provisional translation

Green Growth Strategy Through Achieving Carbon Neutrality in 2050

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1. Green Growth Strategy Through Achieving Carbon Neutrality in 2050

(1) Relationship between Carbon Neutrality and Green Growth Strategy

In October 2020, the Japanese government announced the Carbon Neutrality in 2050. Gone are the days when countermeasures to global warming are considered as a cost or constraint to the economic growth, the world has entered a new era to grasp them as a great opportunity for further prosperity. Changing from the conventional mindset, to take measures positively to tackle climate change heralds transformation in the industrial structure and social economy, and leads to the next strong growth. The Green Growth Strategy is a set of industrial policies to create such a “virtuous cycle of economy and environment”.

It is easy to tell rhetoric such as “changing from the mindset” and “transformation”, but in reality, carbon neutrality will require an enormous effort. In the industry, many companies will have to fundamentally change the business models and strategies they have been using. While, it’s also a chance for them to lead the new era. The role of the government is to provide full support to private companies in conducting their forward-looking challenges, such as a bold investment to make innovation.

The government needs to put up an as-specific-as-possible prospect, set high goals, and develop an environment that facilitates ventures of private enterprises. What is particularly important towards the 2050 Carbon Neutrality will be initiatives in the field of energy that accounts for more than 80% of greenhouse gas emissions. For that reason, from the viewpoint of industrial policies, in order to ascertain which fields and industries are expected to grow, first, the government needs to present a blueprint of energy policies and energy supply/demand structure needed to realize the 2050 Carbon Neutrality, as a reference value in deepening discussions. Through the Green Growth Strategy, the Japanese government will set high goals and muster all possible and necessary policies for the thus-determined industries (14 industrial fields) that are expected to grow.

Decarbonization of the power sector is the major premise. Renewable energy will to be introduced as much as possible. Electric power systems will be established, cost will be reduced, and storage batteries will be utilized to accommodate output fluctuations, while maintaining harmony with the surroundings. Accordingly, offshore wind power generation industries and storage battery industries need to be nurtured as a growth strategy.

Regarding thermal power, the government will pursue its use as an option, presupposing recovery of carbon dioxides (CO_2). Technology will be established, suitable sites will be developed, and the cost will be reduced. Globally, thermal power will remain necessary, especially in Asia, although the extent of use should be as minimal as possible. Considering that, the government shall pursue the use of hydrogen power generation where possible, as an option. Both supply and demand quantities will be increased, infrastructure will be established, and the cost will be reduced. To achieve them, creation of hydrogen industry will be required. At the same time, carbon recycling industries and fuel ammonia industries will have to be developed.

Nuclear power is an established decarbonization technology. While making efforts to improve its safety and reducing the reliance on it as much as possible, the Japanese government will continue to seek making the most of nuclear power. It is necessary to proceed with restarting of reactors with placing utmost priority on safety, as well as to develop safer next-generation reactors.

In industrial fields other than the power sector, the primary course of action will be electrification. For heat demands, decarbonized fuel such as hydrogen as well as recycling of CO_2 and recovery of CO_2 from fossil fuel will also be utilized. To address the anticipated increase in electricity demand due to electrification, Industries related to energy saving need to be developed as growing fields.

The industrial sector will require reform of existing manufacturing process, such as hydrogen reduction steelmaking. The transportation sector has to use biofuel and hydrogen fuel, while promoting motorization. The business and household sectors anticipate net zero energy houses/buildings, electrification, hydrogen-powered systems, and use of storage batteries. Accordingly, the hydrogen industry, EV/storage battery industries, transportation-related industries, and housing- and building-related industries have to be bolstered as growing industrial fields.

When pursuing the 2050 Carbon Neutrality, in addition to realizing such an energy supply and demand structure, digital control of power network will become necessary. What upholds the Green Growth Strategy is resilient digital infrastructures; green and digital are the 2 inseparable wheels of a car. Digital infrastructures are required to be reinforced, and the Japanese government definitely needs to cultivate the semiconductor/information and communication industries as growing industrial fields. For example, in the power sector, digital technology is essential in managing smart grids for advanced operation of systems, supply-demand adjustment for solar power and wind power generation whose output varies depending on the weather, and also essential for maintenance and inspection operations of infrastructures. In the transportation sector, automatic driving of cars, drones, aircrafts, and trains will not only improve the convenience of the people but also contribute to improved energy use efficiency. In addition, at factories, manufacturing will be automated through factory automation (FA) and robots. Meanwhile, in the tertiary industry and household sectors, advent of smart houses (which combine renewable energy and storage batteries using an energy management system for optimal energy use) and service robots will not only realize comfortable life but also achieve efficient energy use.

Buds of technology to realize such a society has already come to the surface through research and development (R&D) conducted to date. In January 2020, the government formulated the Environment Innovation Strategy, aiming to establish innovative technologies for achieving the “Beyond-Zero” initiative to reduce CO_2 that has accumulated since the Industrial Revolution, under which the Japanese government exhibited the issues to overcome and has been making relevant deliberations. Challenges awaiting ahead of the establishment of such innovative technologies are social implementation and cost reduction by investment for mass production. The government has to muster all available and necessary policy measures such as budget, taxation, finance, regulatory reform/standardization, and international cooperation under the Environment Innovation Strategy to steer private enterprises to in the direction of positively investing the cash equivalent of 240 trillion yen they amass. According to an automatic preliminary calculations, it is expected to generate a positive yearly economic impact of around 90 trillion yen in 2030 and of 190 trillion yen in 2050 by this strategy, respectively.

(2) Realization of Carbon Neutrality in 2050

One estimate says the power demand in 2050 will increase by 30-50% compared with the current demand level due to electrification in the industrial, transportation and household sectors. For heat

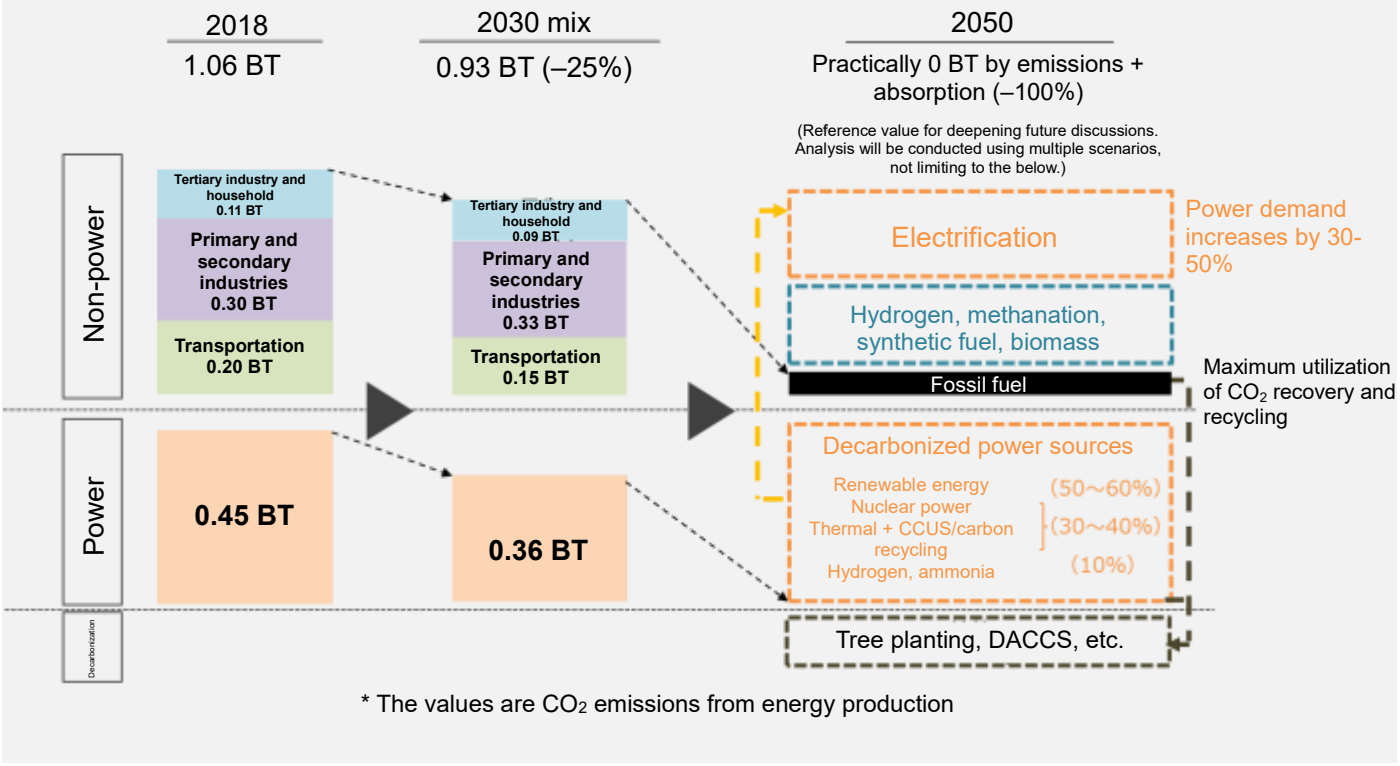
demands, decarbonized fuel such as hydrogen as well as recycling of CO_2 and recovery of CO_2 from fossil fuel will also be utilized.

Renewable energy will be introduced as much as possible. Renewable energy poses many issues, however, such as ensuring the adjustability, ensuring the transmission capacity, maintaining the inertia, addressing natural conditions and social restrictions, and reducing the cost. Therefore, it is practical to think it impossible to cover all electricity demands by renewable energy alone, even if all possible policies are effectively implemented. Covering approximately 50-60% of electric power generation with renewable energy including solar, wind, hydro, geothermal, and biomass in 2050 is regarded as a reference[1] for deepening discussion on the basis of opinions exchanged among various specialists in the energy field, and the government will proceed with future discussions.

Regarding thermal power presupposing CO_2 recovery and recycling and hydrogen and ammonia power generation, relevant technology is still in the stage of development and demonstration, and their use will depend on the state of establishment of technology and industry. Assuming smooth social implementation according to the Green Growth Strategy, the reference values for deepening discussions are set to about 10% for hydrogen and ammonia power generation and about 30-40% for nuclear power and thermal power presupposing CO_2 recovery.

In the future, toward revision of the Strategic Energy Plan, the government will deepen discussions using multiple scenarios, not limited to those shown above.

(Reference) Proposed process of transition to carbon neutrality



* The values are CO_2 emissions from energy production

2. Framework of Green Growth Strategy

The Japanese government is committed to lead challenges towards the 2050 Carbon Neutrality to major growth via reforms of industrial structure and economic society. The Green Growth Strategy will encourage private investment to utilize the cash equivalent of 240 trillion yen in Japanese companies. Also it will draw environment-related investment funds in the world that are said to be in the scope of 3,000 trillion yen into Japan, and thereby generate employment and growth. The government will mobilize all available political tools to realize that.

For each priority industrial field which is necessary for realizing the 2050 Carbon Neutrality, the Japanese government will formulate an Action Plan which includes [1] goals with clearly specified time frame to achieve them, [2] R&D and demonstration, [3] institutional development such as regulatory reform and standardization, and [4] international cooperation, and the relevant ministries and agencies will join forces to work on them.

An Action Plan for priority industrial field shall clearly state the current situation, issues, and future courses of action for the relevant field, and present a time schedule toward 2050. Relevant policies shall prioritize creation of demand through regulatory reform/standardization and financial market, and price reduction through expansion of private investment.

A time schedule shall show specific measures to strengthen the international competitiveness of Japan and facilitate autonomous market expansion regarding key technology for realizing growth in relevant fields, with keeping in mind:

[1] “research and development phase” to be processed by funds set up by the government and by private investment into R&D;
[2] “demonstration phase” to be processed by public-private cooperative investment on the premise of instigating private investment;
[3] “introduction and expansion phase” for expanding demands through public procurement and development of relevant systems such as regulations and standards, and for reducing cost through associated shifting to mass production; and,
[4] “autonomous commercialization phase” where commercialization develops autonomously without public support, presupposing systems such as regulations and standards.

Attention needs to be paid, however, that the rate of progress in each phase varies depending on the field, and in some cases the phase may shift from a “research and development phase” to an “introduction and expansion phase” leaping over a “demonstration phase”.

In the budgetary aspects, the Japanese government shall set an example of making a huge step forward in environment investment; it will create a fund in an unprecedented scale of two trillion yen, and keep supporting enterprises that attempt ambitious innovation for the next ten years.

In the tax system aspects, in order to rouse private investment, the government will establish an investment promotion tax treatment toward carbon neutrality, expand R&D tax systems, and take a special exception to raise the upper limit of tax deduction for loss carried forward targeting companies that work on business restructuring or reorganizing.

In the financial aspects, the Japanese government will call for financing on innovative technology toward low carbonization or decarbonization through creation of rules in the financial market about, for example, information disclosure and basis of appraisal.

Regarding regulatory reform and standardization, the government will deliberate various matters including reform of regulations on hydrogen stations, revision of system operation rules to prioritize renewable energy, utilization of fuel consumption regulations to promote the electrification of automobiles, and public procurement of concrete made by absorbing CO_2, to create demand and reduce prices.

As for private funding, the government will proceed with creation of rules of financial market, such as standards of information disclosure and appraisal, while cooperating with relevant agencies and institutions overseas.

3. Major Cross-cutting Policy Tools

(1) Budget (Green Innovation Fund)

Achieving the 2050 Carbon Neutrality is an extremely challenging task, and requires attempting more ambitious innovation than ever. For that reason, regarding particularly important projects, the government will, once the public and private sectors share bold and specific goals, provide thorough support to companies committed to take on challenges toward achieving the goals, from technology development through demonstration to social implementation. In line with that, the government will create a new fund of two trillion yen at the New Energy and Industrial Technology Development Organization (NEDO).

Regarding the priority industrial fields that are essential for carbon-neutral society and form the basis of industrial competitiveness, [1] greenification of power and electrification, [2] realization of hydrogen economy, and [3] CO_2 fixation and recycling, the Japanese government will set aggressive 2030 targets (e.g., performance, introduction rate, price, CO_2 reduction ratio) in accordance with Action Plans of the Green Growth Strategy, and continuously provide support on enthusiastic R&D of enterprises that pronounce commitment to the targets for the next ten years.

Amid intensifying global competition over commanding power in business that leads realization of carbon-neutral society, in order to follow R&D through to social implementation, the government will ask the management of companies to commit themselves into such challenges as management tasks. Specifically, a company that is adopted to a relevant project shall, at the time of adoption, submit to the government a long-term business strategy and vision (e.g., 10-year innovation plan, formation of teams directly managed by the management) for the relevant field under the commitment of the top management. In addition, the government will ask the top management to clarify the priority of the project among his/her tasks, and periodically participate in public conference of discussions set up for making the project successful.

By creating such mechanisms to ask commitment of the top management, and using two trillion yen of governmental budget as priming water, the government will induce approximately 15 trillion yen of R&D and capital investment by private companies and steer them into the direction of ambitious innovation. It will also draw in ESG (environmental, social and governance) funds, it is estimated to be 3,000 trillion yen from the world and thereby generate income and employment for Japanese people in the future.

(2) Tax systems

Realization of the 2050 Carbon Neutrality is a high-set goal, and short-term capital investment by companies that is highly effective in achieving the goal needs to be encouraged, let alone R&D investment from long-term views. Therefore, also from the aspect of tax systems, the Japanese government will strongly push decarbonization investment by companies.

Specifically, the government will establish tax treatments to induce private investment toward decarbonization in order to cultivate new demand through early marketing of products with large greenhouse gas reduction effect, or to promote decarbonization of production process currently in use. In addition, the government will take a special exception to raise the upper limit of tax deduction for loss carried forward targeting companies that are resolutely taking on challenges towards “new normal” and realization of carbon neutrality, even though their business is in the red, amid the severe business environment induced by the COVID-19 pandemic. Further, as for R&D tax systems, the government will strengthen incentives to positive R&D investment amid the coronavirus crisis to prop up enterprises’ desire to make medium- to long-term investment.

These measures are anticipated to generate approximately 1.7 trillion yen of private investment over the course of 10 years, as they will strongly encourage enterprises to make every sort of short-, medium-, and long-term decarbonization investment.

[1] Establishment of a tax treatment (tax deduction or special depreciation) to promote investment toward carbon neutrality

Based on a plan approval scheme that is to be newly established in the to-be-revised Industrial Competitiveness Enhancement Act, for introduction of facilities described in (i) and (ii) below, the government will apply a maximum of 10% tax deduction or 50% special depreciation (for three years from the date of enforcement of revised Industrial Competitiveness Enhancement Act to the end of FY 2023).

(i) Introduction of production facilities for products with large decarbonization effect

The Environment Innovation Strategy (decided by Integrated Innovation Strategy Promotion Council on January 21, 2020) specifies 39 themes that greatly reduce greenhouse gas emissions and Japan is considered to have technical capability for. Among these 39 themes, focusing on the energy conversion sector that accounts for more than 40% of CO_2 emissions in Japan, the government will support introduction of facilities primarily used for the production of the products below selected from the said sector that have an immediate need for investment yet private companies will likely face a difficulty in expanding introduction in the early stage by their autonomous initiatives alone.

<Target products>

- Compound power semiconductor devices or semiconductor substrates used for manufacturing them
- Lithium-ion storage batteries for electric vehicles or plug-in hybrid vehicles
- Stationary lithium-ion storage batteries (those that satisfy at least 7,300 discharge/charge cycles)
- Fuel cells (those that satisfy one of the following: power generation efficiency is at least

50%, overall efficiency is at least 97%, or pure hydrogen is used as fuel)

- Main exclusive parts of offshore wind power generation facilities (those that satisfy the rated output of at least 9 MW per unit)
  (nacelle, generator, speed-up device, bearing, tower, foundation)

(ii) Introduction of facilities that realize both decarbonization and improved added value of production process, etc.

The government will support introduction of facilities that improve the carbon productivity ([amount of added value]/ [energy-related CO_2 emissions]) of a place of business, etc. to a considerable degree (those that improve the carbon productivity of a place of business by at least 1%).

<Improvement of carbon productivity to a considerable degree and rate of preferential measure>

As criteria to be fulfilled by companies for the government to provide assistance in investment into existing equipment and facilities toward the 2050 Carbon Neutrality, the government specifies the carbon productivity improvement rate and the according ratio of preferential measures:

- Improve by 7% or more within 3 years (*1): 5% tax deduction or 50% special depreciation
- Improve by 10% or more within 3 years (*2): 10% tax deduction or 50% special depreciation

*1: Calculated based on factors including the target of energy-related CO_2 emissions in FY 2030 assumed in existing governmental schemes such as the Basic Energy Plan (Cabinet decision on July 3, 2018), the Plan for Global Warming Countermeasures (Cabinet decision on May 13, 2016), and Long-term Energy Supply and Demand Outlook (Ministry of Economy, Trade and Industry, July 2015) and the GDP growth rate shown in the Economic and Fiscal Projections for Medium to Long Term Analysis (document submitted to the Council on Economic and Fiscal Policy on July 31, 2020).

*2: Calculated assuming CO_2 emission levels lower than the target of energy-related CO_2 emissions in FY 2030 assumed in existing governmental schemes stated above, in the view of achieving the 2050 Carbon Neutrality.

[2] Establishment of a special exception to raise the upper limit of tax deduction for loss carried forward targeting companies that work on business restructuring or reorganizing

The government will take a special time-limited measure to raise the upper limit of tax deduction[1] for loss carried forward by up to 100% within the scope of approved amount of positive investment for companies that are in deficit due to the COVID-19 pandemic but make investment towards “new normal” and realization of carbon neutrality according to a plan approval scheme that is to be newly established in the to-be-revised Industrial Competitiveness Enhancement Act.

Investments covered by this measure shall be those made by enterprises for the purpose of business restructuring and reorganization based on an approved business adaption plan, and are required to likely achieve certain goals within the term of the plan (e.g., ROA increases by at least 5.0% points). Specific examples include R&D investment into the development of new technology that contributes to realizing the 2050 Carbon Neutrality, introduction of equipment that greatly reduces CO_2 emissions through consolidation of production equipment, and investment to increase production of high-added value products.

[1] A system in which a loss carried forward from a previous business year can be deducted (offset) from taxable income of present or later business year. Currently, 50% is the upper limit for middle- and large-sized enterprises.

Losses eligible for the special exception are to be those generated in two business years including February 1, 2020 to April 1, 2020, and the period to raise the upper limit of tax deduction is to be five business years at the longest.

[3] Expansion of R&D tax system

Amid the protracted impact of COVID-19 pandemic, business environment of enterprises remains severe, and income and sales are feared to keep dropping. At the time of the bankruptcy of Lehman Brothers where business conditions of enterprises just shattered, the amount of R&D investment in Japan plummeted and took long time to recover after that. Leaning from that experience, as for R&D investment that is the very source of medium- and long-term growth and indispensable for realizing carbon neutrality in Japan, it is important for the government to strengthen incentives for pandemic-hit enterprises to increase the amount of their R&D investment.

Under the current R&D tax system, enterprises can deduct experiment and research costs (multiplied by a certain ratio) up to 25% of the amount of corporate tax. However, if the amount of corporate tax decreases due to reduced sales and deteriorated earnings, the amount exceeding the upper limit is generated or increases, and that may disincentivize enterprises from investing. To that end, for enterprises that are increasing experiment and research costs even though the amount of their sales is reduced by 2% or more compared to prior to the COVID-19 pandemic (last business year that ends by the end of January 2020), the upper limit of tax deduction will be raised up to 30% of the amount of corporate tax. By this, the Japanese government will bolster enterprises' desire to make investment toward creation of innovation for realizing the 2050 Carbon Neutrality.

(3) Financing

Toward the 2050 Carbon Neutrality, the Japanese government will draw in private investment using governmental funds as priming water. An estimate by the International Energy Agency (IEA) says realization of the Paris Agreement requires up to 8,000 trillion yen in the world. Considering that, financing is required on renewable energy (**green**), steady low carbonization including energy conservation (**transition**), and innovative technology toward decarbonization (**innovation**).

According to the Climate Innovation Finance Strategy 2020 (September 2020), the government will take measures to attract private investment into green, transition and innovation initiatives.

Transition finance is a concept to provide funds to technology that is required in the transition stage toward steady low carbonization. A binary approach of “green” or “not green” may not realize proper evaluation of initiatives taken by enterprises for steady transition to low carbon economy. In the future, based on the international principles of transition finance announced in December 2020, the Japanese government will formulate Japan’s basic principles and roadmaps toward implementation of the principles targeting industries with large CO_2 emissions that are unable to realize decarbonization in one stride.

In addition, targeting business operators whose long-term business plan for 10 years or over has been approved (*), the Japanese government will promote their long-term initiatives for transition by establishing a long-term funding program for realizing the plan and a performance-based interest subsidy system (funding scale of one trillion yen over three years).

(*) Establishment of a new approval system is planned to be included in a revision proposal for the Industrial Competitiveness Enhancement Act.

Further, the government will propel initiatives for promoting investment into advanced low-carbon facilities utilizing operating lease that has a large capital investment inducting effect, and thereby bring about investment of more than 150 billion yen.

Regarding the innovation finance, the Japanese government has been conducting visualization of enterprises that engage in decarbonization as information for investors (Zero-Emission Challenge: 320 companies as of October 2020). In the future, the government will expand the target industrial fields and create opportunities of dialogs for investors, enterprises and policymakers to call in finance to enterprises working on decarbonization innovation.

In addition, the government will provide risk money support to green ventures including renewable energy business (e.g., offshore wind power), utilization of low fuel consumption technology, and next-generation storage battery business. Specifically, it will establish the Green Investment Fund (business size of 80 billion yen) as part of specified investment business of the Development Bank of Japan (DBJ). Also, to assist overseas development of high-quality infrastructure and other overseas business activities toward decarbonized economy conducted by Japanese companies, the government will establish the Post-coronavirus Growth Facility (tentative name; business size of 1.5 trillion yen) at the Japan Bank for International Cooperation (JBIC).

Positive disclosure of information by companies is a common base for attracting finance into their initiatives toward decarbonization. Japan has the largest number of institutions that support the Task

Force on Climate-related Financial Disclosures (TCFD) and its recommendations in the world, and leads the utilization and development of TCFD by, for example, hosting the TCFD Summit since 2019. As for obligation of disclosure, considering that Japan already obligates reporting under the Act on Promotion of Global Warming Countermeasures, the government will clarify the application of disclosure aligned with TCFD in the future.

The amount of ESG-related private funds is 3,000 trillion yen in global total, and approximately 300 trillion yen in Japan alone. The amount in Japan has increased six times in three years. The government will take in such ESG funds toward carbon neutrality, including approximately 30 trillion yen set forth by the three megabanks as an environment finance target.

So that financing funds for carbon neutrality, i.e., domestic and overseas growth funds will be fully utilized in activities by Japanese enterprises that have a high level of technology and potential to contribute to the realization of carbon neutrality, the Japanese government needs to develop an environment in which financial institutions and financial and capital markets function properly.

To that end, the government has to consider a cooperation system with financial institutions to back up execution of the Green Growth Strategy, including enhanced collaboration with policy finance.

In addition, the government is required to consider measures to accelerate ESG investment by, for example, vitalizing the corporate bond market, to broadly provide the people with opportunities of investment that contributes to carbon neutral economy through the financial and capital market and proceeds thereof.

Further, from the viewpoint of establishing an environment to facilitate smooth issuance of social bonds offered for financing projects that contribute to resolve social issues, the government must consider formulating practical guidelines under which enterprises can issue bonds and stock companies can support them with sense of security.

On top of that, the Japanese government needs to lead international discussions on taxonomy and transition finance utilizing the occasions of G7 and G20 meetings.

To establish such financing systems toward carbon neutrality, relevant ministries and agencies will intensively deliberate and reflect the outcome of deliberations on the revision of the Green Growth Strategy by spring next year.

(4) Regulatory reform and standardization

Regarding innovative technologies that would become the keys of future growth, after the verification phase to be processed by public-private cooperative investment on the premise of instigating private investment, the government will expand the demand by working on [1] tightening of regulations to create technology demands, [2] rationalization of outdated regulations that do not cover new technology, [3] international standardization to facilitate use of new technology in the world, and reduce prices through attraction of investment toward mass production.

<Specific initiatives (examples)>

[1] Hydrogen

- Obligate electricity retailers to procure carbon-free power source at no less than a certain percentage, and utilize carbon-free value trading markets. Evaluate hydrogen as a carbon-free power source along with renewable energy and nuclear power, and establish power markets that incentivize utilization of hydrogen.
- Work on international standardization of related equipment and facilities, such as loading arms for transferring hydrogen from international hydrogen carrier vessels to receiving bases.

[2] Offshore wind power

- Start the new rule on the access to grids throughout Japan in order to connect more renewable energy, provided that the outputs are curtailed when they exceeds the available capacity of transmission network. Further, consider the drastic change of rules on the use of transmission networks in order to prefer renewable energy to thermal plants like coal-fired.
- Consolidate examinations by the Ministry of Land, Infrastructure, Transport and Tourism (Port and Harbor Act, Ship Safety Act), along with rationalization of safety review by the Ministry of Economy, Trade and Industry (Electricity Business Act).
- Clarify criteria for permission of leaving behind when removing windmills based on the Act on Prevention of Marine Pollution and Maritime Disaster.
- Regarding the floating offshore wind farms with large windmills that are regarded as an emerging field in the world, work on international standardization of safety assessment methods.

[3] Automobile and battery

- Consider utilization of fuel economy regulations to promote vehicle electrification.
- Contribute to establishment of international rules and standards on storage batteries regarding visualization of CO_2 emissions in their life cycle, ethical material procurement, and promotion of reuse.
- Work on the development of standardization of product life performance labels on household storage batteries.

As for economic instruments (e.g., carbon pricing) using market mechanisms, the Japanese government will introduce without hesitation those that contribute to materializing its growth strategies, including the enhancement of existing systems, expansion of targets, and establishment of new systems, to strengthen the

industrial competitiveness and promote innovation and investment. The government decided that relevant deliberations are to be jointly conducted by the Ministry of the Environment and Ministry of Economy, Trade and Industry, which requires specialized and technical discussions on whether systems can be designed in accordance with the purport of the growth strategies, taking into account various factors including international trends, circumstances in Japan, and impact on the international competitiveness of the industry.

(i) Credit trading

Credit trading, especially emissions trading system for which the government determines upper limits has own issues like how to allocate emissions according to the economic growth. Japan has established trading markets for carbon free values and J-Credit Scheme along with obligating electricity retailers to procure carbon-free power source at no less than a certain percentage, following the movement of private enterprises to procure carbon-free power to draw in ESG investment, and the government will consider further enhancement of these trading systems. Specifically, the government will:

[1] consider adding hydrogen to carbon free values, not just renewable energy and nuclear power; and,

[2] thoroughly consider the trading markets to find what their ideal form and state would be, in order to facilitate procurement of carbon free values by end users, including automobile and semiconductor manufactures.

(ii) Carbon tax

Carbon tax has some issues like the relationship with the purport of this Growth Strategy that is induction of investment utilizing the cash equivalent of enterprises, and the emission reduction effects. Japan has already introduced the Global Warming Countermeasure Tax.

(iii)Carbon border adjustment

Carbon border adjustment is currently being deliberated in the Europe from the viewpoint of international carbon leakage prevention. (Also in the US, presidential candidate Joe Biden mentioned it in his campaign promise.)

The Japanese government will consider its response in cooperation with other countries to secure a level playing field with countries that are not willing to take sufficient measures against global warming, as an integrated internal and external industrial policy for securing the international competitiveness of the industry including the steel sector.

(5) International cooperation

The viewpoint of integrated internal and external industrial policies is essential in promoting the development and social implementation of innovative technology toward the realization of the 2050 Carbon Neutrality. The Japanese government will strengthen the competitiveness of Japanese industry through cost reduction taking advantage of the scale merit, by acquiring not only the domestic markets but also overseas markets, in emerging countries in particular. At the same time, Japan will take in overseas technology, markets, and management through foreign direct investment into Japan, internal/external collaboration, and M&A.

To that end, while cooperating with other countries in innovation and technology development in priority industrial fields and other relevant fields, the Japanese government will assist their social implementation by, for example, implementing overseas demonstration projects that bring social implementation and market acquisition in the view, providing support for composition of overseas infrastructure projects utilizing technology of Japanese enterprises, and enhancing the functions of export and investment insurance. In addition, the Japanese government will actively participate in formulation of international rules, norms and standards including the market mechanisms under the Paris Agreement and standards of information disclosure and appraisal in the financial market.

<Cooperation with major countries>

With major countries such as the US and European countries, the Japanese government will work on cooperation in innovation policies, promotion of individual projects in critical industrial fields and other relevant fields including support for initiatives in third countries including emerging countries towards decarbonization, standardization of elemental technologies in critical industrial fields, and making of relevant rules (e.g., removal of trade barriers).

Also, with emerging countries in Asia that are especially important from the viewpoint of promoting global decarbonization, taking into account relatively large social and economic restrictions of Asian emerging countries compared with developed countries, the Japanese government needs to spur them to commit to decarbonization via more practical approach, while cooperating with international organizations such as the International Energy Agency (IEA) and Economic Research Institute for ASEAN and East Asia (ERIA). From such a viewpoint, in accordance with the concept of utilizing “all-fuels and all-technologies” put forward by IEA, the Japanese government will propose a wide range of solutions towards decarbonization including, but not limited to, renewable energy, CO_2 recovery, nuclear power, hydrogen/biofuel, and ammonia/hydrogen mixed fuel or single fuel firing that uses existing infrastructure. Some of the solutions shall also cover financial aspects. In addition, from the viewpoint of market acquisition, the government will promote bilateral and multilateral cooperation.

<International dissemination and cooperation through “Tokyo Beyond-Zero Week”>

Under the brand of ”Tokyo Beyond-Zero” Week, the Japanese government will intensively hold energy- and environment-related international discussions and gather experts and leaders in various countries and industrial fields to globally disseminate Japan’s growth strategies realizing a virtuous cycle of economy and environment toward carbon neutrality (ICEF), promote cooperation among advanced research institutions (RD20) and develop an environment toward realization of innovation and mobilization of fund for supporting transition (TCFD Summit). In addition, the government will

utilize it as a platform for leading international discussions and cooperation in priority industrial fields, such as hydrogen, Carbon Recycling, and decarbonization of fossil fuel.

4. “Action Plans” in key industrial fields

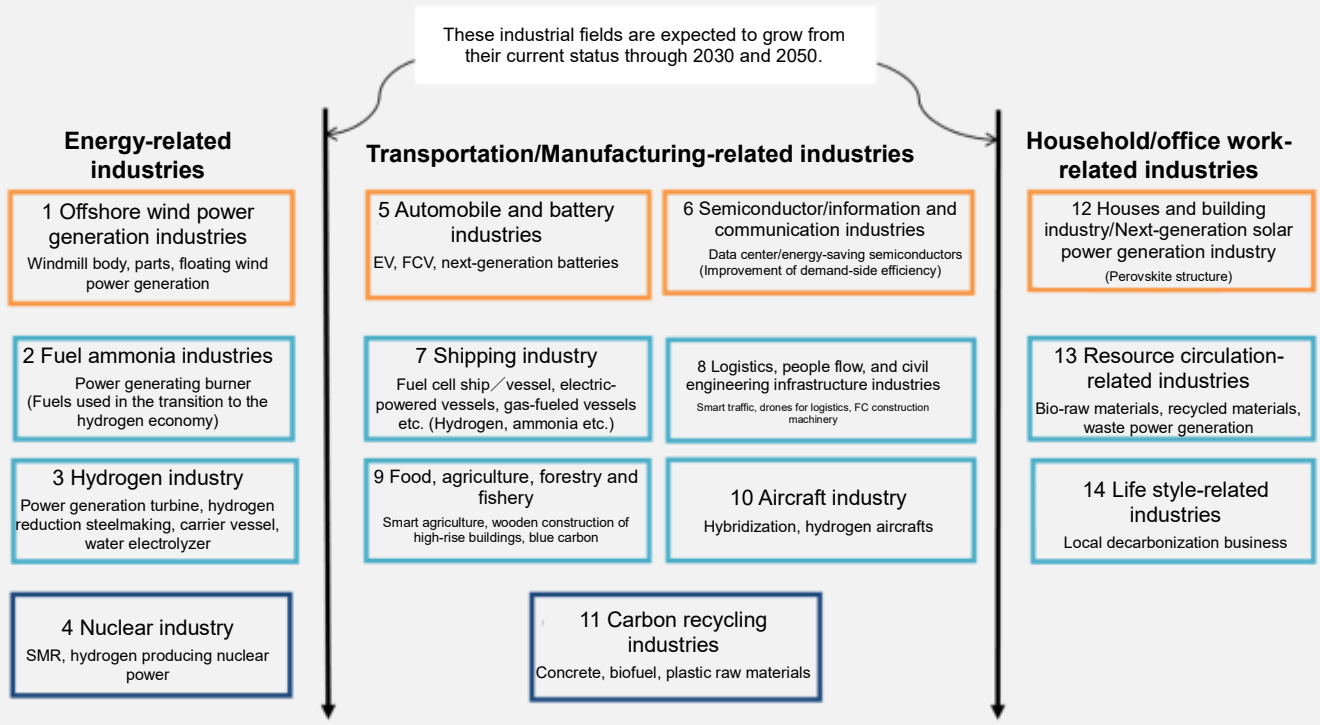
From the viewpoint of taking on the challenge of 2050 Carbon Neutrality as a growth strategy, the government shall establish “Action Plans” in the key industrial fields where future growth is expected, and efforts are essential to achieve 2050 Carbon Neutrality also from the viewpoint of reduction of greenhouse gas emissions.

From the fields of which market is expected to grow from their current status through 2030 to those to launch through 2050, 14 fields of different time axis are discussed.

These fields, namely, energy-related industries, transportation/manufacturing-related industries, household/office work-related industries and so on, are with different necessities from one to another, from those require actions in current “introduction and expansion phase” to others for future “research and development phase”. Considering characteristics of respective fields, the government intends to incorporate concrete measures, which will strengthen Japan’s international competitiveness and lead to autonomous market expansion.

Towards a revision of the Green Growth Strategy in coming spring, steady implementation of action plans in these fields and deeper examination of goals and measures are considered further.

(Reference) Organized chart of key industrial fields



(1) Offshore wind power generation industries

Given the feasibility of large-scale introduction and cost reductions as well as the anticipated economic ripple effects, offshore wind power generation holds the key to making renewable energy a main source of power. With a project scale of several tens of billions of yen and the number of pieces of equipment and parts totaling in the tens of thousands, the economic ripple effect on related industries will be significant. It is important to make full-scale efforts to introduce offshore wind power in Japan from both an energy policy and industrial policy perspective while reducing costs by cultivating Japan's offshore wind power industry and strengthening competitiveness. It is also vital for the public and private sectors to work together to build strategies to capture growth markets in Asia in the future. Therefore, firstly, the government commits to creating an attractive domestic offshore wind power market to attract domestic and foreign investment. On top of that, the government and the Industry will develop a competitive and resilient domestic supply chain by promoting investment through the establishment of business and other infrastructure. In addition, the government and the Industry will engage in next-generation technology development and international cooperation with an eye to expanding into Asia and create next-generation industries that can compete on the global stage.

Based on “Vision for Offshore Wind Power Industry（1st）” indicating the above direction, and by “Public-Private Council on Enhancement of Industrial Competitiveness for Offshore Wind Power Generation”, the efforts will be promoted by public-private partnership.

(1) Creation of attractive domestic market

<Current status and issues>

The global offshore wind power market is currently enjoying steady growth, and analyses by international organizations project the introduction of 562 gigawatts (GW) of offshore wind power generation capacity worldwide by 2040, about 24 times higher than that of 2018[2].

On the other hand, wind turbines are manufactured by foreign companies located mainly in USA, Europe and China. Especially in Europe, cost reductions have been made over the past decade through the enlargement of wind turbines and investment in mass wind turbine production while at the same time reducing transportation costs by building factories close to demand areas. Against this backdrop, there have been cases where companies have won bids to supply wind power at less than 10 yen/kWh or at market price (unsubsidized).

Meanwhile, the Asian offshore wind power market is expected to grow rapidly going forward, with Asia projected to account for 41% of the global market in 2030[3]. This has spurred European and U.S. wind turbine manufacturers to enter the Asian market in earnest, while competition to attract industry players has begun across the region. Also in Japan, public offerings (four sites, approx. 1.5GW) based on the Act on Promoting Utilization of Sea Areas for Renewable Energy Generation started this fiscal year, and efforts mainly by power producers to win projects have been ramping up across the supply chain.

In order to newly establish an offshore wind power supply chain in Japan, it is necessary to first attract investment from both Japan and overseas. The Industry has expressed the view that it is

[2] IEA “Offshore Wind Outlook 2019” (sustainable growth scenario)

[3] GWEC “Global Offshore Wind Report 2020”

necessary to project the size of the market in order to make investment decisions. Therefore, the government will set clear introduction targets as well as promote efforts to realize them so that targets don't just become a "pie in the sky.".

<Future efforts>

Firstly, to encourage domestic and foreign investment by committing to create an attractive domestic market, sets offshore wind power generation introduction targets (authorized capacity under the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities). Specifically, the government will continue to award capacity of 10GW by 2030 and 30-45GW, including floating offshore wind, by 2040[4].

Secondly, based on Act on Promoting Utilization of Sea Areas for Renewable Energy Generation enforced in April 2019, project formation process will be steadily developed. In addition, considering the knowledge obtained by the enforcement, necessary improvements to expedite the project formation will be made. Moreover, the national government will systematically promote the establishment of power grids, ports and harbors, and other infrastructure necessary to realize the above offshore wind power capacity introduction targets. For example, regarding the securing of power grids, which has been a problem in terms of multiple grid operators securing the same grid, introduce a scheme whereby GOJ provisionally secures power grids necessary for project development. Moreover, GOJ establish more efficient approaches to conducting wind surveys and seafloor/ oceanographic surveys necessary in project development by carrying out demonstration projects led by GOJ to accelerate project formation.

Thirdly, GOJ will systematically promote the establishment of power grids, ports and harbors, and other infrastructure necessary to realize the above offshore wind power capacity introduction targets. The first draft of the Power Grid Establishment Master Plan, which will contribute to the realization of introduction targets will be detailed and a by coming spring. Furthermore, since the power grid for transmission from a suitable location for offshore wind power generation to a large demand area is essential, concrete study toward the introduction of HVDC power transmission, including technical issues and costs will be launched. Moreover, on condition that the output will be partly suppressed when renewable energy exceeding available capacity of the power grid is generated, a structure to connect more renewable energy to the power grid will be expanded nationwide with in 2021, and a fundamental review of rules will be considered to allow renewable energy to use the power grid with a higher priority than coal-fired thermal power and so on. In addition, review functions required of Japan's future base ports, considering the schedule for power grid development and designation of promotion zones, as well as the trend toward larger wind turbines in addition to steadily undertaking construction such as strengthening of soil bearing capacity necessary for installation and maintenance of large wind turbines at base ports at four locations throughout Japan. In order to revitalize the local economy and create jobs, implement focused measures to attract companies to coastal and other areas across Japan.

[4] Moreover, while the Action Plan of the Growth Strategy Committee (decided on December 1, 2020) declares, "In Japan, by 2040, creation of large construction-related demand equivalent to 30 million kW, or 30 large thermal power stations is aimed for", this introduction goal by 2040 will be raised in order to draw investment from the industries to achieve 2050 Carbon Neutrality. However, to realize 45 million kW, cost of floating offshore wind must be significantly reduced in the future through technological development and mass production.

(2) Promotion of investment and formation of supply chain

<Current status and issues>

From the perspective of stable power supply and economic ripple effects, it is important to establish a competitive and resilient supply chain, using the creation of a domestic market by GOJ as a catalyst for investment. On the other hand, wind turbines are currently imported from overseas due to the absence of manufacturing sites in Japan, and the reality is that both the potential of domestic parts manufacturers with technical capabilities built up through their experience in onshore wind power and manufacturing sites in Japan, including generators, accelerators, bearings, carbon fiber for blades, are not being fully utilized.

Therefore, the Industry will promote the formation of a resilient supply chain by setting targets for Japan content. GOJ will strengthen industrial competitiveness by providing incentives for capital investment, promoting business partnerships in Japan and overseas, and improving the business environment through regulatory reforms. At the same time, the Industry, GOJ, and academia will work together to develop the human resources necessary for offshore wind power generation.

<Future efforts>

Firstly, for establishment of a competitive and resilient supply chain, The Industry sets two targets, namely, to increase Japan content to 60% by 2040, and to reduce cost of fixed-bottom offshore wind turbine-generated power to 8 to 9 yen/kWh by 2030-2035, and promote efforts to realize them.

Secondly, for creation of a supply chain, GOJ will evaluate the supply chain in public tenders, provide incentives for capital investment, and promote global business matching. Specifically, when assessing public occupancy plans related to the Act on Promoting Utilization of Sea Areas for Renewable Energy Generation, evaluate the formation of a resilient supply chain (domestic or equivalent) from the perspective of securing a stable power supply. Moreover, support for formation of a supply chain will be considered. In addition, efforts to promote business matching between overseas companies and Japanese firms, to secure raw materials needed for manufacturing of wind turbines but of high dependence to specific countries such as rare earths and so on will be implemented.

Thirdly, to improve the business environment, GOJ will conduct a comprehensive assessment of the requested regulatory review items in cooperation with individual ministries. Among them, the Industry will first streamline the safety inspection process with the Ministry of Economy, Trade and Industry (under the Electricity Business Act) and also establish a common screening process with the Ministry of Land, Infrastructure, Transport and Tourism (under the Port and Harbor Act and Ship Safety Act). . In addition, clarification of the criteria for leaving in place permission at the time of removal of bottom-fixed wind turbines based on the Law Relating to the Prevention of Marine Pollution and Maritime Disaster, relaxation of the criteria and conditions related to the installation of aircraft warning lights on wind power generation facilities based on the Civil Aeronautics Act and so on will be checked in cooperation with individual ministries. Moreover, the Industry will conduct a comprehensive review of the standards that need to be developed for the introduction of offshore wind power and will work with GOJ to develop highly necessary standards.

Fourthly, in order to ensure the long-term and stable penetration of offshore wind power, it is necessary to develop human resources in a wide range of fields, including engineers involved in the manufacture of wind turbines, survey and construction engineers, and maintenance workers. To achieve this end, the Industry will formulate a program for the development of offshore wind power

human resources, which will include taking an inventory of the required skills and concrete measures for acquiring those skills. The program will promote the transfer and redeployment of engineers from different industries in the short term as well as the development of human resources over the mid to long term.

(3) Next-generation technology development and cross-border collaboration with a view to expansion into Asia

<Current status and issues>

While enhancing competitiveness through development of the supply chain, it is important to aim for expansion into Asia in the future, where weather and sea conditions are similar, and the market is expected to grow.

Although introduction of offshore wind power currently in progress in the world is mainly of fixed-bottom offshore wind, there is a bigger chance for new players such as the shipbuilding industry with floating offshore wind, for which particularly intensified competition is expected in the future. It is necessary to accelerate the development of technologies and cultivate Japan’s competitiveness to play in the global market, while consistently looking ahead toward commercialization. At the same time, looking ahead to future expansion into Asia, GOJ and the Industry need to lay the groundwork with corporation through international standardization and bilateral dialogue

<Future efforts>

Firstly, the government will proceed with the next-generation technology development with a view to expansion into Asia. While identifying and listing up the necessary elemental technologies to strengthen industrial competitiveness of the offshore wind power industry and formulate an "Offshore Wind Power Technology Development Roadmap.", as for important technology developments, establish a fund to promote innovation toward the realization of carbon neutrality by 2050 and secure the commitment of companies to achieving targets. Based on this, provide seamless support for the development and validation of technology over the long term.

Secondly, in anticipation of future expansion into the Asian market, GOJ will promote the building of cooperative inter-governmental relationships as well as cooperation among domestic and foreign companies through policy dialogue and international demonstration projects. In addition, GOJ will provide supports to Japanese companies looking to participate in overseas offshore wind power projects in the areas of feasibility studies, demonstration, and finance. Furthermore, GOJ will work towards international standardization of methods to assess the safety of floating offshore wind. Through these initiatives and other efforts, GOJ will lay the groundwork for overseas deployment of floating offshore wind.

(2) Fuel ammonia Industries

Ammonia, which does not emit carbon dioxide (CO_2) when burned, will be the main decarbonized fuel used in the transition to the hydrogen economy, being used for co-firing of thermal power (coal-fired etc.) and so on. CO_2 emission is reduced by 20% by co-firing of 20% ammonia (calorie-based) at one thermal power plant, therefore, if 20% co-firing is implemented at all coal-fired thermal power plants in Japanese major power companies, about 10% of CO_2 emission by domestic electric power sector will be reduced.

In terms of usage, since technology to stabilize combustion so as not to emit NOx has already been completed for 20% co-firing, the demonstration with actual equipment of 20% co-firing will be conducted from around 2021FY to 2023FY. Practical application will start in the late 2020s, and its introduction will be expanded in 2030s. In the future, improvement of co-firing ratio and shift to ammonia-fired power generation as well as expansion of power generating burners (for co-firing and ammonia single fuel) to Southeast Asia and expansion of applications are aimed for.

On the other hand, in terms of supply, Japan will be the first to construct an international supply chain through by establishing new plants and so on, and take the initiative among supplier and utilization industries of fuel ammonia. Utilization of other decarbonized fuels will also be considered.

Specifically, by means of the following measures for use and supply, a market of 1.7 trillion yen per year is anticipated in 2050. The government aims for the scale of 100 million ton worldwide including Japan as a procurement supply chain to be engaged by Japanese companies.

(1) Use (Power generating burner for co-firing and so on)

<Current status and issues>

As for the co-firing technology for thermal power, a 20% co-firing burner without NOx emission was developed between 2014 and 2018 in the Cross-ministerial Strategic Innovation Promotion Program (SIP) by the Cabinet Office, and a co-firing test at a large-scale combustion test facility of New Energy and Industrial Technology Development Organization (NEDO) between 2018 and 2020 was implemented.

Hereafter, also with actual equipment, demonstration of controlled suppression of NOx emission by the above-mentioned co-firing burner technology is required. Moreover, since flame temperature during combustion and radiant heat are lower with ammonia than with coal, development of a heat collection technology is required to secure the amount of heat needed for power generation in order to improve co-firing ratio of ammonia and to aim for a shift to ammonia-fired power generation.

<Future efforts>

In the short term (until 2030), introduction and diffusion of co-firing with 20% ammonia to thermal power is set as a goal. For that purpose, the technology of 20% co-firing shall be established by demonstration of 20% co-firing utilizing actual equipment in the NEDO operation for about three years from next fiscal year, then installation of co-firing burners to the existing power plants and introduction of fuel ammonia are aimed for with the cooperation of electric companies.

Moreover, in order to contribute continuously to decarbonization of the world, especially Southeast Asia where significant portion of power source is thermal power, expansion of the co-firing technology including burners will be considered. If the co-firing technology can be introduced to 10% of thermal power in Southeast Asia, investment of ca. 500 billion yen is anticipated.

In order to improve international awareness of Japan's original co-firing technology and to promote its overseas expansion, in addition to bilateral meetings and policy dialogues with Southeast Asian countries, cooperation with international organizations such as IEA and ERIA as well as discussions in occasion of international conferences including ASEAN+3 will be realized. Moreover, utilizing financing by NEXI and JBIC, and by setting standards and leading international standardization regarding combustion of ammonia and its management technique, environment for overseas expansion will be prepared. In addition, new applications such as transportation including shipping and industrial use will be considered.

On the other hand, in the long term (until 2050), improvement of co-firing ratio (over 50%) including development of a heat collection technology as well as development of ammonia-fired power generation technology will be actively promoted, aiming for implementation by replacing existing thermal power. With this practice, efforts for decarbonization of thermal power generation will be accelerated.

(2) Supply (Ammonia production plant)

<Current status and issues>

Annual global production of ammonia is about 200 million ton worldwide, most of which is used as fertilizer and locally consumed. In the future, if 20% co-firing with ammonia is implemented for thermal power, ca. 0.5 million ton of ammonia will be required annually for one plant (1 GW). For example, to implement 20% co-firing at every thermal power plant of domestic major power companies, ca. 20 million ton of ammonia will be required, which is comparable to the current world trade volume. Therefore, formation of fuel ammonia market apart from the market for conventional ammonia and construction of a supply chain become an issue.

<Future efforts>

Toward 2030, to expand the production of fuel ammonia, new production plants will be established to construct a stable supply system for required fuel ammonia.

Moreover, the government will consider investment for environmental improvement of quay, supply system and so on to make them adequate to ammonia export at the port of shipment overseas, and, in Japan, for review of technical standards and port planning to enable delivery and storage of fuel ammonia required for the port.

In order to stabilize the supply of fuel ammonia, considering political stability and geographical characteristics of countries of origin, through organic cooperation between producing countries (North America, Australia and Middle East) and consuming countries (Asia including Japan), construction of the procurement supply chain engaged by Japanese companies will be aimed for. As a concrete volume, 100 million ton for the whole world including Japan is set as a goal.

Furthermore, for introduction of competitive fuel ammonia, cost reduction in procurement, production, transportation and storage, finance and so on is aimed for, while technology development for high efficiency in each process will be implemented. By means of these efforts, fuel ammonia market will be prepared to realize supply in the higher 10-yen range per Nm^3 (hydrogen conversion calorie equivalent) by 2030 (assuming the current natural gas price and so on).

Ammonia is produced from fossil fuels such as natural gas. For the time being, the government will make efforts to widely introduce ammonia, putting emphasis on its diffusion. After that, CO_2 emission reduction during production with reasonable cost should be considered, and necessary

technology development for the purpose will be implemented.

Furthermore, as with ammonia, technology development for efficiency with other fuel without CO_2 emission is aimed for.

(3) Hydrogen industry

Hydrogen, which can be widely used in various sectors (power generation, industry, and transportation etc.) is a key technology to achieve carbon neutrality. Although Japan was the first in the world to formulate the “Basic Hydrogen Strategy” and possesses advanced technology in multiple fields, Europe and Korea among others have also established strategies and are following Japan. Hereafter, the government positions hydrogen as a new resource, and will involve wide range of players not only automobile applications. Moreover, for example, in the fields of usage, transportation and manufacturing, by estimating global market size based on a certain hypothesis and taking various measures described below, decarbonization will be promoted and, at the same time, industrial competitiveness will be strengthened.

For that purpose, by increasing introduction amount, the level competitive enough against fossil fuels, i.e. supply cost of 30 yen/Nm^3 in 2030 (less than one third of the current selling price) and hydrogen power generation cost lower than gas fired power generation cost (less than about 20 yen/Nm^3) in 2050, is aimed for. As for the target amount, while being conscious that the situation is different between countries and regions with regard to renewable energy potential, market size and so on, from the viewpoint of early launch of the domestic hydrogen market, hydrogen introduction amount of up to 3 million tons in 2030 is aimed for[5]. Specifically for the supply amount of clean hydrogen (hydrogen produced from fossil fuels + CCUS, renewable energy and so on) in 2030, the target is to exceed the supply amount of hydrogen derived from renewable energy (ca. 420,000 tons) announced by Germany in their national hydrogen strategy published in June 2020. In addition, supply amount of ca. 20 million tons in 2050 is aimed for.

(1) Hydrogen utilization

By utilization and application of hydrogen, realization of decarbonization in various fields such as electric power generation (fuel cell, turbine), transportation (automobile, shipping, aircraft, railway and so on) and industries (steelmaking, chemical, petroleum refining and so on) is expected. The government will strengthen international competitiveness focusing on the fields where Japanese companies possess excellent technologies therefore growth is expected, such as hydrogen power generation turbine, commercial vehicles including fuel cell (FC) truck and hydrogen reduction steelmaking.

<Current status and issues>

Large-scale hydrogen power generation using turbines is one of the options of power source in the era of carbon neutrality, which may also contribute to stabilization of system as a balancing capacity. Japanese companies, which are leading technology development in controlling combustion of flammable hydrogen in turbines and so on, have competitive advantage against foreign companies. However, verification of stable combustion by real machine has not been completed yet. The potential domestic hydrogen demand (introduction amount based on a certain hypothesis) is estimated to be ca. 5 to 10 million tons per year.

Moreover, commercial vehicles such as trucks, for which long haul is regularly required therefore it is difficult for EV to be adopted, is one of the areas in transportation field where hydrogen utilization

[5] The supply amount includes the introduced amount of hydrogen carrier including ammonia by direct use.

is expected. The potential domestic hydrogen demand of ca. 6 million ton per year of is anticipated. Since Europe, China and other countries are also working actively on the conversion of commercial vehicles to fuel cell (FC) vehicle, Japanese companies must accelerate the development by forming alliances and using the knowledge obtained through their experience with passenger vehicles.

In addition, the great demander in the industrial field is the steel industry. If coal and so on currently used as reduction agent of iron ore can be replaced by hydrogen by the hydrogen reduction steelmaking, significant amount of CO_2 emission reduction can be achieved. However, 100% hydrogen reduction steelmaking is still to be technically established, and large amount of low-cost hydrogen supply is essential. The potential domestic hydrogen demand is ca. 7 million ton per year.

<Future efforts>

As for the hydrogen power generation turbine, cumulative amount of introduction up to 300 million kW (ca. 23 trillion yen) worldwide is anticipated by 2050[6]. In order to acquire this global market, the government, first of all, will support early real machine verifications to accelerate commercialization in Japan. In addition, as with renewable energy and nuclear power, hydrogen will be valued as a carbon-free power source, and a power market where incentive is granted for utilization of hydrogen will be developed. In this manner, a full launch of the domestic hydrogen market by creating a large demand in the electric power generation field will be supported. After that, making use of knowledge and experience obtained in the launched domestic market, export not only to the developed countries where projects are going ahead, but also to Asia with vigorous growth of electric power demand and so on is aimed for.

As for commercial vehicles, FC trucks in particular, cumulative number of introduction is up to 15 million, equivalent to ca. 300 trillion yen in 2050 is anticipated[7]. In order to achieve this, demonstration of FC trucks to accelerate their commercialization and introduction support measures as a part of promotion of electrification will be considered. In addition, necessary infrastructure development such as hydrogen refueling stations will be implemented in a flexible and timely manner according to the situation. Specifically, in addition to development and demonstration of large hydrogen refueling stations, efforts for cost reduction such as consideration of the boost of hydrogen tank accepted in Europe will be continued by means of further regulatory reform and so on.

Also for steel, since the global market size of zero emission steelmaking (total of hydrogen reduction steelmaking, blast furnace + CCUS and so on) is anticipated to be up to 500 million tons per year (ca. 40 trillion yen per year) in 2050[8], the government will support establishment of the world's first hydrogen reduction steelmaking technology to acquire this market. The established top runner technology will be successively designated as the decarbonization standards required for the industry to promote its introduction. Through these efforts, realization of "zero-carbon steel" contributing to decarbonization of Japanese manufacturing industry including automobile is aimed for.

Furthermore, from the viewpoint of international competitiveness, ideal form of the border adjustment measures will be considered as a domestic and external integrated industrial policy.

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[6] Estimated based on the IEA Energy Technology Perspectives 2020 Sustainable Development Scenario(SDS) and so on (Turbine price: 80,000 yen/kW)

[7] Estimated based on the Hydrogen Council Hydrogen Scaling up and so on (Average price: 20 million yen/vehicle)

[8] Estimated based on the IEA Energy Technology Perspectives 2020 SDS and so on (Average steel price: 80,000 yen/ton)

(2) Hydrogen transportation (liquefied hydrogen carrier ship and so on)
<Current status and issues>

Future launch of international transactions of hydrogen is expected as Germany and other countries are showing interest in import of hydrogen. Since our country has been assuming to utilize imported hydrogen from the beginning, the government has been supporting technology development and verification of marine transportation technology and infrastructure using liquefied hydrogen and MCH (methylcyclohexane). As a result, Japan has the world-leading technology to build the world's first liquefied hydrogen carrier ship and so on.

The problem is how to achieve early commercialization hereafter. Moreover, since marine transport of hydrogen has not been foreseen, there is a concern for inconsistency of regulations between countries.

<Future efforts>

Assuming that 10% of hydrogen is being traded in the international market in 2050, size of the trading market is anticipated to be up to ca. 55 million tons per year (ca. 5.5 trillion yen per year) [9]. In order to create such market, it is important to aim to achieve commercialization, setting 2030 as a target, by supporting enlargement of the transportation-related equipment contributing to further reduction of the transportation cost of hydrogen by various means such as R&D, verification and creation of domestic demand. Through these efforts, realization of supply cost of 30 yen/Nm^3 in 2030 is aimed for.

Moreover, in order to establish a foundation for export of equipment, technology and so on to the world in the future by securing international safety and compatibility of the equipment, international standardization of related equipment such as loading arm for transfer of hydrogen from liquefied hydrogen carrier ships to the receiving terminal is promoted. In addition, the government will consider investment for quay, supply system and so on to make them adequate to hydrogen export at the port of shipment overseas, and, in Japan, for review of technical standards and port planning to enable delivery and storage of hydrogen required for the port.

(3) Hydrogen production (water electrolyzer and so on)
<Current status and issues>

For hydrogen production, the water electrolyzer to create hydrogen by electrolysis of water will become important in the future. Due to cost reduction of renewable energy and the water electrolyzer, it is anticipated that, in 2050, production of hydrogen with lower cost than producing it from fossil fuel + CCUS will be available in some areas. In response to such anticipation, Europe and other countries, which are actively introducing renewable energy, aims at introduction of the electrolyzer at the same time.

Japan has built one of the world's largest electrolyzer, and also possesses underlying technologies of the world's highest level. However, with regard to the technology development aiming for further enlargement and so on, companies in other countries including European countries precedes partially.

[9] Estimated based on the Hydrogen Council Hydrogen Scaling up and so on (Average hydrogen transaction price: 100 yen/kg)

<Future efforts>

For the electrolyzer, annual introduction up to an average of ca. 88 GW (ca. 4.4 trillion yen per year) globally is anticipated by 2050[10]. Hereafter, focusing first on acquisition of the market in Europe and other countries where it will launch earlier, the government will intensively support enlargement, installation of the excellent underlying technologies to equipment and so on by Japanese companies, aiming for further cost reduction and maintenance and strengthening of international competitiveness by increasing durability. In addition, by preparing an environment for performance evaluation of the water electrolyzer in Japan as in Europe and other countries, the government aims at lowering entry barriers to the overseas market for companies intending to do development in Japan and to export products. Furthermore, in anticipation of increase of surplus renewable energy in medium- to long-term also in Japan, active utilization promotion measures of low-cost electric power will also be considered with proper evaluation of a raised DR (demand response).

Not limited to the above-mentioned efforts for individual theme, the government will continue to work on R&D and verification of the innovative technologies related to utilization, transportation and production of hydrogen as cross-thematic efforts, and implements verification of hydrogen utilization intensively in various fields, mainly in locations including Fukushima where hydrogen production facilities and so on have already been developed, and ports, coastal areas and airports where power plants and so on, for which large hydrogen demand is anticipated, are located. In addition, review of regulations and so on will be considered as necessary. Moreover, verification, transition support and diffusion of the autonomous distributed energy system utilizing local resources such as renewable energy and so on will also be implemented. After such advanced cases will have been established as a model, its nationwide expansion is envisioned. On the other hand, area expansion of hydrogen will be implemented in close cooperation with private-led initiatives such as recently launched Japan Hydrogen Association, Hydrogen Utilization Study Group in Chubu, Hydrogen Utilization Council in Kobe/Kansai area.

In addition, international collaboration for international standardization of technically neutral definition of clean hydrogen and so on will be accelerated. Moreover, considering also the viewpoint of stable supply of hydrogen and export of infrastructure, by strengthening of relations with resource-rich countries, not only in terms of fossil fuels, but also those with high potential in renewable energy, and by active development of countries of demand, the government will lead establishment of stable, flexible and transparent international hydrogen market. In order to promote such global cooperation, the Hydrogen Energy Ministerial Meeting led by Japan will be put to optimal use. Lastly, a close cooperation will be ensured with the fields which utilize hydrogen in their value chain such as ammonia and carbon recycling, etc.

[10] Estimated based on the IEA Energy Technology Perspectives 2020 Faster Innovation Case and so on (Average equipment price: 50,000 yen/kW)

(4) Nuclear industry

For realization of 2050 Carbon Neutrality, it is important to pursue every option including nuclear power, therefore, needless to mention further safety improvement of light-water reactors, it is necessary to proceed with R&D for nuclear power innovation by innovative technologies, also considering its contributions to the purpose. In addition to being able to supply stable carbon-free electric power, with further innovation, nuclear power may respond to various social demands such as coexistence with renewable energy, carbon-free hydrogen production and heat utilization on top of further improvement in safety, reliability and efficiency.

With regard to the current light-water reactors, China and Russia are dominating the market with the support of government financing, while developed countries including USA, UK and Canada found a way in small reactors and innovative reactors of which R&D is being accelerated by investing large government budget, aiming for commercialization around 2030.

The targets are; 1) verification of the small module reactor technology through international cooperation by 2030; 2) establishment of underlying technologies related to hydrogen production by high-temperature gas-cooled reactors (HTGR) by 2030; and 3) steady promotion of R&D for fusion energy through international cooperation including the ITER project.

1) Small module reactor (SMR)

<Current status and issues>

For small modular reactor (SMR), since the core size is small, it is possible to avoid undesirable shutdown due to human error or failure of safety-related equipment by incorporating natural principles such as natural circulation for reactor cooling, where reliability of safety system is enhanced by its simplification. By such design methods, probability of occurrence of loss of coolant accident due to piping rupture is significantly reduced and, as a result, reduction of evacuation area is aimed for. In addition, by reducing the initial investment cost by shortening construction period by means of modular production, mitigation of constraints to site selection and financing for construction is aimed for.

With regard to these innovative characteristics for safety and economic improvement adopted by the SMR, while technology development and verification are partly required, USA is ahead of the rest of the world in establishing safety standards and industrial standards. In addition to USA, projects for construction of an SMR demonstration unit and for further expansion to the third countries are proceeding in UK, Canada and other countries, while some Japanese companies are making efforts to participate in these projects with their high design and production capacities. In addition, development of the SMR by Japanese companies with their original designs considering diverse needs, for which continuous R&D support is essential.

<Future efforts>

The government will actively support the efforts of Japanese companies in cooperation with foreign demonstration projects by USA, UK, Canada and other countries, which aims at commercial operation at the end of 2020s, giving thoughts to safety, economy, supply chain construction, regulatory compliance and so on. Based on the development of regulations foregoing by foreign stakeholders, participation in development and demonstration will be realized. While cooperating in solving R&D issues of the innovative technologies adopted for the SMR, contributions

will be made to realize the SMR, which is a decarbonization technology, by utilizing excellent design and production technologies. Through these efforts, while further enhancing design and production technologies for the SMR, the position of major supplier will be acquired and the mass production system in line with global expansion of the SMR will be established.

(2) High-temperature gas-cooled reactor (HTGR)

<Current status and issues>

High-temperature gas-cooled reactor (HTGR) utilizes carbon-free high temperature heat over 700°C by using chemically stable helium coolant, Tri-isotropic coated fuel particles (TRISO-CFPs) which does not melt even at high temperature and structure material absorbing high temperature heat and, in addition to electric power generation, attracts attention with its possibility for effective heat utilization and massive and low-cost carbon-free hydrogen production.

As for hydrogen production which attracts attention with regard to decarbonization in industrial fields including steelmaking and chemical, there is a possibility that one HTGR decarbonizes one shaft furnace capable of complete hydrogen reduction steelmaking. Since required footprint is 1/1600 compared to the case of electrolysis of water by solar power, if a high level of safety is verified of the HTGR, local production for local consumption of hydrogen combined with heat supply needed for industrial process will become possible without incurring additional transportation cost of hydrogen. Combined use for electric power generation and heat supply may realize a cost comparable to natural gas (ca. 12 yen/Nm^3) in 2050.

USA has just decided on development support of up to 160 billion yen to an HTGR venture company aiming for construction of a demonstration reactor within seven years. UK, too, has announced establishment of a fund of ca. 23 billion yen for innovative module reactors, among which HTGR applicable to hydrogen production and so on is named as a strong target for support.

In Japan, JAEA possesses the High Temperature Engineering Test Reactor (HTTR). The HTTR is equipped with world-leading technologies, which has achieved a high-temperature continuous operation at world's highest 950°C for 50 days, conducted a simulation test for loss-of-coolant accident similar to TEPCO Fukushima Daiichi Nuclear Power Station accident and confirmed natural cooling of the reactor and so on. Moreover, while manufacturers are developing various concepts including hydrogen production using high temperature heat and storage of thermal energy, it is necessary to establish underlying technologies also for hydrogen production.

<Future efforts>

Utilizing the HTTR which recorded world's highest temperature, the government will support, in addition to international safety demonstration, necessary technology development for massive and low-cost carbon-free hydrogen production by 2030. Simultaneously, development of carbon-free hydrogen production method using ultra high temperature heat including IS process and methane pyrolysis method will be supported. In supporting the development, the government will participate in technology development and verification giving thoughts to safety, economy, supply chain construction, regulatory compliance and so on, and will compose overseas joint projects considering the status of preceding overseas projects.

Moreover, considering the situation where Japan is leading the world also in terms of establishment of standards, cooperation with related organizations of other countries for diffusion of Japanese standards will be promoted through construction, operation and restart of the HTTR.

(3) Fusion energy

<Current status and issues>

Fusion reactor, which generates plasma of over 100 million °C, is a technology which can be used for heat utilization and hydrogen production in addition to electric power generation by heating coolant up to ca. 1,000 °C. Its fuel is basically hydrogen and no high-level radioactive waste requiring long-term management is generated. Since plasma generation is a technology of which reaction is difficult to maintain, it is of high level of safety without risk of reactor excursion.

With regard to the ITER project, towards the commencement of operation in 2025, construction and production of various equipment is being implemented with the cooperation of seven members in the world to start ITER machine assembly and its installation in July 2020. Japanese companies are manufacturing major equipment such as superconducting toroidal filed (TF) coils, which are being delivered to the ITER site in France.

Simultaneously, towards complementation and support of the ITER project and a future fusion DEMO (Demonstration) reactor, with the cooperation of Europe and Japan, Broader Approach (BA) activities are implemented. Test implementation for advanced plasma control technology utilizing a large Tokamak device (JT-60SA) which is under construction in Japan (starting the operation from spring in 2021), development of structural material with durability against fusion neutrons and with reduced activation characteristics for fusion DEMO reactors, development of fuel fabrication technologies such as recovery of lithium from seawater and production of tritium from lithium are being conducted.

Moreover, a large number of venture companies aiming for early realization of fusion power generation are being established in USA, UK and Canada, and venture companies in the fusion energy field have been founded since late 2010s also in Japan, though private investment to fusion energy is relatively small compared to other countries.

<Future efforts>

As for the ITER project, commencement of operation in 2025 and commencement of fusion reaction with real fuel operation in 2035 are aimed for. Also in the BA activities, commencement of operation of JT-60SA in spring of 2021 and other R&D will be steadily implemented for a fusion DEMO reactor. Through these efforts, technological verification of the major equipment and a technology to maintain energy output state for a long time will be established to realize fusion energy. Simultaneously, various design and technology development for the fusion DEMO reactor construction project in Japan will be implemented to promote R&D to have a prospect of practical application of fusion energy by the mid-21st century.

Moreover, by expanding the range of fusion research through outreach activities aimed at arousing interest for fusion energy and at mutual understanding, the government will encourage more companies to join from a long-term viewpoint aiming for participation of domestic venture companies and so on in overseas projects.

Furthermore, not limited to power generation, R&D of underlying technologies which may contribute to carbon neutrality such as a carbon-free hydrogen production process utilizing high temperature of fusion reactors will be promoted.

(5) Automobile and battery industries

The government will promote the electrification of automobiles. As exemplified by some European countries and the state of California in the U.S. announcing bans on selling gasoline-powered vehicles one after another, the electrification of automobiles is progressing at a faster pace than expected. Japan must strive to play the leader's role in this field.

The government will take comprehensive measures to make electrified vehicles[11] account for 100% of new passenger vehicles sold each year no later than the mid-2030s. Similarly to passenger vehicles, the electrification of commercial vehicles will be studied by the summer of 2021.

In the next ten years, the government will vigorously push forward introducing electric vehicles, building world-leading industrial supply chains, including batteries, and creating a mobility society. The government will take special measures in this process, especially for converting light vehicles (kei-cars) and commercial vehicles to electric vehicles and fuel cell vehicles.

Through such efforts and other initiatives to make energy carbon-neutral, the government will pursue a variety of options for carbon neutrality, aiming to achieve zero CO_2 emissions in 2050 through the production, use and disposal of automobiles.

To reduce CO_2 emissions and activate mobility at the same time, the government will also work on resolving local mobility issues through the transformation of how to use automobiles. The government will also accelerate the social implementation of new services and infrastructures in response to users' behavior changes and the progress of electrification.

On the other hand, batteries are the key to carbon-free as the adjusting power required to further spread vehicle electrification and renewable energy. The government will strengthen batteries' industrial competitiveness through policies such as supporting research and development, demonstrations, and capital investment, studying institutional frameworks, and developing international cooperation toward standardization.

[1] Promoting vehicle electrification and transforming how to use automobiles

< Current status and issues >

Europe and China are strategically promoting the spread of electric vehicles and plug-in hybrid vehicles, and the penetration of these vehicles is increasing rapidly. On the other hand, Japan falls behind Europe and China in the widespread use of these types of vehicles[12]. Moreover, each country is strengthening its initiatives to support developing fuel cell trucks and buses.

The challenges to be addressed toward the widespread use of electrified vehicles include expanding social acceptance through vehicle price reductions and infrastructure development such as electric vehicle charging infrastructure and hydrogen stations. As additional challenges, Japan must strengthen electrified vehicle-related technologies such as batteries, fuel cells, and motors, and their supply chain and value chain. Especially critical issues are (i) strong cost awareness of light vehicle and commercial vehicle users, (ii) the electrification of automobiles with body design restrictions, and (iii) the need to strengthen the competitiveness of suppliers such as SMEs.

[11] Electric vehicles, fuel cell vehicles, plug-in hybrid vehicles, and hybrid vehicles

[12] The number of electric vehicles and plug-in hybrid vehicles sold in the third quarter of 2020 was approximately 270,000 in the entire EU (three times or more compared to the same period of 2019, according to preliminary results announced by the European Automobile Manufacturers' Association(ACEA)), and approximately 6,000 in Japan (about 50% compared to the same period of 2019, according to a summary by the Ministry of Economy, Trade and Industry based on data published by the Japan Automobile Dealers Association)

Facilitating procurement of low-carbon energy sources would also be essential to reducing life-cycle CO_2 emissions from automobiles.

In addition to the above, each country is currently demonstrating/implementing sustainable urban transportation utilizing Mobility as a Service (MaaS) and autonomous driving technology. For example, Europe is set to formulate a strategy called "Sustainable and Smart Mobility Strategy" to optimize environmental load reductions and urban transportation systems, with a large-scale demonstration project[13] underway in collaboration among member states in the region. In Japan, while MaaS demonstration efforts are underway across the country, there are only a few cases where such initiatives have led to large-scale commercialization. For this reason, there is a need for the entire region to pursue both reducing environmental loads and solving mobility issues. Regarding autonomous driving technology, driving data collection through public road demonstrations is not easy in Japan, compared with the U.S. and China. For this reason, there is an urgent need for creating a development and evaluation environment utilizing digital technology.

< Future efforts >

The government will take the following actions to promote vehicle electrification.

(a) Expanded introduction of electrified vehicles and their infrastructure

The government will utilize fuel economy regulations, promote public procurement, expand charging infrastructures, support the introduction of electrified vehicles, encourage car replacement, and the like.

(b) Strengthening electrified vehicle-related technologies such as batteries, fuel cells, and motors, and their supply chain and value chain

The government will work on the following matters: (i) supporting large-scale investment, (ii) supporting technology development/demonstration and the electrification of light vehicles and commercial vehicles, (iii) studying the support of business transformation for suppliers such as SMEs and digital development platform building to support such business transformation, and (iv) studying how to help the local automotive industry including car dealers with electrification and business transformation. To facilitate the purchase of decarbonized electricity and improve power users' convenience, the government will also study how the non-fossil value trading market and other schemes should be.

(c) Transformation of how to use automobiles

To encourage users to select and use electrified vehicles and realize sustainable mobility services and enhanced efficiency and productivity improvement in logistics, the government will utilize autonomous driving and digital technologies and interact with initiatives for roads and urban infrastructure.

[2] Carbon-neutral fuel (such as synthetic fuel (e-fuel))

< Current status and issues >

Pushing for carbon neutrality would also require carbon-neutral energy sources. Especially for commercial vehicles whose electrification is considered challenging, efforts to make carbon-neutral

[13] Sixty-nine organizations from 13 EU countries are jointly implementing the SHOW project. The project plans to actually place at least 70 autonomous driving vehicles in 12 cities within the region by 2024, with a dedicated driving lane and 5G network installed.

fuel are essential, in addition to the efficient use of fuel.

Toward the development of carbon-neutral fuel, synthetic fuel (e-fuel)[14] is attracting the industry's attention because the existing infrastructure can be utilized. However, its integrated manufacturing process for commercialization has yet to be established. Manufacturing such synthetic fuel would require building a new dedicated facility, involving a large-scale investment and facility maintenance costs. Therefore, it is necessary to reduce costs by improving manufacturing efficiency and other methods.

< Future efforts >

To produce synthetic fuel at a cost equal to or below the gasoline price in 2050, the government will increase the efficiency of and reduce the cost of existing technologies and implement innovative new technologies and processes. Simultaneously, the government will conduct applied research to establish its integrated manufacturing process for commercialization.

[3] Battery

< Current status and issues >

An electric vehicle is mounted with batteries having a storage capacity of about 50 to 100 times that of a hybrid vehicle. Similarly, a plug-in hybrid vehicle is loaded with batteries having a storage capacity of about 10 to 20 times that of a hybrid vehicle. Given this fact, ensuring the supply of batteries and stabilizing their supply chain are essential in promoting mobility electrification, such as for automobiles. In Europe, the "European Battery Alliance" was built to support raw materials suppliers, battery manufacturers, automobile manufacturers, and other players[15] to create a battery supply chain in the region. Also, France and other EU countries announced their support for investment in battery plants[16]. Furthermore, the EU announced in December 2020 the final draft of the Battery Regulation, indicating the introduction of labeling regulations on life-cycle CO_2 emissions from batteries and discipline on reuse and recycling of them. The ability to procure energy with less CO_2 emissions may determine batteries' competitiveness in the future.

Chinese and South Korean companies are aggressively investing in batteries, with their global market shares increasing. On the other hand, Japanese companies' market share is declining[17]. China and South Korea are also strengthening their technological development of next-generation batteries[18]. Expanded use of electrified vehicles and further spreading stationary batteries for energy storage systems would require batteries' light-weighting, down-sizing, and price reductions. To make this happen, the government must solve issues with large-scale investment and industrial technology enhancement.

Meanwhile, given the widespread use of home-use solar panels and growing interest in disaster

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[14] This is a liquid fuel produced by synthesizing hydrogen and CO_2 recovered from power plants and factories. This fuel can be used to power engines.

[15] The participating countries committed supporting research funds up to a total of 3.2 billion euros towards 2031 (2019), etc.

[16] "Plan de soutien à l'automobile" (automobile support plans) that France announced in May 2020 included supporting battery manufacturing plants by injecting public funds up to 850 million euros.

[17] According to private surveys, Japanese manufacturers' global market share of in-vehicle batteries for EVs and PHEVs declined from 37% in 2016 to 29% in 2019. On the other hand, during the same period, Chinese manufactures' share increased from 35% to 46%, and South Korean manufacturers' share rose from 14% to 19%.

[18] For example, Japan accounted for about 37% of the cumulative number of patent applications for all-solid-state lithium-ion batteries between 2001 and 2018. On the other hand, China accounted for about 28%. However, China became the world's leader in terms of the number of the same patent applications in FY2018.

resilience, the market size of home-use batteries in Japan has grown to the world's largest[19] on a capacity basis. On the other hand, South Korean companies accounted for about 70% of the market, and Japanese companies' market share is only around 30%. As part of its industrial technology enhancement, Japan is working on aqueous lithium-ion batteries and other product developments to significantly reduce production costs and improve safety by using clay and resin for main battery components. The government must resolve issues with further cost reductions and the need to increase the predictability of investment recovery toward self-reliant penetration for batteries, including those for business, industrial, and power grid use.

< Future efforts >

The government aims to achieve at the earliest before 2030 an automotive battery pack price of 10,000 yen/kWh or less, making electric vehicles on economic parity with gasoline-powered vehicles. The government also aims to achieve a home-use storage system price of 70,000 yen/kWh or less (including construction cost), at which home-use storage batteries combined with solar panels make economic sense. Moreover, the government aims for the practical use of next-generation batteries after 2030, anticipating further improvements in the performance of batteries. Specifically, the government first aims for full-scale commercialization of all-solid-state lithium-ion batteries, then the practical use of innovative batteries (such as fluoride batteries and zinc batteries) around 2035. To this end, the government will take the following actions and capture the growth markets[20].

(a) Lower battery prices through the economics of scale

The government will support large-scale investment in batteries, resources, materials, etc., and the introduction of stationary batteries.

(b) Research and development/technology demonstration

The government will work on the following matters: (i) improving the performance of all-solid-state lithium-ion batteries and innovative batteries, (ii) improving the performance of battery materials, (iii) high-speed, high-quality, and low-carbon production processes for batteries and their materials, (iv) reuse and recycling, and (v) the research and development and technology demonstration of the technologies, such as power supply and demand balancing capability utilizing stationary batteries.

(c) Development of rules and standardization

The government will work on the following matters: (i) visualizing life-cycle CO_2 emissions from batteries, (ii) ethical procurement of materials, (iii) developing international rules and standardization concerning the promotion of reuse, (iv) developing and standardizing performance labels for home-use batteries, (v) institutional design in preparation for participating in the power supply and demand balancing market (scheduled for opening in 2024), (vi) clarifying the position of storage batteries for power grids under the Electricity Business Act, etc.

[19] About 28% of the global market in 2019 on a storage capacity basis

[20] According to private sector estimates, the global market of all solid-state batteries will double between 2018 and 2030 (from approximately 8 trillion yen to 19 trillion yen). The global market of in-vehicle batteries alone will grow five-fold during the same period (from approximately 2 trillion yen to 10 trillion yen).

(6) Semiconductor/information and communication industries

Amid rapidly advancing information utilization and digitization, an increasingly electrified and digitalized society can realize carbon neutrality in all fields including manufacturing, services, transportation, and infrastructure. Therefore, the semiconductor/information and communication industries, as a foundation for digitization and electrification, are the key to advancing green and digital initiatives at the same time.

Regarding initiatives in the "semiconductor/information and communication industries," the government will take the following two approaches as two wheels on the same axle: [1] Pushing for efficient energy demand management and CO_2 emission reductions through digitalization (Green by Digital) and [2] Energy saving and greening for digital equipment and information and communication industries themselves (Green of Digital).

[1] Pushing for efficient energy demand management and CO_2 emission reductions through digitalization (Green by Digital)

< Current status and issues >

The advancement of digitalization will result in the efficient use of energy and CO_2 emission reductions through the optimization of flows of people, things, and money. For example, converting enterprise systems to cloud-based could slash energy consumption by 80%, and the adoption of telework and online conferences could save energy required for commutation and trips. As these examples show, energy-saving effects through digitization will significantly contribute to all industries.

Toward the realization of carbon neutrality in 2050, the government aims to achieve the efficient use of energy in the entire society and economy by developing domestic digitalization-supporting data centers and information and telecommunication infrastructures and driving digital utilization and CO_2 emission reductions in urban and all other areas. Simultaneously, the government should support the development of digitization and digital transformation (DX) in all industrial fields.

(i) Promoting DX regardless of whether the target is an urban or rural area

The importance of DX is becoming recognized widely in recent years. However, a closer look at what Japanese companies are doing in this area would reveal that most of them are not working on DX at all, or they have just started such efforts from scratch. As a result, a sense of crisis is not shared among the entire industries and companies, and management reform has not yet occurred. Moreover, even in the same industry, each company develops and uses its software and systems, hindering system integration and abolition, utilization rate improvements, and business process optimization through information sharing across companies and industries. Thereby energy-saving and CO_2 emission reductions hasn’t progressed.

As power-intensive infrastructures and industries are becoming commonplace from this time forward, promoting DX will contribute to energy-saving and CO_2 emission reductions and strengthening Japanese companies' competitiveness. Therefore, the government should expedite the development of DX.

(ii) Locations of data centers as the core of digital infrastructure

The development of digitization in the future, mostly due to the widespread use of AI and big data, would require data centers to have more advanced computing power, anticipating large-scale data

center markets to grow worldwide. As far as domestic markets are concerned, the data centers built in the 2000s account for more than 40% of the total number of data centers today, generating demand for replacement soon.

In the past, points to consider in determining data centers' locations were 1) electricity costs, 2) the availability of backbone networks, 3) the distance to points of demand, and 4) environmental conditions such as natural disasters. In recent years, however, the "use of renewable energy and decarbonized power sources" was added to the list of essential requirements.

Japan has geopolitical advantages such as a large economy and stable political situations, but has the following downsides at the same time: 1) high electricity costs, 2) the difficulty efficiently purchasing decarbonized power, and 3) connection to a power infrastructure takes a few years when the data center consumes a considerable amount of energy.

Data centers are the heart of a digital society. In a society with advanced edge computing, where data centers located within a country are linked to the communication infrastructure, new data-based services such as autonomous driving and smart factories work favorably. Furthermore, the aggregation and accumulation of data in the country are favorable from an economic security viewpoint. Given this background, the government will support to build data centers within the country. To ensure the stable utilization of data centers, the government must support to build those centers dispersedly across the country and respond to power disruptions in an emergency.

(iii) Advanced information and telecommunication infrastructure (5G, Post 5G, Advanced 5G, Beyond 5G)

Promoting efficient energy demand management and CO_2 emission reductions through digitization would require building data centers and expediting the development of information and telecommunication infrastructures such as 5G. Japan just started the 5G service in 2020, but the government should move ahead with the early development of safe and secure 5G infrastructure, and also strive to realize various new services. In addition to enhanced Mobile Broadband services, Doing this would require the promotion of research and development on an improved version of 5G leveraging its unique features like Ultra-Reliable and Low Latency and massive Machine Type Communications(Post 5G) and an information communication system compliant with enhanced 5G functions (Advanced 5G).

Meanwhile, Beyond 5G's commercialization is expected around 2030, but international competition in its research and development has already started. Not to fall behind other countries, Japan should take strategic initiatives for research and development and standardization by bringing together the power of the industry, government, and academia.

< Future efforts >

The government will strive for Japan to become the world's green digital power by promoting DX, developing green data centers on the land in Japan, and developing the next-generation information and telecommunication infrastructure.

As specific measures for DX promotion, the government will strive to establish necessary technologies and enhanced competitiveness by supporting research and development on next-generation software and the demonstration needed to promote regional CO_2 emission reductions by utilizing digital technology. The government will also study measures to accelerate further DX promotion within each industry, company, and region. The government aims to acquire a DX-related

market size of 24 trillion yen in 2030 by driving DX for social/economic systems and enterprises from now on.

Regarding the development of data centers on the land in Japan, the government will create models for the zero-emission and enhanced resilience of data centers and implement demonstration, subsidized projects, and institutional support to promote the introduction of renewable energy. The government should also facilitate the purchase of decarbonized power. To improve consumers' convenience, the government will consider how the system of a non-fossil value trading market should be. To shorten the time needed from selecting a data center to the start of the operation, the government will also study measures to expedite the development of power infrastructure in cooperation with electric power companies and data center installation vendors in matching the needs on both sides. To expand the domestic market of data center facilities and equipment, the government will also study measures to strengthen domestic companies' competitiveness and support equipment introduction. As a result of these efforts, the government aims to create a domestic data center service market of 3 trillion yen in 2030, investing approximately one trillion yen in data centers.

For information and telecommunication infrastructure, the government will support research and development and standardization on Post 5G, Advanced 5G, and advanced optical electronics. Simultaneously, under the industry, academia, and government's cooperation, the government will steadily drive efforts toward Beyond 5G in 2030 based on the Beyond 5G promotion strategy.

[2] Energy saving and greening of the digital equipment industry (Green of Digital)

< Current status and issues >

CO_2 emissions will decrease thanks to "Green by Digital." On the other hand, as the electrification and digitization of houses, factories, and automobiles advance, digital-related power consumption will increase, suggesting that CO_2 emissions will increase accordingly. For example, some large-scale data centers consume as much power as a large thermal power plant can generate. IT-related power consumption in 2016 was 41 billion kWh, 4% of the total power consumption. However, a survey report shows that the number will increase 36 times to 1,480 billion kWh in 2030. The government expects that digital-related power consumption will dramatically increase in the future. For this reason, promoting further energy saving and CO_2 emission reductions such as utilizing renewable energy in electrical equipment, data centers, and communication networks is crucial from the viewpoint of net CO_2 emission reductions.

As some companies internationally developing a digital platform are poised to strive for carbon neutrality through investment in renewable energy power generation and green power purchase, greening has already become a significant movement in the information and communication industry.

Furthermore, in fields such as power semiconductors, memory chips essential for information processing, semiconductors, optical electronics (optical interconnection), and software, which are integrated into every electrical device, competition in investment and research and development toward energy-saving and high performance is intensifying. Therefore in the entire information and communication industry, the early achievement of energy-saving and greening will determine the winner in such competition.

From now on, the government will expand the fields where Japanese companies have competitive advantages, such as power semiconductors (Japanese companies have a world market share of 29%).The government should also promote energy-saving, CO_2 emission reductions, high

performance, and early introduction in semiconductor-related areas such as memory chips, optical electronics, and high-performance computing. These efforts include information and communication infrastructure areas such as data centers, 5G and Post 5G, Advanced 5G, and Beyond 5G.

As just described, for Japan to continue to grow by balancing green and digital, the government must promote energy-saving of digital equipment itself and industry and also convert the energy in the digital fields mainly consumed at data centers, to renewable energy.

< Future efforts >

The government will strive to create a green digital society by promoting energy-saving, CO_2 emission reductions and high-performance of power semiconductors used in various fields, semiconductors indispensable for information processing such as memory chips, data centers, , and information and communication infrastructures, etc.

Regarding the utilization of power semiconductors and next-generation semiconductors, the government will support research and development toward the practical use of ultra-high efficiency next-generation power semiconductors (such as GaN, SiC, and Ga_2O_3). To encourage the introduction of these semiconductors, the government will promote the practical and widespread use of next-generation power semiconductors with an energy-saving rate of at least 50% no later than 2030 by supporting equipment investment in selected areas of the semiconductor supply chain. As a result of these efforts, the government will strive for Japanese companies to achieve a world market share of 40% (1.7 trillion yen). The government will also promote research and development on next-generation energy-efficient equipment (such as power electronics and motor control semiconductors) and next-generation passive elements and mounting materials (such as coils). The government will also support the demonstration, implementation and sophistication of technology relating to the applications for which the results obtained from the development of next-generation semiconductors (such as GaN) can be utilized (such as LED and wireless power transmission).

Furthermore, the government will promote research and development and demonstration for conversion to energy-efficient data centers and research and development and demonstration for energy-saving of the entire system through enhanced efficiency in software development and processing. The government also aims to reduce energy consumption at 30% or more of all the newly built data centers and convert part of the power consumed in domestic data centers to renewable energy no later than 2030. Doing this would require the support of equipment investment to expand the manufacture of energy-efficient semiconductors and the promotion of renewable energy at data centers.

While steadily implementing these efforts, the government will strive to achieve carbon neutrality in the semiconductor/information and communication industries in 2040. Doing this would require studying the institutions needed to achieve carbon neutrality, such as promoting energy-saving and CO_2 emission reductions, including the electrical industry and the information and communication industry, where power consumption is growing.

(7) Shipping industry

Measures for tackling the climate change have been attracting increasing attention in a global manner, and efforts to achieve carbon neutrality in 2050 have been accelerated. Amid the situation, Japan will acquire technical competence relating to developing gas-fueled ships, such as those powered by LNG*, hydrogen, and ammonia, which are essential to achieving zero emissions. At the same time, Japan will strengthen the international competitiveness of its shipbuilding and shipping industries and strive for carbon-neutral maritime transportation by leading the establishment of international regulations. Japan aims to realize the commercial operation of zero-emission ships by 2028 and along with strengthening its shipbuilding and shipping industry's international competitiveness in the field of de-carbonized shipping. It will then strive to further spread those ships toward 2030. In 2050, the fuel used for ships is expected to be converted alternative fuels such as hydrogen and ammonia.

*Realizing carbon neutrality in 2050 would essentially require conversion to gas fuels such as hydrogen, ammonia, and clean methane from recycled carbon dioxide. LNG has a larger fuel volume per unit heating value than the heavy oil. It is in the gaseous state at ordinary temperatures because its boiling point is below zero, and its features are common to these carbon-neutral gases. It is vital to introduce hydrogen/ammonia-fueled ships ahead of the world by accumulating technical competence through introduction of LNG-fueled ships (fuel tanks, fuel supply systems, and gas-fueled engines). When the supply of clean methane from recycled carbon dioxide are realized in the future, LNG fuel ships and the onshore fuel supply infrastructure can be diverted without modifications to those for carbon-recycled methane, which can contribute to achieving net-zero emissions.

[1] Conversion to carbon-free alternative fuels

< Current status and issues >

Some companies are developing and demonstrating small-sized hydrogen fuel cell ships diverted from automotive hydrogen fuel cell systems and battery-powered ships using lithium-ion batteries. However, the application of hydrogen fuel cell systems and battery propulsion systems is limited to short-distance and small ships due to output, weight, and size. While long-distance and large ships require engines with higher output, there are no marine engines today that can burn hydrogen and ammonia directly.

< Future efforts >

Japan will spread hydrogen fuel cell systems and battery propulsion systems for short-distance and small ships. It will also promote the development and practical use of hydrogen/ammonia-fueled engines, fuel tanks and fuel supply systems for long-distance and large ships.

[2] Improving energy efficiency of LNG-fueled ships

< Current status and issues >

LNG is capable to emit less CO2 emissions per transport work than the conventional petroleum-based fuel such as heavy oil. The International Maritime Organization (IMO) already developed international rules on LNG fuel for ships (the International Code of Safety for Ship Using Gases or

Other Low-flashpoint Fuels (IGF Code) came into effect in January 2017). In Japan, the government promotes the spread of energy-efficient, CO_2 emission-reducing LNG-fueled ships by the certification system for introduction plan of smart ship and the rating system for energy efficiency of coastal ship. On the other hand, gas fuel, which has a low energy density and is bulky, has many issues, including the fuel tank taking up a lot of space from the cargo area.

< Future efforts >

The government promotes to develop space-efficient, innovative fuel tanks and fuel supply systems and also to achieve a CO_2 emission reduction rate of 86% by using a combination of LNG fuel and low-speed operation and wind propulsion systems. Furthermore, the government will push for net-zero emissions by utilizing clean methane from recycled carbon dioxide.

[3] Development of international frameworks to promote low-carbon ships

< Current status and issues >

The government has been contributing to the IMO's work to introduce the energy efficiency design index (EEDI), which has been gradually strengthened. However, EEDI does not apply to existing ships. Consequently, the absence of international frameworks on CO_2 emissions from existing ships hinders the replacement of old inefficient ships to new greener ships.

< Future efforts >

The government is striving to develop international regulations to improve energy efficiency of ships so as to promote the replacement of old inefficient ships with new greener ships. The government drafted and co-sponsored a joint-proposal to the IMO on the mandatory energy efficiency requirements on existing ships, consisting of the energy efficiency existing ship index (EEXI) and the annual operational carbon intensity indicator rating (CII rating) , which was approved in last November at the IMO. The early implementation of the EEXI and the CII rating will require existing ships to achieve the same level of energy efficiency performance with the new greener ships, and will incentivize replacement of old inefficient ships with new greener ships.

(8) Logistics, people flow, and civil engineering infrastructure industries

Logistics/people flow systems and civil engineering infrastructure, which provide a foundation for all socioeconomic activities, are indispensable to the public's lives. The government will strive for carbon neutrality through technology development and social implementation in each phase of the formulation, introduction, construction, maintenance, and utilization of an eco-friendly transportation network and the like.

Specifically, the government will move ahead with the following activities: (i) introducing smart traffic, (ii) streamlining green logistics and transportation networks, (iii) improving the efficiency of construction at sites, and promoting the spread of EV/FCV construction machinery, (iv) pushing for more energy-efficient and sophisticated road facilities and conducting research and development on EV charging systems, and (v) reducing environmental loads in logistics and people flow at zero-emission ports.

[1] Formation of Carbon Neutral Port

Hydrogen is a crucial energy source indispensable for realizing carbon neutrality, which can contribute to decarbonization in many areas, including power generation, transportation, and industrial fields. A report of the International Energy Agency (IEA) (2019) proposed positioning industrial cluster ports at the center of where hydrogen utilization will be expanded to solve various energy-related issues.

Our international ports are logistics bases handling 99.6% of Japan's total imports and exports and industrial centers where diverse companies operate. At such international ports, the government will build "Carbon Neutral Port (CNP)" to realize net-zero greenhouse gas emissions through decarbonization-oriented sophistication of port functions and coastal industry accumulation, including mass imports, storage, and utilization of next-generation energy sources such as hydrogen and ammonia. As a result, the government will strive to achieve carbon neutrality at ports in 2050.

< Current status and issues >

Refineries and power plants in the steel and chemical industries, accounting for about 60% of Japan's total carbon dioxide emissions, are located mainly in port and coastal areas. On top of that, mass container cargo transportation on trailers and horizontal cargo transportation using trucks are a familiar scene at ports. This means that ports and coastal areas have substantial room for carbon dioxide emission reductions. Also, ports will become import hubs for next-generation energy, making them indispensable places where efforts to reduce greenhouse gas emissions take place. For this reason, port and coastal areas have a high potential for the utilization of next-generation energy (i.e., manufacturing, transportation, storage, and utilization).

On the other hand, expanding the utilization of next-generation energy would desperately require low-cost, mass procurement using gas carriers such as liquefied hydrogen, methylcyclohexane (MCH), and ammonia. However, each gas carrier's transportation means and receiving systems have not been established yet.

Concerning the transportation and utilization of next-generation energy, each business operator is currently studying and developing ideas and necessary technologies individually, but creating considerable supply and demand is needed for cost reductions.

Furthermore, importing low-cost next-generation energy in large quantities would require securing

resources overseas and developing ports of shipment, in addition to developing domestic infrastructure.

< Future efforts >

Toward the formation of CNP, the government will implement planar decarbonization efforts at ports where various companies such as port operators, warehouse companies, trucking companies, and shipping companies operate and use the facilities. In doing so, the government will support matching next-generating energy suppliers and consumers and sophisticate port functions. The government will hold panel meetings in six regions and create manuals for CNP formation. The government will then spread the CNP formation efforts across the country by formulating plans for CNP formation at each port based on the manuals and promoting the demonstration and implementation of initiatives based on the manuals.

Specifically, the government will work on the following activities: (i) alleviating traffic congestion in front of port gates using digital logistics systems, (ii) converting to FC-powered port cargo-handling equipment, (iii) developing fuel supply systems for hydrogen-, ammonia-, LNG-, and other gas-fueled vessels, (iv) utilizing offshore wind power, (v) constructing a coastal transportation network for hydrogen and other energy sources derived from extra offshore wind power, (vi) utilizing blue carbon ecosystems, and (vii) promoting decarbonization efforts by companies operating in ports and coastal areas.

In addition to the above, the government will support companies' efforts in the infrastructure improvement of ports of shipment to import low-cost next-generation energy in large quantities from overseas.

[2] Introducing smart traffic and promoting the use of bicycles for transportation

< Current status and issues >

Automobiles account for 15.9% of Japan's total CO_2 emissions. For this reason, the government will strive to reduce environmental loads through decreases in automobile traffic volume by encouraging the public's behavior changes, including how to use cars in everyday life. Specifically, it is critical to secure, maintain, and promote public transportation systems in rural areas. In doing this, the government will provide MaaS and promote automobiles' electrification, which will contribute to resolving local issues. The government will also support the social implementation of sustainable mobility services in response to automated mobility in cooperation with road and urban infrastructure initiatives.

Meanwhile, the government is developing road space for bicycles to improve bicycle user environment and promote bicycle usage further under the Bicycle Utilization Promotion Plan and bicycle network plans. The total length of bicycle tracks is approximately 2,930km as of the end of 2019 fiscal year, requiring further progress.

< Future efforts >

The government will provide MaaS that contributes to resolving local issues and build the foundation needed to spread such MaaS side-by-side with the private sector, spreading MaaS that can cope with various transportation needs via public transportation systems. As a result, the government will create an environment where one can move around without relying solely on privately owned cars. The government will also create an environment where one can find some

benefit in choosing electric-powered vehicles.

The government will secure transportation means designed to reduce environmental loads through enhanced regional public transportation and improved convenience by utilizing the Act on Revitalization and Rehabilitation of Regional Public Transportation Systems. At the same time, the government will promote the introduction of CO_2 emission-reducing transportation systems utilizing new technology such as light rail transit (LRT), bus rapid transit (BRT), and electrified/automated public transportation systems, in cooperation with Machizukuri (community development) initiatives.

The government will help local governments formulate their Bicycle Utilization Promotion Plans**.** Simultaneously, the government will also formulate a new Bicycle Utilization Promotion Plan to create a safe and pleasant cycling environment.

[3] Promoting green logistics and promoting transportation networks, hubs, transportation efficiency, and low carbonization

< Current status and issues >

In the logistics field, given the fact that trucks (commercial- and private-use combined) account for about 7% of Japan's total CO_2 emissions, the government must convert transportation means to those with smaller specific CO_2 emissions and improve transportation efficiency.

Concerning logistics facilities, the government must solve the following issues: (i) efforts to reduce energy consumption, such as for lighting, associated with labor-saving in warehouse operations, (ii) energy consumption reductions due to the introduction of energy-efficient natural refrigerant equipment in freezing-refrigerating warehouses, and (iii) efforts to eliminate chlorofluorocarbon (CFC).

Concerning domestic cargo transportation, truck transportation accounts for about 80% of the total. To solve current traffic issues such as traffic jams, the government should take road traffic flow measures and improve logistics efficiency using double-trailer trucks and other methods.

In depopulated areas, the government should improve transportation efficiency and ensure logistics networks' sustainability by replacing low-loading-efficiency, inefficient transportation/distribution by existing logistics means with unmanned aerial vehicles.

In the railway field, experimental fuel-cell railway vehicles are being developed. However the current related standards and regulations do not deal with fuel-cell railway vehicles, thus they should be revised as necessary. For promoting introduction of fuel-cell railway vehicles, cost reductions and infrastructure development should be required.

In the airport field, the government formulated guidelines for realizing eco-friendly airports (Eco Airport Guidelines) and is implementing voluntary efforts toward low carbonization at each airport. When introducing, maintaining, and managing each system that contributes to CO_2 reductions, the government must solve issues such as the need for cost reductions.

Besides, until today, the air traffic system has been sophisticated to improve efficiency, however, due to technical limitations and operational challenges for increasing air traffic volume, we need more improve for various social needs such as reduction of CO2 emissions through reduction of fuel consumption.

For this thing, to develop suitable air traffic systems would require synchronizing the sophistication of avionics (on-board equipment on the airline) side with the sophistication of systems on the civil aviation bureau side.

To tackle these challenges, based on the long-term vision developed through industry-academia-

government collaborations called the "Collaborative Actions for Renovation of Air Traffic Systems (CARATS)",It has been accelerating for implementing various measures to CO2 reductions through shortened flight routes (i.e., promoting the introduction of RNAV routes) in cooperation with the long-term plans the International Civil Aviation Organization (ICAO) .

< Future efforts >

To ensure sustainable growth, efforts to reduce CO_2 emissions must not hamper economic activities, for example, traffic and transportation volume reductions. Furthermore, such measures must contribute to simultaneously solving social issues such as a shortage of drivers.

From these viewpoints, the government will simultaneously realize improvement in efficiency and productivity of logistics, electrification, and fuel decarbonization.

In addition to the above, the government will promote modal shift (by which truck transportation will be converted to other transportation means with smaller specific CO_2 emissions) and cooperative transportation and distribution. The government will also push forward with efficient transportation throughout the entire supply chain. Furthermore, the government will strive for the decarbonization of logistics with the help of digitalization, thorough improvement in productivity and loading efficiency through collaboration between cargo owners and business operators (drastic improvement in specific CO_2 emissions), electrified regional transportation/distribution, and fuel decarbonization for long-distance transportation.

The government will also promote labor-saving equipment and renewable energy-powered equipment at logistics facilities and conversion to energy-saving natural refrigerant equipment in freezing and refrigerating warehouses.

The government will further promote traffic flow measures by improving road networks such as ring roads in the three major metropolitan areas and using roads wisely with the help of big data. The government will also improve the efficiency of logistics by spreading the use of double-trailer trucks.

Toward the practical use of drone-assisted logistics in depopulated areas, the government will continue to support institutional development, technological development, and social implementation.

As to the railway field, necessary measures, such as revision of the related standards and regulations through demonstration tests on service line and application of automobile standards to hydrogen fueling equipment, should be considered in order to implement fuel-cell railway vehicles in the society. In addition, the low-carbon hydrogen supply chains including other fields will be considered.

As to the airport field, the government, through various studies including possible amendments to Eco Airport Guidelines and the steady operation of the Eco Airport Council, will introduce facilities to supply power and conditioned air (ground power unit/GPU) from airports to airplanes, energy-saving systems such as LED-lit airport facilities, and clean energy airport vehicles such as FC-powered, electrified forklifts, with cost reductions kept in mind.

As stepped-up sophistication, the government will enable more flexible flight route settings and further reductions in holding patterns no later than 2040 by managing and operating the best flight routes in all flight phases from departure to arrival utilizing satellites and data communications. In doing this, the government will consider various factors that may affect aircraft navigation, such as weather conditions that could increase aircraft fuel consumption. Specifically, the government will

conduct research and development toward the practical use of critical traffic control systems in cooperation with its international counterparts.

[4] Zero-emission infrastructure and urban space

< Current status and issues >

Regarding energy-efficient road lighting, the government is currently changing road lights to LED lights upon road maintenance and equipment renewal. The government still needs to continue to install LED road lights on government-administered national roads.

Regarding renewable energy generation utilizing road space, road administrators install solar power generation equipment and others to use the electricity for road administration. The government is also promoting solar power generation equipment by adding it to a list of properties subject to permission for occupancy of roads in 2013.

Regarding electric vehicles (hereinafter, "EV"), the government supports the development of the electric road system, and a social experiment on EV chargers on public roads. As to the electric road system, development of road structures in which a power supply system is embedded, technical standards, and evaluation of EV chargers' impact on road traffic are necessary.

Regarding sewage heat energy, collecting such heat is possible in urban space, and there are already 32 installation cases (as of August 2020). While the consumption of heat from sewage is smaller than other heat supply systems, the amount of heat sewage contains is smaller than other heat systems. For this reason, the government must use this heat combined with multiple renewable energy heat sources. The government must solve issues using sewage heat energy, including the difficulty in matching where such heat sources are available and where they are consumed, and the lack of economically justifiable low-cost technology.

The government should create a sustainable green society by achieving urban greening as carbon sinks and resolving various regional issues simultaneously, such as rainwater storage/infiltration and other disaster prevention and mitigation measures through the social implementation of "Green Infrastructure" that utilizes the natural environment's various functions. The Ministry of Land, Infrastructure, Transport and Tourism has been conducting cross-disciplinary, public-private surveys and studies on social dissemination of green infrastructure and the technology introduction applied to the green infrastructure in the framework of the "Green Infrastructure Public-Private Partnership Platform" (established in March 2020), in which various entities from the industry, academia, and the government participate. However, the social implementation of green infrastructure has not progressed well.

< Future efforts >

The government will encourage developing new road lighting technologies to realize the further cost-saving, energy-saving, and sophistication of road lighting systems. To promote the introduction of such technologies, the government will review technical verification and evaluation and road lighting equipment installation standards. Furthermore, the government will promote conversion to LED road lighting on government-administered national roads, with cost-effectiveness kept in mind.

The government will promote the installation of renewable energy to generate the power required for road administration.

Regarding the electric road system, the government will support research on the development of the technology and the road structure in which the power supply system will be embedded. While

conducting verification and evaluation for social implementation depending on the research's progress, the government will study road-related institutions and technical standards, including the installation of EV chargers on public roads.

Regarding the sewage heat energy, the government will utilize manuals and a collection of examples for horizontal development of actual applications. The government will also create an environment in which sewage heat energy will be utilized through cost reductions of existing systems.

The government will promote technology development relating to the planning, development, and maintenance of green infrastructure (such as urban space greening, rain gardens that combine green and rainwater storage/infiltration, blue carbon, and monitoring using remote sensing). The government will also support the introduction of green infrastructure into the region by conducting regional model demonstrations. Through the expansion of social implementation of green infrastructure technologies, the government will drive green finance and ESG investment utilizing private finance-raising methods such as green bonds.

[5] Realizing carbon-neutral construction work

< Current status and issues >

Construction work accounts for 1.4% (approximately 5.71 million t-CO_2) of the industrial sector's total CO_2 emissions. If ICT utilization improves productivity at construction sites, it will shorten work time, contributing to reductions in CO_2 emissions. If innovative construction machinery powered by electricity, hydrogen, or biomass is developed and introduced in the future, it will provide opportunities for further CO_2 emission reductions. The government has been reducing CO_2 emissions by introducing ICT-assisted construction (i-Construction) and improving work efficiency at construction sites. Today, the implementation rate of i-Construction (civil engineering) at government-administered construction sites has reached about 80%. However, that implementation rate in local governments stays around only 30%. From now on, local governments should further promote the spread of i-Construction at their construction sites. As to construction machinery, the government has encouraged the introduction of energy-efficient diesel engine-powered vehicles by formulating stepped-up fuel-efficiency standards and equipment certification schemes. The government also supported this approach through government financing. As international efforts to further reduce CO_2 emissions in construction work are currently underway, Japan should also promote the introduction of innovative technology in this field.

< Future efforts >

First, the government will spread i-Construction among small and medium-sized constructors engaged in local government-administered construction programs, targeting a CO_2 reduction rate of 32,000 (t-CO_2/year) in 2030. The government, toward the realization of carbon-neutral construction work, its 2050 target, will promote the spread of innovative construction machinery (powered by electricity, hydrogen, or biomass) replacing diesel engine-powered equipment. The government will study the possibility of the mandatory use of innovative construction machinery at government-administered construction sites by 2050. The government will formulate new standards based on various related standards for conventional construction machinery and international situations.

(9) Food, agriculture, forestry, and fisheries

In addition to the fact that Japan's agriculture, forestry and fishery industries are themselves considered to be important CO_2 absorption sources, as shown in the penetration of "wood culture" that utilizes wood in the right place, and the expectation that forests, wood, farmland, and oceans are huge CO_2 sinks, efforts are being made to reduce greenhouse gas (GHG) emissions such as for CO_2 reduction by work optimization and N2O reduction by proper fertilization through research and development and social implementation related to smart technology. Therefore, it has many potential strengths toward the realization of carbon neutrality.

In order for the fields of food, agriculture, forestry, and fisheries in Japan to fully fulfill the role of the stable supply of food to the people and the realization of the 2050 carbon neutrality, it is important to develop measures from the basic viewpoint of achieving both productivity improvement and sustainability of the fields of food, agriculture, forestry and fisheries through innovation. From this viewpoint, it is necessary to aim to build a sustainable food system through the procurement of raw materials and energy, and to make efforts at each stage of the supply chain from food production to consumption, such as promoting zero emission of CO_2 originating from fossil fuels by accelerating the implementation of smart agriculture, forestry and fisheries, reduction of GHG (methane, N2O, etc.) derived from agriculture and livestock industry, long-term carbon in forests and wood, agricultural land and oceans, establishment of mass storage technology, utilization of smart food chains, and promotion of sustainable consumption, etc.

These efforts cannot be done overnight, but with an understanding of the sustainable efforts of producers, businesses, and consumers that make up the food systems, creation and social implementation of innovation through research and development with a solid time axis as well as behavior change is indispensable. For this reason, the Ministry of Agriculture, Forestry and Fisheries is to formulate the "Green Food System Strategy" as a medium- to long-term policy to achieve both improvement of productivity and sustainability of food, agriculture, forestry and fisheries through innovation. Furthermore, as an advanced country in paddy field agriculture, Japan can provide countries such as Southeast Asia with methane-reducing water management technology, etc., this strategy will contribute to enhance sustainability of agriculture in the Asia-monsoon region. And also contribute to the international rule making discussions (UN Food System Summit (September 2021), etc.).

[1] Common matters

<Current status and issues>

In light of the fragile production base and the decline of local communities, such as the decrease in the number of producers responsible for agriculture, forestry and fisheries, and the further progress of aging, strengthening the productivity of food, agriculture, forestry and fisheries has become a challenge to overcome. In recent years, as it has been strongly pointed out that the stable supply of food, the sustainable development of agriculture, forestry and fisheries, and the global environment are compatible, it is an important and urgent task to reduce the environmental load and maintain a rich natural environment.

In order to achieve a stable supply of food and the development of agriculture, forestry and fisheries in the future, in anticipation of further decline and aging of producers and post covid 19, there is an urgent need to reduce the environmental burden by maximizing the use of local resources

and curbing the use of chemical pesticides, fertilizers and fossil fuels, and to build a sustainable food system that is resistant to disasters and global warming in addition to carbon neutrality as well as to improve labor productivity by labor saving, and the base of producers will be expanded.

To achieve this, the government will promote the understanding of stakeholders regarding the challenges facing the food system, and draw out ambitious and enterprising efforts that are not an extension of the past for agriculture, forestry and fisheries, food companies, and consumers. In addition, it is necessary to promote innovations involving the public and private sectors and work to resolve challenges for the future. Moreover, in advancing such efforts, it is important to clearly convey that it aims to bring about concrete benefits such as income improvement, in addition to improving occupational safety and productivity by promoting "visualization" of the effects of sustainable efforts and showing them to consumers, and introducing new technologies to agriculture, forestry and fishermen and local communities.

<Future efforts>

As regards greenhouse gas emission reduction and sink measures, etc., while creating a process chart from research and development of individual technologies to social implementation, the government intends to gradually review policy guidance methods such as subsidies, investment and loans, taxes, and systems.

Specifically, by 2030, the government aims to concentrate the support targets of the measures on those who carry out sustainable food, agriculture, forestry and fisheries. Regarding the subsidization project of the Ministry of Agriculture, Forestry and Fisheries, it aims to support carbon neutrality by 2040, taking into account the status of technological development. In addition, it will shift to facilities that do not use fossil fuels for horticultural facilities by 2050.

In addition, from the perspective of supporting the social implementation of innovative technology and production systems and sustainable efforts, it will review the regulations required at that time and consider new systems while listening to the voices of researchers and users.

Furthermore, in order to promote efforts such as information disclosure of companies working on environmental conservation including sustainable use of food, raw materials and materials, by considering the attraction of commendations and ESG investment, and by properly evaluating the efforts of agriculture, forestry and fisheries/food businesses, it will promote the visualization of the efforts of businesses that promote behavior change of consumers.

In addition, the government will promote innovative technology development through moonshot-type research and development, etc., as well as technology development and dissemination that will be an advantage for agriculture, forestry and fishermen and the region, and efforts for public incentive systems such as the J-credit system.

From the perspective of overseas expansion and international collaboration, in addition to its efforts to continue its participation in and collaboration with the "4 Per Mille Initiative", an initiative to promote the increase of soil carbon through soil management technology, and the global research network on GHG reduction in the agricultural field, the government aims to contribute to the reduction of GHG emissions worldwide by expanding Japan's excellent agriculture, forestry and fisheries field decarbonization technology overseas through collaboration with international organizations and the bilateral credit system (JCM).

[2] Reduction of greenhouse gas emission — Energy procurement and production to distribution/consumption stages —

<Current status and issues>

As regards the production and utilization of renewable energy that maximizes the abundant local resources in agricultural, mountain and fishing villages, there is a need for technological development for further cost reduction and efficiency improvement, and construction of a sustainable local production for local consumption type energy system suitable for agricultural, mountain and fishing villages.

In order to reduce GHG (methane, N2O, etc.) emissions from the agriculture and livestock industry, the development of basic technologies to suppress the generation of methane from paddy fields is progressing, and it is necessary to promote the early dissemination of technologies in the practical stage.

It is necessary to develop and socially implement smart technology for labor saving and optimization from production to distribution/consumption stage. In addition, decarbonization is also required for machinery used in agriculture and forestry as well as fishing boats that rely on fossil fuels for power.

It is necessary to promote the use of wood, which consumes less energy in manufacturing than other materials, by wood construction for high-rise buildings, etc. At the same time, it is also required to promote the replacement of fossil fuel-derived products such as plastic by developing and disseminating new materials derived from woody biomass. In addition, regarding the use of woody biomass energy, from the viewpoint of ensuring the sustainability of forest resources, it is necessary to use the cascade (multi-step use by collection/reuse) and efficient use based on thermal efficiency.

<Future efforts>

The government will promote measures in line with the 2050 target "CO_2 zero emission originating from fossil fuels in agriculture, forestry and fisheries".

Specifically, in addition to newly considering the introduction target of renewable energy in the agricultural, mountain and fishing village areas toward the goal of realizing carbon neutrality in 2050, it will introduce a logo mark to visualize the efforts of renewable energy that contributes to the revitalization of agricultural, mountain and fishing villages. Additionally, to support the decarbonization of agricultural, mountain and fishing village areas, it will promote local production and local consumption of renewable energy, such as small hydropower generation, introduction of local production and local consumption type biogas power generation facilities, promotion of utilization of bio liquid fertilizer (digestive juice, which is a by-product of biogas power generation), and more, as well as review the regulations as necessary for the construction of a production area-consumable energy system.

While promoting innovative technology development aimed at reducing GHGs derived from the agriculture and livestock industry by controlling microbial activity, it aims to develop, demonstrate, and disseminate smart technology, and develop technology for electrification and hydrogenation of agricultural and forestry machinery, fishing boats, etc. through collaboration among industry, academia and government. Moreover, it aims to build a smart food chain that will achieve both improvement in productivity and reduction of food loss and waste and CO_2 by linking data not only at the production stage but also at the distribution/consumption stage.

Furthermore, while promoting wooden construction of high-rise buildings, development of new

materials such as lignin derivatives and CNF to replace plastic, and efficient use of woody biomass energy (heat utilization, etc.), it aims to build a cascade use of forest resources in multiple stages, as well as to introduce a forest cloud system that conforms to standard specifications, and to develop and disseminate automated machines and ICT production control systems that are consistent with the cloud system.

[3] Absorption/fixation of CO_2

<Current status and issues>

In order to maximize the effects of absorption and emission reduction by forests and timber, it is necessary to establish a cyclical use of "harvesting, using, and planting" for planted forests whose absorption amount is declining as the population is getting aged, and promote the use of wood and utilize new technologies such as F1 plus trees to rejuvenate forests. In combination with these efforts, it is necessary to develop and introduce wood utilization technology that sequestrates a large amount of carbon for a long period of time, such as wooden construction of high-rise buildings and development of new materials derived from woody biomass.

Regarding biochar, a new method for calculating the carbon storage effect of biochar applied on agricultural land and grassland soil was added to the 2019 refinement to the 2006 IPCC guideline, and the report on the production of charcoal for agricultural use from the 2020 Convention Inventory, a methodology for biochar farmland application in the J-credit system has been formulated in Japan.

As regards Blue Carbon (carbon storage by marine ecosystem), the government is now developing a carbon absorption quantity evaluation method and a creation, regeneration, and maintenance technology for seaweed bed/tidal flat by each seaweed bed type in marine ecosystem.

<Future efforts>

In order to realize carbon neutrality by 2050, it is indispensable to have negative emissions that cover emission sources that are difficult to zero-emission, and it is necessary to realize long-term and mass storage of carbon in forests, timber, agricultural land, and the ocean.

Specifically, development of F1 plus trees by speeding up timber breeding, etc., and promotion of reforestation after harvesting by utilizing sensing technology, etc., will be pursued to improve the amount of forest absorption. In addition, by developing wooden building materials that will materialize the wooden construction of high-rise buildings, standardizing construction methods, and developing new materials such as lignin derivatives and CNF, long-term and mass storage of carbon from wood will be realized.

As regards biochar, in aiming to develop biochar materials that have both carbon storage effect and soil improvement effect, the government aims to develop biochar standards, and establish a sustainable and high-value-added farming model that utilizes biochar derived from regional biomass.

In respect of Blue Carbon, the government aims to register the amount of carbon absorption as an inventory, promote efforts to create, regenerate, and conserve seaweed beds and tidal flats in coastal areas by local governments, and consider a carbon offset system for seaweed beds, tidal flats, etc.

(10) Aircraft industry

International Civil Aviation Organization (ICAO) has adopted an objective of not increasing CO_2 emissions concerning international aviation in and after 2020, and in order to achieve this objective, it is deemed necessary to combine the improvement of operation methods, the efficiency improvement of airframes and engines (introduction of new technology), alternative fuels, and the utilization of market mechanisms[21]. Meanwhile, International Air Transport Association (IATA) has set a goal of halving CO_2 emissions from 2005 levels by 2050[22]

With the increasing demand for low carbon, the development of low carbon related technology is indispensable from the viewpoint of climate change countermeasures, and will contribute to maintaining and strengthening the competitiveness of Japan's aircraft industry.

[1] Electrification of equipment and propulsion system

<Current status and issues>

As regards the electrification of aircrafts, while, currently, the range of applications is limited, such as installing storage batteries for auxiliary power and power supply when staying on the ground, but in the future, it is expected to be expanded to applications related to power during flight and operation of internal systems. In order to achieve this, it is necessary to dramatically improve the performance of technologies such as batteries and motors.

In recent years, competition has become active for the acquisition of electrification technology and the development of demonstrators, centered on Western aircraft and engine manufacturers. Japanese companies have potential competitiveness in elemental technologies in related fields such as batteries and motors. However, the current adoption record for aircraft system and equipment is only a part.

In the "Agreement between the Ministry of Economy, Trade and Industry of Japan and The Boeing Company on Cooperation in Aircraft Technology" in 2019, electrification of aircraft is positioned as one of the specific fields of cooperation[23].

<Future efforts>

In order to establish the electrification technology for aircraft, the government will continue to promote research and development conducted in collaboration with aircraft-related manufacturers and electronics-related manufacturers, and it aims to achieve a goal that domestic manufacturers meet the technology level required by the time the technology to be installed in future aircraft is selected. At that time, the government will utilize and strengthen the framework of cooperation with overseas companies that manufacture aircraft, aiming to incorporate the developed technology into future aircraft. In addition, it will promote international standardization activities through domestic industry-academia-government collaboration.

[2] Hydrogen-powered aircraft

<Current status and issues>

In order to realize low carbon in the aircraft field, it is expected that hydrogen fuel will be used in

[21] https://www.icao.int/environmental-protection/Documents/ICAOEnvironmental_Brochure-1UP_Final.pdf
[22] https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet--climate-change/
[23] https://www.meti.go.jp/press/2018/01/20190115007/20190115007.html

addition to the installation of electrification technology. There are many technical challenges for the realization of hydrogen-powered aircraft, such as a lightweight and safe hydrogen storage tank, and the development of new engine parts when directly burned in a turbine. Additionally, it is also necessary to consider the feasibility of peripheral infrastructure and hydrogen supply chain from the viewpoint of safety and cost.

In September of this year, Airbus announced that it would launch a hydrogen-powered aircraft in the market in 2035. At present, Japanese companies have also started concrete efforts regarding hydrogen aircraft, and it is necessary to accelerate research and development and concrete studies in the future.

<Future efforts>

The government will promote the development of necessary elemental technologies for the realization of hydrogen aircraft. At that time, it will seek cooperation with overseas manufacturers from the initial stage of development, identify issues that will lead to practical use, and focus on them. Moreover, in addition to aircraft manufacturers, it will continue to study peripheral infrastructure and hydrogen supply chains in collaboration with related companies and academics.

[3] Weight reduction and efficiency improvement of the airframe/engine

<Current status and issues>

As for aircraft and engine materials, the introduction of new materials that contribute to weight reduction and heat resistance improvement is in progress. In respect of aircraft structures (body, main wings, etc.), the conversion from aluminum alloys to carbon fiber composite materials is in progress, and in aircraft engines, the application of lightweight and strong carbon fiber composite materials to fan parts and the application of ceramics-based composite materials, which are promising as materials that can withstand high temperatures, to turbine parts have begun.

As the demand for low carbonization increases, it is expected that the needs for applying materials that will lead to further weight reduction and efficiency will continue in the future. At present, Japanese companies have technological advantages in the material field, but it is important to respond to further performance improvement and cost reduction demands in the future.

<Future efforts>

In collaboration with domestic material manufacturers and aircraft/engine manufacturers, the government will promote required technological development including production technology, aiming to achieve a goal that Japanese companies meet the technology level required by the time when the technology to be installed in future aircraft is selected. On that occasion, the government will utilize and strengthen the framework of cooperation with overseas companies that manufacture aircraft, and aim to incorporate the developed technology into future aircraft.

[4] Bio jet fuel etc. and synthetic fuel

<Current status and issues>

The market for bio jet fuel etc. is almost nonexistent at the moment, but with regard to international aviation, it has steadily expanded due to the introduction of the ICAO system; as of 2030, the market size of Japanese airlines (international flights) alone will reach a maximum of 190 billion yen; it is expected to expand.

For this reason, companies in each country, including Western companies, are activating the development of alternative fuels for jet fuel. As regards the technological development of multiple bio jet fuel etc., Japan is in a state of side-by-side competition. Companies are developing elemental technologies and have begun demonstrating them.

The main manufacturing technologies for bio jet fuel etc., as an alternative fuel to jet fuel, include gasification FT synthesis technology[24], ATJ technology[25], and microalgae culture technology[26].

As a challenge of these fuel manufacturing technologies, it is necessary to establish a crushing treatment technology that equalizes the quality of various raw materials for gasification FT synthesis, and for ATJ, it is also necessary to establish control technologies for catalytic reactions at high temperatures, and these technologies are in the small-scale demonstration stage.

Synthetic fuel[27], which utilizes carbon recycling technology, is attracting attention because it can use existing infrastructure, but an integrated manufacturing process for commercialization has not yet been established. In addition, large-scale investment such as the installation cost of dedicated equipment for manufacturing and equipment maintenance is required. Therefore, in addition to establishing an integrated manufacturing process, it is necessary to reduce the cost by improving manufacturing efficiency.

<Future efforts>

The government will carry out large-scale demonstrations of gasification FT synthesis technology and ATJ technology, and aims to put them into practical use by reducing the manufacturing cost of Neat[28] to the 100 yen /L level, which is equivalent to that of ready-made products, around 2030 ahead of other countries. In addition, it will expand the supply of competitive bio jet fuel etc. to aircraft in response to trends in the international market for bio jet fuel etc.

Regarding synthetic fuel, the government will develop innovative new technologies and processes in addition to improving the efficiency and cost of existing technologies, and will carry out applied research to establish an integrated manufacturing process for commercialization.

[24] The Fischer-Tropsch process is a technology for producing biojet fuel by steaming (gasifying) organic materials such as wood waste and liquefying them using a catalyst.
[25] Abbreviation for "alcohol to jet. A technology to reform bioethanol into biojet using a catalyst.
[26] See the implementation plan for the carbon recycling industry sector.
[27] It is a liquid fuel produced by synthesizing hydrogen with CO_2 collected from power plants and factories.
[28] It refers to jet fuel produced from biomass materials, etc., before being mixed with fossil-derived jet fuel. When using neat, a certain percentage of it must be mixed with fossil-derived jet fuel before it is loaded on an aircraft.

(11) Carbon Recycling industry

Carbon Recycling is a key technology for realizing a carbon neutral society with technology that effectively utilizes CO_2 as a resource, and Japan has a competitive edge in this field.

The Carbon Recycling industry is diverse, as shown in the Carbon Recycling Technology Roadmap, which includes major fields such as minerals (concrete products, concrete structures, carbonates, etc.), fuels (microalgae jet fuel, microalgae diesel fuel, synthetic fuel, biofuel, gas fuel from methanation, etc.), chemicals (polycarbonates, urethane, etc. biomass-derived chemicals, general-purpose substances such as olefin and paraxylene), etc. Focusing on these major products, the government will promote technology development and social implementation for cost reduction and application development, and aim for global development through International Conference on Carbon Recycling

[1] Concrete material

<Current status and issues>

In Japan, there are companies that have succeeded in putting CO_2 absorption type concrete (CO_2 -SUICOM) into practical use. By manufacturing a material that hardens by absorbing CO_2 from slaked lime produced as a by-product from chemical factories, etc., and using this for concrete manufacturing, it is possible to (i) absorb CO_2 in the manufacturing process, (ii) reduce the amount of cement used, and reduce the CO_2 emissions of concrete.

In other countries, in addition to US companies developing and putting into practical use similar technologies, British companies are putting into practical use a type of technology that absorbs CO_2 into aggregates, and each country is in a side-by-side competitive state.

While the market size of CO_2 absorption type concrete is expected to reach about 15-40 trillion yen as of 2030, in anticipation of such market expansion, it is necessary to achieve price reduction at an early stage and acquire market share.

On the other hand, there is a challenge that the cost of the current CO_2 absorption type concrete is high (= 100 yen/kg, which is about three times that of ready-made products), and the reinforcing bars in the concrete are relatively easy to rust (because they are easily oxidized by CO_2 absorption), so its use is limited.

<Future efforts>

By expanding sales channels through public procurement, the government aims to achieve the same price (= 30 yen/kg) as existing concrete in 2030 as a cost target. For this purpose, it has registered CO_2 absorption type concrete in the database of the Ministry of Land, Infrastructure, Transport and Tourism on new technologies (NETIS), and it will disseminate this information widely to local governments. Additionally, it aims to expand public procurement by national and local governments by introducing it at the 2025 Osaka Expo and other. In the global market as well, concrete demand is expected to grow in Asia, where economic growth is remarkable, so the government aims to expand sales channels to Asia through global standardization, PR at large-scale international exhibitions, etc.

Furthermore, the government aims to develop new products with rust preventive performance by 2050 and expand the sales channels by expanding the applications to buildings and concrete blocks.

It will also consider expanding demand in the private sector through support for the introduction of standardization.

[2] Fuels (Biofuel from culture of microalgae)

<Current status and issues>

As regards international aviation, ICAO (International Civil Aviation Organization) plans to introduce a system that "does not increase CO_2 emissions compared to 2019" from next year (the system will continue until 2035). With the introduction of the system, the market for bio jet fuel is expected to expand steadily, although it is almost nonexistent at the moment, and as of 2030, the market size of Japanese airlines (international flights) alone is expected to reach a maximum of 190 billion yen.

For this reason, starting with European companies, companies in each country are activating the development of alternative fuels for jet fuel. Regarding the technological development of bio jet fuel by culturing microalgae, Japanese companies are proceeding with the development of elemental technologies and have begun demonstrations while each country is in a state of side-by-side competition.

On the other hand, in the current situation, there are technical issues, such as (i) the efficiency of microalgae absorbing CO_2 is low, the growth speed is slow (low productivity), and (ii) the microalgae's resistance to the external environment is weak, making it difficult to grow stably (production stability is vulnerable), which results in higher cost, and it remains in the small-scale demonstration stage. (*The current Neat(*) production cost is 1,600yen/L (ready‐made products 100 yen/L))

(*) Refers to jet fuel manufactured based on biomass raw materials, etc. before mixing with fossil-derived jet fuel. When using Neat, it is necessary to mix a certain ratio with fossil-derived jet fuel before mounting it on an aircraft.

<Future efforts>

The government will promote research and development of CO_2 absorption related to technology for increasing efficiency and accelerating microalgae growth (microalgae production process technology) and breeding to increase microalgae resistance. By means of these, a large-scale demonstration will be carried out, and around 2030, ahead of other countries, the cost will be reduced from the current 1600 yen/L to the 100 yen /L level, which is equivalent to ready-made products, and practical application will be achieved. In addition, the government will expand the supply of competitive microalgae jet fuel to aircraft in response to trends in the international market for bio jet fuel (international certification has been obtained).

[3] Chemicals (Plastic raw material by artificial photosynthesis)

<Current status and issues>

Only Japanese companies are developing artificial photosynthesis technology that separates hydrogen from water by sunlight using a photocatalyst and combines hydrogen and CO_2 to produce plastic raw materials. Basic research (labor level) has already succeeded.

The market size of chemical products such as plastics derived from fossil resources is 10 trillion yen in the Japanese market alone and several hundred trillion yen in the world market. It is necessary to acquire such a large market by establishing artificial photosynthesis technology which

only Japanese companies have.

On the other hand, at present, since the conversion efficiency of photocatalysts is low and the manufacturing cost is high, there are technical issues in conducting large-scale demonstrations. In addition, separation membranes such as hydrogen and backbones are required to establish artificial photosynthesis technology. It is also necessary to develop and demonstrate catalysts, etc. required for the synthesis of hydrocarbons as fundamental substances.

<Future efforts>

By developing a photocatalyst with high conversion efficiency in collaboration with the AIST Zero Emission International Collaborative Research Center, the government aims to reduce the cost of plastic manufacturing by artificial photosynthesis by about 20% by 2030. Also, in order to accelerate the development of photocatalysts, it considers the relaxation of related regulations such as the High Pressure Gas Safety Law and the Fire Defense Law, and establish safety and safety standards for handling mixed gas of hydrogen and oxygen.

After that, the government will carry out a large-scale demonstration in 2050 and realize the same price (= 100 yen/kg) as the ready-made product.

[4] Separation and recovery equipment (separation and recovery of CO_2 in exhaust)

<Current status and issues>

Development and demonstration of CO_2 separation and recovery technology is indispensable to secure the negative emission (carbon removal) of CO_2 emission sources that are difficult to net zero emission and the CO_2 source required for Carbon Recycling. Amid the trend toward decarbonization in countries such as Japan and Europe and the United States, the market size of CO_2 separation and recovery technology will expand to about 6 trillion yen/year in 2030 and to about 10 trillion yen/year in 2050. It is predicted that it will reach about 400 billion yen/year in 2050 in Japan alone. Japanese companies have completed high-concentration CO_2 separation and recovery equipment from power plants for EOR and chemical applications, and have secured top shear by constructing a CO_2 separation and recovery plant. Also, regarding CO_2 separation and recovery technology in Japan, the number of industry-academia patents is large compared to other countries.

On the other hand, low-cost recovery technology from CO_2 emission sources with various concentrations and characteristics is a future development issue.

<Future efforts>

In the future, the government will develop highly efficient CO_2 separation and recovery technology, and in 2030, the government aims to realize further reduction in cost of separation and recovery technology and expansion to applications other than EOR. On top of that, in 2050, it aims to secure 30% of the world's separate collection market of 10 trillion yen annually.

[Reference] Direct recovery of CO_2 from the atmosphere (DAC: Direct Air Capture)

<Current status and issues>

As regards technology development for DAC (Direct Air Capture), although Western venture companies are accelerating research and development with an eye on commercialization, they are still in the stage of elemental technology development worldwide. In Japan as well, development at the laboratory level has started in 2020.

At present, energy efficiency is low and CO_2 recovery cost from the atmosphere is high.

<Future efforts>

The government will advance technological development on a highly efficient CO_2 recovery method from the atmosphere, realize low cost, and aim for practical use in 2050.

(12) Houses and building industry/Next-generation solar power generation industry

The houses/building field is a key field for carbon neutrality in the home/business sector, and once built, becomes a long-term stock; and is a field that should be addressed immediately. The global trend in Europe, United States and other countries, is to aim for carbon neutrality through bold investment in heat insulation renovations in houses and buildings and introducing solar-power generation, which creates a market towards employment and economic recovery affected by the corona virus, as well as improving the quality of life by supplying high-quality housings.

Japan has been working on the improvement of energy efficiency performance, the promotion of life cycle carbon minus (LCCM), the conversion to net zero energy houses and buildings (ZEH/ZEB), and the extension of life of houses and buildings, but the progress is halfway through. Upon aiming for the 2050 carbon neutrality in the future, in addition to the spread of LCCM houses and buildings that make carbon dioxide emissions negative throughout its life cycle (from construction to dismantling, reuse, etc.), the spread of ZEH/ZEB, the promotion of energy-efficient renovation, introduction of high-performance heat insulating materials, high-efficiency equipment, and renewable energy, and the usage of wood in buildings will be promoted as much as possible. Regarding renewable energy, if the thin and lightweight next-generation solar cells, which Japan has strengths in, are put into practical use, installing solar panels on the roofs of existing houses and buildings with a small load capacity, and on the walls and windows of houses and buildings, which are now technically difficult will become possible and the goal to realization will become closer. At the same time, it is necessary to promote energy management that contributes to the adjustment of power supply and demand according to the amount of power generated by the photovoltaics system, using the energy management system (HEMS/BEMS) of the house/building.

[1] Energy management through utilization of AI・IoT and EV etc.

<Current status and issues>

In the field of energy management, the government has been conducting domestic demonstration, joint research and business development with overseas, etc. for market acquisition. On the other hand, lack of evaluation, awareness, and demand are issues upon the efforts for introducing energy management. In particular, incentive design that encourages consumers to change their behavior in response to the power supply and demand situation is an issue for expanding the market such as energy management systems that leads to optimization of energy use on the consumer side. Specifically, control equipment manufacturers, etc. that specialize in energy management have developed systems that can automatically perform optimal control without impairing users' comfortability in response to the demand side equipment such as hot water supply, air conditioning, and lighting, and have put them into practical use. However the incentives to be introduced on the demand side are scarce, and the introduction is not progressing. In addition, usage of power storage system such as EVs plays an important role as energy management. EVs have a large storage capacity, and it has a large potential that will lead to the expansion of the introduction of renewable energy by building a mechanism that enables stored surplus electricity generated by solar power generation during the day to be used at other times. Currently, the government is addressing issues to expand peak shift EV charging through demonstration projects, etc., the future challenges include the examination of incentives that encourage the actions of consumers that leads to the introduction and utilization of EVs. The expansion of the introduction of renewable energy, etc. entails the

concern for the lack of dispatchable power. Promoting efforts to reduce the cost of procuring dispatchable power as well as expanding the resources that are utilized through the establishment of a supply/demand regulation market, and considering measures on the demand side in the event of system instability is necessary. Furthermore, the needs for grid stabilization responding to mass introduction of renewable energy and demand-side energy management due to the mass introduction of reusable energy are increasing overseas as well, and demonstration projects have been carried out in developed countries such as Europe and the United States. It is expected that the needs for introducing these will increase in emerging countries such as ASEAN, and there is a potential for overseas expansion.

<Future efforts>

While energy management within consumers is becoming more widespread, in addition to this, it is expected that some aggregation business that bundles a large number of decentralized energy resources will be activated and the introduction of resources and control systems necessary for it will be expanded with the opening of the supply/demand regulation market, etc., in the future.
For this reason, while the government currently supports the demonstration and introduction of optimal control using big data and AI, in order to promote further introduction, etc., including the establishment of standards, specifications and review of systems (Act on the Rationalization etc. of Energy Use, Imbalance Settlement System, etc.) for strengthening the introduction of energy management such as optimal control of EVs/storage batteries, solar power generation, air conditioners, etc., as well as institutional measures such as demonstration support of related ministerial ordinances under the Electricity Business Act to promote new businesses such as aggregators and power distribution businesses that utilize renewable energy, EVs, storage batteries, etc., will be considered.

As regards of EV utilization, for the time being, while promoting demonstration projects for peak shift of EV charging, the government will consider incentives for EV utilization according to the power supply and demand situation, also, its issues and directions will be organized. Furthermore, as a control that contributes to the adjustment of supply and demand of the equipment itself, automatic control technology for air conditioning according to the load fluctuation of the system has been developed, and incentives will be strengthened to expand the introduction to the market.

Furthermore, based on the results of these domestic efforts, the government will support the establishment of institutional arrangements in partner countries and overseas expansion of Japanese technologies through bilateral policy dialogues, capacity building projects, and overseas demonstrations (NEDO international demonstration program), with market acquisition in Europe, the United States and emerging countries in mind.

[2] LCCM houses and buildings, ZEH/ZEB , and improvements of energy efficiency performance of houses

<Current status and issues>

To promote the spread of energy-efficient houses and buildings including LCCM and ZEH/ZEB, the government has so far introduced both subsidy and regulatory methods (The Building Energy Efficiency Act), and tried to expand the number of providers through the registration system of ZEH builder, etc. About 70% of newly built detached houses have achieved the energy efficiency standards based on the Building Energy Efficiency Act (FY2018). The ratio of ZEH to newly custom-

built detached houses reaches about 50% for major ZEH builders, but it is only 20% (13% of all) (FY2019) for all ZEH builders, and to reach the government target of "More than half of custom-built detached houses newly built by house makers become ZEH by 2020." seems to be difficult.

The system, ability, and improving proficiency related to the handling of energy-efficient houses at small and medium-sized builders are issues on the supply side. At the same time, on the demand side, issues include the cost burden for improving energy-efficiency performance of existing houses and buildings, low consumer awareness, low understandings of its merit, and restrictions on energy generation potential in large-scale condominiums, etc. The composition is the same for buildings, and, while Japanese government has been cooperating with stakeholders to develop overseas markets especially for ZEB, further efforts is required. In addition, there is a need to enhance the standards for energy consumption performance of houses and buildings based on the Building Energy Efficiency Act, and reconsider the housing performance display system in which the highest grade of building envelope performance is equivalent to the energy conservation standards.

<Future efforts>

To create the environment where houses and buildings with high energy-efficiency performance and energy- efficiency renovation can be expanded without policy support, for the time being, it is necessary to provide policy support for them, and to consider to introduce further regulatory measures for houses to improve the compliance rate with energy-efficiency standards, based on the expanding situation for energy efficient houses.

Regarding the enhancement of standards, etc., toward carbon neutrality, the government will strive to improve energy-efficiency performance by reviewing the standards for energy consumption performance of houses and buildings, certifying standards for life quality housings, as well as the housing performance display system, and extending the life of houses and buildings. On that occasion, the government will, in aiming to maximize the energy generation potential, establishing a system to encourage the introduction of renewable energy such as photovoltaics (it will also consider regulatory methods for houses and buildings), with in mind the development of solar cells that can also be installed on (1) existing houses/buildings with a small roof load capacity, (2) walls and windows of houses/buildings, etc., on which it is now difficult to install due to technical restrictions. Also, it will take support measures to expand houses and buildings equipped with renewable energy and energy-saving home remodeling by introducing next-generation solar cells on the walls of buildings. On that occasion, it will also promote advertise and PR its advantages to raise consumer awareness. It will also work to reduce carbon dioxide emissions through the spread of LCCM houses and buildings that make carbon dioxide emissions negative throughout the life cycle.

Moreover, as for ZEB, the government will, through the activities for formulation of ISO standard etc., further work on demonstration project and horizontal expansion to foreign countries including ASEAN.

Through the above measures, in addition to cultivating demand for forefront houses and buildings such as LCCM housing and buildings and ZEH/ZEB in the domestic market, it also aims to improve quality of life/living. Additionally, for some technologies and products cultivated in the domestic market, government aims to expand them overseas.

[3] Wooden buildings that contribute to carbon fixation

<Current status and issues>

Wood is reproducible and carbon-storable, will reduce fossil fuel consumption and contribute to reduction of carbon dioxide emissions therefore it is necessary to promote the use of wood in buildings.

About 80% of low-rise houses are wooden structure, while the ratio of wooden buildings in non-residential, middle/high-rise buildings is still less than 10%. In order to promote wooden construction non-residential, middle/high-rise buildings, it is a challenge to disseminate construction methods utilizing new wooden materials such as CLT and wooden construction technology in new fields such as middle/high-rise houses, and to train its architects.

<Future efforts>

The government will continue to support the construction of practical and diverse wooden buildings, etc., to which leading design and construction technologies will be introduced. In addition, it will continue to support efforts to develop information portal sites related to wooden buildings design, such as standard plans and textbooks for non-residential, middle/high-rise wooden buildings, and efforts to train its architects. In addition, it will promote public procurement in Japan to disseminate and promote the use of timber.

[4] High-performance building materials/equipment

<Current status and issues>

So far, the government has been improving the performance of equipment and building materials by the Top Runner Program based on the Act on the Rationalization etc. of Energy use, and supporting the demonstration and introduction by subsidies such as the demonstration of next-generation energy saving building materials. On the other hand, introduction of equipment and building materials by consumers has not progressed due to the fact that the performance improvement of equipment and building materials has partially leveled off and the health benefits of performing energy-efficiency remodeling have not been fully recognized. These may be included in the challenges. In particular, remodeling involves a large amount of expenditure, and there are also cost issues.

<Future efforts>

In order to improve the energy-efficiency performance of houses and buildings, including existing ones, it is necessary to expand the spread of building materials such as heat insulating sashes and equipment such as high-efficiency air conditioners. Therefore, for the time being promoting the introduction of forefront equipment and building materials to the market through demonstration projects, etc., and will work together with the public and private sectors to reduce prices. In combination with this effort, in consideration of the expanded introduction of high-performance equipment/construction materials into the markets through these projects, it aims to significantly strengthen the top runner equipment/building material standards and promote so that the supply of high-performance equipment/building materials to the market will become normal.

Furthermore, it aims to establish a display system and performance evaluation system for equipment and building materials that are easy for consumers to understand, including the impact on costs such as electricity charges and gas charges.

[5] Next-generation solar cell

<Current status and issues>

Japanese organizations are competing with all research institutes around the world in its research and development of next-generation solar cells, and the conversion efficiency of 24.9% has been achieved at of the laboratory level in Japan. On the other hand, South Korea has achieved the world's highest conversion efficiency of 25.4%. As regards in modules, domestic companies have achieved the world's highest conversion efficiency of 17.9%.

In the future it will be a challenge to realize the performance that exceeds current solar cells at the product level (in means of conversion efficiency, durability, cost, etc.) and development of new markets such as building wall surfaces (including building integrated photovoltaics(BIPV), etc.) by technological development that matches the needs (design, etc.) of end users.

<Future efforts>

The government will thoroughly support the development of promising technologies such as Perovskites, and accelerate research and development for performance improvement. It will prioritize R & D investment so that the stage can move from the lab level to a practical one, aiming for commercialization in 2030.

In particular, in order to put next-generation solar cells, which can be installed on walls with technical restrictions for existing solar cells, into practical use and create a new market, it will demonstrate the social implementation etc. of next-generation solar cells and related products.

(13) Resource circulation-related industries

Regarding the goals of Reduce, Reuse, Recycle, and Renewable, the government is supporting technology development and social implementation through laws and planning. Waste power generation, heat utilization, and biogas utilization have already entered the commercial phase and are becoming more widespread and sophisticated. In the future, these efforts will be further promoted by advancing technology, improving equipment, lowering costs, etc., based on discussions at the "The Council for National and Local Decarbonization". By 2050, Japan will reduce greenhouse gas emissions as a whole while advancing the transition toward the Circular Economy.

[1] Reduce and Renewable

<Current status and issues>

As regards the goal of Reduce, the government is promoting efforts based on the Basic Act on Establishing a Recycling Society, the Basic Plan, and various recycling laws.

Regarding the goal of Renewable (biomass conversion, utilization of recycled materials, etc.), it is promoting the replacement of plastics derived from fossil resources with renewable biomass plastics, paper, etc. through a demonstration project. In addition, it is promoting the replacement of fossil resource-derived plastics with biomass plastics through the Green Purchasing Law.

<Future efforts>

As regards the goal of Reduce, the government will demonstrate a system for sharing necessary information on used products and materials among related parties in order to promote efficient resource recycling and CO_2 saving.

In respect of the use of biomass and recycled materials, it will promote technology development/demonstration, development/sophistication of recycling technology, equipment maintenance, and demand creation for higher functionality of biomass materials and expansion/low cost of applications for further expansion of recycling.

[2] Reuse, Recycle, and utilization of exhaust gas

<Current status and issues>

As regards the goals of Reuse and Recycle, the government is promoting efforts under the Basic Act on Establishing a Recycling Society, the Basic Plan, and various recycling laws, and it is promoting the expansion of procurement of recycling products under the Green Purchasing Law, and is also promoting the expansion of procurement of recycling products in Japan. Additionally, the demonstration of the recycling technology, the introduction support of the equipment for recycling in Japan is in progress.

Regarding the utilization of incineration facility exhaust gas, etc., the CCU plant is already in operation at the waste incineration facility. In addition, a demonstration project to generate methane, ethane, etc. from waste gas generated by incineration and gasification of waste is in progress.

<Future efforts>

As regards the goal of Recycle, in order to further expand recycling, the government will develop and advance high-performance materials and recycling technology with high recycling properties, optimize recovery routes, expand installed capacity, and expand the recycling market.

Regarding the utilization of incineration facility exhaust gas, etc., it will promote efforts toward practical use by developing innovative technologies, scaling up, reducing costs, etc. through demonstration projects.

[3] Waste power generation, heat utilization, biogas conversion, fixation of exhaust gas

<Current status and issues>

In order to avoid the generation of methane due to landfill of organic waste, organic waste is incinerated or biogasified, and the energy is collected.

Regarding waste power generation, Japan has improved the power generation efficiency of waste incineration facilities every year through technology development of boiler materials, etc., and achieved an average of 13.58% in FY2018.

As regards heat utilization, the government is promoting effective utilization by supplying heat generated from waste incineration facilities to nearby utilization facilities through heat pipes.

As regards biogasification, since the amount of energy collected per amount of waste processed by incineration at small and medium-sized waste treatment facilities is limited, waste energy is collected by biogasification technology by methane fermentation.

As for the fixation of exhaust gas from incineration facilities, the government is developing technology at the lab level to fix CO_2 separated and recovered from the exhaust gas from waste incinerators.

<Future efforts>

As regards waste power generation, the amount of heat generated will decrease due to major changes in the quality of waste in the future (such as an increase in the ratio of kitchen waste due to a decrease in the ratio of plastic waste), and there is a concern that the power generation efficiency will decrease. The government will proceed with technological development to ensure high-efficiency energy recovery.

As for heat utilization, since the location conditions of waste incineration facilities have a large effect on the degree of heat utilization, in addition to improving the operating efficiency of waste incineration facilities, the government will promote improvement of heat storage and transportation technology for supplying heat to distant facilities and cost reduction.

Regarding biogas, it will proceed with a technology demonstration project with a view to increasing the scale of methanization facilities due to major changes in waste quality in the future.

(14) Lifestyle-related industries

In order to promote the spread of technology for decarbonizing life styles, based on discussions at the "The Council for National and Local Decarbonization", etc., the government will work on introduction support, system construction, etc. to promote the total management of housing/transportation (ZEH/ZEB, equipment on the demand side (home appliances, hot water supply, etc.), local renewable energy, EVs/FCVs as moving storage batteries, etc. that are now being put into practical use), behavioral change through 'nudge' and sharing, technology development/demonstration that promotes CO_2 reduction credit using digital technology, etc. By means of the above, by 2050, Japan will realize a carbon-neutral, resilient and comfortable life (to an era of earning by energy by switching to a decarbonized prosumer).

* Decarbonized Prosumer: Homes that produce more energy than they consume with renewable energy

[1] Total management of housing and transportation (Practical use of combinations of ZEH/ZEB, demand-side equipment, regional renewable energy, EV/FCV, etc.)

<Current status and issues>

Combining ZEH/ZEB, demand-side equipment (home appliances, hot water supply, etc.), local renewable energy, EV/FCV, etc., demonstration and social implementation are currently being carried out in advanced areas and blocks toward ensuring flexibility consistent with the mainstreaming of renewable energy and sector coupling of electricity, heat, and mobility.

<Future efforts>

It is necessary to combine ZEH/ZEB, equipment on the demand side, renewable energy in the region, EV/FCV, etc., and to remotely control a wide variety of equipment for optimization by autonomous control or ICT. It is also necessary to form a market. In addition, in order to further reduce CO_2, it is necessary to promote the spread of renewable energy electricity and heat that is close to demand, and to demonstrate and implement the technology in society.

While pursuing networking between houses and buildings by DC power supply, etc., ensuring flexibility consistent with the mainstreaming of renewable energy utilizing hydrogen, etc., as well as demonstrating and social implementation of technology related to sector coupling of electricity, heat, and mobility, a business model needs to be established by designing an appropriate market for popularization.

[2] Behavior change by means of nudge, digitalization, and sharing, etc.

<Current status and issues>

○ Nudge and BI-Tech (integration of behavioral insights with Tech)

While maintaining Japan's superiority in advocating the concept of fusion of behavioral insights such as nudge and cutting-edge technologies (BI-Tech), the government is implementing demonstration projects for its social implementation, maintaining international cooperation.

○ Digitalization

Using blockchain technology, the government is demonstrating the construction of a market where the CO_2 reduction value (environmental value) of renewable energy of individuals and small and

medium-sized enterprises can be traded freely at low cost.

The government is experimentally developing an urban carbon mapping method that visualizes the area/dynamic energy use through digitization of a combination of various statistical data.

○ Sharing

The government supports the creation of precedent cases related to decarbonized transportation by car-sharing of EVs utilizing regional renewable energy and community-contribution decarbonized logistics utilizing battery exchange type EVs and battery stations.

<Future efforts>

○ Nudge and BI-Tech

The government will pursue the development/implementation, standardization of more advanced system technology that supports daily life by digitalizing behavioral information in daily life, aggregating and analyzing it, and proposing eco-friendly and comfortable life styles based on behavioral sciences and AI, and incorporate them in business models for sales of products and service.

○ Digitalization

While utilizing the results of the demonstrations so far, the government will try to digitize the application procedure, simplify and automate the monitoring and credit certification procedures, so that the environmental value can be traded and utilized in a limited time lag in the J-credit system, as well as to consider creating a trading market using block chains and aim to start operation from 2022 at the earliest.

It aims to develop a tool that can be used universally by the regions using the urban carbon mapping method so that, through potential evaluation of technology introduction for decarbonization prosumer, etc., future scenario and measures for realization of zero carbon city can be utilized by local governments nationwide. It will promote the construction of smart cities equipped with a decentralized energy system nationwide while ensuring security.

○ Sharing

The government will promote the establishment of business models related to decarbonized transportation by car-sharing of EVs utilizing local renewable energy, and community-contribution decarbonized logistics utilizing battery exchange type EVs and battery stations, and horizontal expansion at the national level.

[3] Enhancement of scientific infrastructure related to observation and models

<Current status and issues>

By advancing observation technology, modeling technology, and simulation technology, the government is elucidating climate change mechanisms, reducing uncertainty, and aiming for a more accurate estimation of CO_2 emissions.

The government is building and expanding an observation network based on artificial satellites, aircraft, ships, and ground observations in close cooperation with the international framework.
The government is promoting further utilization of GHG observation data, climate change projection data, etc. through the data infrastructure such as data integration/analysis system (DIAS).

<Future efforts>

The government aims to improve time and spatial resolution in observation and modeling technology, pursue further elucidation of the climate change mechanism, high-resolution and precise climate change projection data, and continuous observation and monitoring, and promote the further utilization of GHG observation data, climate change projection data, etc. through the data infrastructure such as data integration/analysis system (DIAS), etc. in order to enhance the scientific base.

The observation network and the analysis system will be integrated and upgraded. The effect of the decarbonization efforts will be evaluated using the system, and the potential evaluation of effective technology introduction will be performed.

(1) "Roadmap" of Growth Strategies for offshore wind power generation industries

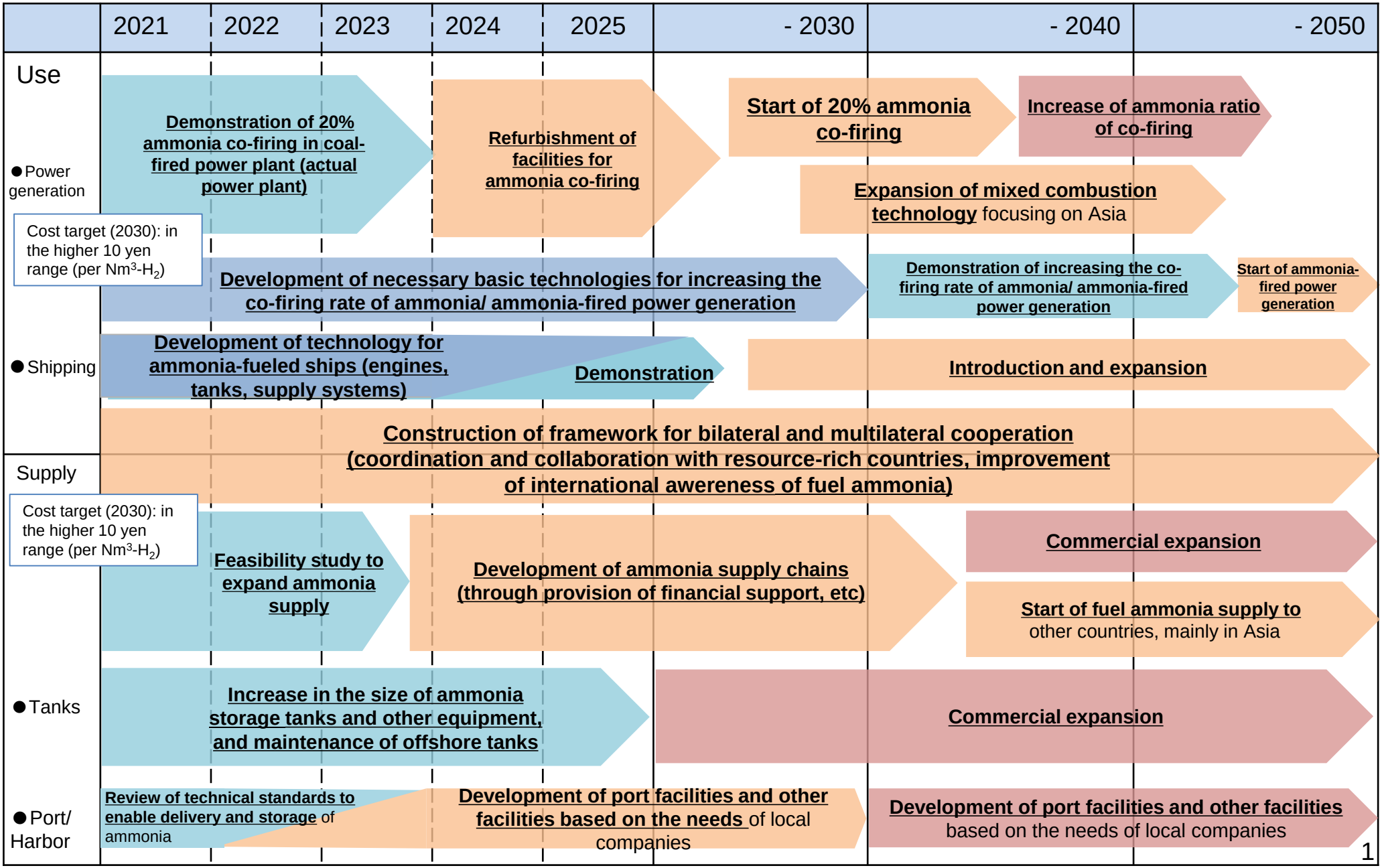
● Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase

● Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

	2021	2022	2023	2024	2025	- 2030	- 2040	- 2050
Creation of attractive domestic market **[Government target]** ● Introduction target 2030 10 GW 2040 30-45 GW	Demand creation by public-private partnership through **Public-Private Council** (**Government commits to introduction target, the Industry commits to Japan content and cost reduction target**)							
	Public tender based on **Act on Promoting Utilization of Sea Areas for Renewable Energy Generation** (prospect for awarding capacity: 1 GW/year, 10 GW/year by 2030)						(30–45 GW by 2040) * including floating offshore wind	
	Social demonstration **led by government (preliminary survey of wind condition, geology and so on)**			**Push-type project scheme** (establishment of Japan version of a centralized model)				
	Establishment of first master plan, detailed study of HVDC power transmission			**System development** to connect suitable location for wind power generation and power demand area				
				Steady development of base ports				
Investment promotion and formation of supply chain **[The industry's target]** ● Japan content 2040: 60% ● Cost target 2030-2035: 8-9 yen	**Formation of competitive and resilient domestic supply chain** (goal setting and steady implementation by the Industry)					2030 - 2035 Power generation cost: 8-9 yen/kWh	In 2040 Japan content : 60%	
	Strengthening of competitiveness of suppliers							
	When assessing public occupancy, evaluate the formation of a robust supply chain (domestic or equivalent) from the perspective of securing a stable power supply, matching support by JETRO, etc.							
	Support for formation of supply chain considered							
	Promotion of regulatory reform (rationalization of safety review, leaving regulations, etc.)			Further promotion of regulatory reform				
	Establishment of offshore wind power talent development program			**Promotion of offshore wind power talent development**				
Next-generation technology development and cross-border collaboration with a view to expansion into Asia	Establishment of technology development roadmap							
	Development of next-generation technology including **floating offshore wind** (using funds)						**Commercialization and expansion of introduction of floating offshore wind**	
	Promotion of bilateral dialogue, joint R&D and international demonstration aiming for global expansion						**Financial support for overseas development** (supported by NEXI/JBIC)	
	International standardization of safety evaluation methods, etc. for floating offshore wind							

(2) "Roadmap" of Growth Strategies for fuel ammonia industries

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.



(3) "Roadmap" of Growth Strategies for hydrogen industry

● Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase

● Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

●Region	2021	2022	2023	2024	2025	- 2030	- 2040	- 2050
Utilization						★Target (in 2030) Cost: 30 yen/Nm3 Volume: up to 3 million ton		★Target (in 2050) Cost: less than 20 yen/Nm3 Volume: around 20 million ton
●Transportation	See execution plans for **Automobile, shipping** and **aircraft industries**							
	Clarification of technical standards for FC railway vehicles and performance requirements for ground equipment → **Review of related standards and regulations**						**Cost reduction**	
	Demonstration test							
●power generation	**Technology development for large-scale Gas Turbine for 100% hydrogen**							
	Real machine demonstration of hydrogen power generation (fuel cell, blending and 100% hydrogen combustion in turbines)							
	Promotion of social implementation by Act on Sophisticated Methods of Energy Supply Structures, etc.							
	Support for domestic and foreign expansion (fuel cell, large and small turbines)							
●Steelmaking	**Large scale demonstration of COURSE50** (30% reduction of CO_2 by hydrogen utilization, etc.)					**Introduction support**		**Set as decarbonization standards**
	Technology development for hydrogen reduction steelmaking						**Establishment of technology**	**Introduction support**
●Chemical	**R&D** for technology to produce plastic raw material from hydrogen, etc.					Large scale demonstration	**Introduction support**	
●Fuel cell	**Technology development** for innovative fuel cell						**Introduction support** for innovative fuel cell	
	Multiuse development, investment support for production equipment, introduction support							
Transportation, etc.	**Technology development** for enlargement of international transportation					**Large-scale verification, international standardization** of transportation technology, **Reform of technical standards to enable delivery, storage, etc.** at port	**Support for commercialization and international expansion**	
	Development and demonstration of large hydrogen refueling station for commercial vehicles							
	Cost reduction and introduction support by regulatory reform, etc. for hydrogen refueling station							
Manufacturing ●Water electrolysis	**Support for enlargement, environmental improvement for performance evaluation** for water electrolyzer, etc.							
	Support for global expansion (acquisition of foregoing overseas market)							
	Promotion of social implementation through **environmental improvement of domestic market (raised DR, etc.)** for utilization of surplus renewable energy						**Further diffusion** by utilization of post-FIT renewable energy, etc.	
●Innovative technologies	**R&D and demonstration** of innovative technologies (photocatalyst, solid oxide-type water electrolysis, hydrogen production utilizing high temperature heat source such as HTGR, etc.)						**Introduction support**	
Cross-cutting	**Hydrogen utilization demonstration in Fukushima** and **at ports, coastal areas, airports, etc.** where power plants, etc. are located						**Nationwide expansion by development of infrastructure, etc.**	
	Demonstration, transition support and diffusion of autonomous distributed energy system utilizing **local resources such as renewable energy**							
	International collaboration for standardization (definition of clean hydrogen, etc.)							
	Strengthening of relations with resource-rich countries, establishment of international hydrogen market through development of countries of demand							
	In cooperation with execution plans for **offshore wind, fuel ammonia, carbon recycling** and **life style-related industries**							

(4) "Roadmap" of Growth Strategies for nuclear industry

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

	2021	2022	2023	2024	2025	- 2030	- 2040	- 2050
Small module reactor (SMR)	Practical application in USA, Canada, etc. by around 2030 -> Japanese companies participate in foreign demonstration projects				Japanese companies acquire position of major supplier		Cost reduction by sales expansion and mass production	Global expansion to Asia, East Europe, Africa, etc.
HTGR Cost target (hydrogen) 2050: 12 yen/Nm^3	Restart of HTTR	Test to confirm "inherent safety" utilizing HTTR			Technology development required for carbon-free hydrogen production		Demonstration of connective technologies between carbon-free hydrogen plant and HTGR Verification required for implementation	Cost reduction by sales expansion and mass production
	Promotion of international cooperation utilizing HTTR capable of world's highest 950°C output							
	Establishment of carbon-free hydrogen production technology utilizing high temperature heat (IS process, methane pyrolysis method, etc.)							
Fusion energy	Construction of fusion experimental reactor (ITER) and production of various equipment with international cooperation				Commencement of operation of ITER ・Plasma control test for fusion energy reaction		Commencement of operation of ITER fusion energy ・Combustion control and engineering test with deuterium and tritium ・Verification of fusion energy engineering technology	
	・Complementary experiment for ITER using JT-60SA ・Conceptual design of DEMO reactor and development of underlying technologies				Engineering design and full-scale technology development for DEMO reactor			Verification required for implementation
	Promotion of human resources development and academic research							
	Venture companies of USA, UK, etc. target practical application by around 2030							
	Japanese venture companies, etc. participate in overseas project as R&D partner and supplier Equipment delivery							

(5) “Roadmap” of Growth Strategies for Automobile and Battery Industries

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

	2021	2022	2023	2024	2025	up to 2030	up to 2040	up to 2050
Promoting vehicle electrification and transforming how to use automobiles	**Expanded introduction of electrified vehicles and their infrastructure** Ex: Utilizing fuel economy regulations, promoting public procurement, expanding the charging infrastructure, supporting the introduction of electrified vehicles and encouraging car replacement, etc.							
	Strengthening electrified vehicle-related technologies such as batteries, fuel cells, and motors, and their supply chain and value chain Ex: Supporting large-scale investment, technology development/demonstration, the electrification of light vehicles and commercial vehicles, studying how to support small and medium suppliers in business transformation and the creation of a digital development platform to support the business transformation, supporting car dealers in vehicle electrification and business transformation, etc.							
	Transforming how to use automobiles Ex: Promoting users choosing and using electrified vehicles, sustainable mobility services, the utilization of autonomous driving and digital technology and cooperation with road and urban infrastructures toward the realization of enhanced efficiency and improved productivity in logistics, etc.							
Carbon neutralization of fuel	**Large-scale synthetic fuel production and technical development support** Ex: Improving the efficiency and lowering the cost of existing technologies, developing innovative new technologies and processes, and establishing integrated manufacturing processes							
Battery	**Lowering battery prices through the economics of scale** Ex: Supporting large-scale investment in batteries, resources, materials, and the like, supporting the introduction of stationary batteries, etc.							
	R&D/technology demonstration Ex: Improving the performance of all-solid-state lithium-ion batteries and innovative batteries, improving the performance of battery materials, high-speed, high-quality and low-carbon manufacturing processes, reuse/recycling, offering power supply and demand balancing capability, etc.							
	Development of rules and standardization Ex: Visualizing CO_2 emissions through the life cycle of batteries, ethical procurement of materials, international rules and standardization for reuse promotion, developing/standardizing performance labels for home-use batteries, institutional designs toward participating in the power supply and demand balancing market (opening scheduled for 2024), clarifying the position of storage batteries for power grids under the Electricity Business Act, etc.							

(6) "Roadmap" of Growth Strategies for Semiconductor/Information and Communication Industries (Green by Digital)

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

	2021	2022	2023	2024	2025	up to 2030	up to 2040	up to 2050
DX-related markets reaching a level of 24 trillion yen in 2030								
● DX promotion	○ Studying measures to further accelerating DX in each industry, company, and region • Studying DX-based energy saving in priority areas (the industries that involve physical movement of people and things, the industries that use considerable amounts of electricity)							
● Software development	○ R&D/demonstration for next-generation cloud software and platforms			○ Demonstration		○ Introduction support such as cost reductions	○ **Further promotion of electrification and DX**	
● Promoting CO_2 emission reductions using digital technology	○ Demonstration for the promotion of regional CO_2 emission reductions utilizing digital technology					○ Introduction support such as cost reductions		
The data center service market reaching a level of 3 trillion yen in 2030, with approximately one trillion yen invested in data centers								
● Promoting data centers on the land in Japan	○ Promoting data centers on the land • Promoting CO_2 emission reductions at data centers / creating preliminary cases of zero-emission data centers • Decentralizing Internet traffic							
● Supporting the introduction of renewable energy ● Coordination for the early construction of data centers	○ Promoting the introduction of renewable energy to the electrical industry, data centers, etc.							
● Expanded purchase of renewable energy certificates for renewable electricity	○ Expediting the development of power infrastructure toward the early construction of data centers		○ Starting the operation of new mechanisms for the early construction of data centers on the land in Japan				○ Expanding domestic green data centers	
● Expanding safe and secure infrastructure markets	○ Studies on how institutions should be toward the promotion of renewable electricity procurement							
	○ Studies on measures for the development, supply and introduction promotion of data centers, HPC, etc.							
Expanded commercialization of Post 5G and Advanced 5G in 2025 Commercialization of Beyond 5G in 2030								
● Advanced information and communication infrastructure	○ R&D toward the commercialization of Post 5G information and communication systems and Advanced 5G ○ R&D toward the sophistication of highly energy-efficient optical electronics (optical chips, photoelectric co-packaging, photoelectric fusion processors, etc.)					○ Supporting equipment investment	○ Expanded introduction	
	○ Strategic promotion of Beyond 5G: Advanced research phase ○ R&D on element technologies toward the realization of Beyond 5G					○ Accelerated research phase	○ Supporting equipment investment	○ Expanded introduction

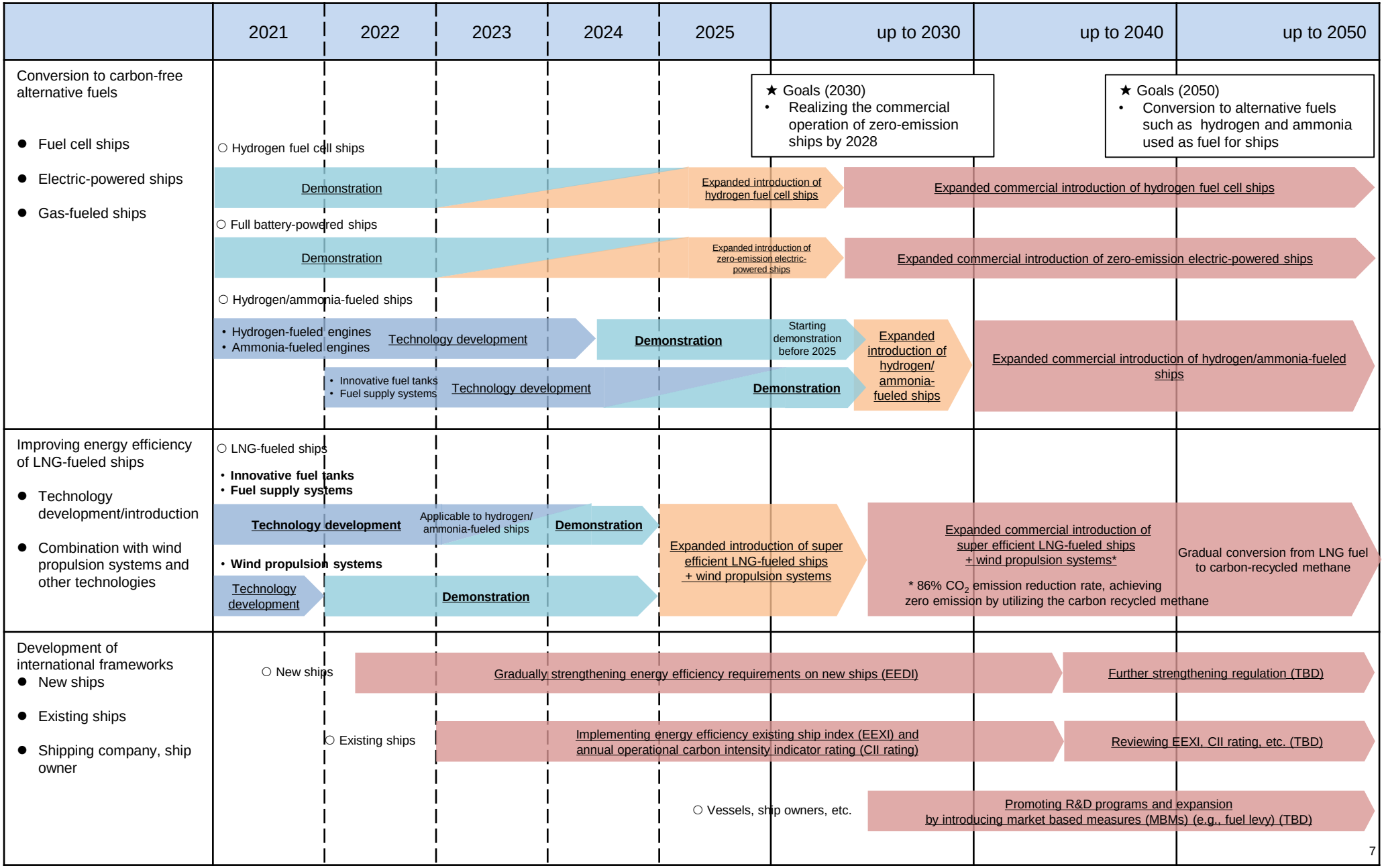
(6) "Roadmap" of Growth Strategies for Semiconductor/Information and Communication Industries (Green of Digital)

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

	2021	2022	2023	2024	2025	up to 2030	up to 2040	up to 2050
Demonstration of equipment using next-generation power semiconductors in 2025 Energy-efficient power semiconductors (50% or more energy saving) in 2030, with a world market share of 40% worth 1.7 trillion yen								
● Next-generation power semiconductors and others	○ Supporting equipment investment to expand the production of state-of-the-art power semiconductors					○ Supporting equipment investment	○ Completing the replacement of existing semiconductors and equipment by 2050	
● Energy-efficient electrical equipment	○ R&D on ultra-high efficiency next-generation power semiconductors (state-of-the-art Si, GaN, SiC, Ga_2O_3, etc.) ○ R&D on ultra-high efficiency next-generation energy-efficient equipment (power electronics, motor control semiconductors, etc.) • Integrated R&D on peripheral technologies such as power devices, circuit systems, passive devices, etc. • Developing facilities/equipment required for R&D on devices, circuit systems, etc. ○ R&D on next-generation passive elements and mounting materials (such as coils)							
	○ Demonstration, implementation, and sophistication of technology relating to the applications for which the results from next-generation semiconductors (such as GaN) can be utilized (such as LED and wireless power transmission)							
30% energy-saving at all new data centers in 2030, converting part of the power consumed at data centers to renewable energy								
● Energy-efficient, sophisticated computing	○ Supporting equipment investment to expand the production of energy-efficient semiconductors						○ Striving to achieve carbon-neutral data centers by 2040	
	○ R&D toward energy-efficient data centers R&D on next-generation computing (such as optical electronics) such as HPC					○ Introduction support		
	○ R&D toward energy-saving of the entire system through enhanced efficiency of software processing							
● Utilizing renewable energy and energy-saving at data centers	○ Promoting CO_2 emission reductions at data centers / creating preliminary cases of zero-emission data centers (described earlier)							
	○ Promoting the introduction of renewable energy to the electrical industry, data centers, etc. (described earlier)							
Expanded commercialization of Post 5G and Advanced 5G in 2025 Commercialization of Beyond 5G in 2030 (realizing significant energy saving compared to present levels (1/100 of the power consumption today)								
● Sophisticating information and communication infrastructure	○ R&D toward the commercialization of Post 5G information and communication systems and Advanced 5G ○ R&D toward the sophistication of highly energy-efficient optical electronics (optical chips, photoelectric co-packaging, photoelectric fusion processors, etc.)					○ Supporting equipment investment	○ Expanded introduction	
	○ Strategic promotion of Beyond 5G: Advanced research phase ○ R&D on element technologies toward the realization of Beyond 5G					○ Accelerated research phase	○ Supporting equipment investment	○ Expanded introduction

(7) "Roadmap" of Growth Strategies for Shipping Industry

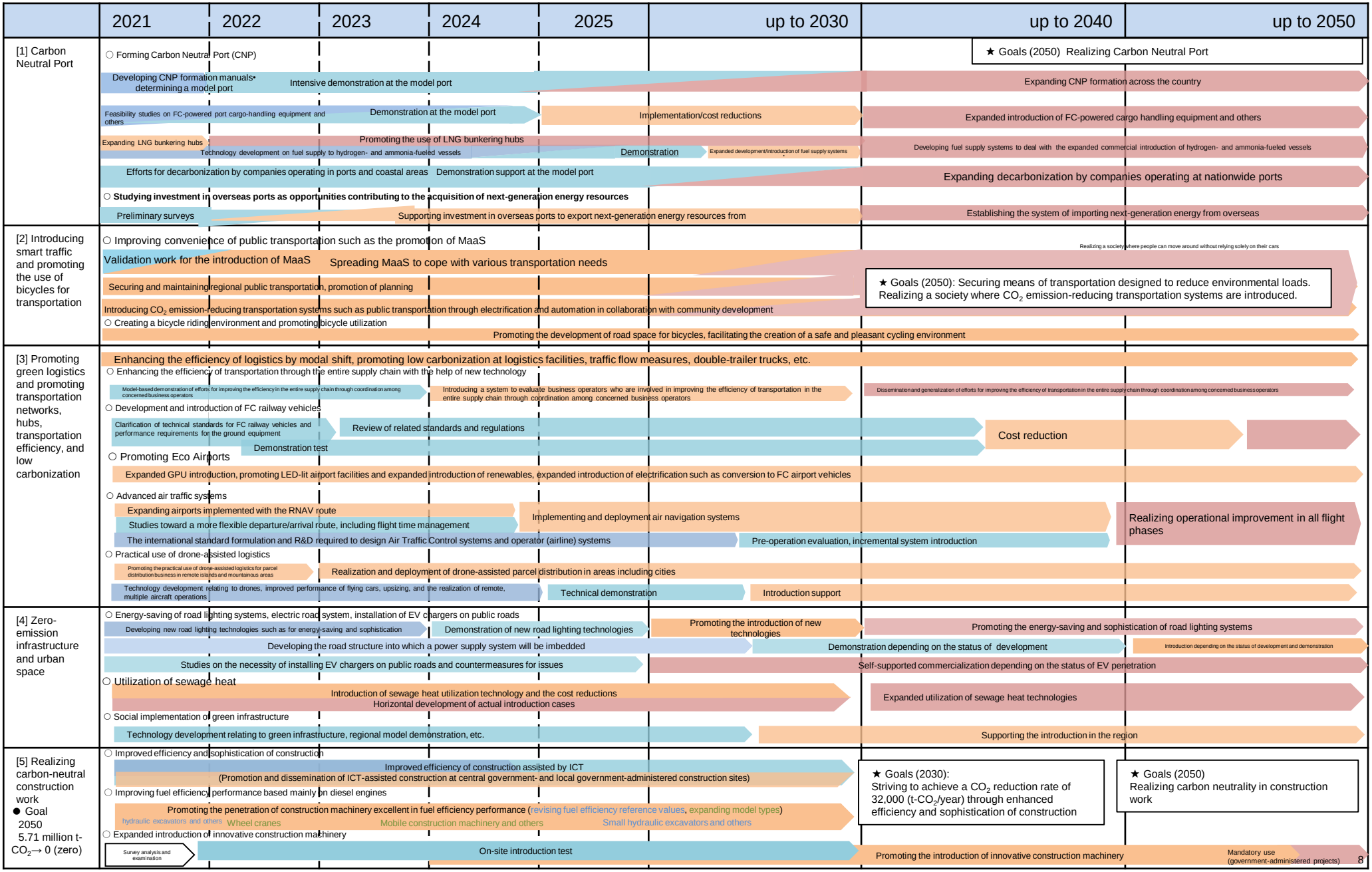
- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.



(8) "Roadmap" of Growth Strategies for Logistics, People Flow, and Civil Engineering Infrastructure Industries

● Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase

● Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.



(9) "Roadmap" of Growth Strategies for Food, Agriculture, Forestry and Fisheries

● Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase

● Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

	2021	2022	2023	2024	2025	-2030	-2040	-2050
Greenhouse gas emission reduction / From energy procurement and production to distribution / consumption stage	○ Construction of local production for local consumption energy system							
	Development of a regional system based on low-cost renewable energy production/utilization technology that maximizes the use of regional resources, energy supply and demand analysis, etc.						Demonstration of VEMS (energy management system tailored to the area of agricultural, mountain and fishing villages)	Introduction of VEMS to be expanded
	○ Reduction of emissions of paddy methane and agricultural land soil N_2O							
	Elucidation of the ecology of soil microorganisms involved in the generation of methane and N_2O, development of low-methane rice breeding materials by genome editing, development of biological nitrification inhibition (BNI) enhanced varieties to reduce GHG and water pollutants						Development and demonstration of microbial materials that suppress the generation of methane and N_2O	Commercialization of practical varieties and commercialization of materials
	○ Reduction of livestock-derived methane and N_2O emissions							
	Development of methane-suppressed feeding technology for livestock and low-methane / low-N_2O feeding management methods					Demonstration of livestock feeding management technology	Utilization of support system by visualizing GHG reduction amount	
	○ Electricity and hydrogenation of agricultural and forestry machinery and fishing boats							
	Promote electrification and hydrogenation of agricultural and forestry machinery and fishing boats						Demonstrate electrification system, etc.	Spread and expansion of electrification systems, etc.
	○ Smart food chain							
	Development and demonstration of smart food chain basic technology					Start of operation of smart food chain, utilization by private companies, etc.		
	○ Wooden construction of high-rise buildings, biomass-derived materials							
	Examination of material standards for timber utilization in high-rise buildings, development of advanced utilization technology for domestic timber						Trial construction / demonstration of high-rise wooden buildings, etc.	Dessemination of high-rise wooden buildings, etc.
	Development of high-performance materials using modified lignin, CNF, etc.		Plant demonstration by a company * Demonstration and dissemination of some materials will start in 2020			Popularization of biomass-derived material products		
	○ Expansion of sustainable consumption							
	Transformation of consumer behavior （Review product selection that emphasizes appearance, promote local production for local consumption, reduce food loss and waste）							
CO2 Absorption / fixation	○ Development and dissemination of new superior varieties and F1 plus trees							
	Search/selection/functional gene analysis of excellent strains, efficiency/speedup of selection of excellent individuals						Demonstration of seedling production such as new generation elite tree	Expanding the spread of afforestation with excellent varieties
	Development of ICT production management system consistent with automated machines and cloud, labor saving of afforestation work utilizing sensing technology					Demonstration and dissemination of comprehensive smart forestry technology		
	○ Wooden construction of high-rise buildings, biomass-derived materials (repost)							
	Examination of material standards for timber utilization in high-rise buildings, development of advanced utilization technology for domestic timber						Trial construction / demonstration of high-rise wooden buildings, etc.	Dissemination of high-rise wooden buildings, etc.
	Development of high-performance materials using lignin derivatives, CNF, etc.		Plant demonstration by company * Demonstration and dissemination of some materials will start in 2020			Popularization of biomass-derived material products		
	○ Biochar							
	Understanding the impact of biochar on farmland production, GHG balance, etc.					Development and demonstration of biochar materials and biochar supply technology	Implementation of LCA, establishment of biochar standards	Spread of bio-charcoal materials, expansion of carbon storage in agricultural land at home and abroad
	○ Blue Carbon							
	Development of seagrass beds / tidal flats creation/ regeneration/conservation technology, identification of useful substances in aquatic plants				Demonstration of seaweed bed/tidal flat creation/regeneration/conservation technology, trial production of pharmaceuticals / new materials using seaweed, etc.		Increase in blue carbon due to expansion of seagrass beds and tidal flats, creation of pharmaceutical and new material industries	

★Goal (as of 2050)
Achieving zero emissions of fossil fuel-derived CO2 in agriculture, forestry and fisheries

(10) "Roadmap" of Growth Strategies for aircraft industry

● Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase

● Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

	2021	2022	2023	2024	2025	-2030	-2040	-2050
Transport-ation	★Regulation Regarding international aviation, ICAO institutionalized not to increase CO2 emissions compared to 2019 (2021-2035)							★Goal CO2 emissions halved from 2005 as of 2050 (IATA target)
● Electrification	R & D for **equipment electrification**					**Technology demonstration**	**Technology installation and expanded adoption**	
	R & D for **electrification of propulsion system (hybrid electric)**					**Technology demonstration**	**Technology installation and expanded adoption**	
	* Electrification technology can be installed sequentially from small machines (from the latter half of the 2020s)							
● Technology development for hydrogen-powered aircraft	R & D for **core technology for hydrogen-powered aircraft**					**Technology demonstration**	**Technology installation and expanded introduction**	
● Weight saving Efficiency	R & D for **engine efficiency (material, design, etc.)**					**Technology demonstration**	**Technology installation and expanded adoption**	
	Technology installation and expanded adoption							**Independent expansion**
	R & D for **carbon fiber** composite for airframe structure					**Technology demonstration**		
	* Engine, electrification, and hydrogen related technologies are partially complementary to one another.							
	Strengthen international cooperation with Europe and the United States for the above items							
● Jet fuel	**【Bio jet fuel, etc.】** Establishment of stable fuel manufacturing technology and cost reduction						**Expanding supply** of competitive bio-jet fuel, etc. in response to **trends in the international market for bio-jet fuel, etc.**	
	【Synthetic fuel】 Establishment of integrated manufacturing process from CO2 to synthetic fuel							
	* For bio-jet fuel by culturing microalgae, refer to the implementation plan of the carbon recycling industry.							

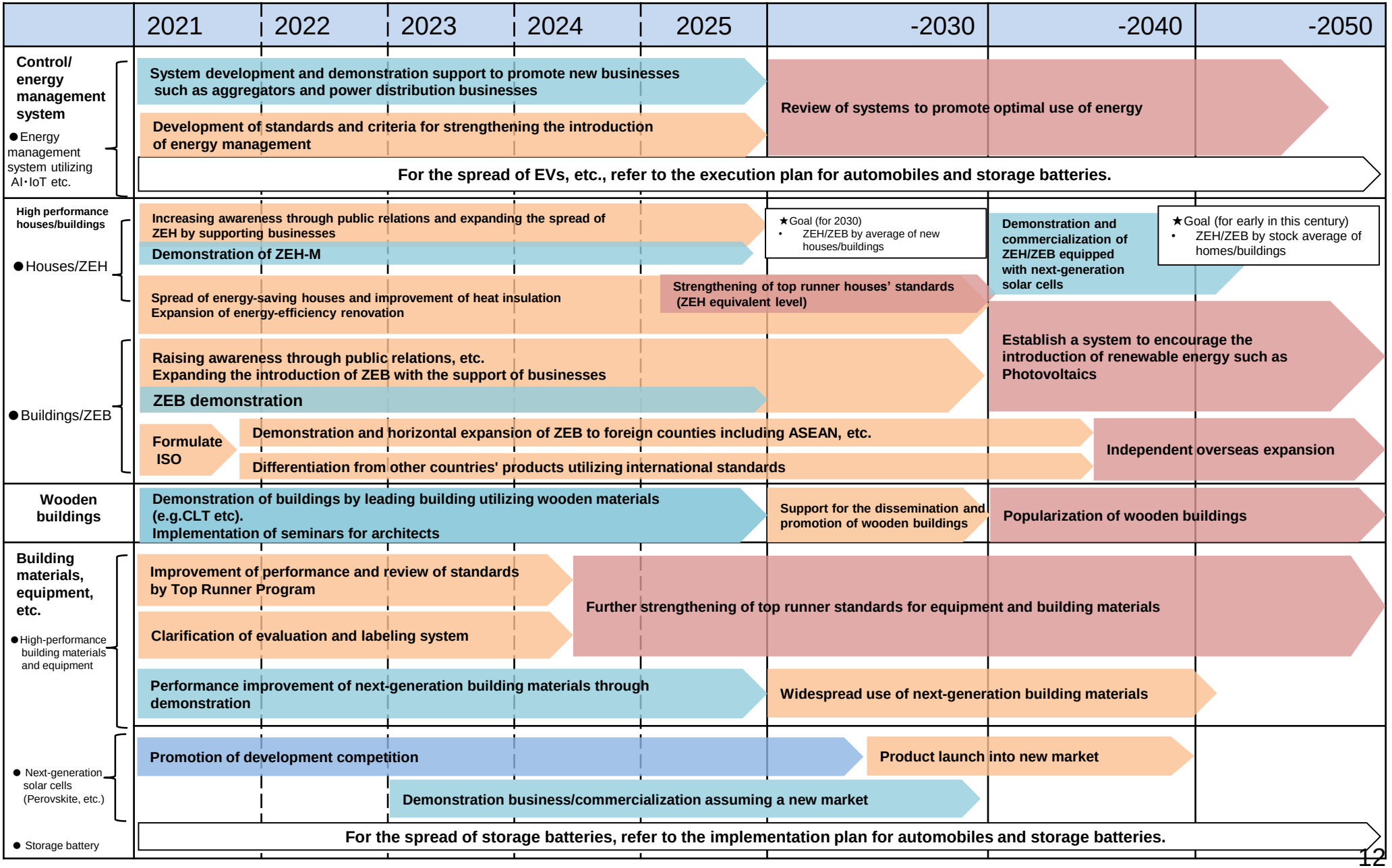
(11) "Roadmap" of Growth Strategies for carbon recycling industry

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

*Representative examples are shown	2021	2022	2023	2024	2025	-2030	-2040	-2050
●Concrete Cost target for 2030 30 yen level /kg (＝Equivalent to existing products)	・Introduction is considered in **Osaka Expo** (2025) ・CO_2 absorption concrete technology will be registered in the **Database of the Ministry of Land, Infrastructure, Transport and Tourism** on new technologies. Expanding awareness to local governments. Furthermore, sales channels will be expanded and costs will be reduced by expanding public procurement.						・**Expanding sales channels to developing countries** through global standardization, PR at large-scale international exhibitions, etc.	
	・Technology development of **concrete with rust prevention performance**			・**Demonstration of concrete with rust prevention performance**				
	・**Industry-academia-government officials from Japan and the United States** carrying out **a joint project on CO_2 carbonate (concrete)** ・ **Concluding MOC concerning collaboration in the field of Carbon Recyclig** with related countries and promote **joint research and demonstration**							
●Fuel Cost target for 2030 100 yen level/L (＝Equivalent to existing products) **(Biofuel from microalgae culture)**	・ **Large-scale demonstration and cost reduction** for commercialization around 2030 ・ Regarding international aviation, **ICAO** has institutionalized not to increase CO_2 emissions compared to 2019 (2021-2035) (*ICAO: International Civil Aviation Organization)						・ **Expanding** supply of competitive microalgae jet fuel to aircraft in response to **trends in the international biojet fuel market**	
	・ Continued technological development for **improving productivity and quality** through improvement of CO_2 absorption efficiency and stable growth of microalgae							
●Chemicals Cost target for 2050 100 yen level/kg (=Equivalent to existing products) **(Artificial photosynthesis)**	・Developing **highly productive photocatalyst** required for large-scale demonstration ・Relaxing related regulations, establish safe-keeping and safety standards						・**Large-scale demonstration**	・**Support for cost reduction/introduction** by subsidy etc.
●Separation recovery Cost target (/CO 2 t) Low-pressure gas: for 2030 2 ,000 yen level High-pressure gas: for 2030 1,000 yen level DAC : for 2050 2,000 yen level Target scale for 2050 About 2.5 billionCO2t in the entire world	○ Derived from exhaust gas							
	・**Developed highly efficient CO2 separation and capture technology to reduce costs**			・**Large-scale demonstration**			・**Expanding introduction** by further cost reduction	
	○ Derived from atmosphere (DAC)							
	・R&D for **technology of direct CO_2 capture from the atmosphere (DAC)** (Enhancement of energy efficiency, **cost reduction**) through utilization of the moonshot type R&D system, etc.						・Further cost reduction through **demonstration**	・ **Expanding introduction** through further cost reduction and subsidy etc.

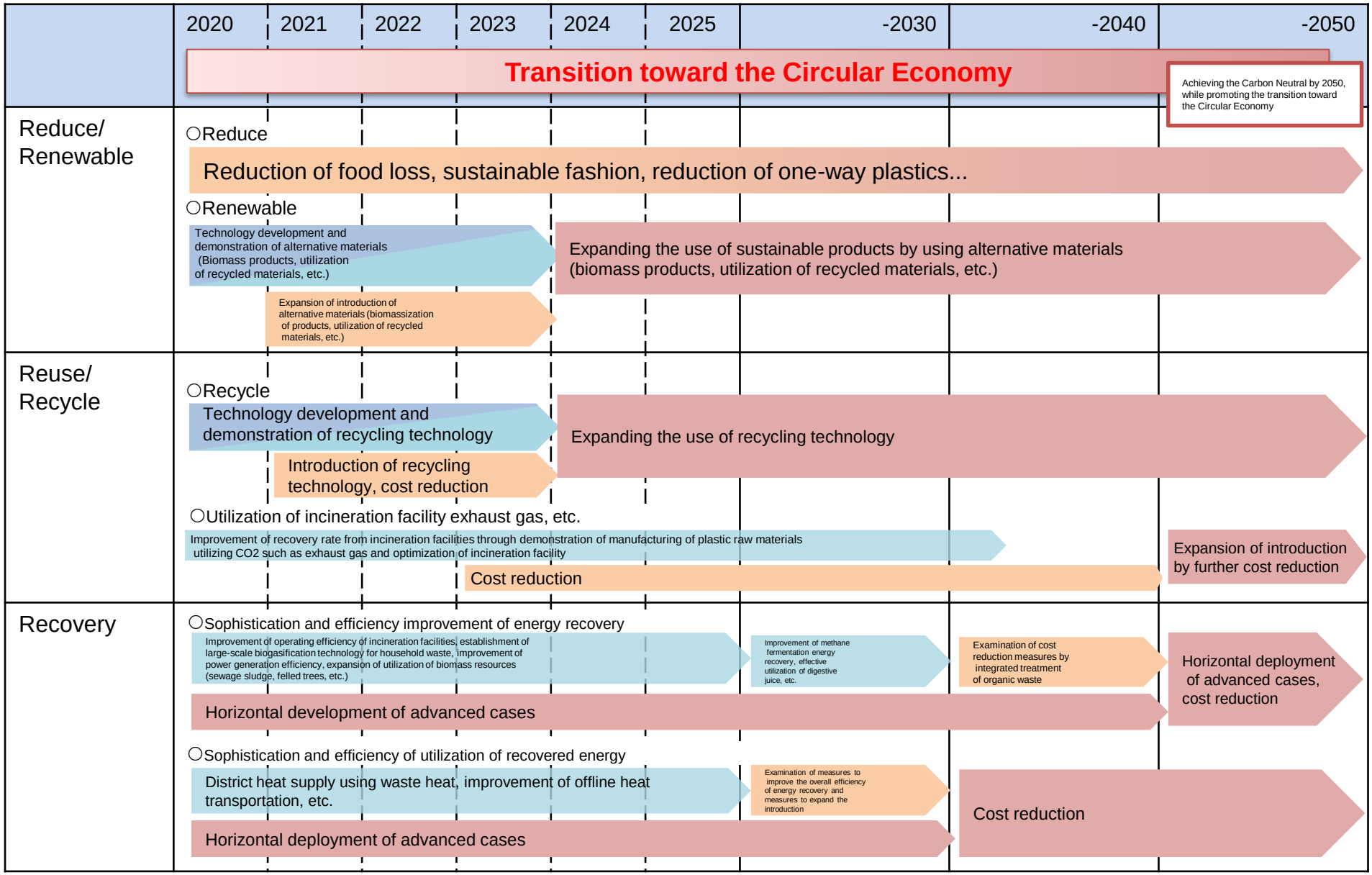
(12) "Roadmap" of Growth Strategies for houses and buildings industry/ next-generation solar power generation industry

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.



(13) "Roadmap" of Growth Strategies for resource recycling- related industry

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.



(14) "Roadmap" of Growth Strategies for lifestyle-related industry

- Introduction phase: 1. Development phase → 2. Demonstration phase → 3. Introduction and expansion/ cost reduction phase → 4. Autonomous commercialization phase
- Policy means to be substantiated: [1] goals, [2] legal systems (such as regulatory reform), [3] standards, [4] tax, [5] budget, [6] finance, [7] public procurement, etc.

	2021	2022	2023	2024	2025	-2030	-2040	-2050
Total management of housing and transportation	Expansion of carbon neutral (decarbonized prosumer) at home ○ Total management that combines ZEH/ZEB, demand-side equipment, regional renewable energy, EV/FCV, etc. Expanding decarbonized prosumers that realize decarbonization of housing and mobility Demonstration/social implementation/dissemination of heat and electric energy derived from proximity demand type renewable energy					Reduction of conversion cost to decarbonized housing / movement	Generalization of decarbonized prosumers ★Goal Achieve a carbon-neutral, resilient and comfortable life by 2050	
	Ensuring flexibility through equipment on the demand side and hydrogenation					Cost reduction	Establishing mainstay of renewable energy and ensuring flexibility	
	Networking between houses and buildings by direct current power supply, etc. Sector coupling of electricity/heat/mobility					Cost reduction	Establishment of autonomous decentralized energy system according to regional characteristics	
Behavioral changes etc.	○ Nudge and BI-Tech BI-Tech technology demonstration			Lifestyle proposals and appropriate scale services according to the characteristics of individuals, households, and communities			Expansion of consciousness change and behavior change by Nudge, BI-Tech, etc.	
	○ Digitization (promotion of credit for SME / individual CO2 reduction, urban carbon mapping, etc.) Considering the creation of a J-credit trading market using blockchain technology					Starting operation of digitalized J-credit system	Expansion of transactions, generalization of decarbonized prosumers	
	City carbon mapping development, etc.			Demonstration/ phased introduction		Establishment of a business model	Examination of generalization methods such as standardization	
	○ Sharing Creation of precedent cases of various sharing including EV					Establishment of a business model	Nationwide expansion through self-sustaining commercialization	
Scientific basis	○ Enhancement of scientific knowledge for verification of reduction effect, etc. Research and development through observation and model development			Demonstration/ phased introduction		Extraction of technologies and development of results that are effective in reducing GHG	Examination of standardization, proposal on scenario for realization of decarbonized society, evaluation of negative emission	