Research and Development for DAC in Japan

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Program Director for Moonshot Goal No. 4

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APEC Symposium on Pursuing Decarbonation of Fossil Fuels

Session 5. Direct （Air） Carbon Capture (DAC)

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Recent Development for Carbon Neutrality in Japan

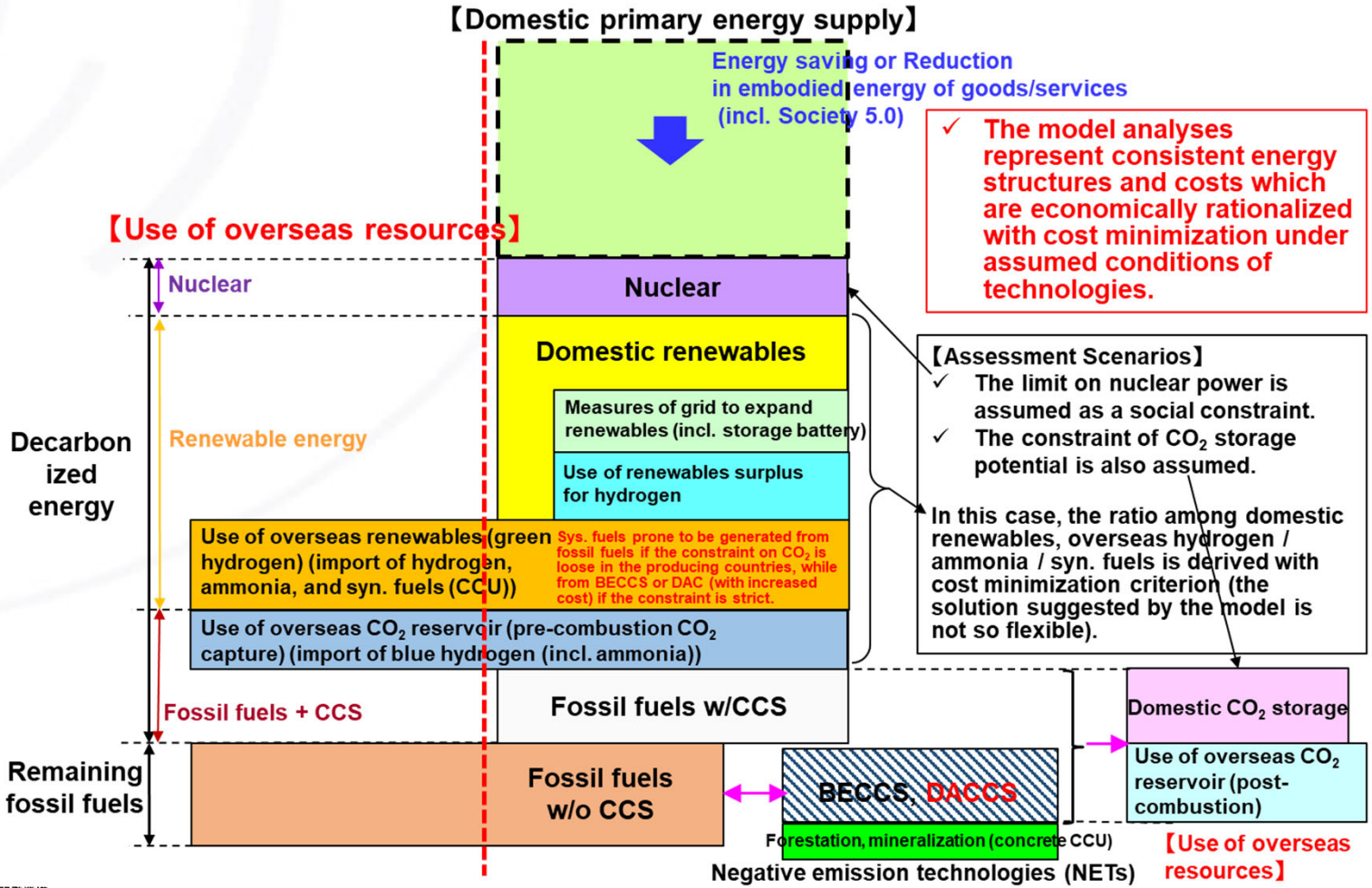
2015/12：Paris Agreement adopted at COP21
2018/10：Special Report of IPCC for 1.5°C (Carbon Neutrality by 2050)
2020/10：Japan announced 2050 Carbon Neutrality
2020/12：Japan decided Green Growth Strategy (updated June, 2021)

2021/04：Climate Summit by US President Biden
Japan announced a new 2030 Target (46% reduction)

2021/10：Japan decided 6th Strategic Energy Plan
2021/11：COP26 in UK

2022/02：Russian invasion of Ukraine started
2022/11：COP27 in Egypt
2023/02：Japan decided Basic Policy for GX (Green Transformation)

Image of Primary Energy in Japan for Net Zero Emissions (by Keigo Akimoto, RITE)



Implications of RITE 2050CN Scenario Analysis Results

◆Various measures such as Energy Conservation, Renewables, Nuclear, CCUS, Hydrogen/Ammonia, NETs(Negative Emission Technologies) are mobilized to realize Carbon Neutrality. Nuclear is used to the level of the upper constraint in the optimal solution.

◆Electrification and decarbonization of electricity are commonly required in all scenarios for Carbon Neutrality while costs of electricity increase. Electricity of 100% renewables further increases the cost, thus suppress the electrification of final demands in the optimal solution.

◆Hydrogen and zero-emission synfuels are used in non-electric demand sectors. NETs are used to offset the emissions from the hard-to-abate sectors for realizing Carbon Neutrality.

◆DAC (Direct Capture of CO_2 in Air) is commonly used in all scenarios to realize Carbon Neutrality. Scale of the utilization of recovered CO_2 is limited. CO_2 storage capacities abroad are used as well as the domestic storage capacities for Carbon Neutrality in Japan.

◆Super smart society (Society 5.0) promotes circular/sharing economies leading substantial energy/material reductions, thus to explore a new perspective to realize a huge energy conservation with low costs.

Moonshot Goals

Goals

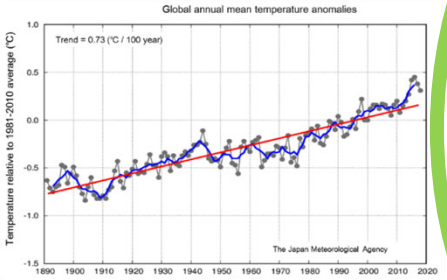
<u>To realize “Human Well-being”,</u>
9 Moonshot goals were decided in the area of society, environment, and economics.

Goal 4 : **Realization of sustainable resource circulation to recover the global environment by 2050.**

Started in 2020 as the first group of MS Goals

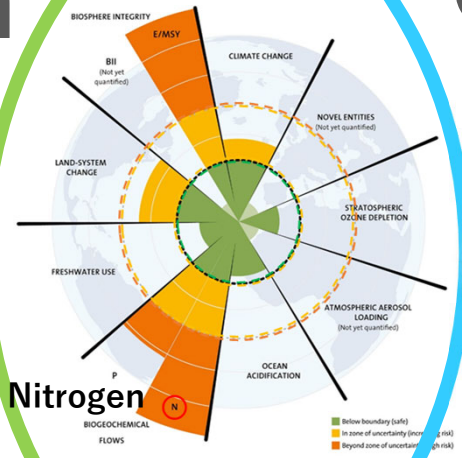
The concept of Moonshot Goal No. 4

Cool Earth



Global Warming

Planetary Boundaries



Nitrogen

Clean Earth

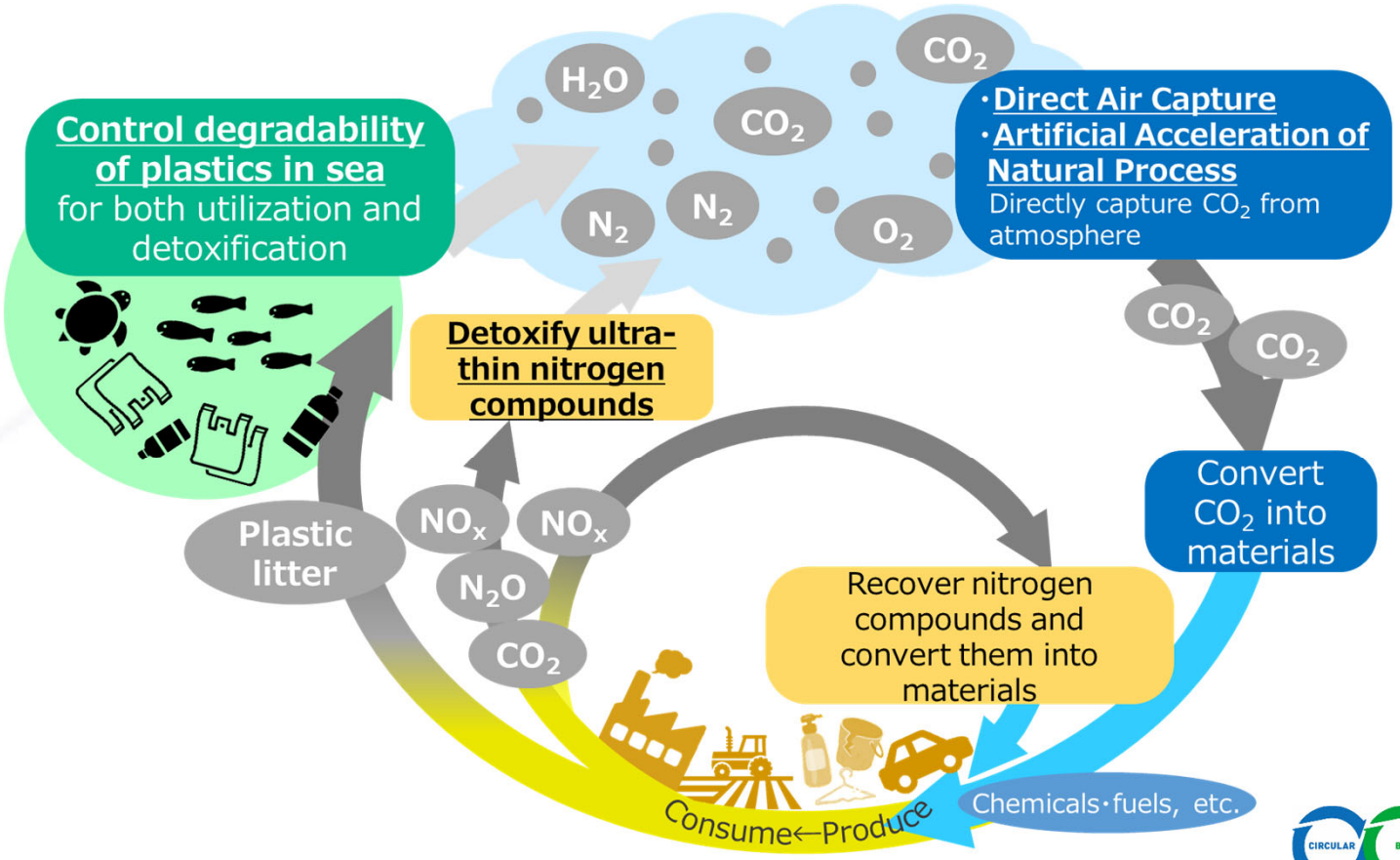
Marine Plastic Litter

Moonshot R&D Program

Moonshot Goal 4 Realization of sustainable resource circulation to recover the global environment by 2050

- **About:**
  To develop radical solutions for difficult societal challenge, the Government of Japan set 9 inspiring and ambitious goals (Moonshot Goals) for challenging R&D. NEDO is pursuing ambitious R&D activities to achieve Moonshot Goal 4. This program began in 2020 and will last up to 10 years.

- **Program Director:**
  Dr. YAMAJI Kenji
  President, Director-General of the Research Institute of Innovative Technology for the Earth (RITE)



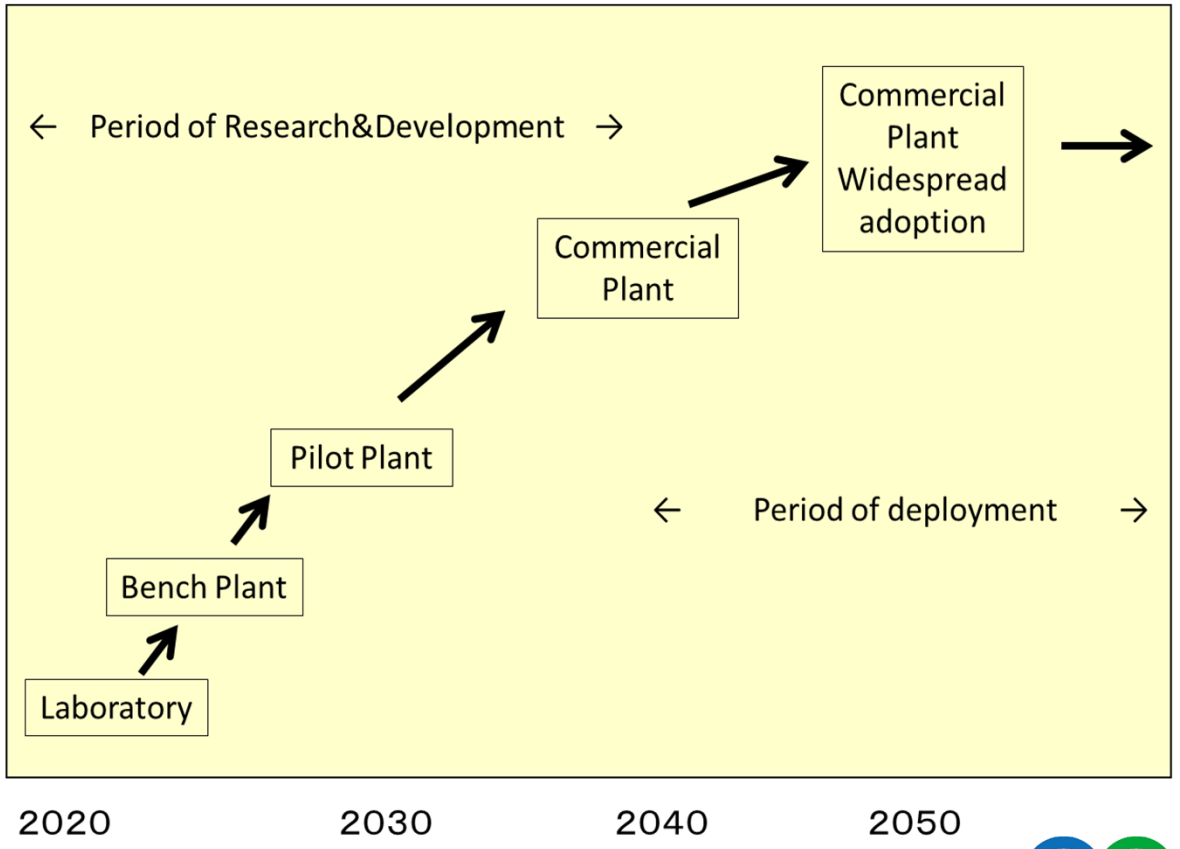
Target of Moonshot Goal 4

Outcome target (2050): **The Cool Earth & The Clean Earth**

Realization of sustainable resource circulation to recover the global environment. Commercial plants or products utilizing circulation technology will be deployed globally.

Output target (2030): **Cool Earth**

Development of circulation technology on a pilot scale for reducing greenhouse gases, that is also **effective in terms of life cycle assessment (LCA)**.



Timeline for realization of the MS Goal

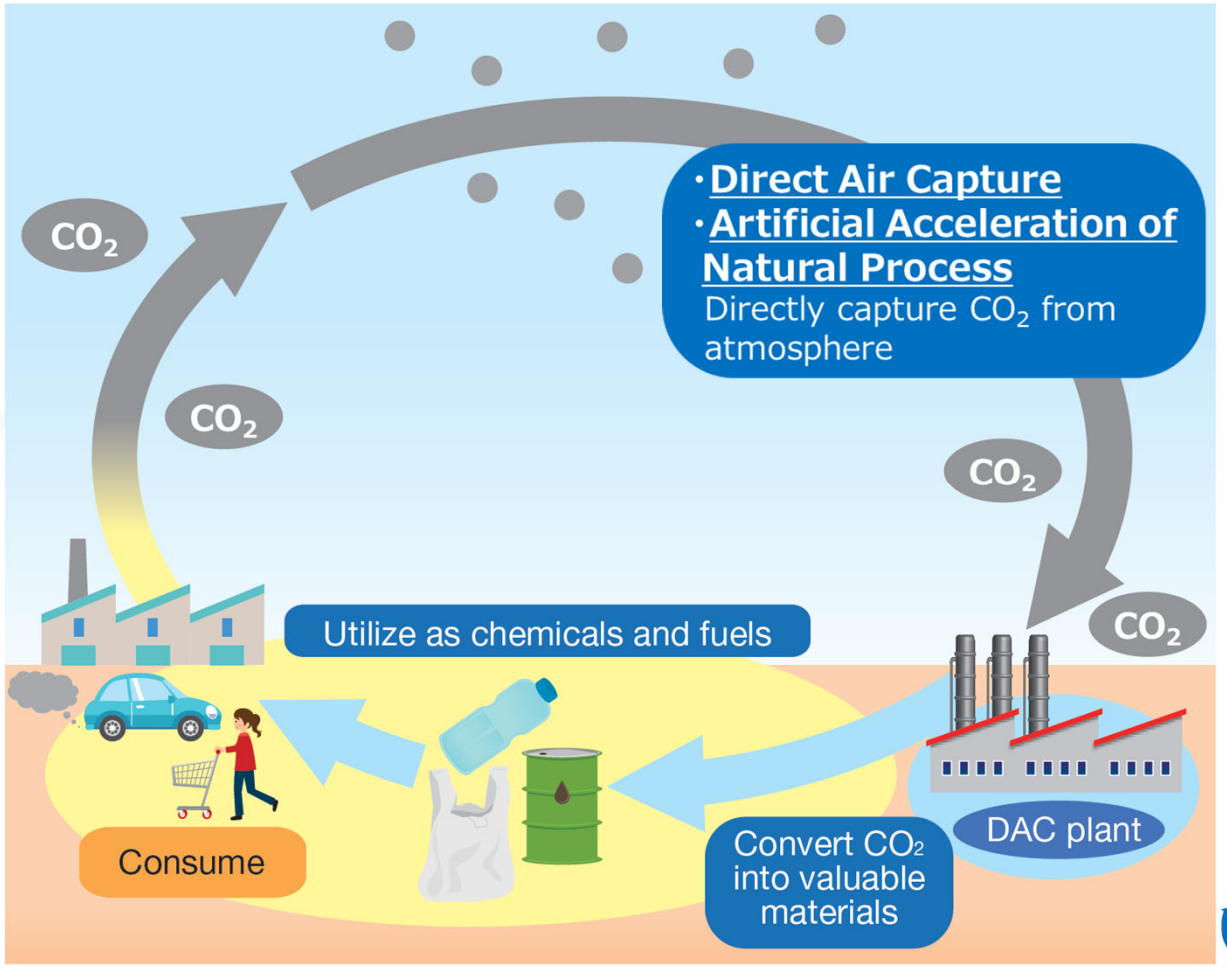
Ministry of Economy, Trade and Industry, Moonshot Goal 4 Research and Development Concept (2022)

Outline of DAC-U projects

Development of Technologies to Recover CO_2 and Convert Them into Valuable Materials

In this program, various technologies to realize direct air capture (DAC) are being developed to capture low-concentration (around 0.04%) CO_2 that diffuses into the atmosphere, with the aim of **commercializing low-cost, high-efficiency DAC technologies**.

In addition to DAC technologies, various new technologies are being developed to convert captured CO_2 into valuable.



Outline of DAC-U projects

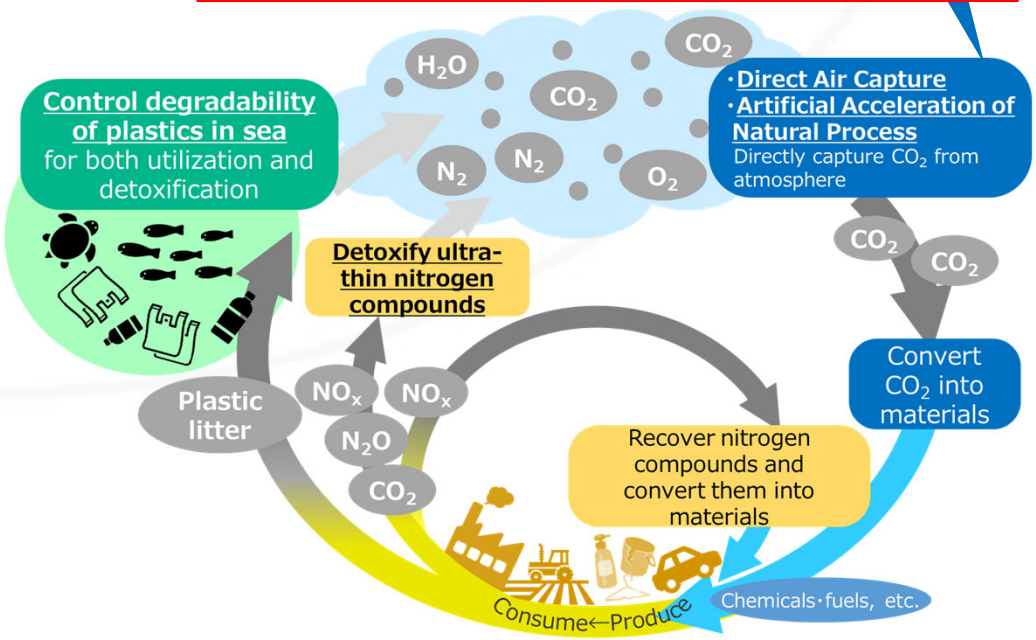
Chemical engineering
Mineralization
Biomass

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM
NEDO

Cool Earth

Development of technologies to recover greenhouse gases (“GHGs”) and convert them into valuable materials

	R&D Projects	Project Managers
1	Development of highly efficient direct air capture (DAC) and carbon recycling technologies	Dr. KODAMA Akio, Kanazawa University
2	Integrated Electrochemical Systems for Scalable CO2 Conversion to Chemical Feedstocks	Dr. SUGIYAMA Masakazu, The University of Tokyo
3	C4S Research and Development Project	Dr. NOGUCHI Takafumi, The University of Tokyo
4	Research and development toward saving energy for direct air capture with available cold energy	Dr. NORINAGA Koyo, Nagoya University
5	Development of Combined Carbon Capture and Conversion (quad-C) modules targeting low carbon dioxide concentration gases for balancing the global carbon budget	Dr. FUKUSHIMA Yasuhiro, Tohoku University
6	Development of Global CO2 Recycling Technology towards “Beyond-Zero” Emission	Dr. FUJIKAWA Shigenori, Kyushu University
7	Redesign of Macroalgae for Highly Efficient CO2 Fixation by Functional Modifications and Their Product Generation	Dr. UEDA Mitsuyoshi, Kyoto University
8	Advanced Enhanced Rock Weathering (A-ERW) Technology Actively Combined With Site Characteristics	Dr. NAKAGAKI Takao, Waseda University
9	Development of Next-generation CO2 -fixing Plant Through the Gene Optimization, Distant Hybrid, and Microbial Symbiosis	Dr. MITSUDA Nobutaka, National Institute of Advanced Industrial Science and Technology (AIST)
10	Feasibility Study of Enhanced Mineralization Based on LCA/TEA Platform	Dr. MORIMOTO Shinichirou, National Institute of Advanced Industrial Science and Technology (AIST)
11	Agrobiotechnological Direct Air Capture Towards Carbon Circulation Society	Dr. YANO Masahiro, National Agriculture and Food Research Organization (NARO)



Outline of DAC-U projects (Chemical engineering)

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM

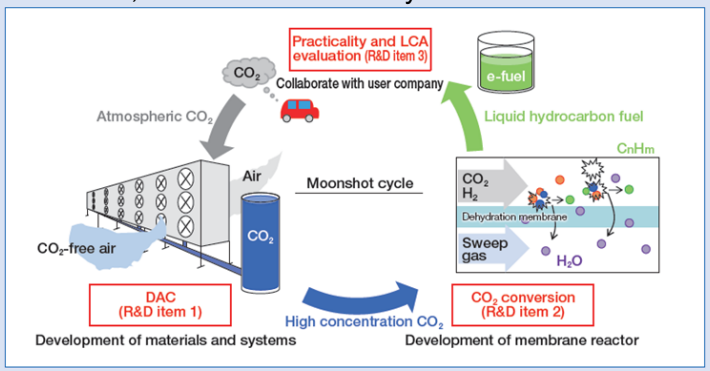
NEDO

PM

Development of highly efficient Direct Air Capture (DAC) and carbon recycling technologies

Dr. KODAMA Akio

Professor, Kanazawa University



POINT

Development of innovative **amine-loaded CO_2 solid sorbent**

CO_2 capture and enrichment process using less energy than conventional technologies

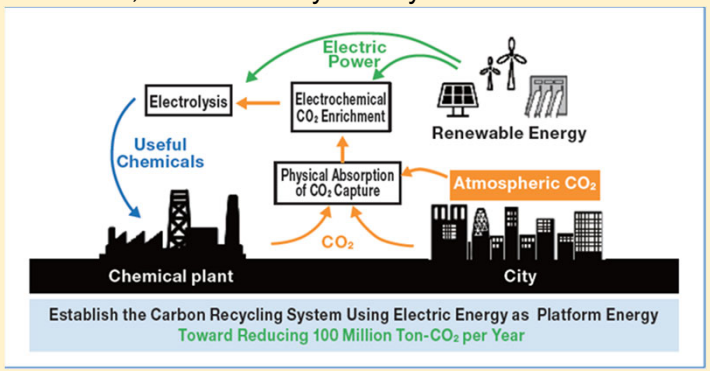
Implementing organizations: Kanazawa University, Research Institute of Innovative Technology for the Earth (RITE)

PM

Integrated Electrochemical Systems for Scalable CO_2 Conversion to Chemical Feedstocks

Dr. SUGIYAMA Masakazu

Professor, The University of Tokyo



POINT

Creation of a system fore CO_2 enrichment and reduction to chemical feedstocks by **electro-chemical process** using renewable electricity

Flexible system that allows for small-scale Distributed deployment

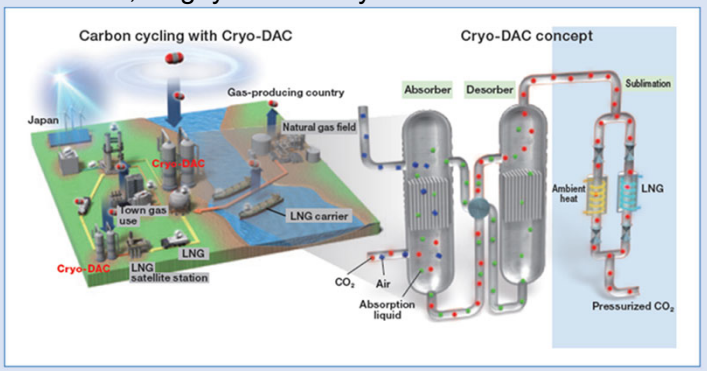
Implementing organizations: The University of Tokyo, Osaka University, RIKEN, Ube Industries, Ltd., Shimizu Corporation, Chiyoda Corporation, Furukawa Electric Co., Ltd.

PM

Research and development toward saving energy for Direct Air Capture with available cold energy

Dr. NORINAGA Koyo

Professor, Nagoya University



POINT

Direct capture of atmospheric CO_2 by employing Unused cold energy from **liquefied natural gas (LNG)**

Pressure swing recovery of CO_2 by the CO_2 sublimation while operating both absorber and desorber at room temperature

Implementing organizations: Nagoya University, Toho Gas Co., Ltd., Tokyo University of Science

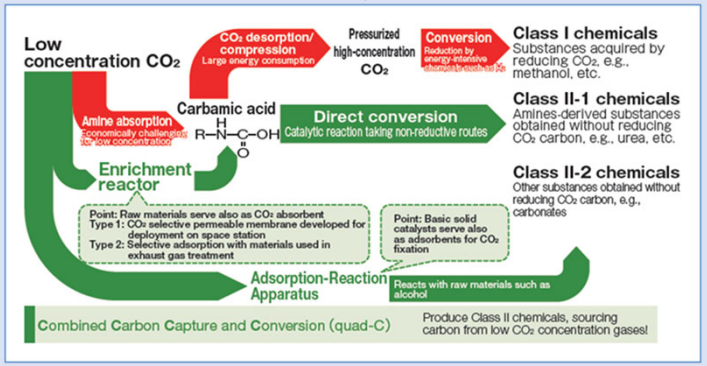
Outline of DAC-U projects (Chemical engineering)

PM

Development of Combined Carbon Capture and Conversion (quad-C) modules targeting low carbon dioxide concentration gases for balancing the global carbon budget

Dr. FUKUSHIMA Yasuhiro

Professor, Tohoku University



POINT

Creation of streamlined reaction system, termed "quad-C", by directly **linking CO_2 fixation and conversion**

Takes energy-efficient conversion routes without Carbon reduction

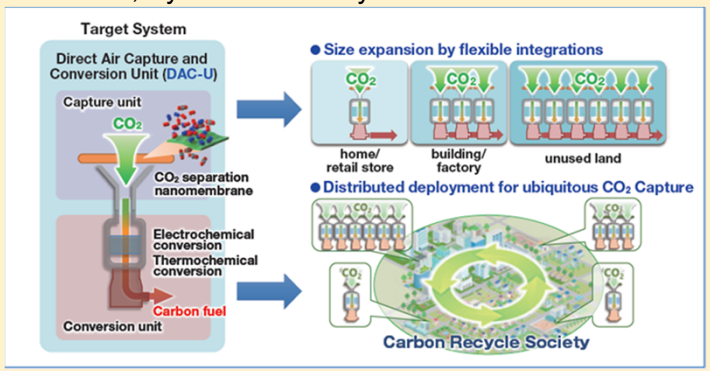
Implementing organizations: Tohoku University, Osaka Metropolitan University, Renaissance Energy Research Corporation

PM

Development of Global CO_2 Recycling Technology towards "Beyond-Zero" Emission

Dr. FUJIKAWA Shigenori

Professor, Kyushu University



POINT

Development of CO_2 capture using innovative **separation nano-membranes** with unparalleled CO_2 permeability

Scalable system for use in small-sized homes and medium-sized buildings

Implementing organizations: Kyushu University, Kumamoto University, Hokkaido University

Outline of DAC-U projects (Mineralization)

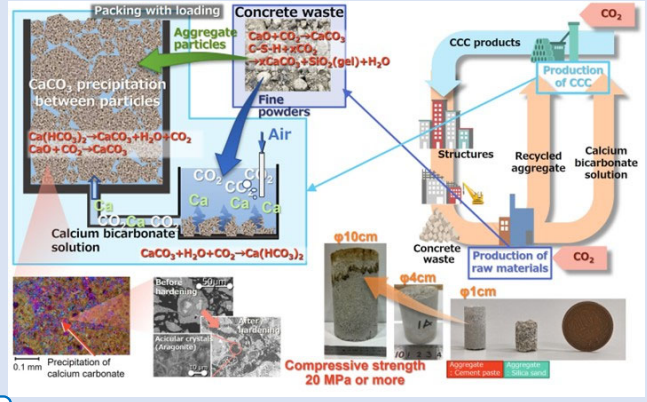
PM

C4S Research and Development Project

C4S: Calcium Carbonate Circulation System for Construction

Dr. NOGUCHI Takafumi

Professor, The University of Tokyo



POINT

Capturing atmospheric CO_2 efficiently with repeated dry & wet cycles of **crushed concrete waste**

Contributing to sustainable circulation of calcium resources as well as CO_2 with low energy

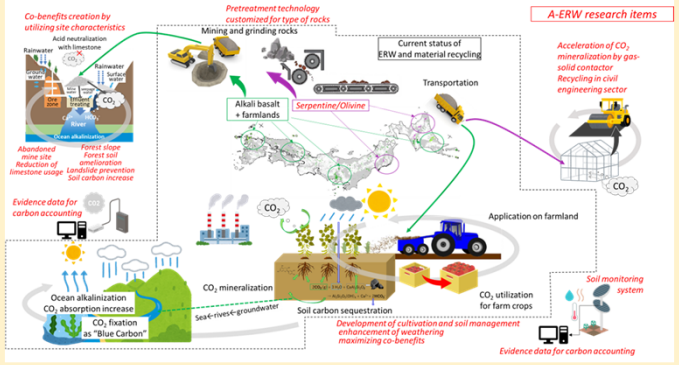
Implementing organizations: The University of Tokyo, Hokkaido University

PM

Advanced enhanced rock weathering (A-ERW) technology actively combined with site characteristics

Dr. NAKAGAKI Takao

Professor, Waseda University



POINT

Various mafic rocks utilizing the geological characteristics of Japan

Site-specific weathering, CO2 mineralization, and co-benefits

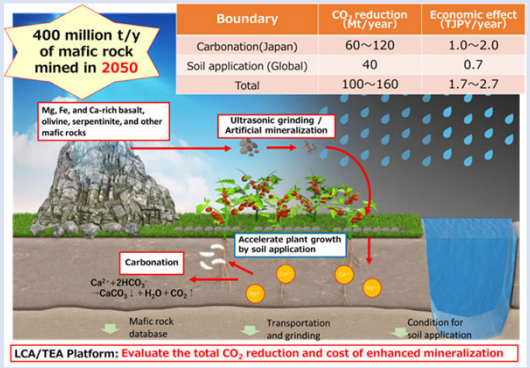
Implementing organizations: Waseda University, Hokkaido University, Kyoto Prefectural University, Mitsubishi Heavy Industries, Ltd.

PM

Feasibility Study of Enhanced Mineralization Based on LCA/TEA Platform

Dr. MORIMOTO Shinichirou

Environmental and Social Impact Assessment Team Leader, National Institute of Advanced Industrial Science and Technology (AIST)



POINT

Accurate **accounting of CO2 reductions**

Clarify the optimal soil application method of mafic rocks for plant growth

Implementing organizations: AIST, RIKEN

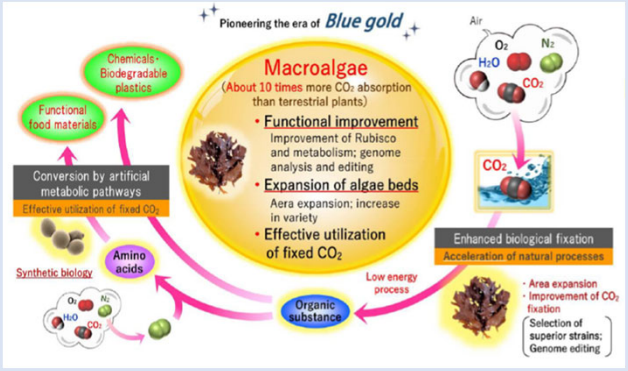
Outline of DAC-U projects (Biomass)

PM

Redesign of macroalgae for highly efficient CO_2 fixation by functional modifications and their product generation

Dr. UEDA Mitsuyoshi

Special Appointed Professor, Kyoto University



POINT

Selection and **breeding of macroalgae** with higher CO_2 fixing capacity than land plants

Genome editing of CO_2 fixation enzyme gene system and production of edited strains for accelerating CO_2 fixation capacity

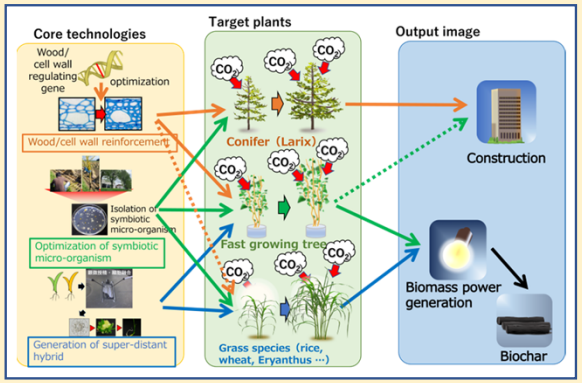
Implementing organizations: Kyoto University, Kyoto Institute of Technology, Mie University, Green Earth Institute Co., Kansai Chemical Engineering Co.

PM

Development of next-generation CO_2 -fixing plant through the gene optimization, distant hybrid, and microbial symbiosis

Dr. MITSUDA Nobutaka

Deputy director of BPRI and the group leader, National Institute of Advanced Industrial Science and Technology (AIST)



POINT

Gene optimization for **reinforced biomass** production

New hybrid plant creation by super-distant cross

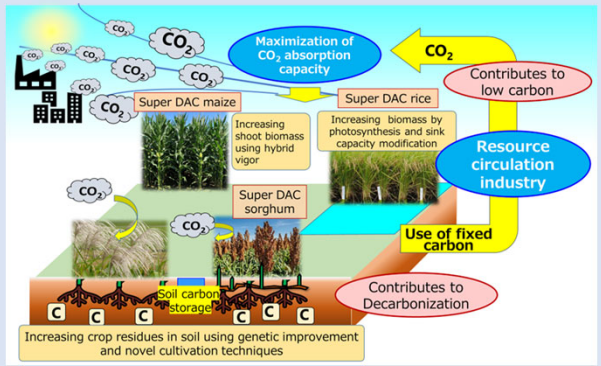
Implementing organizations: AIST, Tokyo Metropolitan University, Sumitomo Forestry Co., Ltd.

PM

New hybrid plant creation by super-distant cross

Dr. YANO Masahiro

Senior Executive Researcher, National Agriculture and Food Research Organization (NARO)



POINT

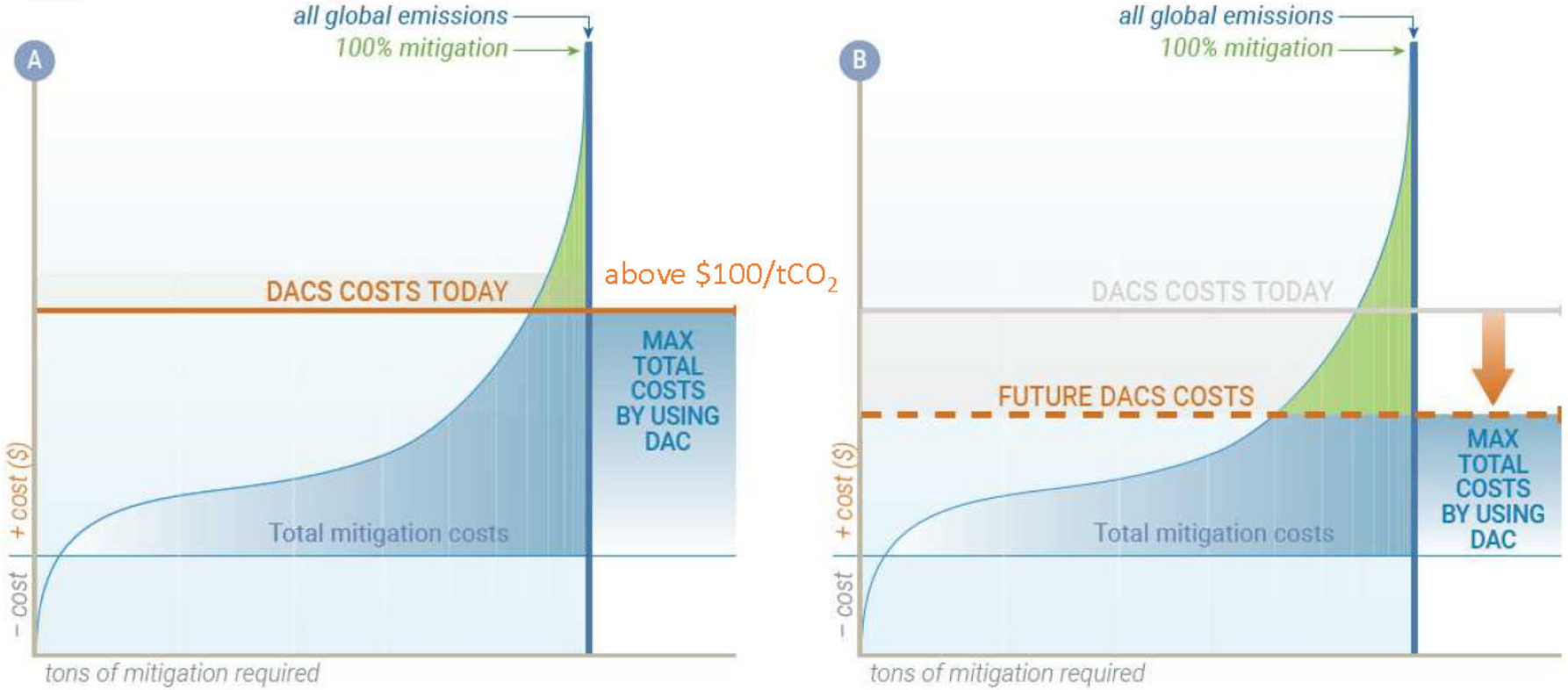
Development of **Super-DAC crops** (rice, maize, and sorghum)

Elucidation of soil carbon dynamics derived from crop residues

Implementing organizations: NARO, Tokyo University of Agriculture and Technology, Nagoya University

Cost for CO2 Removal

(DAC as a Backstop Technology)



Relationship between cost and introduction amount of DAC

Source: Direct Air Capture of Carbon Dioxide Roadmap (ICEF 2018)


ご清聴ありがとうございました
Thanks for your attention
公益財団法人　地球環境産業技術研究機構（RITE）
Research Institute of Innovative Technology for the Earth