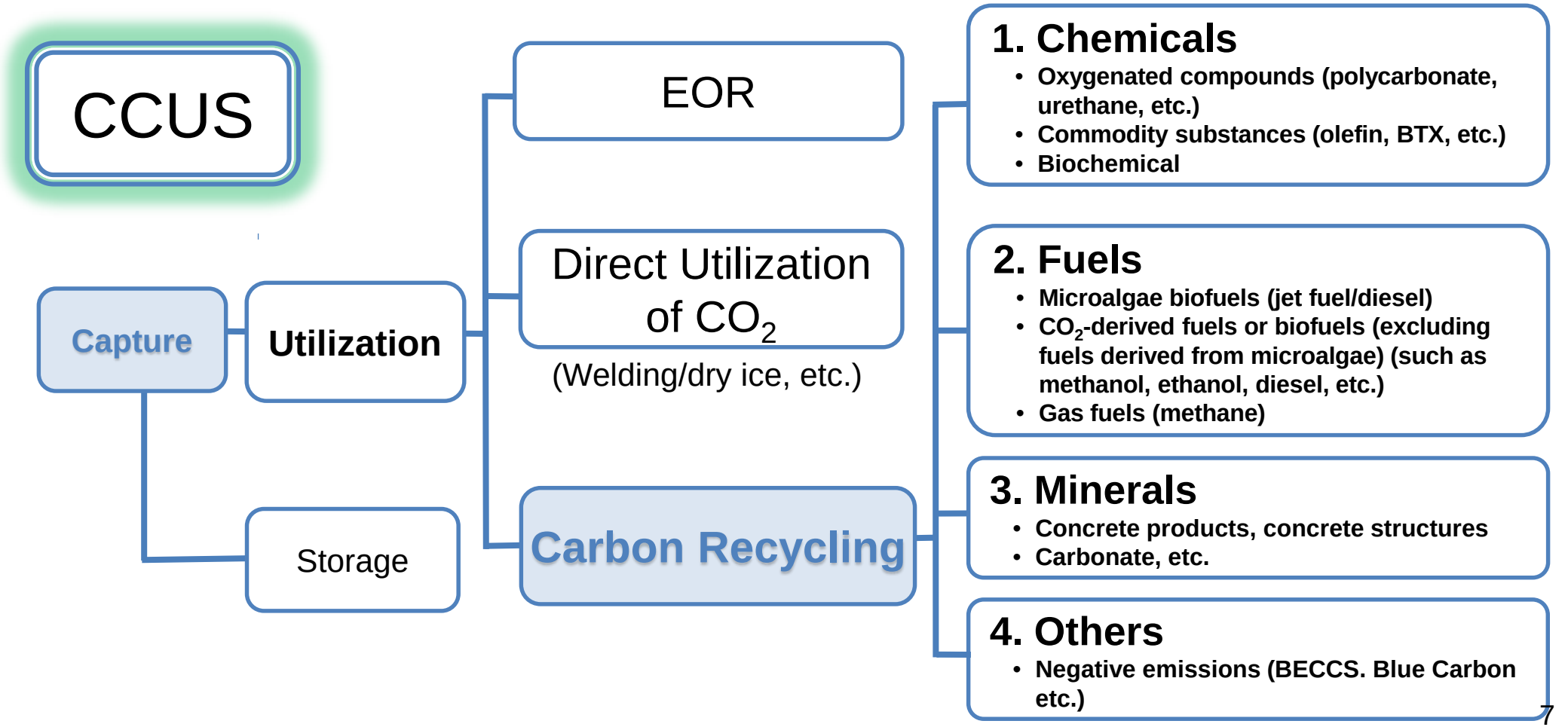
- Need to pursue all options: Hydrogen, CCU/CCS, renewable energy/energy storage, energy efficiency, distributed energy/digitalization, nuclear power, HELE
- CCS is moving firster towards the deployment, focus on CCU including Carbon Recycling,



What is Carbon Recycling?

CCUS/Carbon Recycling

- Carbon Recycling technology, recognizing carbon dioxide as a source of carbon, capturing and recycling it as raw materials and fuels by mineralization, artificial photosynthetic or Methanation as well as controlling the CO_2 emissions to the air.
- Carbon Recycling technology focuses upon the research and development of CO_2 Utilization in collaboration among industries, academia and governments around the world and promotes disruptive innovation.
- Carbon Recycling is one of key technology for the world together with energy saving, renewable energy and CCS



Speech by Prime Minister Abe at the World Economic Forum Annual Meeting (23 January 2019)

I would very much like to highlight what innovation does and how much innovation counts in tackling climate change, because, and this is an important "because," we NEED disruptions. To remind us of that, the IPCC, in its recent "1.5-degree report," tells us that global net human-caused emissions of CO2 should reach "net zero" around 2050, meaning that any remaining emissions would need to be balanced out by removing CO2 from the air.

We must invite more and still more disruptive innovations before it's too late. CO2, ladies and gentlemen, could well be the best and most affordable resource for multiple uses. There is artificial photosynthesis, for which a key discovery, one for photocatalysis, was made by Akira Fujishima, a Japanese scientist. An old technology of methanation is getting attention anew to remove CO2. It's time now to think about CCU, Carbon Capture AND Utilization. Hydrogen, as both a primary source, and more importantly, a carrier of energy, must become cheaper and more easily affordable. My government is aiming to reduce the production cost of hydrogen by at least 90 per cent by the year 2050, to make it cheaper than natural gas.

We will be inviting to Japan topmost experts in science and technology from G20 member countries to combine forces in accelerating innovations. I am also pleased to tell you that my government, first among others, published a guidance paper in December last year along with the TCFD, or Task Force on Climate-related Financial Disclosures. ESG investment world-wide has grown over the last five years by more than 9 trillion US dollars. That's a big amount, but we must channel even more into green innovation. And the guideline we put together will help motivate more companies to spend greater amounts on disruptive innovations.

I must say that spending money for a green earth and a blue ocean, once deemed costly, is now a growth generator. Decarbonization and profit making can happen in tandem. We policy makers must be held responsible to make it happen, as I will be stressing in Osaka this year.

Innovation for Carbon Recycling

- Carbon recycling: Considering Carbon dioxide (CO_2) as source for Carbon, capture CO_2 then utilize and recycle it as Carbon compounds.
- Promoting R&D for these technologies more efficiently
- Solve climate change problems by reducing CO_2 in the air as well as secure stable supply of new resources. Challenging innovative technologies contributing both at once.

Taking following actions to **establish a new eco-system**

① Reduce cost and improve efficiency rate for capturing CO_2

② R&D for producing, converting and processing CO_2 as materials and resources (chemical products, fuels, minerals, etc.)

③ Develop variety of utilization sectors for materials and resources oriented from carbon.

Innovation for Carbon Recycling

In order to implement the actions, current and future activities are as follows:

- **Establishment of Carbon Recycling Promotion Office in ANRE※1/METI※2 on February 1st, 2019**
- **Released Roadmap for carbon recycling technologies on June 7, 2019**
- **Hosting International Conference on Carbon Recycling among industries, academia and governments on September 25, 2019.**
- **Promoting necessary measures to support R&D or any other innovation on carbon recycling**

※1：Agency for Natural Resources and Energy, ※2：Ministry of Economy, Trade and Industry

Roadmap for Carbon Recycling Technologies

カーボンリサイクル技術ロードマップ（日本語版）
https://www.meti.go.jp/press/2019/06/20190607002/20190607002-1.pdf

Roadmap for Carbon Recycling Technologies（English Version）
https://www.meti.go.jp/press/2019/06/20190607002/20190607002-2.pdf

Roadmap for Carbon Recycling technologies

- Develop roadmap to specify the technology sector which needs R&D and clarify its target and schedule.
- Discuss and examine it with the members from academia and private sectors, including other Ministries.
- Roadmap was released on June 7th, as well as disseminated during G20 meeting.

Contents of roadmap (draft)

Review, discuss and examine to cover the following sectors in order to identify

1) core technology and its tasks
2) Target for 2030 and 2050, if possible,
3) Target cost and potential CO2 reduction volume

Sectors:

- ü Capturing CO2 technology (Physical absorption method, chemical absorption method, membrane separation method, etc.)
- ü Transform CO2 into other chemicals technology; such as
  - Chemical products (developing catalysts/artificial photosynthesis, etc.)
  - Fuels (utilize algae, Methanation, etc.)
  - Mineral (manufacturing concrete, etc.)
  - Other (chemical/biological conversion technologies)

Members

National Institute of Advanced Industrial Science and Technology (AIST), Nagoya University, Tokyo Institute of Technology, Waseda University, Idemitsu, Nippon Steel, Toshiba, Japan Gas Association, Federation of Electric Power Companies, New Energy and Industrial Technology Development Organization (NEDO) Cabinet Office, Ministry of Education, Culture, Sports, Science and Technology and Ministry of Environment.

Working Group for roadmap for Carbon Recycling Technologies

Ⅰ Purpose and its status

1. Purpose of WG

Based on the Paris Agreement, in order to realize a decarbonizing society with an eye on 2050, it is important to pursue all options such as renewable energy, hydrogen, CCS, CCU, etc., and to tackle the significant amount of CO2 emissions using all options of innovative technologies that contributes to reduction is important. In the future, with regard to industrial technologies for which Japan has strengths, in order to contribute by Japan as a whole by promoting maximum efforts with a view to the whole world, it is necessary to strongly promote R & D, technology development and commercialization toward 2030, 2050.

Under these circumstances, carbon recycling technology that captures CO2 as a carbon resource, recycle it as various carbon compounds is one of the promising options in the future, and its innovation is important. It is necessary to promote the development and spread of the technology in Japan and abroad and to cooperate with industries, academia and governments all over the world.

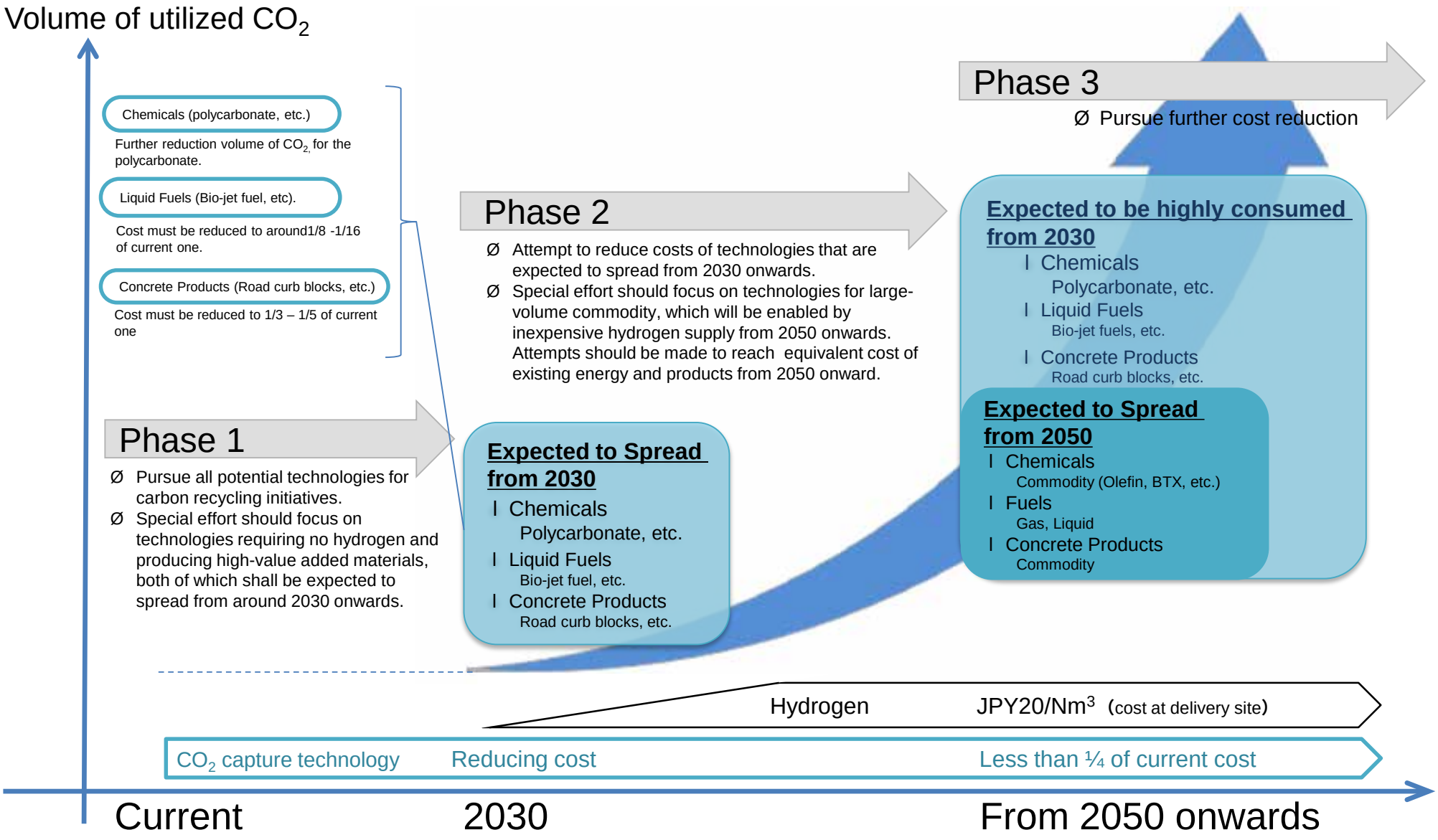
Considering these circumstances, we have recognized the current state of technology, reevaluated the potential level and practical application, and extracted and visualized the bottleneck issues for decarbonization from the result of "Study Committee for Potential and practical evaluation of energy and environmental technology"※. Using the results of the Study Committee, this working group was established to formulate a roadmap for carbon recycling technologies with the aim of advancing technology development effectively and quickly in the future.

2. Status of WG

This Working Group is established as a private study group for the Director of the Carbon Recycling Promotion Office, Director-General of the Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry. The proceedings will be closed, but the results and conclusions of the review will be reported to the Natural Resources and Fuel Committee, under the Advisory Committee for Natural Resources and Energy.

※ This Study Committee was co-chaired by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Economy, Trade and Industry in order to discuss and review following points; to confirm the level of progress of commercialization for energy and environmental technologies for the social image that should be 2050, to extract internal and external factors that impede the commercialization, to evaluate the potential of individual technology seeds, to objectively evaluate bottleneck issues from basic foundation research to social implementation required for practical application of technologies with demand and with potential for decarbonization, to evaluate promising technology options objective point of views.

Roadmap for Carbon Recycling Technologies



<Review process> Be flexible in the addition of technologies based on the state of international technology development obtained through the International Conference on Carbon Recycling among Industry-Academia-Government, or proposals of new technologies. The roadmap should be reviewed in five years as needed, take into account the revision of the “Long term Strategy for Growth strategy based on the Paris Agreement (provisional translation)” .

Summary of Carbon Recycling Technologies R&D

※1 Price researched by secretariat
※2 Basic substances, chemicals(excluding some oxygenated compounds), and many technologies for fuels require large amounts of inexpensive CO_2-free hydrogens. Biomass-derived fuels may require hydrogen for hydrogenation treatment, etc.

Category	Substance After CO_2 Conversion	Current Status※1	Challenges	Price of the Existing Equivalent Product※1	In 2030	From 2050 Onwards
Basic Substance	Syngas/Methanol, etc.	Partially commercialized. Innovative process (light, electricity utilization) is at R&D stage	Improvement of conversion efficiency and reaction rate, improvement in durability of catalyst, etc.	—	Reduction in process costs	Further reduction in process costs
Chemicals	Oxygenated Compounds	Partially commercialized (polycarbonates, etc.), Others are at R&D stage [Price example] Price of the existing equivalent product (Polycarbonate)	Reduce the amount of CO_2 emission for polycarbonate. Other than polycarbonate, etc. commercialized (Improvement in conversion rate/selectivity, etc.)	Approx. JPY 300-500/kg (polycarbonate (domestic sale price))	Costs: similar to those of existing energy/products	Further reduction in costs
	Biomass-derived Chemicals	Technical development stage (non-edible biomass)	Cost reduction/effective pretreatment technique, etc. conversion technologies, etc.	—	Costs: similar to those of existing energy/products	Further reduction in costs
	Commodity Chemicals (olefin, BTX, etc.)	Partially commercialized (Syngas, etc. produced from coal, etc. is utilized)	Improvement in conversion rate/selectivity, etc.	JPY 100/kg (ethylene (domestic sale price))	—	Costs: similar to those of existing energy/products
Fuels	Liquid Fuel (microalgae biofuel)	Demonstration Stage [Price example] Biojet Fuel: JPY 1600/L	Improvement productivity, cost reduction/ effective pretreatment technique, etc.	JPY 100/L level (bio-jet fuel (domestic sale price))	Costs: similar to those of existing energy/products (JPY 100-200/L)	Further reduction in costs
	Liquid Fuel (CO_2-derived fuels or biofuels (excluding microalgae-derived ones))	Demonstration stage (E-Fuel, etc.), partially commercialized for edible biomass-derived bioethanol	Improvement in current processes, system optimization, etc.	JPY 50-80/L (alcohol as raw material (imported price) JPY approx. 130/L Industrial alcohol (domestic sale price)	—	Costs: similar to those of existing energy/products
	Gas Fuel (Methane)	Demonstration Stage	System optimization, scale-up, etc.	JPY 40-50/Nm^3 (Natural gas (imported price))	Reduction in costs for CO_2–derived CH_4	Costs: similar to those of existing energy/products
Minerals	Carbonates/Concrete Products, Concrete Structures	Partially commercialized. R&D for various technologies techniques are underway towards cost reduction. [Price example] order of JPY 100/t (Road curb block)	Separation of CO_2-reactive and CO_2-unreactive compounds, comminution, etc.	JPY 30/kg (Road curb block (domestic sale price))	Road curb Block costs: similar to those of existing energy/products	Other products, except road curb block costs: similar to those of existing energy/products
Common Technology	CO_2 Capture	Partially commercialized (chemical absorption). Other techniques are at research/ demonstration stage [Price example] Approx. JPY4000/t-CO_2 (Chemical absorption)	Reduction in the required energy, etc.	—	JPY 1000-2000 level /t-CO_2 (chemical absorption, solid absorption, physical absorption, membrane separation)	JPY 1000/t-CO_2 or lower
Basic Substance	Hydrogen	Technologies have been roughly established (water electrolysis, etc.) R&D for other techniques are also underway towards cost reduction.	Cost reduction, etc.		JPY 30/Nm^3	JPY 20/Nm^3 (cost at delivery site)

Scope : Roadmap for Carbon Recycling Technologies

The carbon recycling technology, where we consider CO_2 as a resource, will begin with a smaller recycle volume. We expect this initiative will continue to expand into different application areas as achieving cost effectiveness. We set relatively short-term targets in 2030 while 2050 onward is seen as a mid- to long-term target.

2030: Technologies aiming at achieving commercialization as early stage as possible.
(1) Establish an environment that fosters easy utilization of CO_2 (reducing costs for capture and recycle of CO_2)
(2) Processes whose basic technology is established can replace existing products by reducing costs
(Products that do not require inexpensive hydrogen supply, as well as high-value added products can replace existing products)

2050: Technologies aiming at achieving commercialization in the mid- to long-term.
○ Early-stage technologies that have greater impacts by using a large amount of CO_2 (enabled by inexpensive hydrogen)

	2030 (short-term)	2050 onward (mid-to long-term)
Field	Technologies producing high-value added products and/or not requiring inexpensive hydrogen will be commercialized first: • Chemicals (polycarbonate, etc.) • Liquid fuels (bio-jet fuel, etc.) • Concrete products (road curb blocks, etc.)	Extended to products that have large demand: • Chemicals (commodity: olefin, BTX, etc.) • Fuels (gas, liquid) • Concrete products (commodity)

Fuels

Technologies to produce liquid fuel (1) *Microalgae Biofuel (Jet Fuel/Diesel)

<Technological Challenges>
(Microalgae→Biojet fuel/Biodiesel)
- Improve productivity (culture system/ gene recombination)
- Low cost, effective pretreatment technique
- Establish the related techniques such as dehydration/drying, oil extraction, removal of impurities, etc.
- Develop the technology for utilizing oils/fats residues
- Scale-up (from bench-scale to pilot-scale, followed by demonstration level)
- Large-scale technological demonstration
- Pursuit of cost reduction

<Other Challenges>
- Expanding the scope of application and verify economic performance
- Establishing an effective collection system for raw materials

Target for 2030

<Expected Cost>
- Bio-jet Fuel: costs: similar to those for existing energy/products, JPY 100-200/L (Currently, JPY1600/L)

<Production Rate>
- 75 L-oil/day･ha (Currently, 35 L-oil/day･ha)

<CO_2 Emission Intensity>
- With regard to biojet fuels, in LCA, as compared to existing jet fuels, the amount of emissions must be equal to or lower than half of the CO_2 emission intensity from the current process

<Others>
- Compliance with fuel standards
- Scale up to the demonstration level and establish the supply chain
- Expand mixed utilization of the liquid fuel and an existing fuel as well as the mixed ratio
- Since hydrogen is used in relatively small amounts for oil reforming, the presence of CO_2 free hydrogen increases the GHG reduction impact

Target from 2050 Onwards

<Expected Cost>
- Further reductions in costs

<CO_2 Reduction Amount>
- Must contribute to 50% CO_2 reduction relative to that for 2005 in aviation sectors

(FYI) If a biojet fuel with a greenhouse gas emission reduction rate of 50% continues to be introduced at 100 thousand kL/yr, a CO_2 reduction of 123 thousand t/yr will be achieved.

*Such technological development is also common to that in the chemicals sector
(High value added products, such as cosmetics and supplements derived from microalgae are partially commercialized)

Next steps!

Schedule

Working Group for Roadmap for carbon recycling technologies

1st meeting: March 14, 2019 : addressing background information

2nd meeting: April 23, 2019 : presentations from members

3rd meeting: June 3, 2019 : discussion on draft roadmap

Utilize Roadmap for carbon recycling technologies

In order to challenge innovation with all options, industry, government and academia, in Japan and overseas, cooperate to promote R&D effectively and in swift manner to solve goals and tasks indicated in roadmap by sharing them.

June 7, 2019 : Introduction of Roadmap during G20

September 25, 2019 : Hosting International Conference on Carbon Recycling at Tokyo

- Accelerating international collaboration, information sharing and R&D among academia, industries and government
- Contributing Japanese technologies internationally
- Revision of roadmap with international collaboration

International Conference on Carbon Recycling

1. Date, Venue and Other Information

(1) Date: 13:30 – 17:00 on September 25th, 2019

Venue: International Convention Center

"Tsuruno-ma" in Hotel New Otani, Tokyo

(2) Organizer: METI

Co-Organizer: NEDO

Sponsors (P): JOGMEC, AIST, IEA

(3) Outline and Purpose

- In order to collaborate with the industrial, academia and governmental sectors worldwide accelerating discussions for the deployment and the expansion of the concept of "Carbon Recycling". Specifically, aiming to pave the way to international collaboration towards the realization of Carbon Recycling through;

① sharing the Roadmap for Carbon Recycling Technologies,

② sharing the best practice regarding Carbon Recycling of each country,

③ deliberating on potential for international collaboration and discussing the challenges to effectively promoting innovation for Carbon Recycling.

International collaboration project

Algae project: Establishing framework for producing bio jet fuel from algae in Thailand (started 2017FY as NEDO project): Microalgae absorb CO2 by photosynthesis. Grown-up microalgae as a material is utilized to produce transportation fuels such as jet fuels.

- Establish the production technology for jet fuels produced from cultivated algae in Saraburi Province, Thailand
- Provide fuels to Japan
- Commercialization by around 2030
- Reducing cost for production, especially extracting fuels

International Conference on Carbon Recycling

2. Agenda (TBC)

Agenda 13:30-17:00

13:30-14:30 Ministers Session

①Opening Remarks *METI Minister Seko*

②Keynote Address *Ministers (from worldwide)*

③Photo Session *Minister Seko and Ministers*

14:30-17:00 Industry-Academia-Government Session

①Roadmap for Carbon Recycling Technologies *METI*

②Networking Coffee Break

③Carbon Recycling R&D for future

3. Participants (TBC)

Governments

Japan: Minister of Economy, Trade and Industry Seko ＋ 4~5 Ministers

Academia (Area)

catalysts, artificial photosynthesis, utilize algae, Methanation, manufacturing concrete, chemical, biological conversion technologies, etc.

Industry

Oil, Gas, Coal, Iron, Chemical, Material, Electric Power, Auto Mobile, Heavy Industry, Agriculture, etc.

International Organization

IEA, GCCSI, ICEF, CSLF etc.

Thank you!

Ministry of Economy, Trade and Industry

Agency for Natural Resources and Energy

5th Strategic Energy Plan: Approved by Cabinet in July 2018

In order to challenge the energy transition and decarbonization for 2050, maintain all options for decarbonization technologies and tackle the R&D with the collaboration between private and public.

Introduction

if we look ahead to the prospects for 2050, there is the possibility of non-continuous technological innovation. Competition over the development of not only renewable energy but also all decarbonization technologies such as electricity storage and hydrogen, nuclear power, distributed energy systems, etc. is intensifying. Competition among nations and among companies with the aim of obtaining the initiative in energy technologies is accelerating. Japan is not blessed with fossil resources. It is a country for which obtaining the initiative in energy technologies is more necessary than anything else. Japan will maintain all options regarding decarbonization technologies, work their development through public-private cooperation, and lead the challenge to achieve decarbonization. It will challenge itself to achieve energy transitions and decarbonization. This is the basis of the energy choices for 2050.

Chapter 2 Basic Policies and Measures towards 2030,
Section 2 Policy measures towards 2030
5. Efficient and stable use of fossil fuel
research and development will be conducted with a view to practical use of the carbon dioxide capture, utilization and storage (CCUS) technology around 2020 and cooperating with international organizations

Chapter 3 Efforts for Energy Transitions and Decarbonization towards 2050,
Section 1 Ambitious multiple track scenario - Pursue every option
(4) Adopting ambitious multiple track scenario approach that pursues possibilities in all options
Given the uncertainties accompanying the 2050 scenario, lessons from the state of affairs in major countries that are ahead of Japan on the timeline, and the energy environment unique to Japan, GOJ adopts an "omni-directional, multiple track scenario approach that aims at energy transitions and decarbonization" that pursues all options including renewable energy, hydrogen and CCS, and nuclear power.

Section 4 All-out efforts to realize the scenario
(1) All-out efforts
Technology and human resources will be the source of energy security during the energy transitions process. In the 30-odd years to 2050, people currently in their teens and 20s will form the core in 2050. The initiative towards energy transitions is nothing but the long-term strategy for technology and human resources. The public and private sectors will come together to take on the challenge of continuous technological innovation and developing and securing human resources in order to pursue the possibilities in each option, overcome the issues, and seek out the optimum energy choices.