Environment Innovation Strategy

September 18, 2020

What we aim for with this strategy

○ In the “Long-Term Strategy under the Paris Agreement” (approved by the cabinet in June 2019, hereafter “Long-Term Strategy”), Japan’s government set an ambitious target of a “decarbonized society” as a final goal that should be achieved as early as possible in the last half of the twenty-first century. The government stated the drastic actions required for realizing an 80% reduction of GHG by 2050. Moreover, the government clearly expressed Japan’s contribution to the Paris Agreement including the 1.5-degree goal by sharing Japan's mind and actions in the world.

○ However, a large additional annual cost for reducing GHG emissions, roughly estimated as seven trillion USD, is expected for achieving the 2-degree goal written in the Paris Agreement and further additional cost is needed for the 1.5-degree goal. Therefore, disruptive innovation that enables the early introduction of the new technology with reasonably acceptable cost is absolutely necessary for reducing global GHG emissions. (Japan has contributed through innovation; e.g., one-two hundred fiftieth cost reduction in the photovoltaic cell. See next page.)

○ “Environment Innovation Strategy” ※, here formulated based on the Long-Term Strategy consists of:

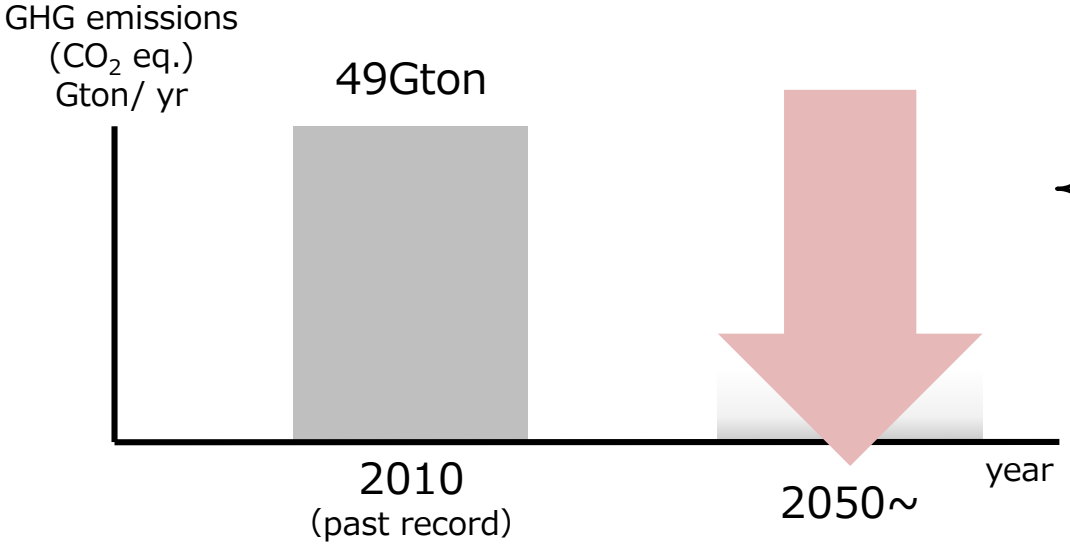
1) “Innovation Action Plans” which describe 16 technological challenges with cost targets.

2) “Acceleration Plans” which detail research frameworks and investment promotion policies.

3) “Zero-Emission Initiatives” which depict collaborative works and outreach activities with global leaders for social implementation.

Environment Innovation Strategy aims to establish innovative technologies that enable the reduction of global GHG emissions toward carbon neutral and further reduction of the accumulated atmospheric CO_2 level ”Beyond Zero” by 2050.

※described as “Progressive Environment Innovation Strategy” in the Long-Term Strategy.



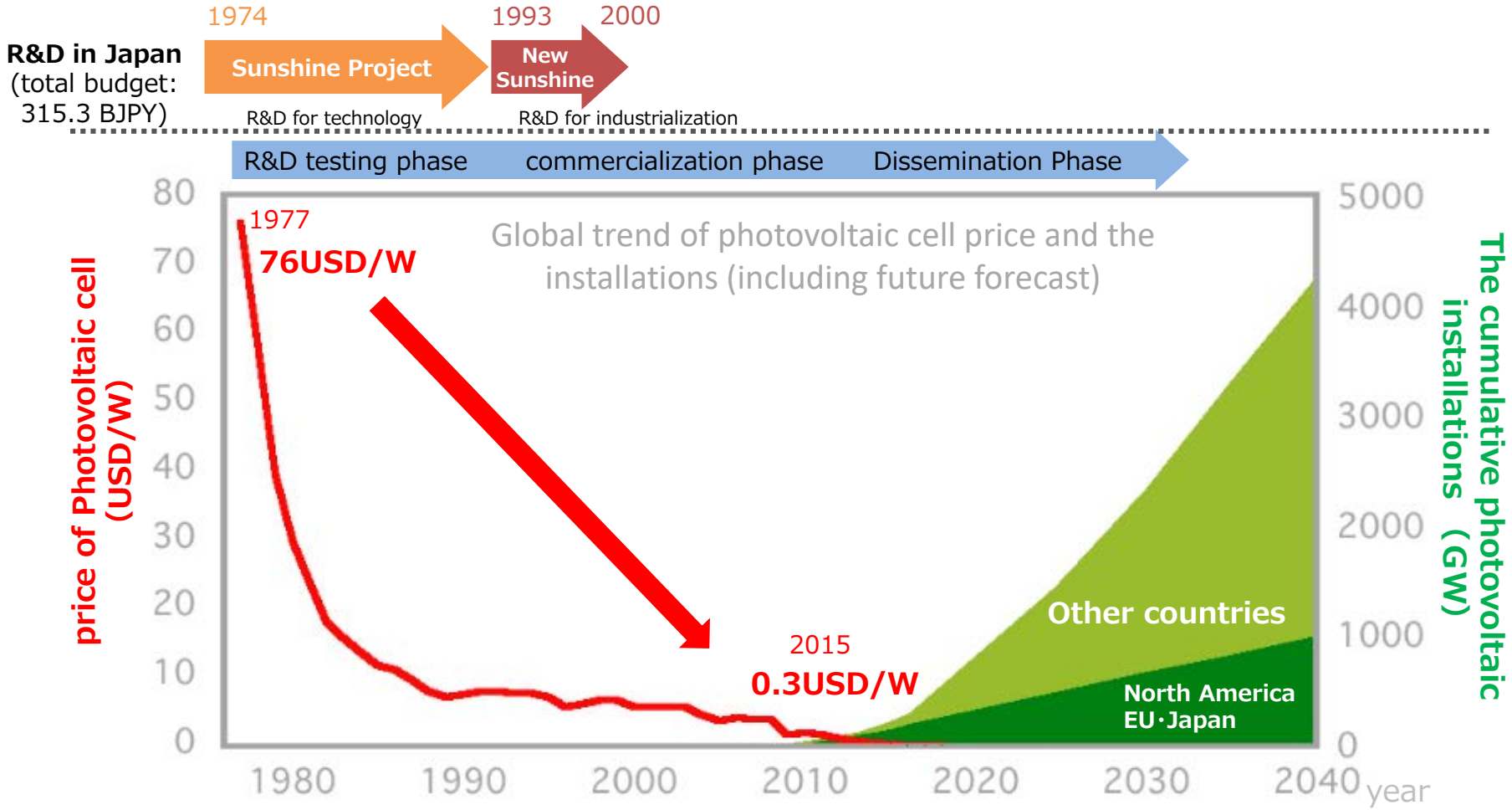
An additional annual cost of 7 trillion USD is needed for GHG reduction by 70% by 2050, which corresponds to the 2-degree goal. 1)

A further additional annual cost is needed for GHG reduction by 100% by 2050, which corresponds to the 1.5-degree goal.

1) A model-based simulation by RITE. The annual additional cost for GHG reduction by 100% is expected to be over ten trillion USD.

(Reference) Cumulative photovoltaic installations and price

Japan's government has invested for more than 30 years in research and development of photovoltaics in the Sunshine Project and New Sunshine Project. As a result, the price of the photovoltaic cell has reduced dramatically by more than one-two hundred and fiftieth, leading to the global trend of mass installation of photovoltaics. The estimated avoided cost for the period from 1977 to 2015 is estimated as large as 17 trillion dollars.



Source: CRIEPI report、Bloomberg New Energy Finance &pv.energytrend.com, IEA-World Energy Outlook 2018.

Outline of Environment Innovation Strategy

Innovation Action Plans

- Action plans for establishment of the innovative technologies by 2050 -
(16 challenges in 5 fields)

Describing i) cost targets, estimation of GHG reduction potential, ii) contents & formation of R&D, and iii) the process from basic research to demonstration.

Acceleration Plans - 3 measures for accelerating the "Innovation Action Plans" -

①Promotion by headquarters

[Green Innovation Strategy Promotion Meeting (tentative name)] Long-term support from basic research to implementation with overcoming of sectionalism. Overhaul of existing projects. Revision of Innovation Action Plans by using the latest knowledge.

②Gathering the wisdom of the world

[Zero-Emission Research Bases] Establishment of the "Global Zero Emission Research Center (GZR)" to connect 120,000 researchers in G20 member countries, "Research Center for Basic Energy Sciences" and R&D and demonstration base on Carbon Recycling. Launch of the "The Tokyo Bay Zero-emission innovation area" to strengthen industry-academia-government collaboration in Tokyo bay area.
[Zero-Emission Creators 500] Intensive support to promising young researchers.
[Strengthen support to promising technologies] Utilization of "advanced research program" and "the Moonshot R&D Program". Creation of "Circulating and Ecological Economy".

③Increase in private investment

[Promoting green finance] Disclosure of corporate climate-related information in the line with the TCFD recommendations. Promotion of dialogue between the industrial sector and the financial sector.
[Zero-Emission Challenge] Improvement of investors' access to corporate information through commendation and information disclosure of excellent projects
[Zero-Emission Start-up support] Promotion of VC investment for R&D startups

Zero-Emission Initiatives - for global collaboration throughout the international conferences -

Green Innovation Summit, RD20, ICEF, TCFD Summit, Hydrogen Energy Ministerial Meeting, and International Conference on Carbon Recycling

Innovation Action Plans

○ 16 important and common technical challenges were extracted from 5 fields; (I) energy transformation, energy demands (II) transportation, (III) industry, (IV) business, household, cross-sectoral and (V) agriculture, forestry and fisheries / absorber. 39 themes having large amount of GHG reduction potential and significantly contributed by Japanese technology were set.

○ Aiming to establish innovative technologies by 2050, which will enable global carbon neutral, (1) concrete cost target of innovation, quantity of global GHG reduction to clarify the social impact, (2) R&D contents, (3) R&D formations, and (4) specific scenarios and actions from basic R&D to practical application and demonstration development are described in the strategy.

Ⅰ. Energy transformation

More than 30 billion tons

Making renewable energy the main power source by drastic improvement to the efficiency and cost reduction of photovoltaic (PV) systems with innovative materials and structures.
Establishment of technologies for decarbonized and affordable energy supply by CCUS/Carbon Recycling technologies.

1. Renewable energy as a main power source

① Flexible, lightweight and highly efficient PV systems
② Supercritical geothermal systems
③ Floating off-shore wind turbines applicable to harsh environments

2. Resilient and robust electricity network using digital technologies

④ Low-cost innovative battery contributing to the expansion of renewable energy
⑤ Electric management system(EMS) with digital technology cutting the grid cost
⑥ High-efficiency, low-cost power electronics technology

3. Low-cost hydrogen supply chain

⑦ Production: cost reduction of CO_2-free hydrogen production to 1/10
⑧ Storage & transportation: compressed hydrogen, liquefied hydrogen, liquid organic hydrogen carrier, ammonia and metal hydride
⑨ Utilization: low-cost hydrogen station, low-NOx hydrogen power generation

4. Next-generation atomic energy, nuclear fusion

⑩ Atomic energy with excellent safety
⑪ Nuclear fusion

5. Low-cost CO_2 capture for CCUS/Carbon Recycling

⑫ Establishment of low-cost CO_2 capture technology for CCUS/Carbon Recycling

GHG reductions (CO_2 equivalents, can be counted twice) are estimates to share a common image to be pursued. Assumptions are different.

Ⅱ. Transportation

More than 11 billion tons

Various approaches, such as electrification and decarbonization of fuels, etc., to significantly reduce GHG from vehicles, aviation and shipping.

6. Green mobility (EV, FCEV, biofuels)

⑬ Expansion of electrification of vehicles and aviation, and significant improvement in environmental performance
⑭ Fuel cell vehicles and infrastructure
⑮ Technologies for manufacturing and utilizing bio fuels and synthetic fuels by Carbon Recycling technologies

Ⅲ. Industry

More than 14 billion tons

Independence from fossil fuel resources through innovative technologies (e.g., zero-carbon steelmaking process). Establishment of sophisticating Carbon Recycling technologies, such as transforming CO_2 into materials and fuels.

7. Independence from fossil fuel (electricity derived from renewable energy and CO_2-free hydrogen)

⑯ "Zero-carbon steel" through innovative technologies
⑰ Higher efficiency of metal resource circulation
⑱ Advanced plastic resource circulation

8. Carbon Recycling technologies to transform CO_2 to materials or fuels

⑲ Polymer by artificial photosynthesis technology
⑳ Fine chemicals with innovative manufacturing process and Carbon Recycling
㉑ Low-cost methanation
㉒ Cement from CO_2/concrete absorbing CO_2

GHG reductions (CO_2 equivalents, can be counted twice) are estimates to share a common image to be pursued. Assumptions are different.

Ⅳ. Business, household, cross-sectoral

More than 15 billion tons

Adopting advanced technologies to business and household sectors.
Change the social system and lifestyle with advanced information and communication technologies.

9. Implementation of advanced GHG reduction technologies

㉓ Cross-sectoral energy efficiency
㉔ Low-cost stationary fuel cell systems
㉕ Increased use of unutilized/renewable thermal energy
㉖ Green refrigerant with extremely low greenhouse effect

10. Smart community using big data, AI, decentralized management technology, etc.

㉗ Smart city

11. Energy saving by sharing economy, telework, work style reform, behavior modification

㉘ Sharing economy, telework, work style reform, behavior modification

12. Accumulation of scientific findings for the verification of GHG reduction

㉙ Elucidation of climate change mechanism, improvement of prediction accuracy, study including observation, reinforcement of information infrastructure

Ⅴ. Agriculture, forestry and fisheries/Carbon Sinks

More than 15 billion tons

Smart ecosystem to achieve the zero-emission in agriculture, forestry and fisheries.
Expansion of CO_2 carbon sinks by innovative technologies.

13. CO_2 absorption and fixation to the ocean, farmland and forest by advanced biotechnology

㉚ Genome editing technology
㉛ Chemicals from biomass
㉜ Carbon sequestration in farmland using biochar
㉝ Wooden high-rise buildings and wood-based bioplastics
㉞ Smart forestry and fast-growing trees
㉟ Blue carbon (carbon capture by the coastal ocean ecosystems)

14. Reduction of methane and N_2O discharged by agriculture and livestock industry

㊱ Breeding and optimal management techniques for farmland and livestock

15. Smart agriculture, forestry, and fishery

㊲ Local production and local consumption type energy system suitable for rural areas
㊳ Reduction of fossil fuel and materials by electrification of agricultural and forestry machines and fishing boats, optimization of work, etc.

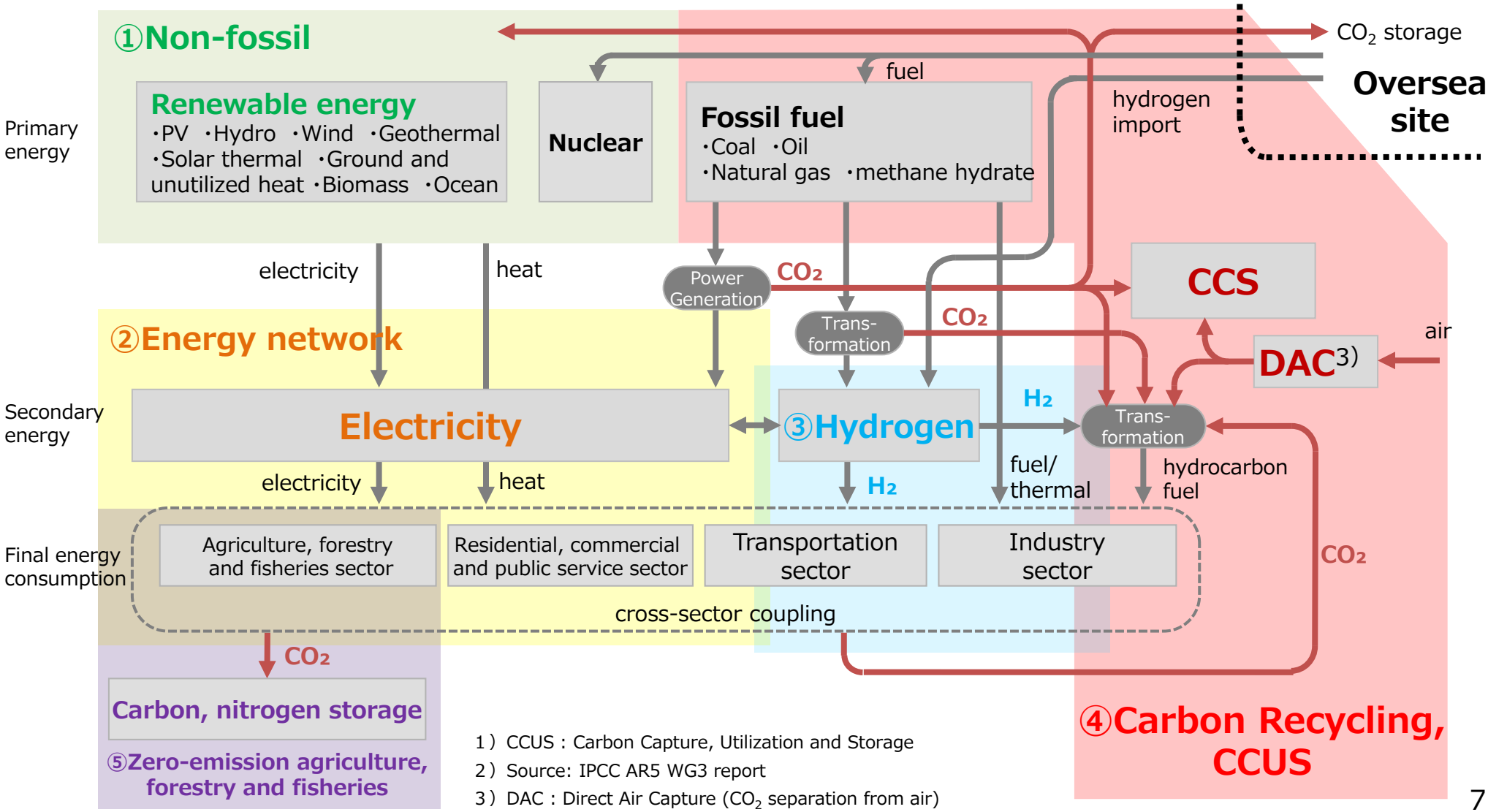
16. Capture CO_2 in the air

㊴ DAC（Direct Air Capture）

GHG reductions (CO_2 equivalents, can be counted twice) are estimates to share a common image to be pursued. Assumptions are different.

Five prioritized areas in the Innovation Action Plans

Technological areas are divided into: 1) Non-fossil fuel energy that contributes to electricity supply, hydrogen, and Carbon Recycling, 2) energy network technologies including batteries for energy storage, integral to wide use of renewable energy, 3) Hydrogen energy, which is utilized in transport, industry and power generation sectors, 4) Carbon Recycling and CCUS, which contribute to a significant reduction of CO_2, 5) Agriculture, forestry and fisheries, which occupy a quarter of global GHG emissions.



1) CCUS : Carbon Capture, Utilization and Storage
2) Source: IPCC AR5 WG3 report
3) DAC : Direct Air Capture (CO_2 separation from air)

①Non-fossil

Photovoltaics installed anywhere

Efficiency more than twice as high as that of current solar cells

- Target cost: Equal to or less than conventional power sources
- Potential of CO_2 reduction: 7 billion tons/year**

【R&D】

- Solar cells : Establishment of extremely lightweight, highly-efficient (more than 35%), and flexible module manufacturing technologies using new materials (e.g., perovskite) and new structures (e.g., tandem, quantum dot), which enables installation of the solar cells anywhere (e.g., facade of buildings).

【Measures】

- Strengthening international cooperation through Global Zero Emission Research Center (GZR) and RD20.
- Organized enforcement from leading study to practical use.

↑Perovskite-type (lightweight･flexible) ↓For cars

②Energy network

Digital electricity network

Cost equivalent to current electric rate, including energy management cost

- Target cost: Equal to current power source
- Inevitable for regulating the variable renewable energy source***

【R&D】

- Technologies that enables renewable energy as main power source (e.g., VPP, DR*, energy management system as next-generation regulating technology, battery, high-efficiency power electronics technology).

*VPP: Virtual Power Plant, DR: Demand Response

【Measures】

- International cooperation through international conferences such as RD20.
- Collaboration between industry and academia.

Image for next-generation energy management system

**Potential for reduction of global GHG emissions is estimated by NEDO.
***Since the technology acts as a regulation of the renewable energy, individual GHG reduction potential is not calculated.

③Hydrogen

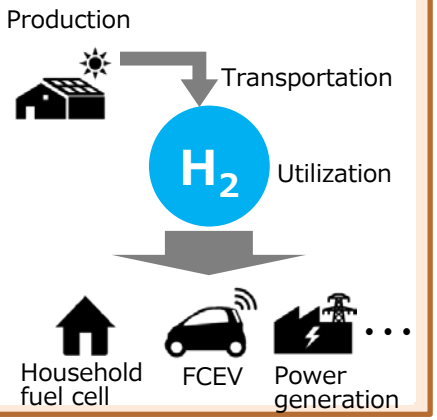
Hydrogen society

Cost equivalent to that of existing energy

- Target cost: 1/10 or less than current production cost
- Potential of CO_2 reduction: 6 billion tons/year*

【R&D】
- Cost reduction to produce CO_2-free hydrogen from renewable energy or fossil fuel with CCUS.
- Transportation and storage of hydrogen (compressed hydrogen, liquefied hydrogen, organic hydride, metal hydride, etc.).
- Establishment of the international supply chain.
- High efficiency fuel cell. Low NOx hydrogen power generation. Utilization of artificial photosynthesis.

【Measures】
- International cooperation through International conferences.
- Collaboration of industry, university, and public institute activated by national R&D projects.



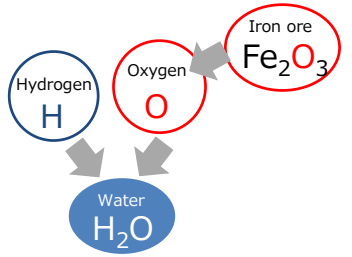
Zero-carbon steelmaking process

Utilization of CO_2-free hydrogen as the reducing agent instead of carbon

- Target cost: Equal to current steel
- Potential of CO_2 reduction: 3.8 billion tons/year*

【R&D】
- Breakthrough technologies for the reduction of iron ore by hydrogen.
- CCUS technology such as CO_2 capture by unused waste-heat.

【Measures】
- Start of feasibility study, and development for practical use by industry.



The reduction of iron ore by hydrogen

④Carbon Recycling, CCUS

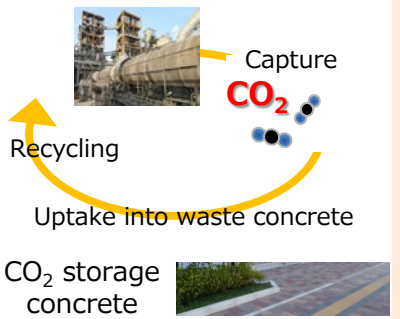
CO_2 uptake using cement and concrete

Utilizing CO_2 emitted during production

- Target cost: Equal to or less than current products
- Potential of CO_2 reduction: 4.3 billion tons/year*

【R&D】
- Capturing of CO_2 from cement burning process. Recycling of CO_2 as cement raw materials and construction materials by uptaking CO_2 into waste cement and concrete.
- CO_2 storage under infrastructure by concrete materials.

【Measures】
- Acceleration of development, including scale-up test, by national R&D projects.



*Potential for reduction of global GHG emissions is estimated by NEDO, etc.

DAC (Direct Air Capture)

Low concentration CO_2 capture from ambient air

- Target cost: Acceptable cost as an industry
- Potential of CO_2 reduction: 8.0 billion tons/year*

【R&D】
- Pursuing technologies for CO_2 capture from ambient air.
- Development of CO_2 fixation technology for the captured CO_2.

【Measures】
- Considering utilization of the Moonshot R&D Program.

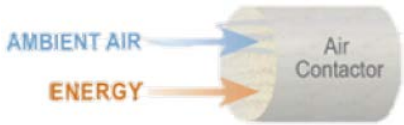


Image for DAC

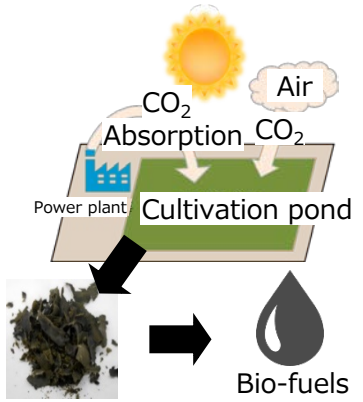
Bio-jet fuel from CO_2

Production of bio-jet fuels and diesel by absorbing CO_2 into Microalgae that grow 1000 times faster than usual

- Target cost: Equal to or less than current jet fuel
- Potential of CO_2 reduction: A part of 2.0 billion tons/year*

【R&D】
- Large-scale demonstration project under various conditions to establish large and constant cultivation systems of Microalgae in the natural environment.
- Establishing a research hub in Hiroshima to conduct the cultivation test using CO_2 from coal-fired power plants. Promoting research to maximize CO_2 absorption efficiency.

【Measures】
- Realizing commercial flights powered by bio-jet fuel in 2030.
- Project operation such as demonstration project in a large-scale cultivation pond.



⑤Zero-emission agriculture, forestry and fisheries

CO_2 absorption and fixation to the farmland, forest, and ocean

Enlarging carbon sinks source by innovative technology

- Target cost: Enabling to continue the business
- Potential of CO_2 reduction: 11.9 billion tons/year*

【R&D】
- Blue carbon such as culture technology of marine algae.
- Biochar application to agricultural soil. Fast-growing trees and elite trees.
- Wooden high-rise buildings. Low-cost mass production technology of biomass materials such as Glycol lignin.

【Measures】
- Advancement of underlying technology through biotechnology.
- Organized enforcement from leading study to practical use.


Upper left : Blue carbon
Upper right : Elite trees
Bottom : Glycol lignin

*Potential for reduction of global GHG emissions is estimated by NEDO, etc.

Acceleration Plans

Acceleration Plans aim to strongly support the enhancement and realization of the Innovation Action Plans, and consist of concrete measures (described below).
(1) Set the headquarters for promoting the Innovation Action Plans by reviewing regularly, (2) gather the wisdom of the world and (3) increase private investment (30 trillion yen by public and private sectors in 10 years), considering the expansion of ESG investment.

Basic Research | **Development for application** | **Demonstration** | **Implement**

Innovation Action Plans

Acceleration Plans

Green innovation strategy promotion meeting (Tentative name) (Overhaul of existing projects, establishment of a scheme to promotion of R&D)

Support to promising young researchers (Zero-Emission Creators 500)
(Discover promising young researchers / Support for joint research with companies)

Advanced research program
(JST[1)], NEDO; excavation innovative technologies aiming for demonstration and implementation)

Utilization of the Moonshot R&D Program
(Basic R&D for Innovative technologies for implementation)

1) Japan Science and Technology Agency (JST)

Inauguration the "Global Zero Emission Research Center (GZR)" for International collaboration
(International cooperation though RD20, ICEF, Hydrogen Energy Ministerial Meeting, International Conference on Carbon Recycling by the collaboration of industry, academia and Government)

Research Center for Basic Energy Sciences

collaboration through the zero-emission forum

International application
(CEFIA, International standardization)

Zero-Emission Start-up Support
(JST、NEDO ; Promotion of VC investment for R&D startups)

"Circulating and Ecological Economy"
(decarbonization, resource circulation)

The Tokyo Bay "Zero-emission" innovation area
(demonstration site)
Establishment of R&D and demonstration base on Carbon Recycling
(R&D for utilizing CO_2 as resources)

Expansion of private investment to innovative technical development
(Promoting green finance through disclosing company information in the line with the TCFD recommendations and "Zero-Emission Challenge" to select promising projects)

Zero-Emission Initiatives (Strengthen international engagement)

Zero-Emission Initiatives

Annually, the leaders of industry, finance and academia from around the world gather in Japan and take concrete actions to combat climate change.
Through the “Green Innovation Summit” and 5 international conferences, i) to share the latest information on innovative technologies, ii) to offer the opportunity of collaboration, to promote the green finance and iii) to accelerate the implementation of outcomes will be continuously proceeded .

Innovation Action Plans

Acceleration Plans

Zero-Emission Initiatives

Green Innovation Summit

Under the Prime Minister, the leaders of industry, finance and academia are gathered to share Japan's concrete initiatives with the world. Strengthening of international engagement.

Hydrogen Energy Ministerial Meeting	International Conference on Carbon Recycling	RD20	TCFD Summit	ICEF
Discuss policy directions with countries, regions, and institutions with a strong interest in global hydrogen utilization.	In order to realize Carbon Recycling, share the latest initiatives and knowledge of each country, explore the chance of collaboration, and promote the network of industry, academia and government among countries.	Share R&D activities and experiences by leaders of research institutes in the field of clean energy technology from G20 member countries in order to create discontinuous innovations for significant reduction of CO_2	Promote dialogue among the global leaders of companies and finance who are positive about implementing measures to address climate change to realize a virtuous cycle of environment and growth.	Discuss climate change measures through technological innovation with more than 1,000 experts in about 70 countries and regions