Japan’s Action toward Public Implementation of Carbon Recycling 【Progress over the Past Year】

September 27, 2023

Ministry of Economy, Trade and Industry

Progress over the Past Year【Overview of Japan's Action】

Action 1. G7 Hiroshima Leaders' Communiqué

→ pp2-3

- **G7 Hiroshima Leaders' communique** and **G7 Ministers' Meeting on Climate, Energy and Environment** communiqué acknowledge the **effectiveness and future of carbon management**, including CCUS/carbon recycling technology.

Action 2. Move for Social implementation of Carbon Recycling

→ pp4-24

- On June 23, 2023, the **"Carbon Recycling Roadmap" was published** to layout issues such as **the significance, challenges, and actions** to further promote carbon recycling, in addition to technology.
  (*The "Carbon Recycling Technology Roadmap" was published in 2019 and was revised in 2021.)
  - Promoting technological development and demonstrations, to **establish the technology** at earliest possible stage**, reduce costs, and spread the use of the technology**.
  - Identifying issues for "inter-industrial collaboration" (**establishment of CO_2 supply chain**), such as **support measures for first movers** by the public and private sectors.
  - Emphasizing the importance of **mechanisms** i) **to appropriately evaluate the environmental value of carbon recycling** (standardization, etc.) and ii) **to distribute environmental value** of recycled carbon products **across national borders**.
  - Japan's start-ups in this area require generous support. **Industry, academia, and government are working together to create support** to develop an ecosystem.
- Regarding CO_2-absorbing concrete, **durability and other properties** in actual environment **has been evaluated** at three construction sites conducted by the national government since 2022.

Progress in CCS development

→ pp25-30

- ✓ On June 6 2023, seven CCS projects were selected as **Advanced CCS project** to **establish a business model that can be deployed horizontally** for the expansion of CCS business in the future, **aiming to start the business by 2030**.
- ✓ **Japan is one of the country that has various technology related to the CCS value chain**, such as CO2 capture, transport and storage. In addition, the value chain could be **expanded to CCU/carbon recycling.**

Treatment of Carbon Recycling in G7 Summit Communique

The **“G7 Hiroshima Summit Communique”** was established as a document of achievements on the occasion of the G7 Summit held in Hiroshima, Japan from May 19 to 21, 2023. Carbon recycling is described as follows:

Paragraph 25

"(Excerpt)... We **acknowledge** that **Carbon Capture, Utilization and Storage (CCUS)/ carbon recycling technologies can be an important part of a broad portfolio of decarbonization solutions** to reduce emissions from industrial sources that cannot be avoided otherwise and that the deployment of carbon dioxide removal (CDR) processes with robust social and environmental safeguard, have an essential role to play in counterbalancing residual emissions from sectors that are unlikely to achieve full decarbonization."

Treatment of Carbon Recycling in the G7 Climate Energy Environment Ministerial Meeting Communique

The **"G7 Climate, Energy and Environment Ministers' Meeting Communique"** was established as a document of achievements on the occasion of the G7 Climate, Energy and Environment Ministers' Meeting held in Sapporo, Japan from April 15 to 16, 2023. Carbon recycling is described as follows:

Paragraph 68 Carbon Management (Excerpt from CR related parts)

"(Excerpt)... We will co-operate to promote development of export/import mechanisms for CO_2. We recognize the need to develop systems or incentives that enhance utilization of CO_2 and the value of CO_2 through utilization. Considering the evolving nature of these technologies, **we recognize that CCU/carbon recycling and CCS can be an important part of a broad portfolio of decarbonization solutions to achieve net-zero emissions by 2050**, and Carbon dioxide Capture, Utilization(CCU)/carbon recycling technologies, including recycled carbon fuels and gas (RCFs) such as e-fuels and e-methane, also can reduce emissions with existing infrastructure from industrial sources that cannot be avoided otherwise by displacing fossil-derived commodities and by using CO_2... (Excerpt)... We will accelerate international cooperation to promote harmonization of MRV of CDR and **exchanges including through collaborative workshops among industry, academia, and government on CCU/carbon recycling technologies, such as RCFs**"

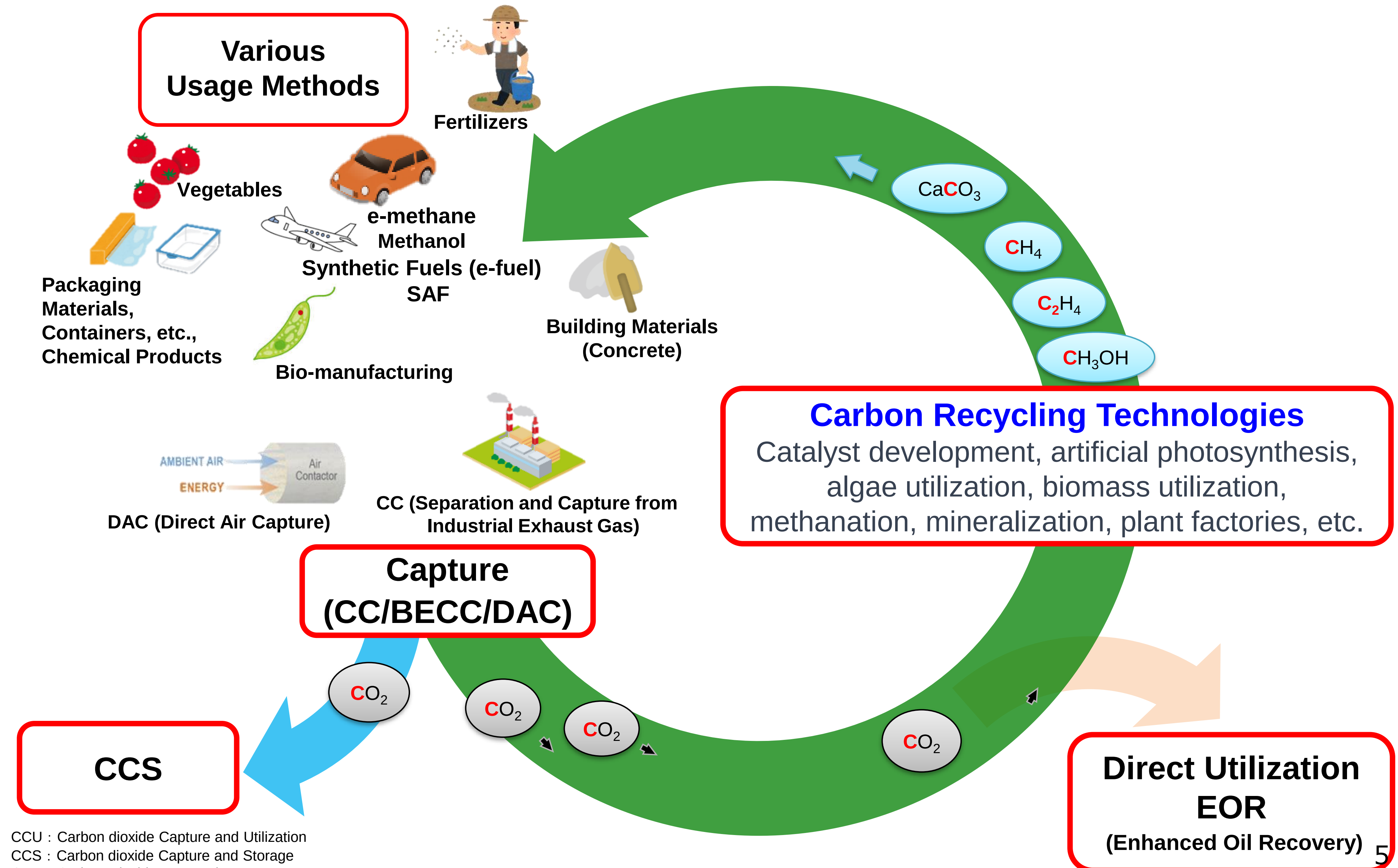
Carbon Recycling Roadmap
＜outline version＞

September, 2023

Ministry of Economy, Trade and Industry

Collaborating Ministries: Cabinet Office, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Land, Infrastructure, Transport and Tourism, Ministry of the Environment.

Concept of Carbon Management (CCU - Carbon Recycling/CCS/CDR)

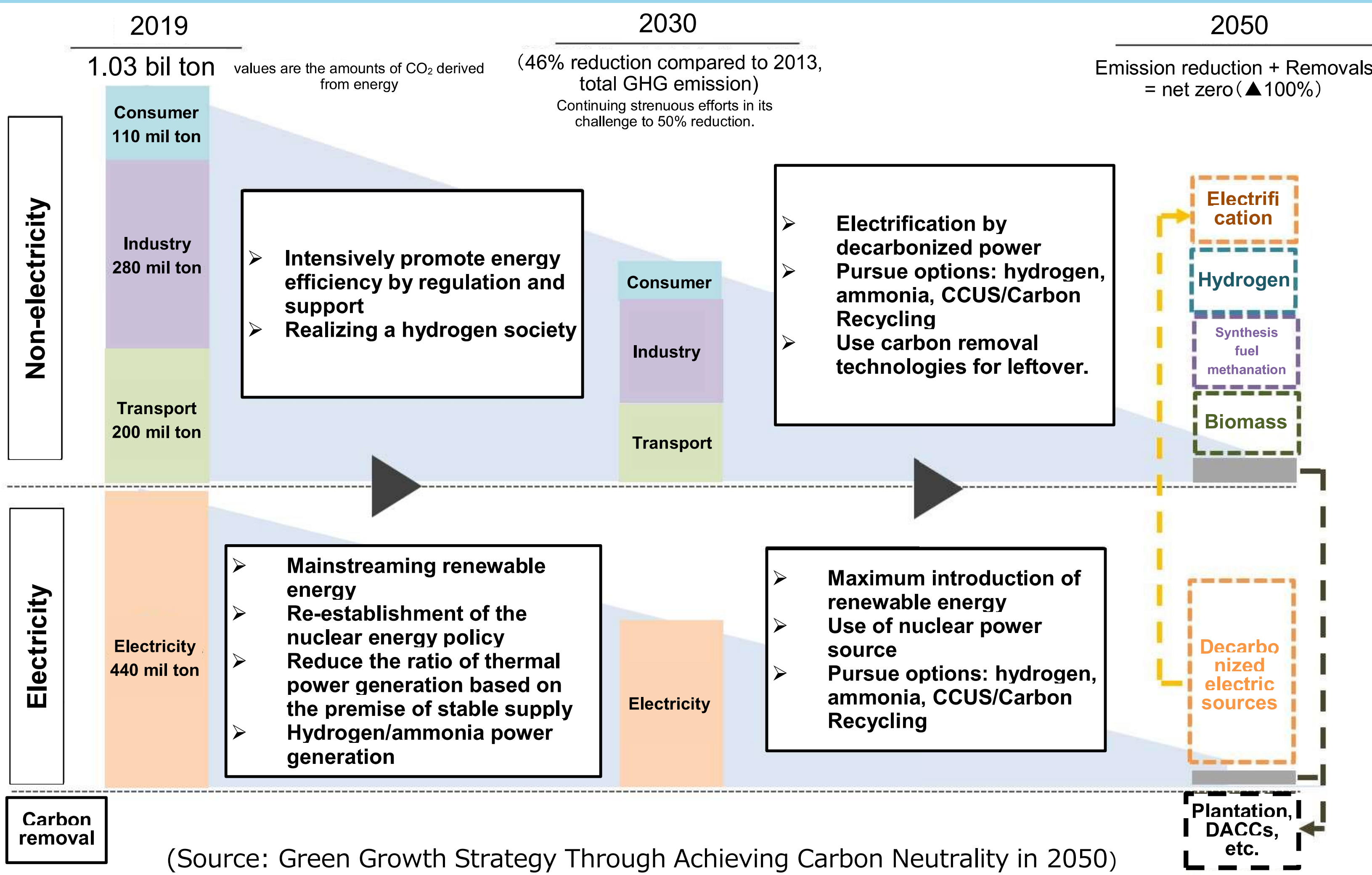


CCU : Carbon dioxide Capture and Utilization
CCS : Carbon dioxide Capture and Storage
CDR : Carbon Dioxide Removal

Ⅰ. The Significance of Carbon Recycling

The Role of Carbon Recycling towards Carbon Neutrality

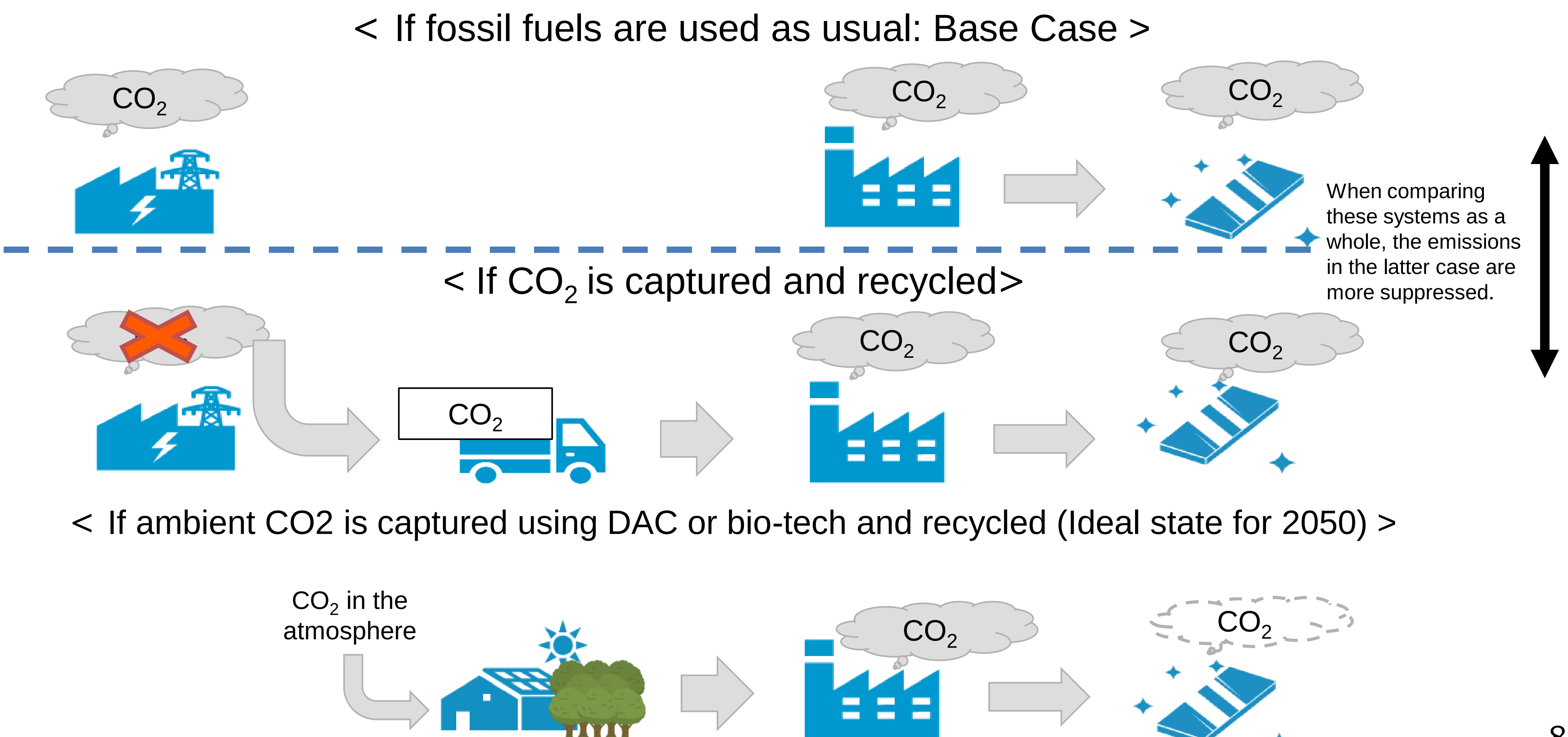
- To achieve the goal of carbon neutrality by 2050, **it is necessary to maximize the use of carbon recycling and CCS as carbon management strategies. Sectors where emissions cannot be achieved through electrification, hydrogenation, etc., and CO2 emissions are unavoidable, are especially noteworthy, such as power plants, the materials industry, and the oil refining industry.**
- **Carbon recycling, which treats and reuses CO2 as a valuable resource, is an important option that serves as a 'key' to realize Japan's decarbonization as well as its industrial and energy policies,** alongside renewable energy, nuclear power, hydrogen, and ammonia.



(Source: Green Growth Strategy Through Achieving Carbon Neutrality in 2050)

The Significance of Carbon Recycling

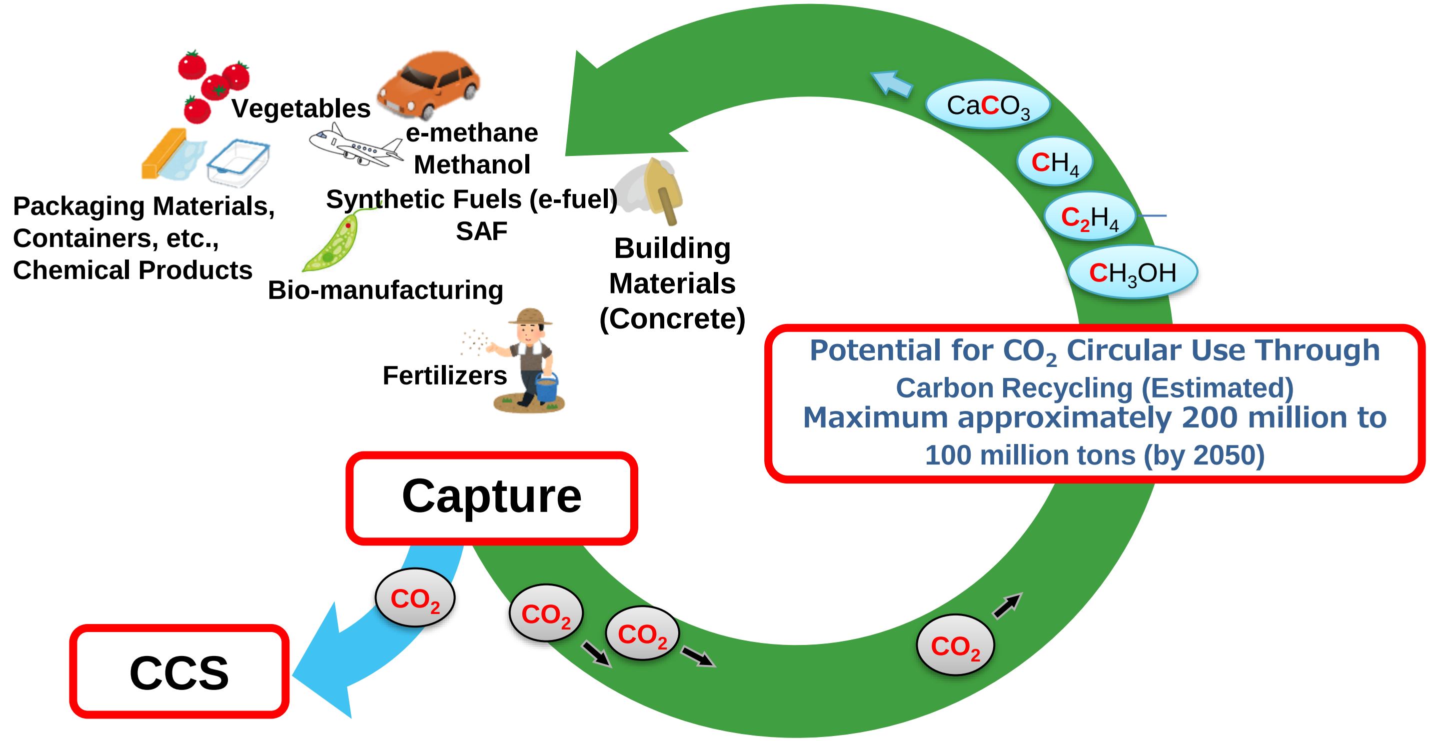
- Carbon recycling is one of the important initiatives for decarbonization, which aims to manage residual CO_2 emissions appropriately after minimizing CO_2 emissions from industrial activities as much as possible.
- By treating CO_2 as a valuable resource and converting it into another valuable product, **it is possible to control CO_2 emissions across the entire supply chain** of products, compared to traditional methods, **thereby contributing to the realization of a carbon-neutral society by 2050**.



(Source) Secretariat's creation from the Techno-Economic Assessment & Life Cycle Assessment Guidelines for CO_2 Utilization (Version 2.0).

Potential for CO_2 Circular Use Through Carbon Recycling

- **The theoretical maximum potential** for CO_2 use in producing **carbon-recycled products** used in Japan is estimated as below.*
  - **This assumption is a maximum scenario of circular use of CO_2** based on Japan's geographical and energy policy constraints**.**
  - Estimated values have no relation to the origin of CO_2, the point of generation (domestic or overseas), of CO_2 or the period during which CO_2 is fixed in the products**.**
- The maximum estimated amount of CO_2 recycled (equivalent to the amount of CO_2 used for carbon-recycled products used domestically) **as of 2050** is **approximately 200-100 million tons**.

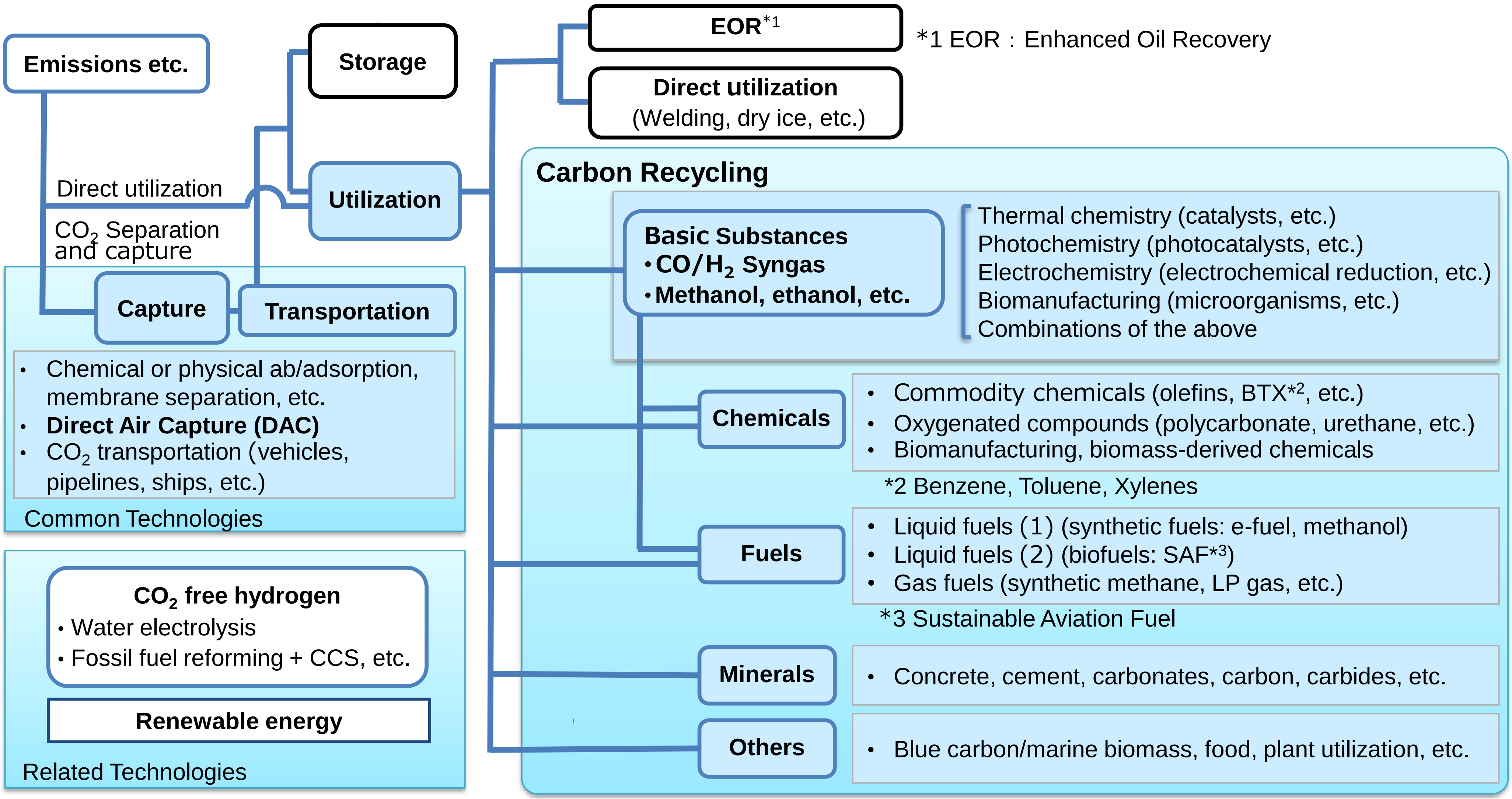


* Estimates are based on demand forecasts published by reliable international organizations such as IEA World Energy Outlook. In cases where related industries have announced individual target figures, those values are referred. Estimates are limited to items that can be calculated based on such available references. The figures may change in the future due to technological advances and changes in the demand outlook. For example, if energy conservation and hydrogen use progress in the future, the maximum potential for carbon recycling is expected to decrease.

II. Technology

What is Carbon Recycling Technology?

- **Carbon Recycling**: We consider CO_2 as a source of carbon and recycle this valuable material. It will be recycled into concrete through mineralization, into chemicals through artificial photosynthesis, and into fuels through methanation. CO_2 emission is reduced by developing and deploying these technologies, which contributes to the realization of carbon-neutral society.



Expanding the Blueprint of Carbon Recycling

- While taking into account the procurement environment for hydrogen and the maturity of the technologies, the aim is to establish technologies as early as possible in each product field, reduce costs, and promote widespread use. This will be achieved through technological advancement, development and demonstration.

*It is crucial to bear in mind the CO_2 reduction effect (environmental value), including perspectives from Life Cycle Assessment (LCA) and other similar frameworks, especially when considering market introduction and overseas expansion.

LCA：Life Cycle Assessment

Present → 2030 → Beyond 2040

Possibility of bringing forward due to:
- cost reduction of production
- change in business environment

For Carbon recycling products that can be disseminated after 2040 with a low-cost supply of hydrogen, we aim to improve the efficiency of manufacturing methods and scale up.

Expected to spread from around 2040

- **Chemicals** Commodity chemicals (olefins, BTX, etc.)
- **Fuel** Green LP gas
- **Minerals** Concrete products (for use in architecture, bridges, etc.)

Promote research, technological development, and demonstration. For commercialization, we will focus on products that do not require hydrogen and products with a high level of technological maturity.

Chemicals (e.g., polycarbonates)
Further reduction of CO_2 emissions through process improvements

Fuels (e.g., SAF)
Reducing costs to about 1/8 to 1/16 of current levels

Minerals (concrete products such as road blocks)
Reducing costs to about 1/3 to 1/5 of current levels

Expected to spread from around 2030

- **Chemicals** Polycarbonate, etc.
- **Fuel** Synthetic fuel, SAF, synthetic methane
- **Minerals** Concrete products (roadblocks, etc.), cement

→

- Further cost reduction
- Consumption expansion

Raw Material Cost	Present	2030	Beyond 2040
Hydrogen	JPY 100/Nm³	JPY 30/Nm³	JPY 20/Nm³* (*Target for 2050)
CO_2 separation and capture	approx. JPY 4,000-6,000 /t-CO_2 (DAC: JPY 30,000-60,000/t-CO_2)	JPY 2,000/t-CO_2 range (DAC: JPY 10,000/t-CO_2)	Below JPY 1,000/t-CO_2 (DAC: Below JPY 2,000/t-CO_2)

Important points for Carbon Recyling Technologies

- In order to effectively advance R&D in Carbon Recycling technologies to address climate change and the security of natural resources, the following points need to be considered:

- Affordable CO_2 free Hydrogen is important for many technologies.
  - ✓ Under the hydrogen and fuel cells strategy roadmap in 'Basic Hydrogen Strategy,' the target cost for on-site delivery in 2050 is JPY 20/Nm^3.
  - ✓ While the problem of hydrogen supply remains, (a) R&D for biomass and other technologies not dependent on hydrogen should continue, (b) CH_4 (methane) should be used in place of hydrogen until the establishment of hydrogen supply.
- Using zero-emission power supply is important for Carbon Recycling.
  - ✓ Conversion of a stable substance, CO_2, into other useful substances will require a large amount of energy.
- Life Cycle Analysis (LCA) perspective is critical to evaluate Carbon Recycling technologies. These analysis methods should also be standardized.
- Reducing the costs of CO_2 capturing technologies including DAC is necessary and will have a positive feedback on carbon recycling.

Reference: Summary of Carbon Recycling Technology and Products

*1 Current prices of carbon recycling products are based on research by secretariat.
*2 Prices of existing products are reference values based on statistical data and research results.
*3 Target value set in the 'CO_2-Based Fuel Manufacturing Technology Development' project's research and development & societal implementation directions (8th Industrial Structure Council GI Project Subcommittee Energy Structure Transformation Area WG, December 23, 2021).
*4 Target value in the 'Green Growth Strategy Through Achieving Carbon Neutrality in 2050' (June 2021).

	Substance after CO_2 Conversion	Current Status	Challenges	Price of the Existing Equivalent product (as of Jan. 2023)	In 2030	From 2040 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 cost
Chemicals	Commodity Chemicals (Olefins,BTX,etc.)	Partially commercialized (e.g., Syngas, etc. produced from coal). Others are at R&D stage.	Improvement in conversion rate/ selectivity, etc.	Approx. JPY 180/kg*2 (ethylene (domestic sale price))	Reduction in process costs	Further reduction in process cost
	Oxygenated Compounds	Partially commercialized (e.g., polycarbonates). Others are at R&D stage. [Price example] Price of the existing equivalent products (Polycarbonate)	Reduce the amount of CO_2 emissions for Polycarbonate. Commercialization of the other compounds (Improvement of conversion rate/selectivity, etc.)	Approx. JPY 400/kg*2 (polycarbonate (domestic sale price))	Costs: similar to those of existing products	Further reduction in process cost
	Biomanufacturing, Biomass-derived Chemicals	Technical development stage (Substance production using CO_2 and non-edible biomass etc. as raw materials)	Cost reduction/effective pretreatment technique, microbial modification technology, etc.	–	About 1.2 times the costs of existing products	Further reduction in cost
Fuels	Liquid fuel (Biofuel (SAF))	Technical development /Demonstration stage [Price example] SAF JPY 1,600/L*1	Improvement of productivity, cost reduction, effective pretreatment technique, etc.	Approx. JPY 100/L*2 level (bio jet fuels (domestic sale price))	Reduction in process costs	Further reduction in cost
	Liquid fuel (Synthetic fuel (e-fuel))	Technical development stage (Synthetic fuel (e-fuel)) [Price Example] Synthetic fuel approx. JPY 300-700/L*1	Improvement in current processes, system optimization, etc.	Approx. JPY 170/L*2 (gasoline (domestic sale price))	–	Costs: similar to those of existing products (about JPY 100-150/L)*3
	Gas fuel (Synthetic methane, LP gas, etc.)	Technical development/ Demonstration stage	System optimization, scale-up, efficiency improvement, etc.	JPY 105/Nm^3*2 (Natural gas (import price))	Reduction in process costs	Costs: similar to those of existing products (JPY 40-50/Nm^3)*4
Minerals	Concrete, Cement, Carbonates, Carbon, Carbides	Partially commercialized. R&D for various technologies and techniques for cost reduction are underway. [Price Example] order of JPY 100/kg (Road curb block)	Separation of CO_2-reactive and CO_2-unreactive components, pulverization, cost reduction, etc.	JPY 30/kg*2 (precast concrete for road curb blocks (domestic sale price))	Road curb blocks, etc., with high technological maturity costs: similar to those of existing products	For products with expanded applications costs: similar to those of existing products
Common Technology	CO_2 Separation and Capture (including DAC)	Partially commercialized (chemical absorption). Other techniques are at R&D stage [Price Example] Approx. JPY 4,000-6,000 /t-CO_2 (Chemical absorption)	Reduction in the required energy, etc.	–	Approximately JPY 1,000-2,000/t-CO_2 (Refer to the slide on common technology (CO_2 separation and capture technology))	≤ JPY 1000/t-CO_2 ≤ JPY 2000/t-CO_2 (DAC)
Basic Substance	Hydrogen	Technologies have been roughly established (e.g., water electrolysis). R&D for other techniques and cost reduction are also underway.	Cost reduction, etc.	–	JPY 30/Nm^3 *4	JPY 20/Nm^3 *4 (cost for on-site delivery)

Ⅲ. Accelerating Industrialization
(1) Inter-Industry Collaboration

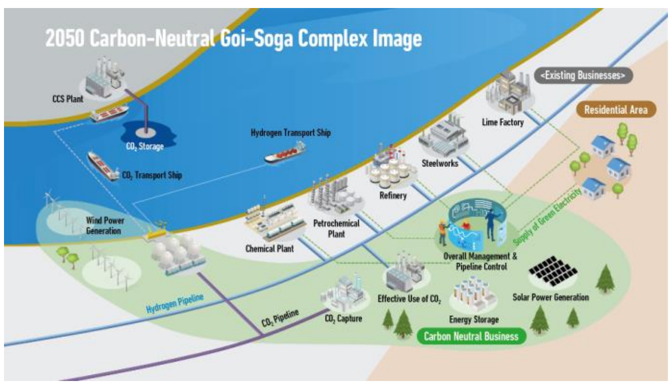
Types of Industrial Collaboration in Carbon Recycling

- **In industrial agglomerations such as complexes, existing infrastructure is well established, and the efficient hydrogen supply necessary for carbon recycling is possible.** On the other hand, **CO_2 is emitted throughout Japan**, and **there are technologies that do not require hydrogen, such as cement and concrete**.
- The way of industrial collaboration is diverse, but based on the supply amount of CO_2, the accumulation degree of users, and the status of existing infrastructure, industrial collaboration can be classified as in the following three types:

Large-scale Industrial Complex Type

- Existence of CO_2 emitters and users
- Multiple CR applications are expected.
- Efficient infrastructure development leveraging scale merits is possible.

(Example of Goi-Soga (Chiba) Complex)

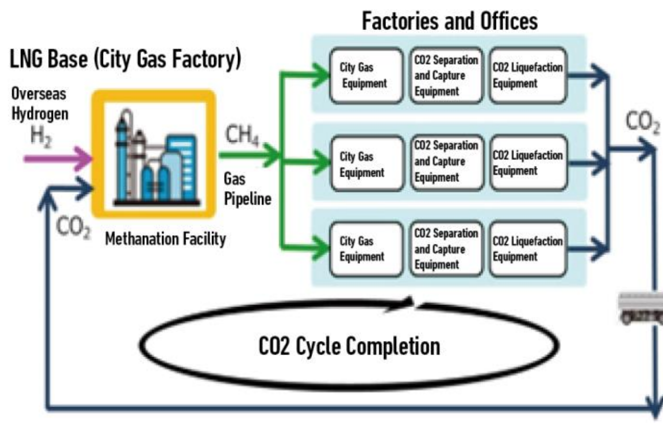


(Source) NEDO Project "Investigation of Industrial Collaboration in Goi Area, Chiba Prefecture (Yokogawa Electric Corporation)"

Small and Medium Scale Distributed Type

- Need to aggregate CO_2 due to absence of large-scale CO_2 emission sources
- CR applications differ depending on hydrogen procurement status. (In inland areas, concrete, cement, food, agriculture, bio, etc.)

(Example of consideration in Chubu Region)

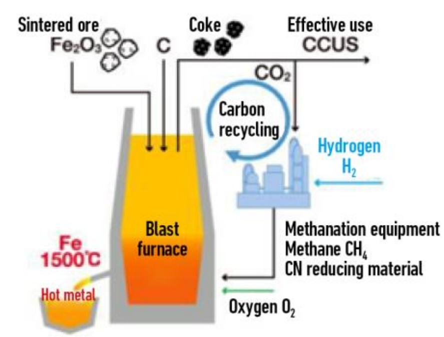


(Source) 9th Methanation Promotion Public-Private Council (Aisin Corporation, Denso Corporation, Toho Gas Co., Ltd.)

On-site Type

- Assuming CR technologies such as methanation
- It can be realized early from the demonstration stage, playing a significant role in the initial stage of CR introduction and the demonstration phase.
- A consideration of the total energy balance, such as effective use of waste heat and steam, is necessary.

(Example of Carbon Recycling Blast Furnace)



(Source) 7th Methanation Promotion Public-Private Council (JFE Steel Corporation)

CR : Carbon Recycling

Management in CO_2 Circulation

- Implementing Carbon Capture, Utilization and Storage (CCUS), energy conservation, and energy transition individually has limitations. **By promoting cross-industry collaboration involving more companies, not only can it lead to CO_2 emission reduction across the region, but it also contributes to stable and efficient supply and demand of CO_2**.

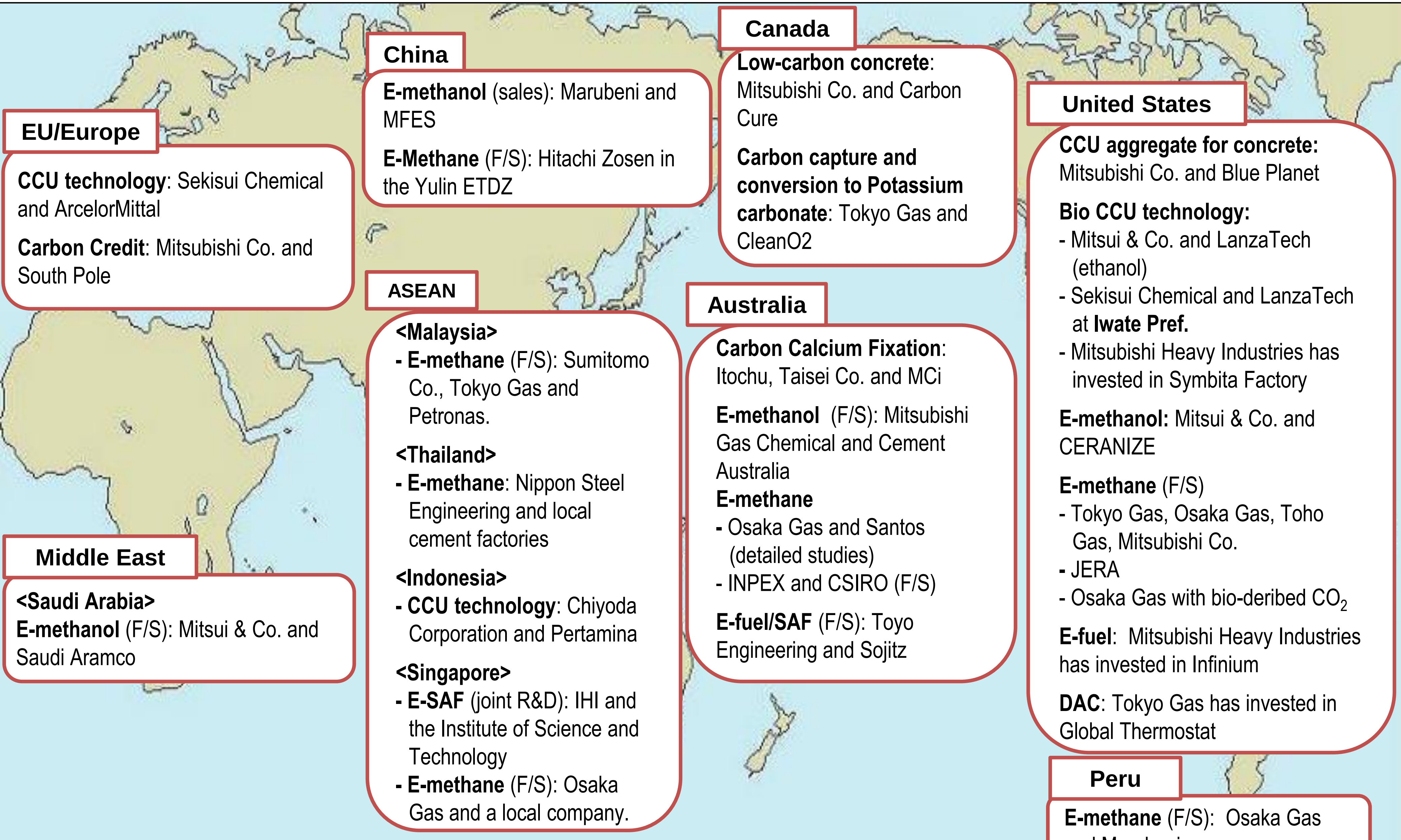
- To achieve this, **it is effective to establish a business entity (CO_2 Management Entity) responsible not only for matching suppliers and users but also for balancing supply and demand, and for managing to maximize CO_2 reduction.** This entity is also expected **to ensure the traceability of CO_2**.

▪ Roles Expected of CO_2 Management Companies (proposed)

Stakeholders	Suppliers	Users	Transport
Goods	Optimal transport network		
	Environmental conservation, safety, compliance with laws and regulations		
	Supply and utilization assurance (balance of supply and demand, quality (concentration, impurities))		
Services Systems	Provision of demand forecasting	Provision of supply forecasting	
	Business planning (environmental value, step-by-step approach to collaboration, etc.)		
	Construction of a digital platform to visualize the value chain (including traceability)		
	Project composition & expansion (matching of suppliers and users)		
	Management of information related to the business activities of participating businesses (encryption)		

Ⅲ. Acceleration of Industrialization
(2) Initiatives for International Collaboration

CCU/Carbon Recycling: initiatives by Japanese Companies



EU/Europe

CCU technology: Sekisui Chemical and ArcelorMittal

Carbon Credit: Mitsubishi Co. and South Pole

Middle East

<Saudi Arabia>
E-methanol (F/S): Mitsui & Co. and Saudi Aramco

China

E-methanol (sales): Marubeni and MFES

E-Methane (F/S): Hitachi Zosen in the Yulin ETDZ

ASEAN

<Malaysia>
- **E-methane** (F/S): Sumitomo Co., Tokyo Gas and Petronas.

<Thailand>
- **E-methane**: Nippon Steel Engineering and local cement factories

<Indonesia>
- **CCU technology**: Chiyoda Corporation and Pertamina

<Singapore>
- **E-SAF** (joint R&D): IHI and the Institute of Science and Technology
- **E-methane** (F/S): Osaka Gas and a local company.

Canada

Low-carbon concrete: Mitsubishi Co. and Carbon Cure

Carbon capture and conversion to Potassium carbonate: Tokyo Gas and CleanO2

Australia

Carbon Calcium Fixation: Itochu, Taisei Co. and MCi

E-methanol (F/S): Mitsubishi Gas Chemical and Cement Australia

E-methane
- Osaka Gas and Santos (detailed studies)
- INPEX and CSIRO (F/S)

E-fuel/SAF (F/S): Toyo Engineering and Sojitz

United States

CCU aggregate for concrete: Mitsubishi Co. and Blue Planet

Bio CCU technology:
- Mitsui & Co. and LanzaTech (ethanol)
- Sekisui Chemical and LanzaTech at **Iwate Pref.**
- Mitsubishi Heavy Industries has invested in Symbita Factory

E-methanol: Mitsui & Co. and CERANIZE

E-methane (F/S)
- Tokyo Gas, Osaka Gas, Toho Gas, Mitsubishi Co.
- JERA
- Osaka Gas with bio-deribed CO_2

E-fuel: Mitsubishi Heavy Industries has invested in Infinium

DAC: Tokyo Gas has invested in Global Thermostat

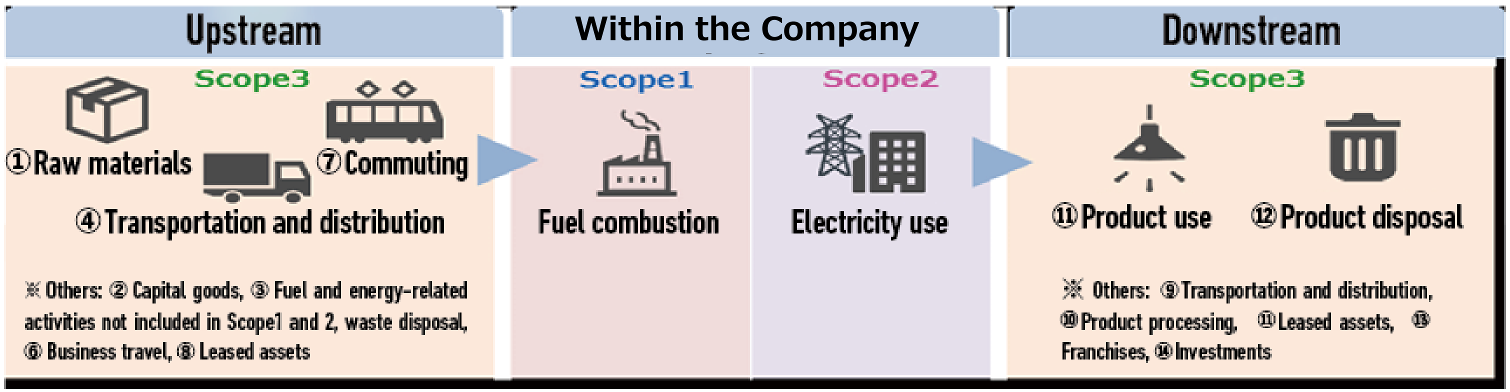
Peru

E-methane (F/S): Osaka Gas and Marubeni

Challenges to the Environmental Value of Carbon Recycling: (a) Information Disclosure by Private Businesses

- The GHG Protocol requires businesses to report all CO_2 emitted during their operations. Among them, the rule for the disclosure of CO_2 emissions throughout the supply chain (Scope 3) demands double or triple counting, **which is not a system able to evaluate carbon recycling (emission control) from a whole system perspective**.
- Therefore, it is necessary to create a system that can evaluate emission suppression by carbon recycling.

Concept of accounting in GHG Protocol Scope 1, 2, and 3



<table>
<tr><th></th><th>Scope1</th><th>Scope2</th><th>Scope3</th><th>Total</th></tr>
<tr><td>Capture company</td><td>CO_2 emitted during capture</td><td rowspan="3">CO_2 from electricity used in-house</td><td>CO_2 emitted during manufacturing and use</td><td rowspan="3">CO_2 emitted during in-house electricity usage, capture, manufacturing, and use</td></tr>
<tr><td>Manufacturing company</td><td>CO_2 emitted during manufacturing</td><td>CO_2 emitted during recovery and use</td></tr>
<tr><td>User company</td><td>CO_2 emitted during use</td><td>CO_2 emitted during recovery and manufacturing</td></tr>
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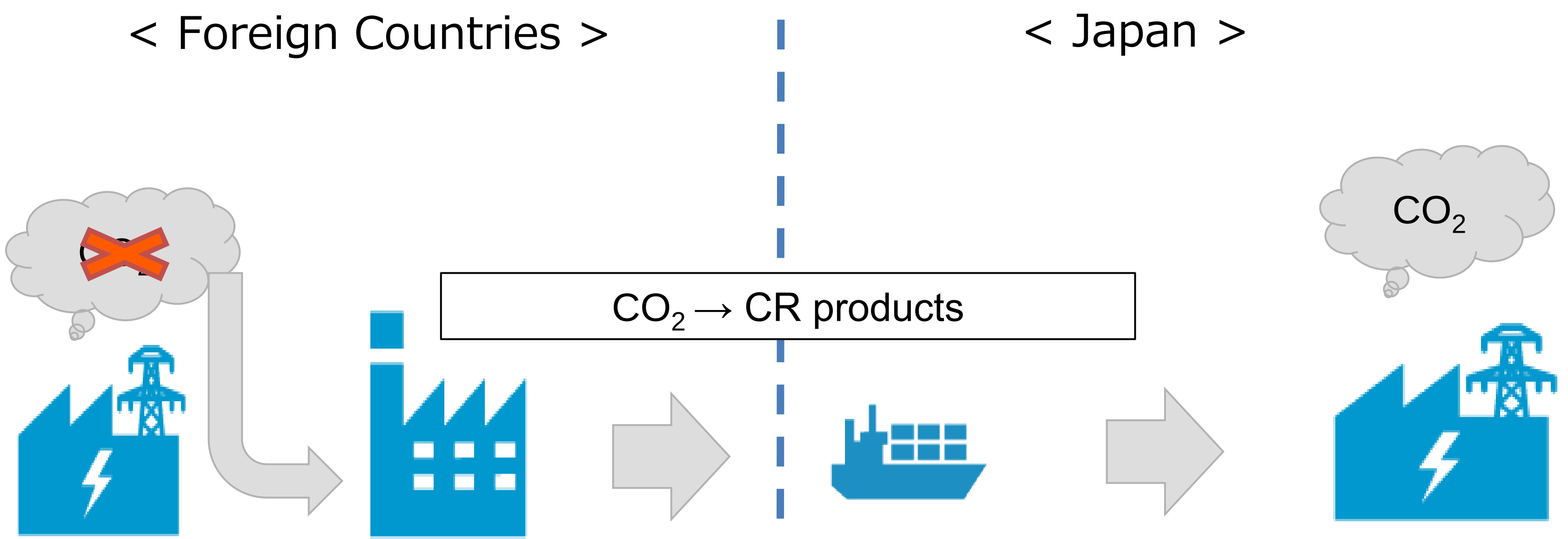
Challenges to the Environmental Value of Carbon Recycling: (b) Handling Cases Crossing Borders

- Carbon recycling using CO_2 derived from industries as a raw material, is considered capable of apportioning emissions in the life cycle in accordance with the principle of eliminating double counting.
- However, in the IPCC guidelines, etc., **the handling of CO_2 from carbon recycling that cross borders is not clarified**, leaving uncertainty when claiming the achievement of NDCs.
- While implementing specific projects, it is important to organize and adjust the handling in Japan's inventory, NDCs, etc.

Clarification is needed on which country's NDC is claimed to contribute to.



Ⅲ. Accelerating Industrialization
(3) Creating Carriers and Efforts Towards an Ecosystem

Efforts towards the Establishment of an Ecosystem

- **<u>Startups in the field of carbon recycling in Japan are mainly in the pre-seed and seed stages</u>**, **<u>requiring substantial support for their development</u>**. Initiatives such as the development of “R&D and demonstration base for carbon recycling" in Osaki-Kamijima Island in Hiroshima Prefecture are underway. This involves **<u>collaboration between academia, industry, and government</u>** to promote technical development, human resource development & network building, and international expansion, **<u>thereby nurturing potential players and establishing an ecosystem.</u>**

- Additionally, there are initiatives to set up carbon recycling centers and research centers at universities in various regions across Japan. These initiatives could be **<u>connected and further developed to create an environment conducive to the establishment of an ecosystem.</u>**

Creation and Development of Potential Players, Establishment of an Ecosystem

METI

Technical Development

NEDO

- ✓ Support research and development
- ✓ Advice from technical and business experts for technology development at the research base

R&D and Demonstration Base for Carbon Recycling

Human Resource Development Network Building

CARBON RECYCLING FUND INSTITUTE 一般社団法人 カーボンリサイクルファンド

ENERGY OF PEACE ひろしま

- ✓ Strengthening industry-academia collaboration with the Carbon Circular Economy Promotion Councils and related research centers established in the region
- ✓ Dissemination and awareness-raising activities of carbon recycling for the next generation
- ✓ Support for human resource development and network building for young corporate employees

Holding networking events with startup companies

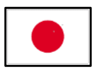
International Expansion

- ✓ Dissemination of information domestically and internationally, and support for collaboration with overseas companies through the provision of international conferences and other venues
- ✓ Collaboration with carbon recycling research institutions both domestically and internationally
- ✓ Collaboration through Memorandum of Cooperation (MOC)
- ✓ Network building with domestic and foreign institutional investors and venture capitalists, and expansion of funding provision

International Conference on Carbon Recycling

【Reference】Domestic and International Startups in Carbon Recycling

Country	Company / Organization Name	Product / Substance	Development Stage
	**O.C.O Technology** (Start-up)	Lightweight aggregate	Commerciali-zation
	**Clime works** (Start-up)	DAC (using amine-based solid absorbents, etc.)	Commerciali-zation *High Cost

Country	Company / Organization Name	Product / Substance	Development Stage
	**Algal Bio** (Start-up)	Bioplastics, etc.	Fundamental
	Hiroshima University	Cosmetics, etc.	Fundamental
	Gifu University	Urea	Fundamental
	Tohoku University	Silicon carbide	Fundamental
	Kanazawa University, RITE	DAC	Fundamental

Some universities have initiated efforts to create new carbon recycling organizations, signaling potential new actors in the field.
(From public information)

- ✓ Ibaraki University: Carbon Recycling Energy Research Center
- ✓ Kyushu University: International Institute for Carbon-Neutral Energy Research
- ✓ Kyoto University: Material Process Innovation Project based on Carbon Recycling
- ✓ Shizuoka University: Institute for Carbon Recycle Technology
- ✓ Tokyo Institute of Technology: Mitsubishi Electric Energy & Carbon Management Collaborative Research Base
- ✓ Doushisha University: Doushisha University Education and Research Platform for Carbon Recycling
- ✓ Hiroshima University: Carbon Recycling Implementation Project Research Center

etc.

Country	Company / Organization Name	Product / Substance	Development Stage
	**Carbon Cure** (Start-up)	Cement raw material	Commerciali-zation

Country	Company / Organization Name	Product / Substance	Development Stage
	**Lanza Tech** (Start-up)	Ethanol	Demonstration
	Opus12 (Start-up)	Methane, Ethane, Ethanol	Demonstration
	Newlight Technologies (Start-up)	Polymers (using biocatalysts)	Commerciali-zation
	Solidia Technology (Start-up)	CO_2 absorbing concrete	Commerciali-zation
	Blue Planet (Start-up)	Lightweight aggregate	Commerciali-zation

Country	Company / Organization Name	Product / Substance	Development Stage
	**HIF** (Start-up)	Synthetic fuels (e-fuel)	Demonstration

CCS Policy Reference

Support for advanced CCS business with models

- **To establish a business model that can be deployed horizontally** for the spread and expansion of CCS business in the future, **advanced CCS businesses led by business operators will be selected** and intensively supported by the national government, **aiming at starting the business by 2030**.

- Specifically, **support will begin for 3 to 5 projects that have different combinations of CO_2 capture sources, transportation methods, and CO_2 storage areas**, aiming at establishing various CCS business models, as well as **securing an annual storage capacity of 6 to 12 million tons by 2030**.

  Note) Shall be set based on the goals of business operators planning to enter CCS. The UK also targets annual storage capacity of 10 million tons by 2030.

- As a model, it shall be a project **that works on large-scale business and overwhelming cost reduction by clustering CO_2 capture sources and developing CO_2 storage areas into a hub**.

Examples of expected CO_2 capture sources, transportation methods, and CO_2 storage areas

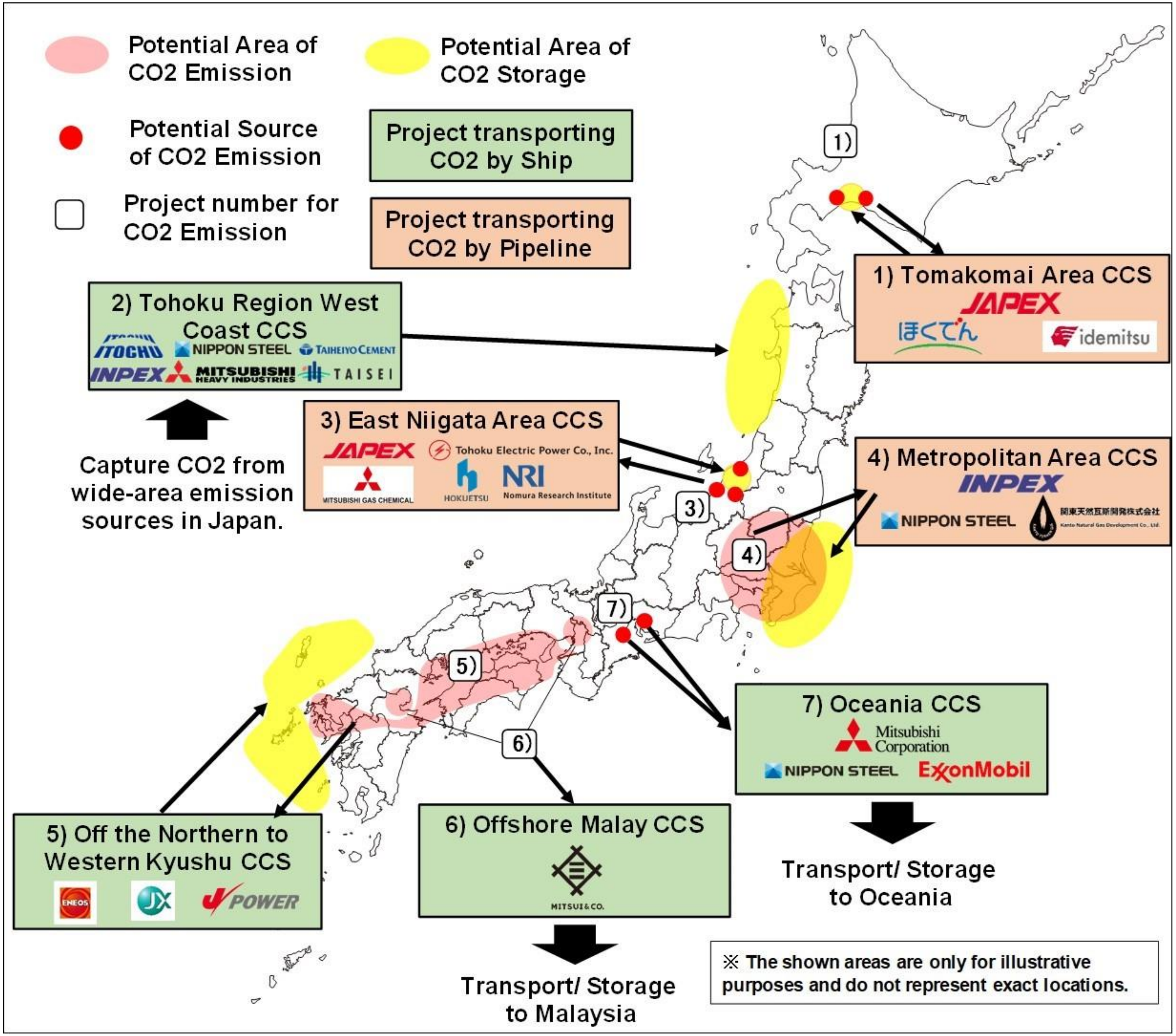
CO_2 capture sources	Transportation methods	CO_2 storage areas
Thermal power plants Steel mills Chemical plants Cement plants Paper mills Hydrogen manufacturing plants, etc.	Pipelines Ships	Terrestrial underground Under the sea (coastal area) Under the sea (offshore)

Overviews of Selected Advanced CCS Projects

- On June 6, Seven CCS projects was selected as Advanced CCS project (including two oversea export projects) which was considered CO2 source, transportation methods, storage areas.
- Selected project target a wide range of industries such as electric pawer, oil refineries, steel, chemical, pulp/paper, and cement, and capture CO2 emitted from various regions in Japan.
- The total estimated annual storage of CO2 in 2030 is about 13 million tons (including 30% exported overseas).

Storage areas	CO2 Sources	Transportation methods	Types of storage site
①Tomakomai Area CCS JAPEX, Idemitsu Kosan, Hokkaido Electric power	Oil refinery, electric power plant	Pipeline	Onshore depleted gas fields and/or Near shore
②Tohoku region west coast CCS ITOCHU Corp., Nippon Steel, Taiheiyo Cement, Mitsubishi Heavy Industries, ITOCHU Oil Exploration, INPEX, Taisei Corp.	Steel plant, Cement plant	Ship, Pipeline	Near shore
③East Niigata Aria CCS JAPEX, Tohoku electric power, Mitsubishi Gas Chemical Company, Hokuetsu Co, Nomura Research Institute.	Chemical plant, Paper plant, electric power plant	Pipeline	Onshore depleted gas fields ～ Near Shore
④Metropolitan Aria CCS INPEX, Nippon Steel, Kanto Natural Gas Development	Steel plant, others	Pipeline	Near Shore
⑤Northern to Western Offshore CCS ENEOS、JX Nippon Oil & Gas Exploration、J-Power	Oil refinery, electric power plant	Ship, Pipeline	Offshore
⑥Offshore Malay CCS Mitsui & Co.	Oil refinery, Chemical plant, others	Ship, Pipeline	Oversea project (Malaysia)
⑦Oceania Mitsubishi Corp., Nippon Steel, ExxonMobil	Steel plant, others	Ship, Pipeline	Oversea project（Oceania)

Locations of the selected projects and companies



Japan's contribution toward CCS value chain

- **Japan is the only country that has various technology related to the CCS value chain, such as CO2 capture, transport and storage.**

CO2 capture

[Engineering]

MITSUBISHI HEAVY INDUSTRIES — Global No.1 Provider for exhausted gases (70% of global market) and Provided for Petra Nova

NIPPON STEEL ENGINEERING — Provided for Steel Makers and Coal-fired power plants.

CHIYODA CORPORATION — Delivered PCC facility as EPC contractor, New technology development under NEDO project

Liquefied CO2 transport ship

[Engineering]

MITSUBISHI HEAVY INDUSTRIES

Low Temperature Low Pressure
First mover in the world

[Shipping Company]

MOL Mitsui O.S.K. Lines — Invested in Larvik Shipping

"K" LINE KAWASAKI KISEN KAISHA, LTD. — Provides for Northern Lights

CO2 pipeline

[Manufacturing]

NIPPON STEEL

Provides Seamless Pipe for CO2 Injection well of Northern Lights

[Engineering]

JFE Engineering Corporation

NIPPON STEEL ENGINEERING

Storage/Total engineering

[Engineering]

JGC — Designed "Tomakomai" Demonstration PJ

CHIYODA CORPORATION — Delivered CCS facilities for LNG plants in Qatar