NEDO

focus NEDO

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No.79

Reporting on Today and Tomorrow's Energy, Environmental and Industrial Technologies

Special Report

Moonshot Research and Development Program

Pursuing Recovery of Global Environment

Cool Earth & Clean Earth

New Energy and Industrial Technology Development Organization

NEDO News Report
Updates on NEDO activities to develop advanced technologies

Topic for this issue Toward a carbon-neutral, decarbonized society in 2050

Fukushima Hydrogen Energy Research Field (FH2R) Attracting Attention as One of World's Largest Hydrogen Production Facilities Using Renewable Energy

Attracting visitors from overseas as well as Japan

NEDO has constructed the Fukushima Hydrogen Energy Research Field (FH2R) in Namie Town, Fukushima Prefecture. FH2R is equipped with one of the world's largest hydrogen production facilities and a demonstration project started there in July 2020.

At FH2R, hydrogen is being produced using electricity generated by a 20 MW solar power generation facility with the aim of realizing power-to-gas technology.

The project has attracted attention both in Japan and overseas, and has been visited by cabinet ministers such as Environment Minister Koizumi, as well as the ambassadors of five Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden), where the introduction of renewable energy is expanding. FH2R is expected to contribute to the realization of a decarbonized society using technology that does not emit CO_2 at any point, from the production of energy to its utilization.

Scan below for further information:

https://www.nedo.go.jp/ugoki/ZZ_100968.html
(only available in Japanese)

Ambassadors to Japan from five Nordic countries visited FH2R on November 17, 2020

Environment Minister Koizumi visited FH2R on July 19, 2020

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Contents

More information about FH2R

What kind of facility is FH2R?

FH2R is a hydrogen production facility that launched operations in February 2020. It is equipped with a 10 MW hydrogen production unit, one of the largest in the world, which uses renewable energy and is capable of producing 1,200 Nm³ of hydrogen per hour under rated operations. The facility also aims to maximize the utilization of renewable energy by adjusting the supply and demand to the electric power system, as well as realize clean and low-cost hydrogen production technology.

What happens with the hydrogen produced at FH2R?

The hydrogen is transported mainly using compressed hydrogen trailers and storage racks and is used for power generation using stationary fuel cells, and for mobility applications, such as fuel cell-powered cars and buses.

For more information, please visit the following webpage:
https://www.nedo.go.jp/english/news/AA5en_100422.html

Compressed hydrogen trailer going to power plants, factories, and various hydrogen stations

Hydrogen produced at FH2R is transported to public facilities and hydrogen stations around Japan by trailers and storage racks for hydrogen storage and usage in transportation.

Fuel cell batteries provided to roadside market in Namie Town. Stationary fuel cell batteries use hydrogen to generate power used for electricity and heat in public facilities.

At hydrogen stations, fuel cell-powered cars and buses are refueled.
Source: Iwatani Corporation

Note: To prevent the spread of COVID-19, persons appearing in photos wore facial coverings except during the time photos were taken.

Reporting on Today and Tomorrow's Energy, Environmental, and Industrial Technologies
"Focus NEDO" is the public relations magazine of the New Energy and Industry Technology Development Organization (NEDO), introducing the public to NEDO's various projects and technology development activities related to energy, environmental, and industrial technologies.

Please let us hear your views!
Reader Questionnaire

We welcome your feedback and opinions on the content and technologies introduced in this magazine. Your feedback will be used for reference purposes in our future public relations activities and magazine publications. We look forward to hearing from you!

A Few Words from the Editor

After Prime Minister Suga announced Japan's 2050 Carbon Neutral Declaration, attention has been focused on the social implementation of new technologies related to green innovation, such as technologies for hydrogen energy and CO_2 capture which are being pursued under NEDO projects. In the opening News Report, we report on recent visits to the FH2R facility by Minister of the Environment Koizumi and other cabinet members, as well as the ambassadors to Japan representing the five Nordic countries. In our Special Report, we introduce the NEDO Moonshot Research and Development Program that aims to recover the global environment using technologies such as CO_2 capture.

Moonshot Research and Development Program

Pursuing Recovery of Global Environment

Cool Earth & Clean Earth

The Moonshot Research and Development Program was created to pursue ambitious goals, known as Moonshot Goals (hereinafter referred to as MS Goals) presented by the Government, which attract people, from the perspective of looking toward a future society, and solving domestic and overseas social issues that will arise.
NEDO is pursuing ambitious R&D activities to achieve MS Goal 4: Realization of sustainable resource circulation to recover the global environment by 2050.
We speak below with Dr. YAMAJI Kenji, the program director responsible for directing and supervising the R&D program conducted under this goal in a unified manner, about the importance of R&D for MS Goal 4 and his aspirations for the future.

Dr. YAMAJI Kenji
MS Goal 4 Program Director
Senior Vice President/Director-General,
Research Institute of Innovative Technology for the Earth (RITE)

Dr. Yamaji, expert on global environmental issues, appointed as program director

In 2018, the Council for Science, Technology and Innovation (CSTI) established the Moonshot Research and Development Program to promote challenging R&D based on bold ideas that will not just be extensions of conventional technology, with the aim of creating disruptive innovations from Japan. Building on input received from the general public regarding social issues that should be addressed and visions that should be pursued in the future, discussions took place at meetings of experts and at the Moonshot International Symposium. On the basis of these discussions, in January 2020 CSTI determined six MS Goals to be pursued.[1] NEDO is taking the lead on pursuing MS Goal 4: Realization of sustainable resource circulation to recover the global environment by 2050.

With a view toward realizing program objectives, NEDO has appointed Dr. YAMAJI Kenji, Senior Vice President and Director-General of the Research Institute of Innovative Technology for the Earth (RITE), as program director (hereinafter referred to as PD) for MS Goal 4. Dr. Yamaji has considerable expertise in global environmental issues and has also served as chair for Moonshot International Symposium Working Group 4, "Sustainable Resources Circulation for Global Environment," which was organized by NEDO.

Moonshot is an ambitious and challenging R&D program

Regarding his appointment as PD, Dr. Yamaji says, "My field of expertise, energy research, is closely related to global warming, and I have been involved in research on measures to prevent global warming, so MS Goal 4 was a topic of great interest to me. At the International Symposium in 2019, we focused on the most pressing issues affecting the global environment today. One such issue is global warming. Before the Industrial Revolution, the concentration of CO_2 in the atmosphere was approximately 280 ppm,[2] but in recent years the CO_2 concentration has exceeded 400 ppm, a level clearly impacting the earth. Second is the issue of marine plastic litter, which was discussed at the G20 Osaka Summit. Another issue concerns nitrogen compounds, which have also been highlighted under the planetary boundaries concept.[3] I decided to become the PD for MS Goal 4 because it will pursue

Notes: 1. In July 2020, the Headquarters for Healthcare Policy determined MS Goal 7.
2. Unit indicating parts per million (1 ppm=0.0001%). Thus, 280 ppm=0.028%, 400 ppm=0.04%.
3. Under this concept, thresholds have been established in nine areas of the global environment to ensure the sustainable development of human society. Exceeding these thresholds will cause irreversible changes to the natural resources upon which humans depend.

Figure 1: R&D to be promoted for realization of sustainable resource circulation

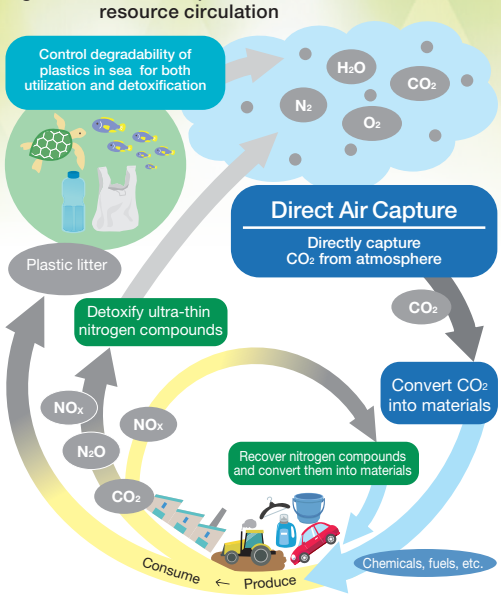
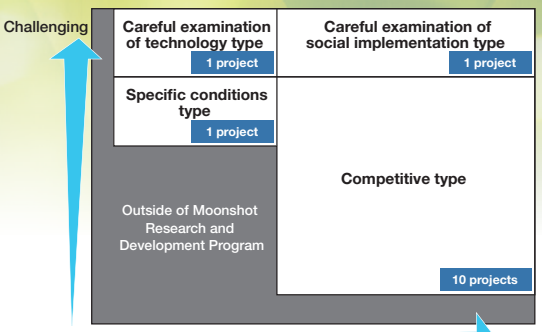


Figure 2: MS Goal 4 portfolio



Competitive type:
Competition takes place between similar fields and technologies to promote R&D, and these are narrowed down in the third or fifth year.
Specific conditions type:
Significant and technically unique technologies are assessed under specific conditions.
Careful examination type:
Projects where assessments indicate careful examination of technology is required. Project plans are reviewed to focus on careful examination and start on small scale. There are two careful examination types: the technology type, for technologies which require the creation of new markets, and the social implementation type, which assess responsiveness to the marketplace.

addressing these issues, which are of great interest to me."

Moonshot R&D is characterized by its more ambitious and challenging approach (see Figure 1). Dr. Yamaji explains, "For example, with regard to greenhouse gases, research has been conducted to reduce CO_2 emissions, which are the main component, and develop technology to capture CO_2 before it is released into the atmosphere, but as a more ambitious approach, we are targeting a technology known as Direct Air Capture (DAC), which directly captures CO_2 that has already been released into the atmosphere and utilizes it effectively. This is a very challenging technology which is one of the pillars for MS Goal 4 research and development."

Emphasizing the importance of NEDO Moonshot R&D projects, Dr Yamaji adds, "In October 2020, Prime Minister Suga announced in a policy speech the new goal of achieving carbon neutrality (effectively zero greenhouse gas emissions) by 2050. This goal is exactly in line with the direction being pursued under MS Goal 4."

As for the issue of marine plastic litter, which has become a growing concern in recent years, Dr. Yamaji notes the importance of designing degradation initiation switches for biodegradable plastics to make them harmless and address functional issues. As for nitrogen, he notes the challenge of detoxifying nitrogen compounds discharged into the environment and converting them into valuable materials.

Boldly pursuing challenges for social implementation by 2050

Commenting on the role of the PD in the long-term research plan to achieve the 2050 goal, Dr. Yamaji says, "In this system, individual research plans are called projects, and multiple projects grouped together under each goal are called programs. The PD constructs a program portfolio[4] by combining multiple projects in consideration of their level of ambition, feasibility, and potential for impact, and also manages and supports the overall program (see Figure 2)."

"If we aim for social implementation right from the start, it will hinder our ideas, so we have put together a portfolio of potential projects that do not nip ambitious ideas in the bud. We select projects according to their level of progress, so that if we find it difficult for a project to achieve the goal of this program, we can spin it out and use the research results for other research. Portfolio management is an important role of the PD, and we have just established a management system in collaboration with NEDO. We will continue to cooperate with NEDO on program management, making use of its information gathering and coordination capabilities."

Dr. Yamaji says he expects the project managers leading each project to display ambition, leadership, and vision, and notes "This MS Goal is very ambitious, so I hope they will assume the challenge of competing with the rest of the world, while at the same time exhibiting strong leadership to the multiple research and development organizations participating in the project. I also hope they possess a strong vision to pursue the goal of social implementation."

Social implementation occurs when products are widely used around the world. The target year for the goal is 2050, but product prototypes need to be on the market by 2030, so in reality only 10 years remain to determine the right direction. The biggest challenge of the Moonshot Research and Development Program is for NEDO to work together with researchers under the leadership of the PD, Dr. Yamaji.

4. A management plan that outlines policies for the composition of projects and resource allocations.

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

Pursuing Cool Earth and Clean Earth

Moonshot Research and Development Program

With a view to recover the global environment, the NEDO Moonshot Research and Development Program aims to solve global warming problem (Cool Earth) and environmental pollution problem (Clean Earth) in conjunction with continued industrial and consumer activity. Under this program, NEDO is pursuing R&D activities to realize a new form of resource circulation that reduces environmental pollutants such as Green House Gases (GHGs), nitrogen compounds, and marine plastic litter.

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

Many global environmental problems are caused by the substances that have been emitted into the environment through human activities.

The Paris Agreement, adopted at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21) in December 2015, represents a global effort to prevent GHG emissions by establishing a target to keep the global average temperature rise well below 2°C compared to pre-industrial levels (2°C scenario). However, there is a large gap between this target and the outlook based on the post-2020 emission reduction targets (Intended Nationally Determined Contributions: INDC) submitted to date by member countries. With a projected gap of 13 Gt CO_2-eq by 2030, new GHG countermeasures such as the ones using Negative Emission Technologies are considered essential in addition to conventional emission source countermeasures.

In addition, the planetary boundary concept states that nitrogen and other elements are in a high-risk state that exceeds the threshold for the continued development and prosperity of human society. There is therefore a need to establish technologies to recover and utilize nitrogen compounds emitted from a variety of industrial activities.

A further issue is the problem of marine plastic litter, which has become widely known in recent years and is affecting marine ecosystems, with growing concerns about its effect on humans through the food chain. Biodegradable plastics currently in widespread use are not sufficiently degradable in the ocean, so the development of marine biodegradable plastics that can degrade appropriately when they flow into the ocean is a pressing issue.

In addition to efforts to reduce the emissions of these substances, it is also necessary to take measures to circulate substances being emitted into the environment.

In light of this situation, MS Goal 4 is implementing challenging R&D projects with the aim of addressing the issues of global warming (Cool Earth) and environmental pollution (Clean Earth) through the realization of sustainable resource circulation for the recovery of the global environment. Specific targets aim to establish technologies on a pilot scale or in a prototype form by 2030, and then, through demonstration testing and the resolution of technology development issues at each stage of development, to globally deploy commercial plants and products utilizing established circulation technologies by 2050.

MS Goal 4 Targets

Realization of sustainable resource circulation to recover the global environment by 2050	
Solutions to the global warming problem (Cool Earth) and environmental pollution problem (Clean Earth) through realization of sustainable resource circulation for the global environment.	
Cool Earth & Clean Earth	
Global deployment of commercial plants or products utilizing circulation technology by 2050.	
Cool Earth	**Clean Earth**
Development of circulation technology on a pilot scale for reducing greenhouse gases that are also effective in terms of life cycle assessments (LCA) by 2030.	Development of technology on a pilot scale or in a form of prototype that converts environmentally harmful substances into valuable or harmless materials by 2030.

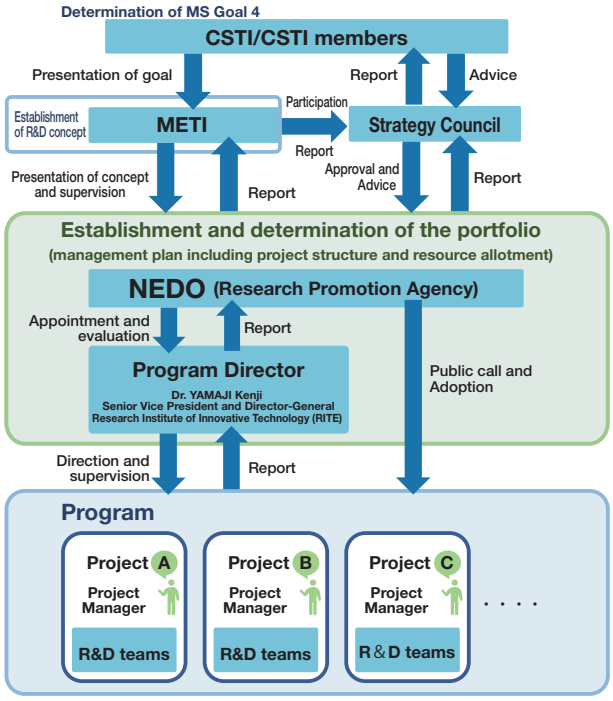
MS Goal 4 Promotion System

Based on the R&D concept paper formulated by the Ministry of Economy, Trade and Industry (METI) to achieve MS Goal 4, NEDO selected 13 R&D projects and project managers (PM) in August 2020. In addition, Dr. YAMAJI Kenji, Senior Vice President and Director-General of the Research Institute for Innovative Technology for the Earth (RITE), has been appointed as the program director (PD) to integrally direct and supervise these multiple R&D projects.

To realize the concept and achieve this MS Goal, the PD will establish a portfolio for strategically realizing the MS Goal and promotes R&D in a challenging and systematic way. The PD leads comprehensive portfolio management by taking into account the life cycle assessment (LCA)[5] perspective as well, in order to ensure that both individual R&D projects as well as the entire program are effective in achieving the MS Goal.

In addition to supporting portfolio management by the PD and project management by the PM, NEDO will establish an R&D management system that flexibly incorporates a variety of knowledge and ideas to achieve the MS Goal, including collaboration with experts from Japanese and overseas technology development projects and industries, and the utilization of views from interdisciplinary perspectives such as ethical, legal, and social issues (ELSI), as well as mathematical sciences, in order to spin out project results and implement them in society.

MS Goal 4 Promotion System



5. Life cycle assessment (LCA) is a methodology for quantitatively identifying the amount of resource consumption and emissions of environmentally hazardous substances and evaluating their environmental impacts by considering the entire life cycle of the resources used in a certain technology or product, from its mining/manufacturing phase to its utilization/ disposal phase. For example, in the case of the capture and utilization of CO_2, energy inputs and catalysts are required for its capture concentration, and conversion into valuable materials, so it is necessary to evaluate whether these processes actually contribute to reduce CO_2 emissions throughout the entire life cycle.

Enthusiastic support from the Moonshot Research and Development Program Office

Since the initial Public Call for proposals stage, the Moonshot Research and Development Program has attracted keen interest from both inside and outside Japan. We will continue to work closely with the PD and PM, and actively promote collaborations between Japanese and overseas organizations with a view toward future social implementation.

In addition, since the MS goals were determined with a view toward addressing various social, environmental, and economic issues and thereby realizing "human well-being", we believe this program is relevant not only to scientific researchers but also to the general public. We will therefore proactively conduct outreach to the public on what kind of research and development is being conducted and what kind of results have been achieved in the NEDO Moonshot Research and Development Program, so that many kinds of people will develop greater interest in it.

NEDO Moonshot Research and Development Program Office (from left to right)
KOJIMA Kano, Chief Officer, YOSHIDA Tomonaga, Director, SUZAWA Mika, Chief Officer

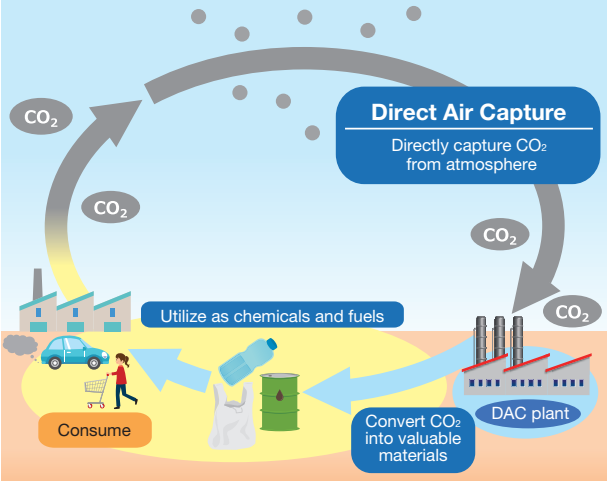
Please scan here for the latest information on the NEDO Moonshot Research and Development Program:

https://www.nedo.go.jp/english/news/ZZCA_100007.html

Outline of projects 1

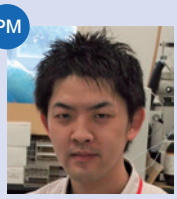
Development of Technologies to Recover Greenhouse Gases ("GHGs") and Convert Them into Valuable Materials

To date, technologies have been developed to separate and capture highly concentrated (ranging from several percent to several tens of percent) CO_2 contained in exhaust gas generated mainly at power plants, steel mills, and oil refineries, and some of these technologies have been commercialized. On the other hand, in these Moonshot R&D projects, 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 by 2050. In addition to DAC technologies, various new technologies are being developed to convert captured CO_2 into valuable materials and to mitigate GHGs with high global warming potential, such as methane (CH_4) and nitrous oxide (N_2O) emitted from agricultural lands.



Development of a bioprocess that uses electrical energy to fix atmospheric CO_2

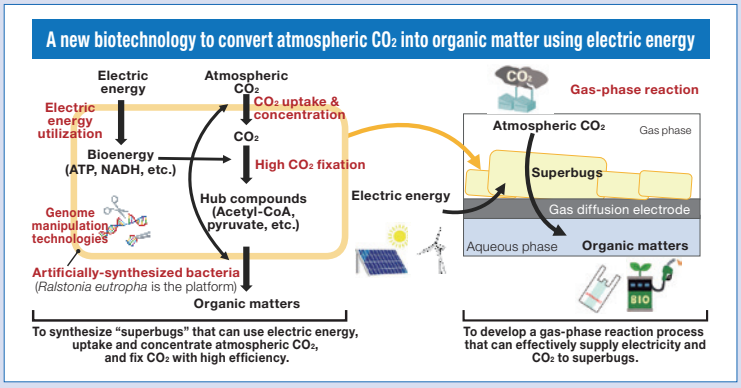
PM



Project Manager
Dr. KATO Souichiro
Senior Researcher,
Bioproduction Research Institute,
National Institute of Advanced Industrial Science and Technology (AIST)

POINT

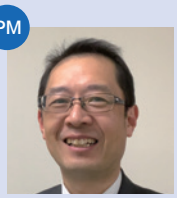
- CO_2 is converted into useful organic matter (conversion efficiency 50 times higher than that of plants)
- Artificial synthesis of super-microorganisms that utilize electricity
- Development of gas-phase reaction process to maximize microbial power



Implementing organizations: AIST, Tokyo Institute of Technology, Nagoya University

Development of highly efficient direct air capture (DAC) and carbon recycling technologies

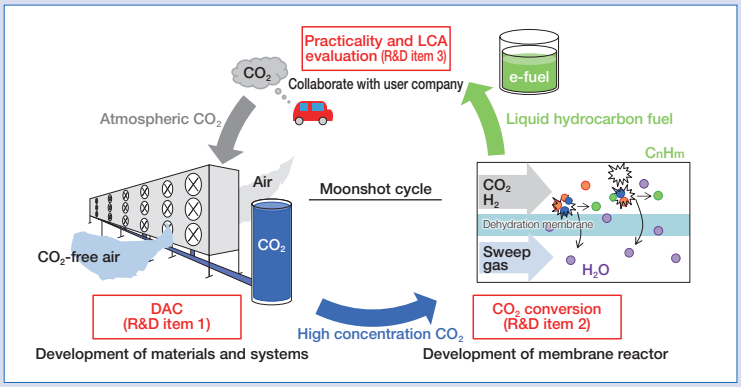
PM



Project Manager
Dr. KODAMA Akio
Professor,
Faculty of Mechanical Engineering,
Kanazawa University

POINT

- Development of innovative amine-loaded CO_2 solid sorbent
- CO_2 capture and enrichment process using less energy than conventional technologies
- Membrane reactor for highly efficient and energy-saving synthesis of liquid hydrocarbon fuels using inorganic membranes



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

Outlines of the R&D projects are available at the below webpage:

https://www.nedo.go.jp/english/news/ZZCA_100007.html

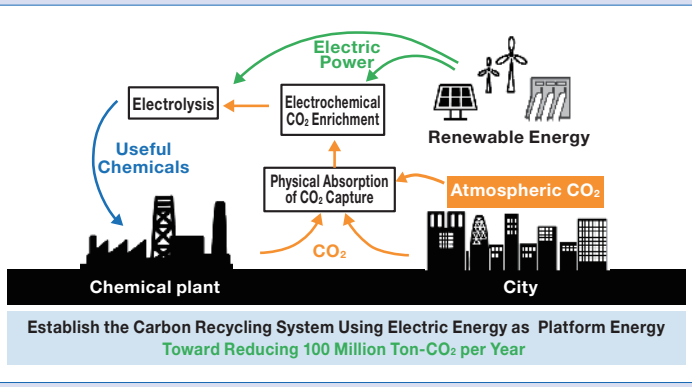
Integrated Electrochemical Systems for Scalable CO_2 Conversion to Chemical Feedstocks

PM

Project Manager
Dr. SUGIYAMA Masakazu
Professor,
Research Center for Advanced Science and Technology,
The University of Tokyo

POINT

- CO_2 enrichment process at medium and low temperatures by physical absorption/desorption and electrochemistry
- Creation of a system for CO_2 enrichment and reduction to chemical feedstocks by electro-chemical processes 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.

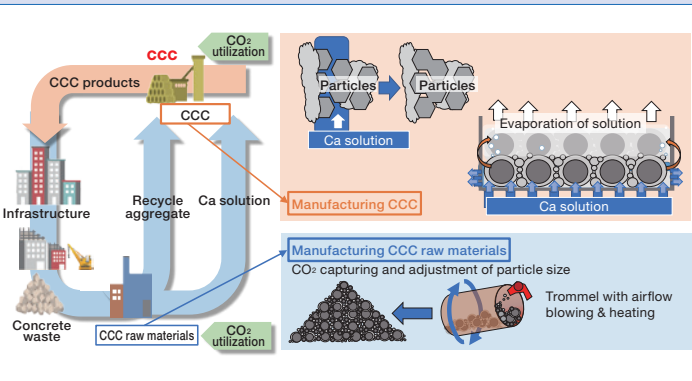
C^4S[6] Research and Development Project

PM

Project Manager
Dr. NOGUCHI Takafumi
Professor,
Graduate School of Engineering,
The University of Tokyo

POINT

- Capturing atmospheric CO_2 with concrete waste
- Permanent resource circulation by regenerating CCC[7] from concrete waste after CO_2 capture
- Contributing to sustainable circulation of calcium resources as well as CO_2

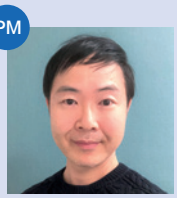


Implementing organizations: The University of Tokyo, Hokkaido University

6. C^4S: Calcium Carbonate Circulation System for Construction
7. CCC: Calcium Carbonate Concrete

Research and development toward saving energy for direct air capture with available cold energy

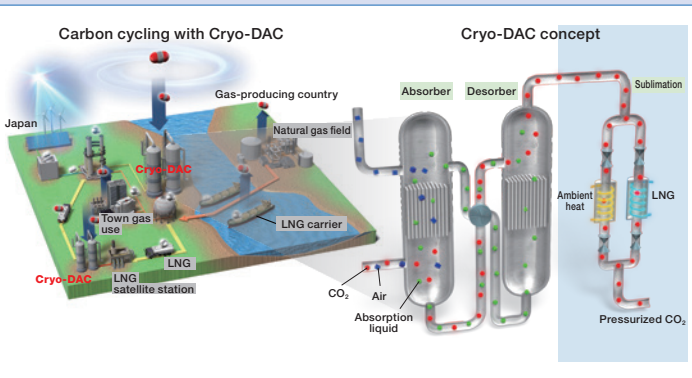
PM



Project Manager
Dr. NORINAGA Koyo
Professor,
Graduate School of Engineering,
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
- Output high-purity and pressurized CO_2 ready for storage and utilization process



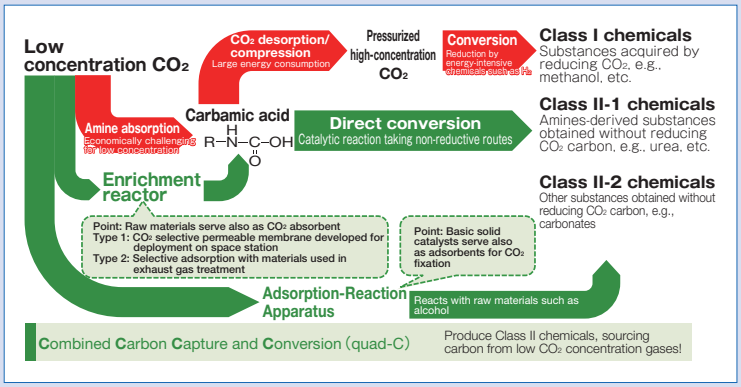
Implementing organizations: Nagoya University, Toho Gas Co., Ltd., Tokyo University of Science

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

Project Manager
Dr. FUKUSHIMA Yasuhiro
Professor,
Graduate School of Engineering
Tohoku University

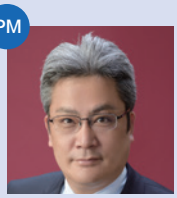
POINT

- Creation of streamlined reaction system, termed "quad-C", by directly linking CO_2 fixation and conversion
- Takes energy-efficient conversion routes without carbon reduction
- Modularized process handles a wide variety of feed gases and products



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

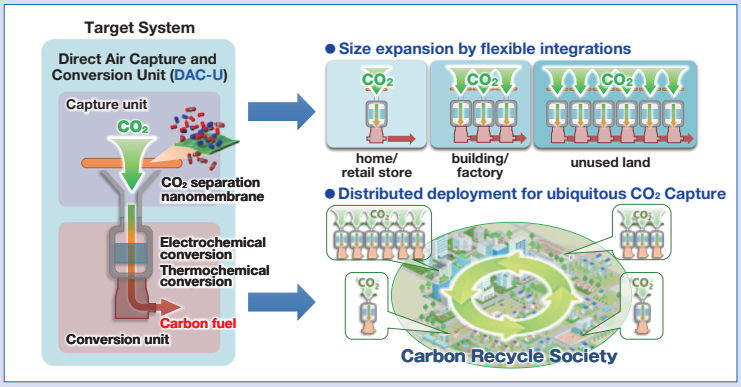
Development of Global CO_2 Recycling Technology towards "Beyond-Zero" Emission



Project Manager
Dr. FUJIKAWA Shigenoi
Associate Professor,
International Institute for Carbon-Neutral Energy Research,
Kyushu University

POINT

- Development of CO_2 capture unit using innovative separation nano-membranes with unparalleled CO_2 permeability
- Development of conversion unit that converts CO_2 into carbon fuel with high efficiency
- Scalable system for use in small-sized homes and medium-sized buildings



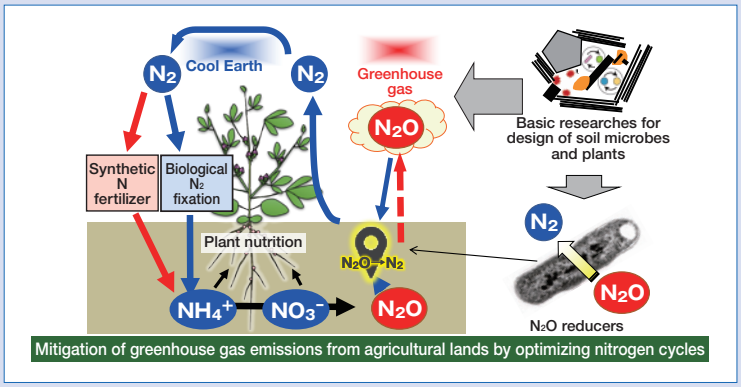
Implementing organizations: Kyushu University, Kumamoto University, Hokkaido University

Mitigation of greenhouse gas emissions from agricultural lands by optimizing nitrogen and carbon cycles

Project Manager
Dr. MINAMISAWA Kiwamu
Specially Appointed Professor,
Graduate School of Life Sciences,
Tohoku University

POINT

- Focusing on agricultural lands as major sources of nitrous oxide and methane emissions.
- Activation of N and C cycling in soil micro-organisms induces 80% reduction of nitrous oxide and methane emissions.
- Design of soil microbial community could provide the establishment and functional expression of inoculated microorganisms.



Implementing organizations: Tohoku University, National Agriculture and Food Research Organization (NARO), The University of Tokyo

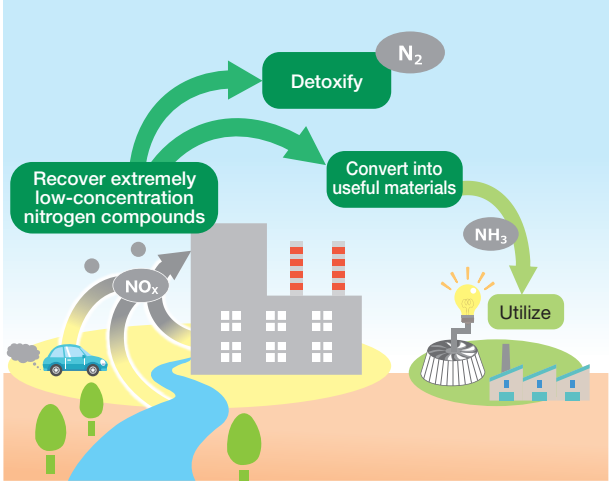
Outline of projects 2

Development of Technologies to Recover Nitrogen Compounds and Convert Them into Harmless or Useful Materials

Outlines of the R&D projects are available at the below webpage:
https://www.nedo.go.jp/english/news/ZZCA_100007.html

In planetary boundary research, nitrogen compounds derived from human activities have been reported to be at a state of extremely high risk, with their emissions exceeding the earth's acceptable limits. Specifically, there are concerns about the eutrophication of lakes and oceans, acid rain, and global warming caused by nitrous oxide due to the emission of nitrogen compounds into the environment.

In the NEDO Moonshot Research and Development Program, technologies will be developed to recover nitrogen compounds contained in exhaust gas and wastewater at extremely low concentrations, which have been considered difficult to recover using conventional technologies and to convert them into harmless or useful materials.



Innovative circular technologies for harmful nitrogen compounds/To solve planetary boundary issues

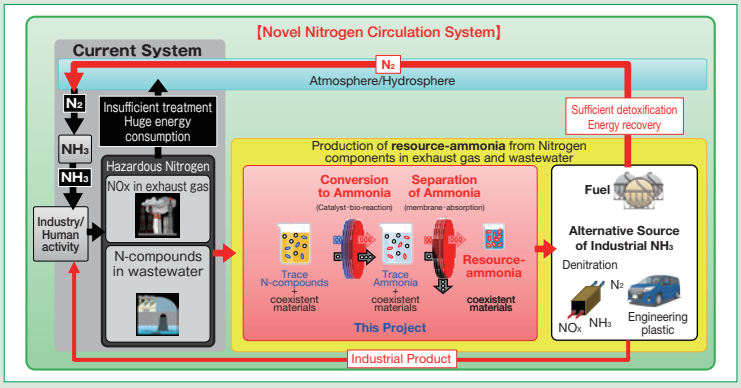
PM

Project Manager
Dr. KAWAMOTO Tohru
Group Leader,
Nanoparticle Functional Design Group,
Nanomaterials Research Institute,
National Institute of Advanced Industrial Science and Technology (AIST)

POINT

Development of technology to transform nitrogen oxides in exhaust gas into ammonia, a useful material

Conversion and recovery of ammonia from toxic nitrogen compounds in wastewater



Implementing organizations: AIST, The University of Tokyo, Waseda University, Tokyo University of Agriculture and Technology, Kobe University, Osaka University, Yamaguchi University, Kyowa Hakko Bio Co., Ltd., ASTOM Corporation, Toyobo Co., Ltd., FUSO Corporation, Ube Industries, Ltd.

Development of recovery and removal techniques of dilute reactive nitrogen to realize nitrogen circulating society

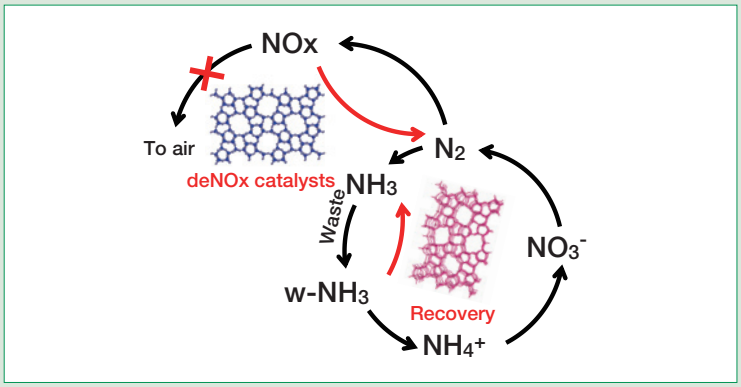
PM

Project Manager
Dr. WAKIHARA Toru
Professor,
School of Engineering,
The University of Tokyo

POINT

Development of SCR[8] systems with both high selectivity and activity/durability by realizing precise control of zeolite structure and composition

Development of absorbents for selective recovery and concentration of extremely low- concentration ammonia



Implementing organizations: The University of Tokyo, AIST, Japan Fine Ceramics Center (JFCC), Mitsubishi Chemical Corporation

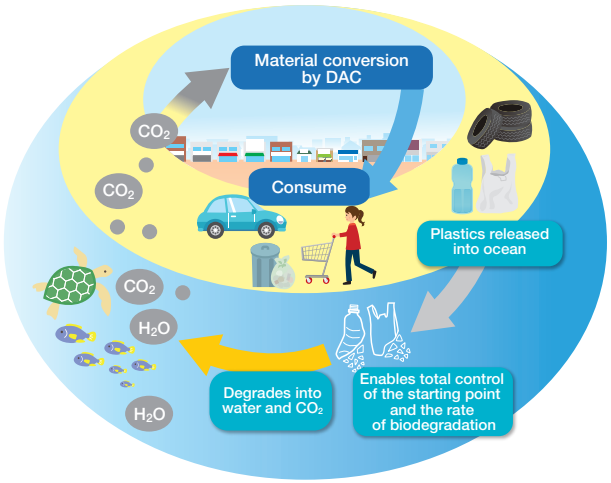
8. Selective Catalytic Reduction

Outline of projects 3

Development of Marine Biodegradable Plastics Which Can Control the Timing and Speed of Their Degradability

To deal with marine plastic litter, which has become a social issue, particularly since plastics continue to flow into the ocean, the development of marine biodegradable plastics that have less environmental impact when released into the ocean is required, in addition to conventional efforts to collect and recycle plastic litter. Though various biodegradable plastics have been developed to date, they are facing challenges to their practical application and widespread use since the timing and speed of their degradation has not been adequately controlled and their durability was insufficient.

In the NEDO Moonshot Research and Development Program, marine biodegradable plastic will be developed that is sufficiently durable and has a switch function to control the starting point and the rate of biodegradation so that it will degrade at an appropriate speed after being released into the ocean.



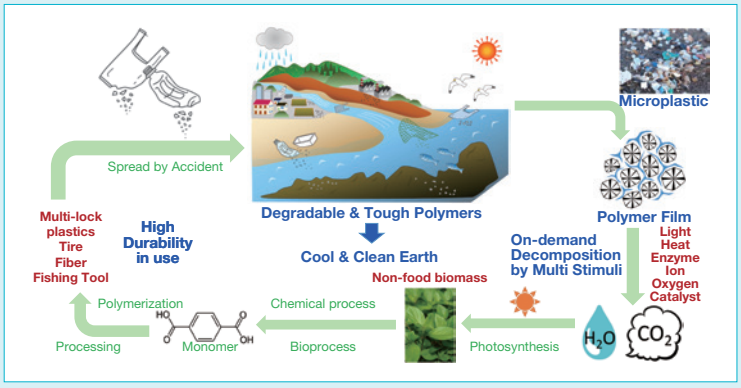
Development of Multi-lock Biopolymers Degradable in Ocean from Non-food Biomasses

PM

Project Manager
Dr. ITO Kohzo
Professor,
Graduate School of Frontier Sciences,
The University of Tokyo

POINT

- Breaking through trade-off between polymer degradability and durability/toughness
- Multi-lock mechanism [9] provides high durability during use and on-demand degradation when accidentally released into ocean
- Produced from non-food biomasses



Implementing organizations: The University of Tokyo, Mitsubishi Chemical Corporation, Bridgestone Corporation, Teijin Limited, Kureha Corporation, Kyushu University, Nagoya University, Yamagata University, Research Institute of Innovative Technology for the Earth (RITE), National Institute of Advanced Industrial Science and Technology (AIST), Ehime University, Tokyo Institute of Technology

9. A mechanism that requires multiple stimuli such as light, heat, oxygen, water, enzymes, microorganisms, and catalysts at the same time for degradation.

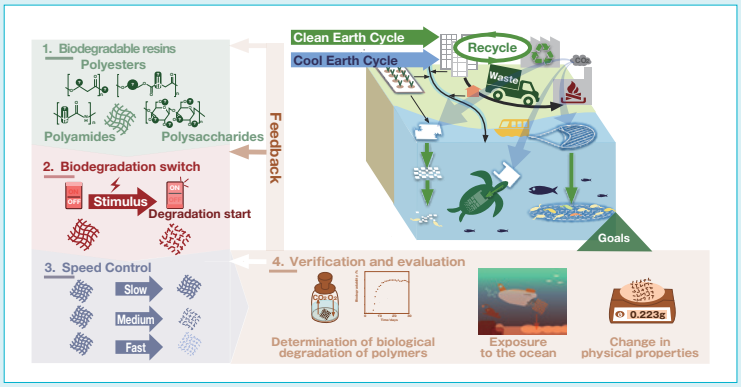
Research and development of marine biodegradable plastics with degradation initiation switch function

PM

Project Manager
Dr. KASUYA Ken-ichi
Professor,
Division of Molecular Science,
Faculty of Science and Technology
Gunma University

POINT

- Development of technology to control timing and speed of degradation
- Marine biodegradability (90% in six months in seawater at 30℃) verified in ocean
- Creation of marine biodegradable polymers based on biomass and CO_2



Implementing organizations: Gunma University, The University of Tokyo, Tokyo Institute of Technology, RIKEN, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Outlines of the R&D projects are available at the below webpage:

https://www.nedo.go.jp/english/news/ZZCA_100007.html

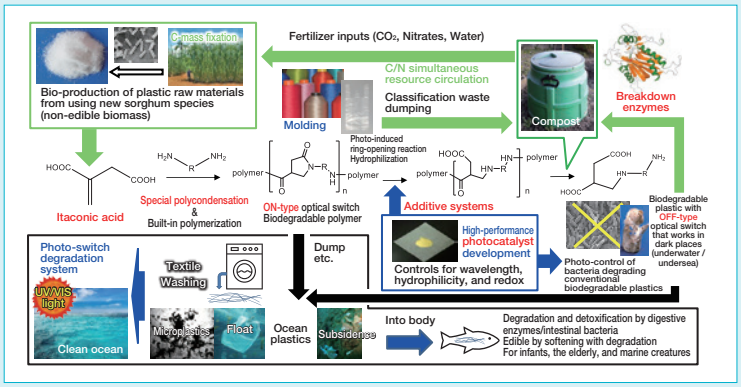
Development of photo- switching ocean-degradable plastics with edibility

PM

Project Manager
Dr. KANEKO Tatsuo
Professor,
Graduate School of Advanced Science and Technology
Japan Advanced Institute of Science and Technology

POINT

- On-type optical switch function that initiates degradation in strong sunlight and water
- Off-type optical switch function that initiates degradation in dark places such as underwater and/or seabed
- Development of non-toxic ocean-biodegradable plastic products incorporating both functions



Implementing organizations: Japan Advanced Institute of Science and Technology, Kobe University, Nagoya University, Kagoshima University, Tokyo University of Science, Tokyo University of Agriculture and Technology, National Institute of Advanced Industrial Science and Technology (AIST), Osaka Research Institute of Industrial Science and Technology (ORIST)

TOPIC

Moonshot International Symposium

Discussion regarding R&D to be carried out

To set MS Goals, applications were invited from the public for proposals and ideas for social challenges to be solved, and visions of future society to be realized, and based on these applications, 25 examples of MS goals were identified through discussions by experts. In this context, the Moonshot International Symposium was held with relevant organizations in December 2019 with the participation of experts from Japan and overseas who discussed the candidate MS Goals and how best to proceed with Moonshot R&D projects. NEDO organized Working Group 4, Sustainable Resources Circulation for Global Environment, chaired by Dr. YAMAJI Kenji, Senior Vice President and Director-General of RITE. Discussions took place at the working group regarding the MS Goal and innovative R&D of GHG reduction technologies by resources and materials circulation such as carbon recycling, resource-saving technologies, environmental remediation technologies, and energy-saving and renewable-energy technologies. As a basis for discussion, the concept “Cool Earth & Clean Earth” was introduced in the form of an initiative report, and the scope and ideal way to pursue research to be carried out were discussed by symposium speakers and participants. The results of symposium discussions led to the determination of MS Goal 4.

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

The initiative report and video of Moonshot International Symposium's Working Group 4 can be viewed at the below webpage:

https://www.jst.go.jp/moonshot/sympo/sympo2019/index_e.html

TSC Foresight Brief Report

U.S. Technology Innovation and Climate Change Policy Changes under President Biden

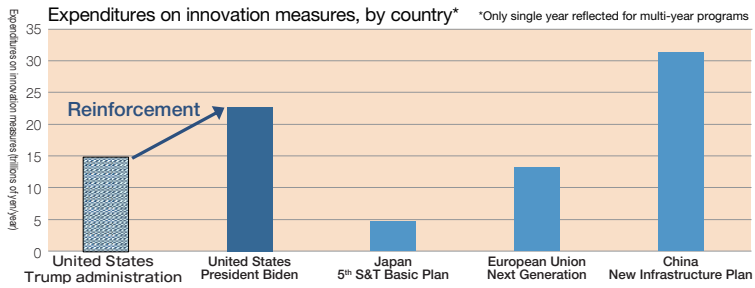
The 46th President of the United States, Joseph Biden, has pledged to implement technology innovation and climate change policies that differ greatly from those of former President Donald Trump, so NEDO has prepared and released a Technology Strategy Center (TSC) report, which objectively analyzes these changes.

TSC Foresight Report may be viewed here:

https://www.nedo.go.jp/library/ZZNA_100044.html
(only available in Japanese)

Point 1 Technology innovation policies

Under the Innovate in America policy, $300 billion (approx. 32 trillion yen) will be invested in R&D for new industries and technologies and create millions of jobs, thus securing U.S. leadership in the world. This policy is cautious about technology outflows, but also emphasizes international frameworks. It is expected to strengthen U.S. efforts to promote the development of technology and innovation while placing more emphasis on cooperation with countries allied with the United States.



Total expenditures on technology innovation measures

United States Trump administration	Approx. $140 billion (approx. 15 trillion yen)
United States President Biden pledge	Approx. $140 billion (approx. 15 trillion yen) + approx. $300 billion/4 years (approx. 32 trillion yen)
Japan 5th S&T Basic Plan	Approx. 23.8 trillion yen/5 years
European Union Next Generation	Approx. 750 billion euros/7 years (approx. 90 trillion yen)
China New Infrastructure Plan	Approx. 2 trillion RMB (approx. 30 trillion yen)

Sources:
Ministry of Foreign Affairs website, Asahi Shimbun, NHK, Nikkei Shimbun, joebiden.com

For consideration:

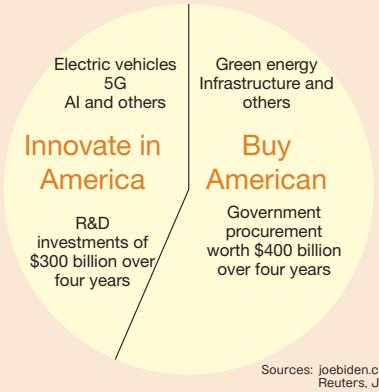
President Biden, following on the policies of the previous U.S. administration, has emphasized the importance of stimulating technological innovation in the United States. However, he has also stressed the need to cooperate with relevant countries in order to regain the initiative in creating rules for international trade. President Biden is therefore likely to further strengthen ties with allied countries such as Japan, Australia, and South Korea in crafting rules regarding advanced technology and innovation.

President Biden's pledges on economic policy

Economic pledges focus on economic policy and COVID-19-related relief and economic recovery.

Economic policies

$700 billion to support manufacturing, 5 million jobs, tax cuts for lower-income earners, tax increases for higher-income earners and large corporations, and a review of the tariffs imposed by former President Trump.

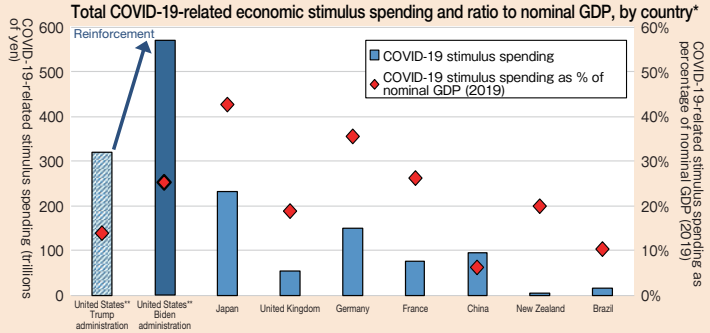


Sources: joebiden.com, Reuters, Jiji Press

COVID-19-related relief and economic recovery policies (4th version only*)

$3.4 trillion (approx. 360 trillion yen)

*$2.2 trillion (approx. 230 trillion yen) as of October 2020, with funding to support state and local governments, households, etc.



*Economic stimulus spending shown here includes loans to private sector.
**Biden pledge and Trump administration figures include $2 trillion in already enacted stimulus legislation.
Sources: Graph prepared by NEDO TSC using data obtained from JETRO website, World Bank, Asahi Shimbun, Nikkei Shimbun, and AFP.

Point 2

Commitments on climate change policy

President Biden's basic philosophy regarding environmental justice is to work toward redressing inequalities associated with climate change by taking bold climate change policies. He has also pledged to return the United States to the Paris Agreement, which the Trump administration withdrew from, and to reduce CO_2 emissions to zero across the U.S. economy by the year 2050 at the latest.

As a concrete step, President Biden has announced a Clean Energy/Sustainable Infrastructure Plan with $2 trillion (approx. 215 trillion yen) to be invested over four years. The plan also proposes the establishment of ARPA-C as an overarching U.S. government advanced research agency focused on climate change. With these steps, U.S. climate change policy is expected to make great progress.

CO_2 emission targets under U.S. presidents

Clinton (1997, Democratic Party)
- Reduce emissions to 1990 levels in 2008-2012
- Reduce emissions to below 1990 levels in next five years

Bush (2001, Republican Party)
- **Withdrawal** from Kyoto Protocol
- Reduce emissions per unit of GDP by 18% in 10 years to 2012

Obama (2015, Democratic Party)
- 26-28% reduction from 2005 levels by 2025

Trump (2019, Republican Party)
- **Withdrawal** from Paris Agreement

Biden (2021, Democratic Party)
- **Return** to Paris Agreement
- Agrees with experts to aim for net zero emissions by 2050 at latest

Sources: Ministry of Foreign Affairs website, Asahi Shimbun, NHK, Nikkei Shimbun, joebiden.com

Specific climate change policy measures

President Biden announced a Clean Energy/Sustainable Infrastructure Plan including major infrastructure improvements. He also proposed the establishment of a new Advanced Research Projects Agency focused on Climate (ARPA-C).

1. On July 14, 2020, announced new Clean Energy/Sustainable Infrastructure Plan. To achieve zero CO_2 emissions for entire U.S. economy by 2050 at latest, $2 trillion (approx. 215 trillion yen) will be invested over four years.
2. Announced commitment to return to Paris Agreement, hold climate summit within 100 days of taking office, and reengage in "mission innovation."
3. Will establish Environmental Justice Advisory Committee and Environmental Justice Interagency Council as part of Environmental Advisory Committee under direct control of President. ARPA-C to be established to promote environmental technology innovation as part of "all of government" approach.

Sources: joebiden.com, Yomiuri Shimbun, Bloomberg, MIT Technology Review

Clean Energy/Sustainable Infrastructure Plan

- Rely on U.S. labor unions and U.S.-made products in building infrastructure.
- Build the United States into global leader in manufacture of electric vehicles and their raw materials and components.
- Invest in battery storage and transmission infrastructure, provide tax incentives for clean energy job creation, and develop innovative financing mechanisms that leverage private sector capital.
- Upgrade buildings, modernize schools, and reduce race-based wealth disparities.
- Focus on strategic research areas such as clean energy, clean transportation, clean industrial processes, and clean materials.
- Provide opportunities for new farmers and ranchers to enter economy, and support use of new technologies and equipment to increase productivity and profits.
- Enable local communities to receive 40% of benefits from areas such as clean transportation and water infrastructure development; creation of data-driven climate and economic justice screening tool.

Source: Prepared by NEDO Washington D.C. office and TSC based on documents retrieved from joebiden.com.

Proposal to establish ARPA-C

ARPA-C would be a new cross-agency advanced research project organization focused on climate change, with the objective of developing game-changing technologies that will help achieve the goal of securing 100% clean energy. The following are target areas:

- Grid-scale energy storage
- Advanced nuclear reactors
- Refrigeration and air conditioning using refrigerants that do not promote global warming
- Zero-net-energy buildings
- Hydrogen production using renewable energy sources
- Decarbonization of industrial heat and carbon-neutral building materials
- Decarbonization of the food and agricultural sectors
- CCU, CCS

Source: joebiden.com

For consideration: Ambitious policy goals have been announced on climate change. Returning the United States to the Paris Agreement and other agreements has also been announced. International cooperation in the field of energy and environment may be accelerated and expectations are high for expansion of public markets for climate change. Confidence in Japan's technological capabilities is still high, and opportunities for further U.S.-Japan and international cooperation will probably be considered.

R&D case study

NEDO PROJECT SUCCESS STORIES

Highlights of Project Results

Volume 3

The results of many NEDO projects can be seen in the manufacturing processes of various companies and in end-products we actually use. This series of articles, taken from the NEDO Project Success Stories website, includes digests of interviews that highlight the development stories of how companies overcame daunting technical challenges to realize commercialization.

WHILL Inc.

A Personal Mobility That Is Truly Inviting

Model C, a small, lightweight personal electric vehicle

WHILL Model A

WHILL proprietary front omni-wheel

The small, lightweight, user-replaceable lithium-ion battery developed for Model C

NEDO's role

Innovation Commercialization Venture Support Project/Development Promotion Project for Practical Use of Welfare Equipment

Against the backdrop of a rapidly aging society, expectations for the development of welfare equipment are growing to create a society more responsive to the needs of the disabled and elderly.

To encourage the practical application of welfare equipment that better meets such social needs, NEDO is carrying out the Development Promotion Project for Practical Use of Welfare Equipment. When selecting recipients for project support, NEDO impartially decides which companies to support, using the following three criteria: 1. the project must be novel with research and development elements, 2. the project must meet the needs of users, and 3. the project must realize concrete benefits, have a certain degree market scalability, and be economically viable for users.

For companies selected under the program, NEDO confirms the status of their development and supports their participation in trade shows to encourage business matching, while providing support based on market feedback and user needs.

WHILL Inc. conducted research and development under this project and developed a front wheel and motor system for a lightweight electric wheelchair that demonstrates exceptional performance.

The NEDO Project Success Stories website features interviews with companies involved in these projects. To date, more than 100 articles have been published.

The original version of this article with more detailed development episodes is available on our website!

For further information regarding this wheelchair, please visit the below website:

Search

https://www.nedo.go.jp/hyoukabu/articles/201901toshiba/

(only available in Japanese)

Aims

New type of Personal Mobility that gives one the independence to go wherever life leads

Challenges

Patented omni-wheels allow users to travel easily on rough terrain and make tight turns

Achievements

Small, popular, lightweight model that can be easily disassembled and is available at an affordable price

Traditional electric wheelchairs have been less than ideal for traveling on rough surfaces, including gravel, and for making tight turns. In fact, many people do not want to be seen using a wheelchair. In this project, a highly functional and stylish personal electric vehicle was developed and put into practical application by defying conventional wisdom about wheelchairs.

Developing optimal omni-wheels

Users of conventional electric wheelchairs often find it difficult to change direction in narrow spaces. For example, they have to maneuver the wheelchair backward when riding an elevator, which causes anxiety and involves a degree of danger. However, WHILL models are developed using proprietary omni-wheels (all-directional wheels) and allow users to change direction immediately. WHILL Inc., the venture company that developed the WHILL electric vehicle, started to work toward the development and commercialization of a novel personal mobility after hearing that a wheelchair user had given up on going to a grocery store just two blocks away. With funding from NEDO, the company developed a unique wheel structure in which each wheel consists of 24 smaller wheels mounted perpendicularly to the direction of forward

motion. The rotation of these main and sub-wheels around the front-to-back and side-to-side axes allows users to move seamlessly in any direction while a four-wheel-drive (4WD) mechanism generates enough torque for users to negotiate obstacles and rough roads. The first commercial model, the WHILL Model A, was released in September 2014, and its novel concept and beautiful form earned it the Good Design Award 2015.

Developing a popular lightweight model that can be easily disassembled

Despite all the praise garnered by the Model A, some users expressed a desire to disassemble it into components that could be transported in a passenger car. This prompted the company to embark on the development of the Model C standard type as part of NEDO's project. The company decided to do a fundamental review of the structural design of the Model A, including its motor and battery, in order to ensure that the new model could be disassembled without needing special tools for loading into a passenger car. The Model C, developed with funding from NEDO, features an aluminum body instead of the steel that was used for the Model A in order to make it more compact and affordable. It also features an electric motor embedded in each of the rear wheels to ensure sufficient power to glide over rough terrain with a two-wheel-drive (2WD) mechanism. The stationary lead battery used for the Model A was replaced by a user-replaceable lithium-ion battery. The in-wheel motor and the battery

were both developed for the model in collaboration with major Japanese manufacturers. Furthermore, the new model allows even a person with little physical strength to separate it into three parts using only a lever and then reassemble it with great ease, the desired feature that had driven the company to develop the Model C. It weighs approximately 52 kilograms, less than half the weight of the previous model, at less than half the price. Moreover, the Model C is available in six colors. The Model C, which was released in April 2017, is a completely new product and not just an upgrade. More than 1,000 WHILL electric wheelchairs have been shipped worldwide, with shipments continuing steadily.

(Interview: November 2017)

Model C can be easily taken apart and reassembled

Model C, shown at the Tokyo Motor Show in October 2017, attracted attention for its color options and refined design

Startup Support and Beyond
The Future for NEDO Startups

NEDO Startups Future

Innovator File.13

Liberaware Co., Ltd.

CEO MIN Hongkyu

Development of IBIS, the world's smallest dedicated indoor drone, and provision of inspection, rental and DX services

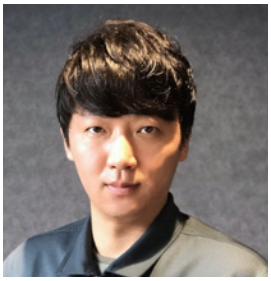
2016: Founding of Liberaware Co., Ltd.

2018: Selected as finalist for IoT Lab Selection by METI and IoT Acceleration Lab (NEDO project adopted as part of support for finalists)

2019: Launched business for renting drones to conduct inspections of indoor spaces

2020: Added image analysis/editing service to rental business. Company featured on JAPAN GOV, the official social media platform of the Japanese Government.

https://liberaware.co.jp/ (only available in Japanese)



IBIS, a small industrial drone for indoor uses

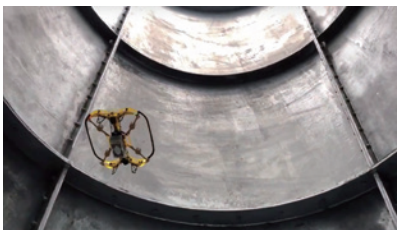
Q1 How do you use NEDO's support programs?

Since the establishment of the company, we have developed in-house all the necessary hardware, software, and applications for the drone, so we needed funds and applied for the NEDO-supported projects. After we were selected, we have been developing the basic technologies necessary for flight in indoor spaces, and this knowledge is now being used in our inspection and rental services. In addition, it was helpful to receive advice from experts on management strategies. Our services are now being used by end-user and maintenance companies that have indoor facilities and equipment. We are also attracting public attention and were featured on JAPAN GOV, which is the official social media platform for the Japanese Government.

Operating behind ceiling

Q2 What is Liberaware's vision for the future?

The infrastructure and maintenance market, which is our target, is increasingly looking for new ideas and maintenance methods, given the impact of the COVID-19 pandemic, aging infrastructure, and labor shortages due to declining birthrates and the aging population. In response to this situation, we have started a service that utilizes our hardware strengths to inspect narrow, dark, and dirty indoor spaces and environments, analyze/edit video images, and provide predictive maintenance. In the future, by collecting more data, we aim to develop infrastructure maintenance solutions both in Japan and overseas that place as little burden on people as possible, thereby supporting people's lives and helping companies improve safety conditions and productivity.



Inspecting smokestack

Comment from NEDO

The company has established its own industrial applications by accurately grasping social issues that need to be addressed by using drones and steadily accumulating the basic technologies necessary to do this. I hope they gain valuable experience in Japan, a country with many such issues, and then expand their business widely.

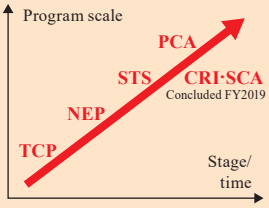
NEDO startup support programs for R&D related to industrial technologies

More information on NEDO startup support programs

https://www.nedo.go.jp/activities/ZZJP2_100063.html

(only available in Japanese)

Programs used by startups featured in this section



TCP Technology Commercialization Program

Support for entrepreneurial development at universities, research institutions, and startups

To revitalize the economy, it is important to foster entrepreneurs that have competitive new technologies. NEDO provides startup support from a variety of perspectives to develop research and development-oriented startups and entrepreneurs. Here, we examine notable startups that are continuing to grow toward the future.

Innovator File.14

Luce Search Co., Ltd.

President WATANABE Yutaka

Next-generation problem-solving company that handles everything from drone development and design to manufacturing, on-site measurements, and image analysis

2011: Founding of Luce Search Co., Ltd.

2014: Conducted demonstration flight for former Prime Minister Abe at Robot Revolution Realization Conference held at Prime Minister's Office.

2016: Received 7th Robot Grand Prize (Minister of Land, Infrastructure, Transport and Tourism Award) for development of a small laser-equipped drone.

July 2016-March 2018: Selected for NEDO project to develop systems to address social issues such as infrastructure maintenance, management, and renewal.

2019: When Ministry of Land, Infrastructure, Transport and Tourism revised inspection guidelines for road bridges, the firm's SPIDER structural inspection robot system was listed in performance catalog as inspection support technology.

https://luce-s.net/ (only available in Japanese)

High-performance drone SPIDER-ST

Q1 How do you use NEDO's support programs?

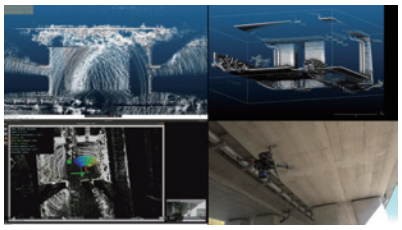
We have been participating in the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) site inspections since 2013, with a focus on using drones for bridge inspections. Since our company is based in Hiroshima, we were initially unable to keep track of national directions in development. After being selected by NEDO, however, we were able to better understand MLIT and METI robot development activities and could focus within the company on development goals. In addition, during the two-year project development period, we were able to speed up the development process by receiving detailed advice from experts at briefing sessions and on-site inspections organized by NEDO.

Drone in automatic flight under conditions where GPS is not available

Q2 What is Luce Search's vision for the future?

Our company designs and manufactures products with a focus on enhancing safety and achieving results under the theme "the company is the worksite." In parallel with the hardware aspect of robot development, we are also focused on software such as high-speed modeling and polygonization of point cloud models to develop more integrated 3D solutions. By fiscal year 2022, we intend to move forward from the "demonstration test" phase, where an idea is new and interesting, to the "regular business" phase, where we are no longer conscious of the idea as being new.

Data can be confirmed at worksite



Real-time confirmation of data

Comment from NEDO

The company's drones, which can fly stably even around structures subject to wind turbulence, demonstrated high performance in demonstration testing conducted by NEDO and MLIT on actual bridges. Expectations are high for this technology to efficiently inspect bridges, including those with poor scaffolding or tall structures.

NEP NEDO Entrepreneurs Program

Support for entrepreneurs through provision of specialists who assist with commercialization efforts

STS Seed-stage Technology-based Startups

Support for commercialization of seed-stage technology-based start-ups by promoting collaborations with venture capitalists and other relevant entities

CRI Collaboration with Research Institute

Support for R&D-based startups to develop commercial applications

Concluded FY2019

SCA Startups in Corporate Alliance

Support for R&D-based startups to conduct joint research with project companies

Concluded FY2019

PCA Product Commercialization Alliance

Support for R&D-based startups to develop concrete business plans for sales activity approximately three years after submission of proposal

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