Strategic Energy Plan

October 2021

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Preamble

Ten years have passed since the Great East Japan Earthquake, including the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company (TEPCO). This unprecedented disaster of 10 years ago is the starting point for all of energy policies, and it is the responsibility of the Government of Japan (GOJ) to firmly face the heartache of the victims who are still forced to live as evacuees and to work for the restoration of Fukushima to the end. This must be forever remembered by all those involved in energy policies. In such circumstances, the Sixth Strategic Energy Plan is formulated based on the two major perspectives: (i) Respond to the climate change issue and (ii) Overcome the challenges facing Japan's energy supply-demand structure.

[Countermeasures to climate change issues]

The issue of climate change has been recognized as an urgent problem common to mankind. It is not easy to clarify the relationship between individual weather disasters and global warming. According to the "Summary for Policymakers of the Report of Working Group I of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)" released in August 2021, increase in the frequency and intensity of extreme high temperatures, ocean heat waves, heavy rainfall, etc. are reported to expand in direct relation to the progress of global warming, and the issue of climate change must be addressed by all nations of the world. Under these circumstances, aiming for decarbonization, countries of the world including developed countries are striving to create not only technologies but also rules that are advantageous to their own countries based on their own industrial structures in the international rule-making phase, and businesses are also beginning to strengthen their competitiveness by using decarbonization technologies. In the 21st century and beyond, as elements of leadership competition on climate change and decarbonization are newly added to the struggle for supremacy in digital technology, Japan is also required to enhance its international competitiveness through new innovations that contribute to energy conservation technologies, decarbonization technologies, and carbon neutrality, which Japan has cultivated so far, in addition to making international rules. It is essential to encourage private sectors to make bold investments and innovations by accurately grasping the trend of major transformation, such as Green Transformation (GX) and Digital Transformation (DX) and by implementing proactive growth strategies for the future and to realize a paradigm shift to a socioeconomic structure that responds to the post-Corona era, while maintaining and creating employment.

Future initiatives to address the climate change issue have the potential to completely change the industrial structure that has been established since the Industrial Revolution, and if we fail to respond to such change, we may lose our industrial competitiveness. On the other hand, if Japan takes the initiative in establishing international rules and applies its decarbonization technologies to solving the issues of decarbonization in the world, especially in Asia, it could lead to an opportunity to create new growth industries.

In light of such global trends, on October 2020, Japan declared that it would aim to realizing "carbon neutrality by 2050," and in April 2021, Japan has also set a new target to reduce greenhouse gas emissions by 46% in FY 2030 from FY 2013 levels. Furthermore, Japan will continue strenuous efforts in its challenge

to meet the lofty goal of cutting its emissions by 50%.
It is necessary for each citizen to recognize as over the era of considering response to climate change as a constraint or cost to economic growth, and that we have entered an era in which response to climate change is considered internationally as an opportunity of growth and an important factor that determines the industrial competitiveness of each country. With this understanding, it is important for all entities to work toward the realization of carbon neutrality.
The major key to addressing the climate change issue is to transform the energy supply-demand structure, and we need to be aware of this global trend as a premise for discussion when considering future energy policies.

[Overcoming challenges of Japan's energy supply and demand structure]
Japan's energy supply-demand structure is on the way to major transformations as global concern over climate change is increasing.
As the energy facilities built during the period of high economic growth are aging, an unprecedented large-scale power outage occurred in Japan, which never occurred in the period of high economic growth. It was due in part to new factors including the increasing scale of natural disasters, and the already recognized importance of stable supplies. In order to establish a strong and stable energy supply-demand structure for the future, the public and private sectors need to continue their unified efforts, including securing the necessary investment and developing the business environment to make it possible.
On the other hand, electricity prices in Japan have remained high since the Great East Japan Earthquake. In addition to the traditional electricity intensive industries, power consumption is expected to increase in new fields including the information and communication industries and in society due to the progress of digitalization. Control of electricity prices is an important issue that directly affects Japan's industrial competitiveness.
The manufacturing industry in Japan, which currently accounts for more than 20% of Japan's GDP, should continue to play an important role in the country's industrial structure in the future. It is therefore essential to introduce not only initiatives to realize carbon neutrality in the industrial world but also provide for a stable and affordable energy supply to support it.
We need to mobilize all policies in order to further pursue the major principle of S+3E, which has always been the major premise of energy policy, that is, ensuring stable and cost-effective energy supply and addressing the issue of climate change, on the major premise of ensuring safety.

[Relationship between the structure of the 6th Strategic Energy Plan and the targets for 2050 and FY 2030]
The Sixth Strategic Energy Plan is formulated based on these two major perspectives. It consists of a long-term vision toward carbon neutrality by 2050 and policy responses toward 2030 based on this vision. It indicates the path that future energy policy should take.

The new target of reducing greenhouse gas emissions for FY2030 is an ambitious target, consistent with carbon neutrality by 2050, and the relationship between the two is newly organized as follows.

In other words, the various measures and technological development in the energy sector that will be undertaken in the future toward 2030 will be all linked to carbon neutrality by 2050. In order to meet the new reduction target for FY2030, we will make the maximum use of existing technologies to achieve this ambitious target. Then, toward carbon neutrality by 2050, we will develop and disseminate decarbonization technologies that have not yet been implemented in society while promoting energy decarbonization by further expanding/deepening the initiatives for the FY2030 target.

On the other hand, it is difficult at this point to accurately predict the success or failure of various technological developments and innovations for the year 2050, and it is required to constantly determine the important points of measures and technological developments based on the latest information while setting an ambitious vision of carbon neutrality for the year 2050.

Even when we are developing measures for decarbonization without eliminating various possibilities and working on technological development to realize innovation aiming for carbon neutrality by 2050, it is a natural premise to aim for stable and cost-efficient energy supply while always ensuring safety as the major premise. Based on the major premise of S+3E, aiming to achieve the new reduction target for FY 2030 and the ambitious vision of carbon neutrality by 2050, our basic strategy for future energy policy will be to take the concept of using all available technologies, without eliminating any possibilities.

The current Strategic Energy Plan will be formulated to organize these concepts.

1. Progress in the past decade after the accident at TEPCO's Fukushima Daiichi Nuclear Power Station

(1) Reconstruction of Fukushima is the starting point of the energy policy

This year is the tenth anniversary of the Great East Japan Earthquake, including the accident at TEPCO's Fukushima Daiichi Nuclear Power Station (FDNPS). The starting point for this review of the Strategic Energy Plan is to make a fresh start of energy policy, keeping in mind the experiences, reflections and lessons learned from the accident at FDNPS.

As of March 2021, there are still 22,000 victims of the disaster subject to the evacuation order due to the accident, and it is the responsibility of the GOJ, which has been promoting an energy policy using nuclear power, to firmly face the heartache of the disaster victims, stay close to them, and make utmost efforts for restoration and reconstruction of Fukushima to the end. Without these efforts, there is no possibility to restore the trust of citizens in future energy policies, and the GOJ, as well as the Ministry of Economy, Trade and Industry (METI), needs to ensure the transfer of this awareness to future generations.

Then, if we are to continue to use nuclear power, we must not forget for a moment that we fell into the "myth of safety" and failed to prevent the disastrous situation.

In order to realize carbon neutrality by 2050 and the new reduction target for FY2030, Japan, which experienced the accident at the TEPCO's Fukushima Daiichi Nuclear Power Station, will reduce its dependence on nuclear power as much as possible, while giving top priority to safety in nuclear power and expanding renewable energies.

(Decommissioning of FDNPS: On-site)

Decommissioning of FDNPS is a major prerequisite for the restoration of Fukushima. Preparing for a serious nuclear accident like the FDNPS accident is a difficult project with no precedent in the world. Therefore, the GOJ takes the initiative rather than leaving it up to the business operators and, with the goal of completing the decommissioning between 2041 and 2051, is concentrating the wisdom of Japan and abroad and is working with an indomitable resolve to implement each measure safely and steadily based on the "Mid- and Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station " ("Mid- and Long-Term Roadmap") (Decided in December 2019 by the Inter-Ministerial Council for Decommissioning, Contaminated Water, and Treated Water Countermeasures).

This Mid- and Long-Term Roadmap is in principle subject to continuous review based on the situation of the site, the progress in decommissioning and measures for the contaminated and the treated water, etc. It was revised for the fifth time in December 2019. In this revision, in light of the gradual progress in the return of residents to their homes and restoration in the surrounding areas, we positioned "coexistence of reconstruction and decommissioning" as the main principle in order to give top priority to early risk reduction and safety assurance.

Based on this main principle, the decommissioning work is moving forward step by step. First, the

environment in the premises has greatly improved since the accident reactors have been maintained in a cold shutdown state. The radiation level in the premises has been greatly reduced, and the operators can work in ordinary clothes at about 96% of the premises. Second, the amount of contaminated water generated has been significantly reduced by multilayered measures such as frozen soil wall (540 m^3 per day (May 2014) → 140 m^3/day (average for 2020)). Third, the removal of fuel from the spent fuel pools has been completed for Units 3 and 4 (Unit 4: completed in December 2014, Unit 3: completed in February 2021). Fourth, grasp of the situation through internal investigation has progressed toward the retrieval of fuel debris. The decommissioning of the FDNPS is a difficult task that is not foreseeable, and we will review the process appropriately in light of newly identified on-site conditions, including delays in individual tasks, and proceed safely and steadily to complete the decommissioning between 2041 and 2051. The method of treatment/disposal of the retrieved fuel debris will be determined by analyzing its properties, etc., after the start of removal.

(Restoration / reconstruction of Fukushima: Offsite)

The evacuation order was lifted in all areas except for the Restricted Area, and the population and size of the Areas under Evacuation Orders decreased by approximately 70% compared to when the areas were established (Number of people subject to evacuation order from the Areas under Evacuation Orders: 81,000 (August 2013) → 22,000 (March 2021); Size of the Areas under Evacuation Orders: 1,150 km^2 (August 2013) → 337 km^2 (April 2020)).

In the affected areas, the environment for returning home has been improving, with the full reopening of the JR Joban Line in March 2020, affected businesses operators are rebuilding their businesses and livelihoods, and new industries are emerging. For example, as of the end of May 2021, about 2,700 business operators resumed their activities through individual support by the joint public-private team, etc. In March 2020, the Fukushima Hydrogen Energy Research Field, one of the world's largest hydrogen production facilities, entered into operation, and the Fukushima Robot Test Field was fully opened. As of the end of May 2021, 343 demonstration experiments were conducted and 55 companies have entered into the local market.

(2) Future efforts for reconstruction of Fukushima

The restoration and reconstruction of Fukushima will continue to be a top priority for GOJ. Until then, we will solve further difficult issues one by one, including the decommissioning of the FDNPS, efforts to lift the evacuation order for the Restricted Area and efforts for independent industrial development.

With regard to the decommissioning of the FDNPS, as the restoration and reconstruction of Fukushima proceeds on a full scale, extremely difficult efforts will be made, such as the removal of fuel from the spent fuel pools of Units 1 and 2 and the retrieval of fuel debris. For this reason, we will be more conscious than ever about the "coexistence of reconstruction and decommissioning." Then, the GOJ will continue to provide necessary support for research and development projects that are technically challenging and require the GOJ to take the initiative under the Mid- and Long-Term Roadmap. We will also share our decommissioning technologies and knowledge with the world through multilateral cooperation frameworks such as the International Atomic Energy Agency (IAEA) and the Organisation for Economic Co-operation and Development / Nuclear Energy Agency (OECD/NEA), as well as bilateral cooperation frameworks with the USA, UK, France, and Russia, in order to contribute to safety improvement and enhancement of the disaster prevention functions of nuclear facilities in each country. In addition, the Japan Atomic Energy Agency (JAEA) will establish the technical basis for decommissioning by steadily developing the facilities of the Naraha Center for Remote Control Technology Development, CLADS Main Building of the Collaborative Laboratories for Advanced Decommissioning Science, and the Okuma Analysis and Research Center.

The "Basic Policy on handling of ALPS treated water at the Tokyo Electric Power Company Holdings' Fukushima Daiichi Nuclear Power Station" (Decided by the Inter-Ministerial Council for Contaminated Water, Treated Water and Decommissioning issues), was announced in April 2021. Against rumor-based adverse impacts on reputation, the ALPS treated water, in which radionuclides other than tritium were removed from contaminated water to meet the regulatory standard for discharge, will be discharged into the sea by TEPCO at the FDNPS in about two years, and only after obtaining approval from the Nuclear Regulation Authority on the premise of strict safety assurance and thorough government-wide measures. To achieve this goal, the GOJ will make a unified efforts to take measures against rumor-based adverse impacts on reputation, support businesses for the future, and realize prompt and appropriate compensation, under the "Inter-ministerial Council toward the Steady Implementation of the Basic Policy on handling of ALPS Treated Water," which was newly established in April 2021. In addition, with regard to the efforts for reduction of the contaminated water generation as much as possible and the separation of tritium, new technological trends will be carefully and continuously monitored, and if a viable technology emerges, it will be implemented as rapidly as practicable.

With regard to the Restricted Area, no matter how long it takes, with an awareness that it is the Government's responsibility to lift the evacuation orders in the all Restricted Area in the future and to reconstruct and revitalize the affected areas, the government proceeds with the improvement of living environment for lifting the evacuation order on the Specified Reconstruction and Revitalization Base Areas. For areas outside of the Specified Reconstruction and Revitalization Base Areas, based on the "Policy on Lifting Evacuation Orders

for Returning to and Living in areas Outside Specified Reconstruction and Revitalization Base Areas" (August 31, 2021, Joint Meeting of the Reconstruction Promotion Council and the Nuclear Emergency Response Headquarters), in the 2020s, the government will decontaminate the areas necessary for the return of residents and work to lift the evacuation orders, after carefully confirming each resident's intention to return, so that residents with the intention to return can do so. The government will continue to consider how to deal with the remaining land and houses in consultation with the local governments.

While steadily implementing the transportation of removed soil, etc. to the interim storage facilities, we will continue to make our utmost efforts to restore the environment in Fukushima by promoting the recycling of the removed soil and developing a nationwide understanding of the situation with a view to the final disposal of the removed soil outside of Fukushima Prefecture.

In order to achieve self-sustaining industrial development in the Hamadori area, etc., we will continue to promote the restoration of businesses and livelihoods and the creation of new industries through further implementation of the Fukushima Innovation Coast Framework as both wheels. In addition, since issues such as securing manpower and attracting visitors have become apparent in the affected areas, we will encourage the return of evacuees, promote migration, and settlement, , and expand the exchange population to attract consumption from outside the region, in order to maintain and form a vibrant local community.

"The Fukushima Plan for a New Energy Society," formulated in 2016, was revised in February this year as it entered its second phase in FY2021, with the aim of further expanding the introduction of renewable energy and hydrogen as the two pillars and achieving development to social implementation in this phase. The Government will work toward the realization of this plan by further expanding the introduction of renewable energies such as wind power generation in the prefecture, building a decentralized energy system such as local micro-grids using local renewable energies by diverse entities, promoting the technological development for further enlargement and modularization of water electrolysis equipment using the Fukushima Hydrogen Energy Research Field (FH2R) opened in Namie Town, and building a model for the realization of a hydrogen society so that hydrogen produced by FH2R is used in the prefecture. Through these efforts, toward the future of Fukushima as well as entire Japan, the Government will facilitate, and solidify in the local context, challenging efforts, which are essential for realizing net-zero by 2050, such as the maximum introduction of renewable energies and the social implementation of hydrogen.

2. Changes in the situation since formulation of the 5th Strategic Energy Plan

The situation involving energy is rapidly progressing. In the three years since the last Strategic Energy Plan was formulated and in addition to the growing interest in the climate change issue, changes in the lives of people due to the rapid spread of COVID-19 infections, the economic security environment in response to the changes in geopolitical and geo-economic situations, etc. are rapidly progressing. As a demand of the times, energy policies are also required to take into account such domestic and international trends.

(1) Global trends toward decarbonization

1) Impacts of global warming and global trends

Responses toward carbon neutrality have become a global trend.

In recent years, extreme heavy rains that have never been experienced before and record-breaking heat occurred frequently in many parts of the world, and there are concerns about increase in damage from floods and wildfires, etc. For example, according to the Japan Meteorological Agency, the global average temperature in 2020 was the second highest since statistics began in 1891, and the average temperature in Japan in 2020 was the highest since statistics began in 1898. In addition, the "Summary for Policymakers of the Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" reported that "it is unequivocal that human influence has warmed the atmosphere, ocean and land." It is not easy to clarify the relationship between individual weather disasters and global warming, but the report states that anthropogenic climate change is already affecting many weather and climate extremes in all regions of the world and forecasts increase in the frequency and intensity of extreme high temperatures, ocean heat waves, and heavy rainfall.

Internationally, the COP21 (the twenty-first session of the Conference of the Parties to the United Nations Framework Convention on Climate Change), held in December 2015, adopted the Paris Agreement, a fair and effective international framework in which all countries participate, and full-scale implementation began in 2020. The Agreement declared to aim at achievement of an equilibrium between emissions from anthropogenic sources and removal from sinks of greenhouse gases (global carbon neutrality) in the second half of this century, to hold the increase in global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, to require all countries including major emitting countries to submit and update their NDCs every five years for global response to climate change, to require them to report and review the status of implementation in a common and flexible manner, etc.

At the same time, based on decarbonization, competition among nations and businesses is accelerating as an industrial policy to capture the technologies that will become the core of future growth industries. Considering the coming wave of decarbonization and digitalization as inevitable, GOJ is required to take measures to support bold investments ahead of time and capture the underlying technologies and equipment in advance for strategic linkage to future economic growth and market acquisition. For example, in the United

States and Europe, there is a growing movement to make climate change measures a policy objective of "green recovery" as part of economic measures for recovery from the economic downturn caused by the COVID-19 pandemic. China has also made clear its policy to promote the development of new energy sources such as renewable energy and nuclear power under its new five-year plan.

In the industrial world, centering on global companies, there is a sign of moving toward large-scale investment in innovations that will lead to carbon neutrality and challenging for a drastic change of their business models in order to survive in a decarbonized society in the future. In terms of investment, ESG investment, which emphasizes environment, society, and governance, is booming in the world, and the global market size is estimated to be worth US$35.3 trillion(approx. 3,500 trillion yen). It is becoming a new responsibility of GOJ to encourage businesses to invest strategically.

Thus, internationally, the era in which response to global warming is considered a constraint or cost to economic growth is over, and we have entered an era in which it is seen as an opportunity for growth.

2) Japan's declaration of carbon neutrality and capture of the global decarbonization market

In view of such changes of the times, GOJ declared in October 2020 to realize carbon neutrality by 2050, and announced in April 2021 a new reduction target for FY 2030, setting an ambitious target which is aligned with the long-term goal of net-zero by 2050.

There are more than 120 countries and regions, including Japan, that have announced their intention to realize carbon neutrality by 2050, and if we can find a way to become carbon neutral ahead of these countries, we can set a precedent for other countries that are facing similar issues to Japan.

The share of greenhouse gas emissions in developed countries in the total global greenhouse gas emissions was about 70% in 1990, but has now declined to about 40%, and the ratio between developed and developing countries is reversing. While developing countries, especially emerging countries in Asia, are expected to achieve a significant economic growth in the future, they are still dependent on fossil fuels for most of their energy sources. In order to reduce global emissions, decarbonization is necessary not only developed countries but also emerging countries including Asia, and the issues that need to be overcome are common to Japan as well.

Therefore, in order to achieve both sustainable economic growth and carbon neutrality, if Japan utilizes its decarbonization technologies and support the efforts for realistic transition in Asian and other countries, it will contribute to ensuring Asia's energy security and decarbonizing the world, especially Asia, and lead to creating new growth industries.

3) Rising global expectations for renewable energy and challenge for a decarbonized energy system by various industries

In recent years, the prices of renewable energy have declined significantly both at home and abroad. According to the analysis in the "Net Zero by 2050" report by the IEA (International Energy Agency) on the scenario for achieving net zero CO_2 emissions in 2050, renewable energies should account for two-thirds of the world's energy supply. The capacity of solar photovoltaic power generation and wind power generation is expected to increase 20 times and 11 times, respectively, between now and 2050 (carbon price is expected

to rise in the future according to the IEA's outlook).

Triggered by these rising expectations for renewable energies, the challenge of developing a decarbonized energy system that combines renewable energies, energy storage, digital control technologies, etc. is being accelerated involving a wide range of industries. Some of the large electric and gas companies have taken on the challenge for development of a distributed energy system based on renewable energy as well as for hydrogen and methanation. On the demand side, some global companies are aiming to cover 100% of their electricity consumption with renewable energy, and are beginning to impose very strict conditions on their Japanese subsidiaries, supply chain companies, etc. in material procurement. In order for Japanese companies to lead decarbonization on a global scale, it is greatly expected to promote the mass introduction and utilization of renewable energy in a way that meets the needs of consumers.

On the other hand, in order to introduce a large amount of renewable energy, it is necessary to work on securing suitable land in a way that coexists with the local community, improvement of the flexibility of the electric power system such as securing balancing power in response to the increase in variable renewable energy sources such as solar photovoltaic and wind, as well as cost reduction, etc.

Expectations for renewable energy have been rising more than ever before, and competition for technological innovation toward self-sustainability and decarbonization will be in full swing in the future, such as improvement in power generation efficiency, increase in the flexibility of electricity system by securing decarbonized balancing power and developing energy storage system, establishment of a distributed network system, and cost reduction. GOJ will also urgently respond to the needs of businesses that venture into development of a decarbonized energy system.

4) Green growth strategy to create a "virtuous cycle of economy and environment"

Proactive implementation of global warming measures will lead to changes in the industrial structure and socio-economy, which in turn will lead to the next great growth. In order to realize such a "virtuous cycle of economy and environment," the "Green Growth Strategy" was formulated in June 2021 in collaboration with relevant government ministries and agencies1, based on the Progressive Environment Innovation Strategy (decided by the Integrated Innovation Strategy Promotion Council in January 2020).

There are many businesses in the industrial world that will need to drastically change their business models and strategies in order to become carbon neutral by 2050. This is an opportunity to lead a new era. The role of GOJ is to fully support the positive challenges of the private sector businesses to make bold investments and initiate innovations.

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1 Relevant ministries and agencies refer to the Cabinet Secretariat, Ministry of Economy, Trade and Industry, Cabinet Office, Financial Services Agency, Ministry of Internal Affairs and Communications, Ministry of Foreign Affairs, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Agriculture, Forestry and Fisheries, Ministry of Land, Infrastructure, Transport and Tourism, and Ministry of the Environment. The above-mentioned ministries and agencies are responsible for the description of their respective parts, etc. in this Strategy. The Cabinet Office has a wide range of responsibilities, but the Economic and Social Research Institute and the Secretariat for the Promotion of Science, Technology and Innovation are in charge of statistics, indicators and areas related to the Progressive Environment Innovation Strategy.

Recognizing that energy policy is directly related to Japan's growth strategy, GOJ should create an environment where private companies can easily take on challenges by presenting a specific vision to the extent possible and setting a high goal. From the perspective of industrial policy, GOJ should set high targets and mobilize all possible policies in the fields where Japan is leading in elemental technologies, such as hydrogen, fuel ammonia, carbon recycling, and nuclear power, as well as in the fields where market expansion is expected in the future, such as offshore wind power and storage batteries.

(2) Changes in the situation related to energy other than the climate change issues

1) Rising tensions in international economic/energy security due to the US-China conflict

In recent years, the U.S. and China have been confronting each other in various areas, including trade issues, competition over advanced technology, and response to the COIVD-19 infection. The confrontation is also extending to the areas of politics, diplomacy, military, and security, media, and education, etc., which has led to frequent accusations and sanctions against the other country. The escalating confrontation between the US and China has increased tensions in the Asia-Pacific region, and the importance of ensuring economic and energy security is rising more than ever.

On the other hand, China's rise in the field of technologies that will contribute to decarbonization, such as solar panels, power storage to support EVs, digitalization technology, and nuclear power, has been remarkable. Japan's supply of solar panels by domestic companies has declined significantly over the past several years, and the country has become increasingly dependent on China. Under such changing circumstances, it is becoming increasingly important to secure core technologies domestically in the energy supply chain and to secure key materials such as copper and rare metals that are essential for electrified vehicles[2] and renewable energy facilities. To that end, it is necessary to work on overcoming vulnerabilities in the supply chain, including the technologies required for each process from resource development at upstream to final product at downstream. and renewable energy facilities. To that end, it is necessary to work on overcoming vulnerabilities in the supply chain, including the technologies required for each process from resource development at upstream to final product at downstream.

In addition, there is also a major change in the Middle East, on which Japan depends for 90% of its crude oil, which accounts for 40% of Japan's primary energy supply. As the US becomes less directly involved in the Middle East due mainly to its independence in energy sources based on the "Shale revolution," the balance of power is shifting, and geopolitical and geo-economic tensions are continuing as the presence of Russia, which is increasing its military presence, and the presence of China, which is becoming more involved through its One Belt, One Road policy, intertwined with movement in this region. As decarbonization is progressing around the world and if oil production in regions with high production cost is stopped, the dependence on the Middle East may increase. Japan is actively working to ease the tensions and stabilize the situation in the Middle East while continuing to monitor the increasingly complex and opaque situation in this region.

In light of these changes in the international situation, in addition to traditional energy security measures such as securing the stable supply of crude oil and strengthening relations with resource-rich countries, the need to ensure strategic autonomy while overseeing the entire supply chain has been increasing. A strategic autonomy is aiming to secure the domestic supply of energy while preventing unauthorized access and cyber-attacks from the outside and developing technologies domestically in the important technical fields that form the basis of energy supply.

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2 Electric vehicles, fuel cell vehicles, plug-in hybrid vehicles and hybrid vehicles.

2) Lessons learned from the COVID-19 pandemic

Various environmental changes caused by the COVID-19 pandemic are also affecting both energy supply and demand, and these changes need to be taken into account when considering future energy policies. However, a careful judgment is required to determine whether the changes caused by the COVID-19 pandemic should be regarded as temporary changes due to infectious disease countermeasures or as structural changes caused by disease countermeasures in combination with the trend toward digitization.

First, on the demand side, it is reported that while energy demand is declining as a whole due to the progress in telework and self-restraint in activities, the decline in electricity demand is relatively small. It is expected that the economy activities will be resumed as a result of vaccination, etc. but some of the changes will be irreversible.

On the supply side, the pandemic gave rise to the awareness of fragility in global supply chain. In the face of the shortage of supply even for essential goods, such as face masks, respirators, and vaccines, people are beginning to share the need to strengthen their ability to procure necessary goods domestically. In addition, the volatility of resource prices caused by the decline in demand due to COVID-19 and the expectation of economic recovery, combined with the current decline in investment in upstream development, has led to the emergence of future energy supply risk.

3) Increase in the risks that threaten the stable supply of energy, such as frequent and severe natural disasters and cyber-attacks

In recent years, energy supply has been disrupted due to the frequent and severe occurrence of natural disasters, including the blackout of the entire Hokkaido area during the Hokkaido Eastern Iburi Earthquake in 2018 and the long-term power outages caused by Typhoons No. 15 and No. 19 in 2019. Accordingly, the importance of building a system for stable energy supply and early recovery in times of disaster has been increasing.

On the other hand, the aging of the energy infrastructure for electricity and fuel, the aging of engineers, etc. has been proceeding and the infrastructure that supports robust energy supply has been deteriorating. Furthermore, in the tight power supply-demand situation that occurred in the winter of FY2020, the risk of too-much dependency on LNG became apparent, and the need to build an appropriate energy portfolio was recognized again.

In addition, the number of cyber-attacks has been increasing in recent years, and given the progress of digitization in the energy sector, the risk of physical damage to energy-related facilities is increasing.

In order to deal with these issues, it is necessary to extract and analyze risk scenarios and promote energy system resilience comprehensively.

4) Changes in supply capacity and investment environment due to deregulation of electricity and expansion of renewable energy

With the progress of electricity deregulation, the volume of transactions in the wholesale electricity market is rapidly expanding, and the importance of market transactions in the electricity business is growing.

In the wholesale electricity market, while the number of hours when trading price falls has increased as a

result of the great contribution of renewable energy introduction under the feed-in tariff (FIT) system, it is recognized that there is a significant risk of price fluctuations, such as the emergence of hours when prices sharply rise depending on demand and fuel procurement conditions.

As the introduction of renewable energies continues to expand and the risk of further price fluctuation is expected, it is difficult to prospect for recovery of investment in power sources other than those that can receive support under the FIT system or the FIP system to be introduced in FY2022. In fact, new investment in power sources has stagnated, as plans for new power station construction have been cancelled, particularly thermal power stations, of which capacity factor is declining, and the aging of power plants is progressing.

In such circumstances, older thermal power stations contributed to the buildup of supply capacity during the blackout at the Hokkaido Iburi East Earthquake in 2018 and during the tight power supply-demand balance in the winter of FY2020. On the other hand, at present, supply capacity has been declining as power source exit proceeds centering on thermal power stations that are becoming less profitable under the economically rational judgment of the power generation utilities, and it is becoming difficult to continue to rely on such aging power sources.

In order to realize carbon neutrality by 2050, there is a growing need to accelerate the securing of the supply capacity necessary for stable supply even after deregulation and the development of a market environment in which new investments in power sources are made in a manner that contributes to carbon neutrality.

5) Rise of new technologies

The rise of new technologies is also a noteworthy change. In the midst of digitalization, the data-driven society is irreversibly advancing, which is changing both the supply-demand sides of energy.

As the digital economy proceeds in accordance with the development and progress of technological innovation and services on a global scale, and if necessary measures such as improvement of energy efficiency are not taken, electricity demand is expected to increase to a certain extent. In the past, the world has responded to the development of digital economy with thorough energy conservation and technological innovation, but it will be necessary to continue to pursue such efforts on a greater scale.

In the energy sector, new players and services based on electricity supply-demand / network technologies as their core, such as aggregator, are emerging. The spread of locally-produced for local consumption-type renewable energy, the spread of cogeneration, technological innovation in storage batteries, use of AI and IoT, etc. are expected to further expand distributed energy systems led by demand side and make the energy supply-demand structure more efficient and productive.

3. Confirmation of the basic viewpoint (S+3E) of the energy policy

As described in Chapter 2, the circumstance surrounding energy has begun to change drastically in just three years since the last Strategic Energy Plan was formulated, and it is necessary to consider energy policy based on the lessons learned from these changes.

The point of the energy policy is to first and foremost ensure stable supply ("Energy Security"), and realize low cost energy supply by enhancing its efficiency ("Economic Efficiency") on the premise of "Safety." It is also important to make maximum efforts to pursue environment suitability ("Environment"). The viewpoint of S+3E as the major principle remains important as usual. New perspectives will be required, such as recognition of the importance of securing stable supply of energy across the entire supply chain as a lesson learned from the COVID-19 pandemic.

While adding new perspectives, the main principle of S+3E is summarized as follows.

(1) Ensuring safety as a major premise

The safety of all energy-related facilities is a prerequisite for energy policy. Particularly for nuclear power, we will give top priority to safety among other things and make our utmost effort to resolve the concerns of the public.

In addition, in light of concerns about future shortage of human resources due to the aging of personnel, etc., about the increasing frequency and intensity of natural disasters, about the increasing complexity and sophistication of cyber-attacks, etc., constant efforts to ensure the safety of not only nuclear power but also other energy sources are required.

(2) Ensuring stable and resilient energy supply

Japan's energy supply is vulnerable because Japan, surrounded by oceans on all sides with no international interconnections, is not blessed with fossil resources. Its area of shallow oceans is one-eighth that of the UK, its area of flat land excluding forests is half that of Germany, and the conditions for using renewable energy are different from those of other countries, although the country has the world's third largest geothermal potential. Japan is constantly facing the risk of supply insecurity due to the issues of limited bargaining power, etc. in resource procurement, the impact of changing conditions in resource-rich countries and sea lanes, etc., so that ensuring energy security continues to be a major challenge for Japan.

In addition, in order to secure stable energy supply, it is necessary to take into account the facts that energy supply has been endangered in recent years due to the increasing frequency and intensity of natural disasters and that the risk of cyber-attacks on infrastructure facilities has been increasing.

In order to overcome these issues and ensure stable energy supply (Energy Security), it is important to enhance the resilience so that the multi-layered energy supply system can function properly not only in ordinary times but also in times of crisis.

In addition, given the increasing importance of new decarbonization technology fields, it is becoming increasingly important to ensure a stable supply system of the entire supply chain, considering the perspective of transitions in addition to the existing level of energy self-sufficiency.

(3) Ensuring environmental suitability from the point of view of climate change and harmony with surroundings

With regard to the environment suitability (Environment), as mentioned above, its importance is rapidly increasing as response toward carbon neutrality is becoming a global trend.

In dealing with the climate change issue, it is particularly important to address the energy sector, which accounts for more than 80% of Japan's greenhouse gas emissions. It is the responsibility of GOJ to address the decarbonization of energy while maintaining the balance of S+3E.

In decarbonization of energy, in addition to excavation, use of construction machines, etc., for civil engineering and construction work to build power stations, it is also necessary to consider CO_2 emissions in the mining and processing of minerals that support decarbonization, such as EVs, storage batteries, and solar panels, and in the manufacturing and transportation processes of products. Accordingly, it is important to have the perspective of promoting decarbonization while assessing the environmental impact not only in energy supply but also in the entire supply chain.

Not only climate change but harmonization with the surrounding environment and coexistence with local communities are also important issues. It is necessary to consider the impact of these issues when introducing, constructing, and operating energy-related facilities and when treating and disposing of waste.

(4) Ensuring economic efficiency of energy

Energy supports the foundation of industrial activities, and in particular, its supply stability and cost have a significant impact on business activities as well as business strategies such as corporate location.

The realization of stable energy supply and reduction of environmental impact while supplying energy at low cost by improving economic efficiency is the prerequisite for Japan to achieve further economic growth by retaining the business base of industry in Japan and attracting new investment to the country. Among other things, Japan's electricity prices continue to be high for both household and industrial use when compared to international levels, which may affect Japan's international competitiveness.

On the other hand, a certain amount of burden is expected to increase in order to become carbon neutral. For example, assuming the current level of technology, switching the existing electricity and gas supply to renewable energy combined with decarbonized thermal power, storage batteries, etc., or to fuels made from hydrogen, etc., could be a factor of cost increase.

In order to maintain and strengthen industrial competitiveness, improve people's lives, and address carbon neutrality as a growth strategy, we need to work on thorough energy conservation, enhancement of supply-demand forecast, optimization and further efficiency improvement of power plant operation through new

technologies such as AI and IoT. We must also overcome grid constraints, improve flexibility of the electric power system by securing balancing power, deregulation, etc. as well as research and development for low-cost decarbonization technologies. It is essential to reduce energy cost as much as possible, while evaluating them from the perspective of cost-effectiveness.

4. Challenges and responses to realize carbon neutrality by 2050

(1) Energy supply-demand structure in the carbon neutral era in 2050

The climate change issue has been recognized as an urgent issue for the international community. Several countries, mostly among the advanced countries, have declared their plans to achieve net zero greenhouse gas emissions in their countries by 2050. In October 2020, Japan has also declared its pursuit of carbon neutrality by 2050.

It is not easy to draw an accurate picture of the society realizing carbon neutrality by 2050 due to factors such as the possibility and uncertainty of technological development as well as the uncertainty of changes in the international political and economic situation. However, if we boldly depict the energy supply and demand structure of the carbon-neutral society on the basis of the current state of technology, following pictures would be envisaged:

- Efficiency in energy consumption will be improved by thoroughly advancing energy efficiency. In addition, the power sector will be decarbonized through introducing decarbonized power sources. Areas of the non-power sector that can be electrified will be electrified by decarbonized power sources.
- In the industrial sector, decarbonization will be promoted through the practical application of hydrogen-reduced iron making, CO2 absorption type concrete, cement capturing CO2, and artificial photosynthesis. On the other hand, in sectors such as with high-temperature heat demand where electrification is not feasible, decarbonization will be promoted through the use of hydrogen, synthetic methane, biomass, etc.
- In the commercial and residential sectors, electrification will be promoted, and decarbonization will also be promoted through the use of renewable heat, hydrogen, synthetic methane, etc.
- In the transport sector, decarbonization will be promoted through the expanded introduction of EVs and fuel cell vehicles (FCVs), along with the use of synthetic fuels that utilize CO2.
- Despite the progress in energy efficiency and decarbonization in each sector, there are some sectors where CO2 emissions are unavoidable. CO2 from those sectors can be removed by specific measures such as Direct Air Carbon Capture and Storage (DACCS), Bio- Energy with Carbon Capture and Storage (BECCS), and forest sink measures.

In order to realize such a society, efforts of the energy sector that accounts for over 80% of GHG emissions are required. However, realizing this vision will not be easy, given Japan's current situation such as the industrial structure where the manufacturing industry, which releases the large amount of CO2, accounts for over 20% of the nation’s GDP, and the conditions for utilizing natural energy, such as the area of shallow oceans and vast plains, which are different from those in other countries. It would not be easy to overcome difficulties to realize this vision without all-out efforts of the people in all sectors of society such as industries, consumers and the Government.

On the other hand, as the difficulties in realizing carbon neutrality are common to many countries around the

world, if Japan can find ways to overcome these difficulties as quickly as possible, that would bring it to a position to lead the world's efforts towards carbon neutrality. Thus, it is imperative to create a virtuous cycle of the economy and the environment by changing the people’s conventional mindset and proactively working towards carbon neutrality, which would transform the industrial structure, drive the socio-economic reform, and lead to the next strong growth.

(2) Importance of multiple scenarios

When overviewing the global situation, in the EU and the UK which have presented multiple scenarios for 2050 carbon neutrality, they describe paths to pursue several potentials and options for carbon neutrality, not sticking to a specific scenario as their target. Also in the energy sector, they describe a scenario to realize carbon neutrality by combining multiple energy sources, not depending on a single energy source. Toward 2050, a future beyond several uncertainties, Japan must describe its path toward 2050 by preparing several options and by referring to other countries' approaches to prepare themselves for several potentials.

<EU's Scenario>

In "A Clean Planet for all" announced by the European Commission in November 2018, the EU has presented multiple scenarios with the understanding that there exists a long-term and substantial uncertainty relating to technological successes, and that a future prospect might bring a different result due to technological developments, consumers' choices, and regulations. The EU positions these scenarios as visions, not determining a concrete target for the energy mix.

As a result of the scenario analysis, it is explained that it won't be possible to achieve zero emissions in such sectors as agriculture, transportation, and industry, etc. with existing technologies, and that it is indispensable to utilize such carbon removal technologies as BECCS and DACCS in addition to utilizing lands for tree planting, etc. to realize carbon neutrality. In each scenario, an increase in EUETS prices (prices for carbon emission allowances in the European Union Emissions Trading System), (In the prospect of such international organizations as IEA, etc., the carbon prices are expected to increase in future.), an increase in electrification rate, electricity demand, and electricity consumption, and an increase in consumers' electricity prices, are also assumed. It is explained that further promotion of research and development is required to keep these factors from increasing.

<UK's Scenario>

In the UK, 2050 carbon-neutral target was legislated in June 2019, and then in December 2020, several analyses, including a future vision for 2050 electricity sector in "Energy White Paper", have been disclosed. However, any scenario in each report is not classified as UK's policy targets or policies, nor a probable prediction or an ideal future vision due to a difficulty, etc. to predict accurate technologies and actions toward 2050.

Also in Japan, after taking opinions of experts from several fields into consideration, GOJ have set reference values for further discussion that such renewable energy as solar photovoltaic, wind, hydro, geothermal, and biomass, etc. will cover around 50 ~ 60% of electricity generated in 2050 hydrogen-fired and fuel ammonia-fired power will cover around 10%, and nuclear and thermal power plant will around 30 ~ 40%. It has been made clear that each power source has several issues and therefore, the importance to prepare multiple paths (scenarios) toward 2050is obvious.

For the paths toward carbon neutrality by 2050, it is required to incorporate new decarbonization technologies into the society by challenging and materializing various innovations throughout all of the common economic activities, including such sectors as industry, commercial, residential, transport, and electricity. Also, for such long-term prospect as 2050, it is appropriate to make an approach by a multiple track scenario, always determining key points based on the latest information, while keeping ambitious targets. It is difficult to make a probable prediction due to the potential and the uncertainty of technological innovations, etc., and the uncertainty in changing situations. To this end, it is important to regularly follow and assess such technological trends and changing situations, and to evaluate and review them under transparent structures and procedures.

At the same time, to pursue such an ambitious target, it is indispensable to secure a stable and inexpensive energy supply to maintain and enhance Japan's national strength. As for a stable energy supply, it is indispensable for Japan, which has little fossil resources to increase its autonomy for energy, to improve its technological self-sufficiency rate by securing various decarbonizing technologies domestically, in addition to securing more self-sufficiency and robustness of energy itself.

Also, in the EU's scenarios toward carbon neutrality by 2050, it is predicted that electricity costs will increase to a certain extent. In Japan, several institutions predict an increase in electricity costs toward carbon neutrality by 2050, and therefore it is necessary to restrain the increase of electricity costs as much as possible. Through the efforts towards carbon neutrality by 2050, it is essential to support the economic activities by ensuring stable and cost-efficient energy supply on the major premise of safety.

On this premise, Japan will address maximum introduction of renewable energy as major power sources on the top priority; societal implementation of hydrogen and CCUS will be promoted; and necessary amount of nuclear power will be continuously utilized on the major premise of ensuring safety and public trust.

Including these efforts, Japan will pursue all options to realize carbon neutrality by 2050 by striving to maintain global competitiveness and to restrain natural burden by securing stable and cost-efficient energy supply.

(3) Efforts required in power sector

Among various economic activities, the power sector has utilized decarbonized power sources including renewable energy and nuclear that have already been at practical stage. Utilizing these power sources will be required to steadily realize decarbonization.

In the society which has realized carbon neutrality by 2050, electricity demand is expected to increase to a certain extent due to the progress of electrification in the industrial, commercial, residential, and transport sectors. In order to meet this demand, it will be difficult to meet 100% of the electricity demand with a single type of energy source. It will be necessary not only to utilize decarbonization technologies that are currently at the practical stage, but also to pursue new options that require innovation, such as hydrogen/ammonia power generation and thermal power generation with carbon storage and reuse by CCUS.

1) Approaches for renewable energy

In order to realize carbon neutrality by 2050, promoting electrification and decarbonizing power sources are imperative. Japan will address maximum introduction of renewable energy as major power sources in 2050 on the top priority on the major premise of S+3E.

When promoting the maximum introduction of renewable energy, it is necessary to secure grid capacity which connects regions with large renewable energy potential to large consumption areas, to deal with the fluctuating output of solar and wind power due to natural conditions, and to deal with grid constraints such as maintaining grid stability in emergencies including in power supply dropouts. It is also necessary to respond to Japan's unique natural conditions and societal constraints such as the limited areas of flat land, and to promote coexistence with local communities by ensuring appropriate communication, environmental considerations, and compliance with relevant laws and regulations.

In addition, as the cost of power generation remains high compared to the level of international standards, it is necessary to reduce the cost and manage excessive natural burdens.

In order to address these challenges, Japan will improve the flexibility of the power system through combining diverse resources including by formulating the master plan for the power grid, expanding the introduction of diverse distributed energy sources[3] such as energy storage systems, securing decarbonized flexibility through the use of storage batteries and hydrogen, which play the key role in making renewable energy major power sources, promoting measures to ease grid congestion, and promoting the development of next-generation inverters which support grid stability. Japan will also promote the development of innovative technologies such as next-generation solar cells and floating offshore wind power generation, which are indispensable for overcoming location constraints and reducing costs. In addition, with respect to the Space Solar Power Systems (SSPS) which use wireless transmission and reception technology to supply electricity from space to the ground, Japan will steadily proceed with R&D as well as demonstration, including consideration of the transition from the ground demonstration phase to the space demonstration

3 Distributed energy resources can be broadly classified into power generators such as variable renewable energy, cogeneration, and fuel cells, energy storages such as batteries, and demand-side resources such as large-scale factories and water electrolysers, and their scale varies from small to large-scale facilities.

phase, by comprehensively and constantly assessing SSPS's role as an energy supply source, its economic rationality, and its ripple effects on other industries, etc.

2) Approaches for nuclear energy

Having experienced the accident at Tokyo Electric Power Company Holdings' (TEPCO) Fukushima Daiichi Nuclear Power Station, Japan will reduce the dependence on nuclear power as much as possible, while giving the highest priority to safety and expanding decarbonized renewable energy with economic independence.

Nuclear power is a practical in-use option for decarbonization. On the one hand, some countries are planning to phase out nuclear power. Meanwhile, many efforts have been made to further enhance its safety, economic efficiency, and mobility in order to respond to the changing energy situation.

In Japan, in order to regain public trust of nuclear power, it is essential to reduce accident risk by enhancing reactor safety, and to implement "back-end" related activities including decommissioning, processing and disposing of radioactive waste. The Government will promote strengthening human resources, technology, and the industrial bases of nuclear power, and will pursue reactors with further safety, economic efficiency, and mobility and will promote R&D to resolve back-end issues.

It is important to hold a responsible and sincere attitude and approaches that look back on the accident at TEPCO's Fukushima Daiichi Nuclear Power Station as the starting point. This is the key to gain public trust in nuclear power in Japan.

3) Approaches for hydrogen, ammonia, CCS, CCU, and carbon recycling

In order to realize carbon neutrality by 2050, it is necessary to promote ambitious and drastic changes in thermal power policies to reduce CO2 emissions from thermal power generation to net-zero. At the same time, thermal power generation is an important power source that has supported stability and resilience in power supply since the Great East Japan Earthquake. Also, on the basis of the current state of technology, thermal power generation retains its important functions as a balancing power to compensate for the variability of renewable energy. It is imperative to replace these functions with decarbonized power sources, while ensuring stable supply.

Therefore, in order to promote decarbonization of thermal power generation, the fuel itself will need to be converted to hydrogen or ammonia, and the CO2 released by thermal power generation will be necessary to be captured, stored, and reused.

< Actions to utilize hydrogen and ammonia>

Hydrogen and ammonia power generation does not emit CO2 during combustion. It maintains the regulating and inertial power functions of thermal power, contributes to the stabilization of grid operations, and is applicable to many of the existing power generation facilities, such as gas turbines, boilers, and denitrification facilities, without modification. Therefore, hydrogen and ammonia power generation is one of the most important options for decarbonizing power sources to realize carbon neutrality. As for hydrogen and ammonia power generation, Japan will work to overcome technical issues so that they can function as major supply and regulating powers in the electric power system in 2050.

In order to expand the supply volume and reduce the supply cost of hydrogen, Japan will develop and demonstrate technologies that will contribute to the establishment of a large-scale international hydrogen supply chain by utilizing the Green Innovation Fund, in an integrated manner with the establishment of hydrogen power generation technologies, aiming to achieve a cost lower than, or equal to, gas-fired power generation in 2050.

< Actions to utilize CCS>

As for CCS, Japan will work to establish the technology, reduce the cost, develop suitable sites, and improve the environment for its commercialization, while formulating a long-term roadmap and sharing it with stakeholders. In order to establish CCS technology and reduce its cost, Japan will conduct R&D and demonstration of separation and capture technology, and promote R&D on storage technology, elaboration and automation of monitoring technology, and cost reduction for drilling, storage, and monitoring. In addition, for the societal implementation of cost-efficient, efficient, and flexible CCS, Japan will work on the demonstration of shipping liquefied CO2, and promote the establishment of a model base for the optimization of the network (hubs and clusters) consisting of CO2 emission sources and reuse/storage clusters in collaboration with the public and private sectors.

With respect to the development of suitable sites, which are essential for the societal implementation of CCS, Japan will continue to conduct studies such as the evaluation of storage potential, taking into account economic efficiency and societal acceptability, in order to select suitable sites for CO2 storage in Japan. In addition, while taking into account the trends of overseas CCS projects and other factors, Japan will work on improving the environment for the commercialization of CCS in Japan.

< Actions to utilize CCU/Carbon Recycling>

CCU/Carbon Recycling is a technology that, taking CO2 as a resource, recycles CO2 into materials and fuels through mineralization and artificial photosynthesis, thereby reducing the emission of CO2 into the atmosphere. This also has the advantage in that the installing CO2 separation and capture facilities can contribute to the reduction of CO2 emissions, simultaneously utilizing existing fossil fuel procurement systems and facilities. As international competition in the development of CCU/Carbon Recycling technology is accelerating, Japan is required to promote the development, social implementation, and global deployment of technologies for cost reduction and application development while ensuring competitive advantage, based on the "Roadmap for Carbon Recycling Technologies".

(4) Efforts required in industry, commercial, residential and transport sectors

In the industrial, commercial, residential, and transport sectors, in addition to improving energy consumption efficiency by thorough energy efficiency measures, it is necessary to promote electrification in areas where electrification by decarbonized power sources is possible. On the other hand, the use of hydrogen, synthetic methane, synthetic fuels, etc. and the implementation of innovative technologies will be essential for heat demand and manufacturing processes where electrification is difficult. For example, hydrogen can also contribute to decarbonization through sector coupling by converting surplus renewable energy and other electricity into hydrogen and using it in the industrial, commercial, residential, and transport sectors.

On the other hand, in the energy-intensive sector, unless innovations are practically realized such as hydrogen-reduced iron making, cement capturing CO2, and artificial photosynthesis and manufacturing processes is drastically changed, carbon neutrality would not be able to be realized in Japan as a whole. Like endothermic reaction in hydrogen reduction process of hydrogen-reduced iron making, there are many areas of challenge, for which a complete technological solution has yet to be found. Overcoming the challenges is not easy to achieve innovation. It is necessary to accelerate the efforts of both industry and the Government so that the realization of innovation will become the source of Japan's industrial competitiveness and that Japan will lead the world's action toward carbon neutrality.

In addition, as in the high temperature heat demand and manufacturing processes, some sectors have difficulty in complete decarbonization, the implementation of carbon removal technologies such as DACCS and BECCS will also be essential. It is necessary to pursue these technologies to realize carbon neutrality by 2050.

Towards 2050, it is required to aim to realize carbon neutrality while pursuing all options, including not just the maximum use of established technologies such as cogeneration to further improve the efficiency of heat supply, but also technologies such as hydrogen and ammonia power generation that are technically foreseeable but will require the construction of a new supply and demand network as well as significant cost reductions, and technologies that are still technically unproven and require technological development from now on, to the possible maximum extent.

As indicated in the "Green Growth Strategy through Achieving Carbon Neutrality in 2050" (formulated on June 18, 2021 in cooperation with relevant government ministries and agencies13 , hereinafter referred to as the "Green Growth Strategy"), in pursuing these innovations with an eye to 2050, the Government will set high targets, focused on industrial sectors with high growth potential, create an enabling environment that makes it easy for the private sector to take on challenges, mobilize all kinds of policies, and verify and modify the policy measures that need to be taken through reviewing the progress.

1) Approaches in industry sector

In order to promote decarbonization in the industrial sector and to realize carbon neutrality, it is necessary to improve efficiency in energy consumption by thoroughly improving energy efficiency, and promote electrification and energy conversion on demand side in conjunction with decarbonization on supply side to

promote decarbonization of heat demand and manufacturing processes.

In the industrial sector, production equipment used in manufacturing is expensive, and energy-efficient equipment and technologies are even more expensive than existing technologies. In addition, since the lifetime of equipment is generally 30-40 years, it is necessary to consider the timing of replacement of equipment with a view to realizing carbon neutrality by 2050. Further investment burden is inevitable so that Japanese companies, which have a high level of energyefficiency technology in the world, will make energy consumption more efficient for realizing carbon neutrality by 2050. Furthermore, promotion of energy conversions such as electrification and gas conversions will require installing not only production equipment itself, but also infrastructure facilities such as power receiving equipment and piping.

In order to accurately grasp the current situation of these businesses and overcome their challenges, it is essential to exploit potential of energy efficiency through technological development and to improve economic efficiency by spreading energy-efficient equipment and facilities. It is necessary for the Government to take policy measures that combine regulatory and supporting measures. Especially, fine support to small and medium-sized enterprises is required including provision of energy efficiency diagnosis and related information.

< Electrification and energy conversion for promoting decarbonization of heat demand and manufacturing processes>

Heat demand in the industrial sector broadly covers the range of temperature zones from low to high. For the heat demand in low-temperature such as steam and hot water, utilizing electrification technologies including heat pumps and electric heating wires would be a relevant option for decarbonization. However, there are challenges in the aspect of cost such as of equipment and electricity bills.

Some of the heat demand in the high temperature zone can be decarbonized by electrification technologies such as electric furnaces using infrared heating methods, etc. However, it may be difficult to economically, calorically, and structurally deal with large-scale heat demand in the high temperature zone.

To decarbonize such heat demand, which is economically, calorically, and structurally difficult to be electrified, the option is to decarbonize the gas and other energy sources that supply heat energy.

For example, synthetic methane and synthetic fuels, which can be regarded as carbon-neutral by combining hydrogen derived from renewable energies etc. and CO2, can reduce investment costs for decarbonization because existing infrastructure and facilities can be utilized, and also contribute to stable supply of energy by securing a diversity of energy supply sources other than electricity. On the other hand, since synthetic methane and synthetic fuels are difficult to increase in size and reduce cost, it is necessary to work on technological development and demonstration to overcome these challenges.

For optimal energy conversion on the demand side, Japan will pursue various options such as the use of synthetic methane and synthetic fuels that can utilize existing infrastructure and facilities.

While there are various challenges to promote decarbonization in the industrial sector, hydrogen is expected to be an energy source that enables to promote decarbonization in this sector by contributing not only to the decarbonization of heat demand through the use of hydrogen boilers, but also to the decarbonization of the manufacturing process itself such as hydrogenreduced iron making. On the other hand, such challenges still

exist as there are many fields which require further innovation because technologies have yet to be established and it is needed to have large quantities of hydrogen supply at low cost from the perspective of international competitiveness, etc. Therefore, Japan will address from now on the development and demonstration of application technologies, and the expansion of supply network that will lead to the reduction in supply costs, and the development of large transport vessels etc.

2) Approaches in commercial and residential sectors

For decarbonization in the commercial and the residential sectors, it is required to maximize the use of such renewable energies such as solar photovoltaic power generation and solar heated hot water, etc., and promote energy transition to decarbonized power source and heat source.

Also, it is necessary to enhance the insulation performance for houses and buildings, and introduce highly efficient equipment. Because those equipment have the lifetimes of several decades, the timing to reconstruct houses and buildings and to replace equipment must be considered in view of carbon neutrality by 2050.

On the other hand, there are issue that the performance improvement of construction materials and energy consumption equipment slows down once it reaches a certain level, and that it costs more for further performance improvement. Therefore, it is required to start a technology development for performance improvement from now on towards carbon neutrality.

When addressing the commercial sector and the residential sector, approaches that consider differences in characteristics of each region and building, are required. For example, city gas is used as heat source in urban areas, and LP gas and kerosene are used in rural areas. Therefore, the measures must be taken on considering issues such as different paths for energy transition, and limited equipment installation space, depending on the building types. Taking these points into consideration, it is important to pursue various options such as utilization of synthetic methane and synthetic fuels which can use existing infrastructure and equipment, as options for optimal energy transition at demand side.

Having these issues in mind, GOJ aims to ensure the energy efficient performance[4] at the level of ZEH[5] and ZEB[6] standards as the average for all of the existing houses and buildings in 2050 by promoting a renovation to increase energy efficiency and an introduction of energy efficient equipment, etc. This will be achieved through a combination of enhancement of regulatory measures and support measures based on “The Act on the Improvement of Energy Consumption Performance of Buildings” and “the Act on the Rationalization etc.

4 “to ensure the energy conservation performance at the level of ZEH and ZEB standards as the average for all of the existing houses and buildings” means the situation where houses achieve the reduction of primary energy consumption by around 20% from the energy conservation standard, and buildings achieve the reduction by around 30% or 40%, depending on the building usage, as the average for all existing houses and buildings.

5 ZEH (Net Zero Energy House): For houses further reducing energy consumption by introducing renewable energy, etc., after achieving an energy conservation of 20% or more, depending on the volume of reduction, such definitions as 1/ “ZEH” (reduction of 100% or more), 2/ Nearly ZEH (reduction of 75% or more and less than 100%), and 3/ ZEH Oriented (no introduction of renewable energy) are applied.

6 ZEB (Net Zero Energy Building): For buildings further reducing energy consumption by introducing renewable energy, etc., after achieving an energy conservation of 50% or more, depending on the volume of reduction, such definitions as 1/ “ZEB” (reduction of 100% or more), 2/ Nearly ZEB (reduction of 75% or more and less than 100%), and 3/ ZEB Ready (no introduction of renewable energy) are applied, and buildings, having introduced such technologies that have not been currently evaluated as per the energy conservation calculation program based on the Building Energy Conservation Act, though expected to contribute to energy conservation, and having achieved energy conservation of 30 ~ 40% or more, and having the area of 10,000 m^2 or more, are defined as 4/ ZEB Oriented.

of Energy Use."

Also, the development of digitalization leads to an efficient use of energy and energy conservation by helping the optimization of movement for people, goods and money such as sharing, etc. For example, the effect of the efficient use of energy through digitalization including the reduction of energy use for transportation due to a work from home, the reduction of energy for corporate systems through cloud computing, and a shift to more sophisticated energy management system, etc. will substantially contribute to all industries and sectors. From this viewpoint, it is necessary to promote both more efficient and greener energy consumption and digitalization like the two wheels of a cart, to establish a sustainable society in future. On the other hand, the data flow volume and the calculation volume are expected to rapidly grow with a development of digitalization, and in line with such growth, there exists a possibility for energy consumption in digital equipment and digital infrastructure to drastically increase. To restrain such rapid energy increase, such innovative energy efficient technologies, as photonics-electronics convergence technology expected to drastically reduce power consumption, are developed, and it is necessary to reduce energy consumption and to improve performance for data center, server, various IT infrastructure, communication devices, and semiconductors, etc., by expanding application of such new technologies.

3) Approaches in transport sector

For decarbonization of the transport sector, GOJ aims to realize carbon neutrality by reducing CO_2 emissions through the production, use, and disposal of automobiles, by improving energy efficiency and by making efforts to decarbonize the fuel itself.

Firstly, for pursuing carbon neutrality for automobiles, which generates 86% of CO_2 emissions in the transport sector, GOJ aims to achieve zero CO_2 emissions through the production, use, and disposal of CO2-emitting automobiles in 2050 by pursuing various options through efforts to realize carbon neutrality for fuel and energy. To this end, with regard to passenger vehicles, GOJ will take such comprehensive measures as expanding the introduction of electrified vehicles and its infrastructure and strengthening electrified-vehicle related technologies, such as batteries, etc., the supply chain and the value chain, to make the ratio of electrified vehicles 100% of new vehicle sales by 2035. Also, with regard to commercial vehicles, for small-sized vehicles of 8 tons or less, GOJ will promote electrification and decarbonization by taking comprehensive measures in the same manner as those for passenger vehicles, to make the ratio of electrified vehicles 20% ~ 30% of new commercial vehicles sales by 2030, and to make the ratio of electrified vehicles and vehicles suitable for use of such decarbonized fuels as synthetic fuels, etc. combined 100% of new sales by 2040.

To reduce CO_2 emissions and activate mobility at the same time, GOJ will promote social implementation of new services and infrastructure, responding to users' behavior modification and to electrification, by trying to solve local mobility issues through transformation of how to use automobiles.

At the same time, for fields other than automobiles, it is necessary to promote digitalization and drastically improve efficiency through entire supply chain by utilizing technologies such as AI and IoT, based on data coordination in the logistics. It is also essential to improve energy efficiency through labor-saving efforts.

To this end, GOJ will promote a modal shift helping to switch to a transportation method having small energy

consumption intensity, joint transportation and distribution, consolidation of transportation network, and improvement of transportation efficiency in the entire supply chain. GOJ will also promote technological development and demonstration for applying hydrogen and ammonia to such other transportation fields as commercial vehicles, large vehicles moving around at ports, and vessels, etc. More concretely, GOJ will make technological development and demonstration for decarbonization of vessels aiming to realize commercial operation of zero emission vessel at earlier than 2028, the previous target, and initiate a preparation of international framework for energy efficiency and decarbonization through the International Maritime Organization (IMO). Furthermore, GOJ will promote technological development, demonstration, and introduction support for vessels contributing to modernization of coastal operation and operational efficiency by utilizing such technologies as innovative energy efficient technology and digital technology, etc. including LNG-fueled vessels, vessels with hydrogen fuel cell vessels, and EV vessels. Also, for decarbonization of aviation fields, GOJ will promote 1/ the introduction of new technologies for equipment and materials, etc., 2/ the improvement in operational method by more sophisticated air traffic control, 3/ the introduction of support for sustainable aviation fuel (SAF), 4/ the reduction of CO_2 emission for airport facilities and airport vehicles, etc. GOJ will study and initiate measures to make the airport a hub for renewable energy, and will promote efforts under public and private cooperation.

Also, GOJ will promote a zero-energy approach for logistics facilities by introducing energy efficient equipment and labor-saving equipment at warehouses and port terminals, etc., and renewable energy facilities, fuel cells, etc.

Ports are the international logistics hubs handling 99.6% of Japan's imports and exports, and where many power generation, steel, and chemical industries, etc., emitting around 60% of Japan's CO_2 emissions, are located. GOJ aims to realize a carbon neutral port (CNP), making the emission of greenhouse gas zero as a whole, by preparing a receiving environment enabling the importation of large-scale, stable, and inexpensive hydrogen and fuel ammonia, etc., and by improving port functions considering decarbonization, and by coordination with industries located in seaside areas, etc.

It is also necessary to promote decarbonization of fuel, and it is important to pursue such options as biofuel and synthetic fuels, etc. which can utilize such existing facilities as fuel infrastructures and be used in internal-combustion engines, etc. For bioethanol and biodiesel, GOJ continues to study an introduction approach considering global trend, etc. For synthetic fuels, GOJ will promote the establishment of highly efficient and large-scale production technology by 2030 through focused technology development and demonstration during the next 10 years. It will promote the expansion of its introduction and cost reduction during 2030s and will realize an independent commercialization (taking environmental values into account) by 2040.

Also, for such SAF as bio-jet fuel and synthetic fuels, etc. which are alternative fuel for jet fuel, GOJ will promote technology development and large-scale demonstration. It will establish the structure under public and private cooperation considering such viewpoints as securing required raw materials and establishing its supply chain, to comply with restrictions in the international aviation filed at ICAO (International Civil Aviation Organization)

5. Policy responses towards 2030 looking ahead to 2050

In light of the challenge to realize carbon neutrality by 2050, Japan drastically pushed up its emissions targets for FY 2030, setting a new target to reduce its greenhouse gas emissions by 46% in FY 2030 from its FY 2013 levels. Furthermore, Japan announced to continue strenuous efforts in its challenge to meet the lofty goal of cutting its emissions by 50%.

This new reduction target is more than 70% higher than the previous target and can't be easily realized. As it is not easy to realize innovations and incorporate them into the society in nine years up to 2030, it is required to aim to realize such an ambitious target by utilizing existing technologies at the maximum.

Looking ahead to carbon neutrality by 2050 and toward new reduction target in FY 2030, it is not possible to achieve new reduction target in FY 2030 unless presenting drastic policy measures and directions beyond existing ideas.

Toward the new reduction target in FY 2030, it is a major premise for the energy policies to ensure stable and cost-effective energy supply with ensuring safety as the major premise. It is necessary to make efforts to reduce the electricity cost as much as possible while improving the self-sufficiency ratio in energy supply, which is currently ranked in the lower position among OECD countries.

In making these efforts, it is important to carefully consider timing of implementation of concrete measures. For example, efforts to reduce fossil fuel-fired power sources need to be made after ensuring that other measures, such as the introduction of non-fossil fuel-fired power sources and securing stable energy supply, are sufficiently advanced.

(1) Position of each energy source on the basis of the current technologies

To establish a stable energy supply-demand structure in Japan, it is important to identify the characteristics of the respective supply chains of individual energy sources and clarify the energy sources' position in the supply-demand structure so that their strengths can be exercised to complement each other's weakness. Though these strengths and weaknesses might change in accordance with future technology development, the position for each energy source can be explained on the premise of current technologies and regulations. Each energy source has its advantages and disadvantages in terms of supply chain. Considering there is no all-purpose energy source that can support a stable and effective energy supply-demand structure on its own at the moment, relying on one energy sources carry a high risk. To create a supply-demand structure that ensures stable supply even in times of crisis, it is necessary to establish a multilayered supply structure which has a combination of energy sources so that the strengths of individual energy sources can be maximized to appropriately offset each other's weaknesses.

1) Renewable energy

Renewable energy is a promising, multi-characteristic and important domestic energy source which can contribute to energy security as it can be domestically produced and be used to decarbonize energy source

free of greenhouse gas emissions. Having S+3E as a premise, GOJ will maximize its promotion by pursuing renewable energy as a major power source, by approaching renewable energy on the top priority, by managing excessive national burden and by ensuring harmony with local communities.
More concretely, GOJ will steadily make such efforts as ensuring optimal siting while living in harmony with local communities, cost reduction, overcoming power grid constrains, rationalizing regulations, and promoting of technological development, etc. Through these efforts, GOJ will expand the renewable energy introduction while managing excessive national burden, securing a stable supply in the entire power system, ensuring project implementation and living in a harmony with local communities.

(a) Solar photovoltaic

Introduction of solar photovoltaic has been expanding so far as a major source for renewable energy, having the largest introduced capacity per flat area in the world, and the power generation cost for commercial solar photovoltaic has been steadily decreasing. At the same time, solar photovoltaic can be utilized from the viewpoint of resilience as a distributed energy resource for own use and local production for local consumption, not only in large-scale developments. On the other hand, for future expansion of its introduction, it is necessary to secure suitable lands considering a harmony with local communities, to make efforts for further cost reduction, to secure sufficient balancing power to respond to output fluctuations, to further review system rules relating to output control, and to develop further technology to overcome site restrictions.
In the mid- to long-term, cost reduction is expected to promote the introduction of solar photovoltaic based on its position as an energy source which is utilized as a large power source anticipating the sale of electricity to the market. Solar photovoltaic complements peak demand in daytime hours as a distributed energy system, and contributes to the implementation of energy management involving the participation of consumers.

(b) Windpower

Given the cost reduction internationally due to large-scale introduction the trend toward larger wind turbines, wind is an energy source which can secure economic efficiency. GOJ will steadily make efforts for securing a system to efficiently supply power from areas suited to wind such as Hokkaido, Tohoku, and Kyushu to large consumption areas. To reduce costs, it will be securing sufficient balancing power to respond to output fluctuation, utilizing storage batteries, etc., securing suitable lands and coordination with local communities.
For onshore wind power generation, GOJ will continue to secure suitable location and pursue cost reduction. Especially, it is necessary to promote offshore wind power generation because it holds the key to making renewable energy as a main source of power, since it can be introduced on a large scale, while at the same time reducing costs and having major ripple effects on the economy.

(c) Geothermal

Geothermal is a stable power source that can play a role as a base-load power source. Japan has the world's third largest amount of geothermal resources. Various ways to use it include the recycling of hot water produced after power generation.
On the other hand, since the development of geothermal power generation requires long lead times and costly,

it is necessary to promote a sustainable development from the mid- to long-term point of view by reducing the investment risk, establishing transmission lines, pursuing harmonious developments with local communities. With a consideration to local communities as a premise, it includes helping the business environment through operational review of restrictions by related regulations, etc., and accelerating the development of geothermal at lower cost.

(d) Hydropower

Hydropower is an energy source which can be utilized for a long time playing a role of excellent energy source of purely domestically produced and stable supply without being affected by the weather except for drought-related problems. Also, it is expected to expand its role as an energy source harmonious with local communities. Ordinary hydropower (run-of river type), whose operation cost is low, serves as a base-load power source, while the pumped storage type of hydropower is expected to play an important role as a balancing power source for expansion of introduction for renewable energy.

On the other hand, as it is difficult to make a new development of large-scale hydropower on the timescale up to 2030, it is necessary to promote a new development of hydropower energy not yet used at such dams and headrace channel that are utilized for other purposes, and promote an optimized and highly efficient power generation through efficient utilization of existing power plants with digital technologies and replacement of existing aging facilities, etc.

(e) Biomass

Biomass power generation and heat utilization, etc. including woody biomass is an energy source having various values as a regionally distributed, local production for local consumption-type energy source. It improves resilience in times of disaster and has a large ripple effect to economy and employment through revitalization of local industries. On the other hand, as there are issues such as limited availability of biomass resources, including wood and wastes, which can be utilized for energy, ensuring sustainability and remaining high power generation cost, it is necessary to expand a stable supply of biomass fuel and to reduce cost of power generation projects, etc., by mobilizing various policies on the major premise of securing sustainability.

As for biofuels, which are mostly imported, it is necessary to continue the introduction of such fuels while taking into consideration international situation and the technology development trend concerning next-generation biofuels.

2) Nuclear

Nuclear power, whose output per amount of fuel is overwhelmingly large, can continue producing power for several years only with domestic fuel stockpile. Nuclear is an important low carbon base-load power source and a quasi-domestic energy source, contributing to the stability of the energy supply-demand structure in the long term, on the major premise of ensuring its safety. Nuclear is important because of these perspectives; 1) superiority in stability of energy supply and efficiency, 2) low and stable operational cost, and 3) free from GHG emissions during operation.

On the other hand, public trust for nuclear power has not been fully gained due to many anxieties. For

example, there were several incidents that undermine public trust, including physical protection incidents of nuclear materials at TEPCO's Kashiwazaki-Kariwa Nuclear Power Station. Moreover, there have been several issues such as how to deal with the spent fuels, nuclear fuel cycle, final disposal, and decommissioning of reactors, etc., It is imperative to tackle these issues.

3) Fossil energy

The fossil energy currently takes most of the energy supply and is an important energy source in future as well. On the other hand, it is required to take measures from the viewpoint of decarbonization, and GOJ will establish such technologies as CCUS technology, synthetic fuels, and synthetic methane, etc., which are the keys to decarbonization and will utilize it aiming to reduce costs.

(a) Natural Gas

Natural gas accounts for around 40% of the energy sources, has high efficiency as a heat source and has relatively low geopolitical risk compared to oil. For power generation, including the cogeneration systems, it plays a central role as a power source with balancing power for renewable energy, while emitting the least amount of greenhouse gases among fossil fuels. Also, it contributes to environmental load reduction, as a shift to natural gas is promoted through fuel switching, etc. in various sectors. In the future, it is expected to realize decarbonization of gas itself by expanding its utilization as a feedstock for hydrogen and ammonia which do not emit CO_2 when burning by concurrently utilizing CCS or establishing such technologies as methanation producing synthetic methane, etc. Therefore, it is an important energy source after realization of carbon neutral society. Also in the future, it is expected to expand its utilization which can be regarded as carbon neutral through credits, etc., by effectively utilizing such existing infrastructure as pipelines for city gas, etc.

On the other hand, considering the risk of fuel procurement as prices increase, which occurred at the tight supply-demand period in the winter of FY2020, it is necessary to improve the stability of supply and the resilience through market expansions and diversification of supply sources, etc. It is important to lower the price fluctuation risks, and to promote decarbonization of the entire value chain, including measures for methane. Its ratio in the power generation mix will be reduced on the major premise of securing a stable supply.

(b) Oil

Oil still accounts for about 40% of Japan's primary energy supply and is an energy source applicable as fuel in the transport, buildings, power sectors, etc. and as a feedstock for chemical and other products. As it has a high energy density, a well-developed supply system to end users as well as a stockpile system, it can be moved to respond to supply disaster areas. Though its demand as a power source is on a downward trend, and it has a high geopolitical risk relating to procurement, it is still an indispensable energy source for the people's lives and industrial activities as an energy contributing to energy supply not only in normal times, but also at a crisis.

To maintain and enhance a robust oil supply system responding to a crisis in addition to the normal times, it

is necessary to make efforts for diversification of supply sources, cooperation with oil producing countries, strengthening such risk management as stockpiling, etc., maintaining domestic oil refineries and service stations (SSs), and further enhancement of supply network preparing for a disaster, etc.

(c) LP Gas

LP gas has been supplied to around 40% of households and has a well-developed stockpiling system maintaining strategic supplies in case of a crisis, in addition to the nation-wide supply system. Also, it is an important energy source contributing to energy supply not only in normal times but also during a crisis, as "last resort" like oil. It has a well-developed system of supply to end-users and can be stockpiled or stored easily.

For securing the supply system, it is necessary to steadily implement stockpiling, to enhance facilities of core filling stations, to make retail prices more transparent, and to reduce costs through rationalization of operations, etc.

(d) Coal

On the premise of the current technologies and regulations, though it has the biggest CO_2 emissions among fossil fuels, it is an important energy source having excellent supply stability and economy at this moment, with the lowest geopolitical risk for procurement, low unit price per calorie, and storage easiness.

In the future, coal-fired power generation is expected to play a role of balancing power while introducing renewable energy at the maximum, and its ratio in the power generation mix will be reduced on the major premise of securing a stable supply.

4) Hydrogen and ammonia

Hydrogen is a secondary energy indispensable for carbon neutrality enabling not only decarbonization of electricity, but also decarbonization of the transport sector and industry sectors, etc. where electrification is difficult. As for ammonia, a demonstration for co-firing at coal-fired power plant is in process, and beyond that, it is considered to be utilized for dedicated firing and for vessels.

While efforts to utilize hydrogen are being accelerated among several countries, it is already a time to make efforts for incorporating it concretely into society by overcoming technological issues, preparing infrastructure, and reducing costs, to realize carbon neutrality.

Also, as it is possible to produce hydrogen and ammonia from various energy sources, it will contribute to strengthening energy security through diversification of energy procurement sources including utilization of domestic resources. Although hydrogen and ammonia can be produced from redundant electricity from renewable energy, etc., it also enables the effective use of fossil fuels in a clean manner when combined with CCUS. Moreover, hydrogen is used to produce ammonia and synthetic fuels in addition to a supply source for heat and electricity. It is expected to play the central role in the carbon neutral era, as it is possible to supply energy in industry, commercial, residential, transport, and power sectors depending on the characteristics of each user.

5) Heat

At this moment, final energy consumption in Japan is made mostly for non-electricity applications, mainly usage of heat and, toward carbon neutrality by 2050, it is important to utilize heat more efficiently, through energy conservation and fuel switching, etc. As the way of utilizing heat may vary depending on the lifestyle of individuals and families as well as the presence of local heat sources, it is important to make efforts to enable flexible usage that suits the lifestyle and local circumstances.

Cogeneration, which supplies heat and electricity together, is one way of utilizing energy more efficiently. In addition to its energy efficiency, it can be easily scattered, as it utilizes existing infrastructure such as gas, etc. Also, since cogeneration systems occasionally have a room for generation capacity depending on the season or the time, it is expected to serve as a backup to make up for a shortage of power supply in times of emergency or as balancing power required when introducing such variable power source as renewable energy, etc. Also, it is important to consider the different forms of heat as utilize such renewable heat and use them more effectively (solar heat, geothermal heat, biomass heat, snow ice storage, hot spring heat, seawater heat, river heat and sewage heat, etc.) by taking advantage of the characteristics of each region.

(2) Basic points of view of the energy policy towards 2030

Energy is the foundation that supports all human activities.

Japan cannot keep developing without establishing an energy supply-demand structure that realizes a stable energy supply system which imposes a light burden on society.

However, Japan's energy supply-demand structure is vulnerable. In particular, carrying out a bold reform of the energy supply-demand structure is inevitable in order to overcome challenges Japan has faced since the Great East Japan Earthquake and the TEPCO's Fukushima nuclear accident.

In promoting energy policy, it is important to look at the entire supply chain of energy from production and procurement to distribution and consumption, clarify basic viewpoint, and tackle mid- to long-term issues.

Even for new reduction target for FY2030, the point of the energy policy is to first and foremost ensure stable supply ("Energy Security"), and realize low cost energy supply by enhancing its efficiency ("Economic Efficiency") on the premise of "Safety". It is also important to make maximum efforts to pursue environment suitability ("Environment").

As mentioned before, within three years after the formulation of the previous strategic energy plan, Japan faced energy supply risks, such as the power outage in the entire Hokkaido region (blackout) due to the Hokkaido Eastern Iburi Earthquake in 2018 and the occurrence of long power outage due to Typhoon No. 15 and No. 19 in 2019. To respond to these risks, GOJ has implemented several countermeasures by revising the Electricity Business Act and taking such measures to accelerate the enhancement of coordination among business operators during a crisis. Also, in recent years, there has been an increase in such risks as a large-scale power outage threatening lives and assets due to cyber-attacks physically damaging the social infrastructure.

In the future, along with the grand direction toward decarbonization, it is required to incorporate in large volumes renewable energy having a natural variability into the existing network, and to establish a stable energy supply system responding to various situations such as changes in the social structure including the decrease in fossil fuel demand due to more electric cars and a lower population, and the increased risks of cyber-attacks against the energy infrastructure.

Also, for energy costs, it is expected that a surcharge for renewable energy will increase toward 2030[7]. It is important to restrain electricity price hikes for industries and for households that have remained high prices since the Great East Japan Earthquake. Though the power generation cost for renewable energy continues to decrease, its introduction cost per 1 kWh (FIT purchase price) is relatively higher than the cost of existing power sources utilizing fossil fuel. On the premise of current technologies, FIT price, and fuel costs, etc., it

7 The purchase price based on the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities has a potential to turn to decrease after 2032 when the purchase period for cases that had started earlier will start finishing among such cases for commercial solar photovoltaic, etc. which had been certified during the profit consideration period in the initial stage of the system introduction. On the other hand, it needs to be carefully considered that the timing and extent of such decrease might vary depending on the decreasing speed in power generation cost for each power source, and the setting of purchase price, etc. based on such decreasing speed, and future operational situation of non-operating power sources, and development of newly approved cases, etc., and also that there will be enhancement costs, etc. for such power grid as interconnections between areas required for expansion of introduction for renewable energy based on the Act of Partial Revision of the Electricity Business Act and Other Acts for Establishing Resilient and Sustainable Electricity Supply Systems.

is estimated that the FIT purchase price will increase with more renewable energy in the future, and will be more expensive than the fuel cost. How to reduce the FIT purchase price will become a big issue.
Having these points in mind, we will summarize concrete efforts in energy policies toward 2030 as follows.

(3) Demand side's thorough energy efficiency measure and supply side's introduction and expansion of non-fossil energy by electrification and hydrogenation in view of decarbonization

Due to the combined efforts of the public and private sectors, Japan's energy consumption efficiency has improved by 40% since the oil crises in the 1970s and is at the highest level in the world. On the basis of the Act on the Rationalization etc. of Energy Use established in 1979 in response to the oil crises, GOJ has encouraged the business operators that consume massive amounts of energy to use energy efficiently by obliging them to report the state of their energy efficiency measures and so on. Also, the act encourages manufacturers, etc. to improve their energy consumption efficiency by the Top Runner Programs for equipment. Regarding houses and buildings, on the basis of the Act on the Improvement of Energy Consumption Performance of Buildings, GOJ has taken regulatory measures such as requesting for new house or building designs that meet the energy efficiency standard. GOJ has aimed to realize the more rational energy supply-demand structure by implementing both the regulatory measures based on these acts and effective assistance measures such as budgetary measures, etc.

In 2018, the Act on the Rationalization etc. of Energy Use was revised and the collaborative energy-efficiency planning system was created that allows GOJ to certify and evaluate energy efficient measures to be taken jointly by multiple business operators. In addition, in order to promote further energy efficiency in freight transportation by strengthening cooperation among freight carriers, consignors, and consignees of freight, GOJ has taken measures such as re definition of the consignors, etc. In 2019, by revising the Act on the Improvement of Energy Consumption Performance of Buildings, GOJ has expanded targets that are obligated to meet the energy efficiency standard in buildings, and taken such measures as mandatory provision of a description on conformance with the energy efficiency standard to clients of small-scale buildings and houses and further expansion of targets of the Top Runner Program for housing. It is expected that further energy efficiency measures will make progress through the review of these systems.

On the other hand, the energy supply-demand structure is undergoing a great change, due to changes in the supply structure caused by an increase in the variable renewable energy such as solar photovoltaic power generation, etc., technological changes attributable to the advancement in digitalization such as AI/IoT, etc., and systems changing in response to the electricity system reform, etc. Towards the realization of carbon neutrality by 2050 and the ambitious reduction target of greenhouse gas emissions in FY2030, while the thorough energy efficiency measure is conducting, it is essential to build an institutional framework for promoting every measure to contribute to S+3E, such as increasing the introduction of non-fossil energy through electrification, hydrogenation, and etc. on the demand side, etc. in light of such changing situations or the decarbonization on the supply side.

1) Further pursuit for the thorough energy efficiency

(a) Industry

In the industry sector, although the regulations, etc. based on the Act on the Rationalization etc. of Energy Use have decreased the energy efficiency intensity, the improvement has stagnated in recent years. In some types of industries such as the iron and steel industry, the introduction of the energy efficient technology has

advanced in the world. Thus, for further energy efficiency, it is necessary to strengthen measures to develop or introduce new energy efficient technologies with high energy efficient potential, utilize unused energy such as exhaust heat from plants, etc. In addition, there are issues such as the long life-cycle of facilities, limited renewal timing, delays in investment in large-scale facilities due to a huge amount of initial investment, etc. Hence, towards further energy efficiency, GOJ continues to strengthen the measures both in terms of regulations and assistance.

In addition to setting the target of 1% improvement per year in the energy consumption intensity, the Act on the Rationalization etc. of Energy Use has promoted introduction of the benchmark system which sets a target such as the energy consumption intensity for each industry. While this program has already been introduced in six industries and 10 fields, based on the state of the energy efficient efforts of the business operators or international trends, etc., GOJ reviews indicators or target values of the benchmark and studies the possibility of expanding the target industry types. In addition, regarding the business operator class division evaluation system based on reports from the specified business operators, GOJ will take more sharp execution such as strengthening the response to business operators who have not made adequate improvements, etc.

Regarding the assistance measures, the development and practical utilization of innovative energy efficient technologies are critical to realize drastic energy efficiency which is not merely an extension of previous energy efficiency. Hence, in order to further deepen the energy-efficiency potential in light of the target in FY2030, GOJ will revise “Energy Efficiency Technological Strategy 2016” (September 2016), and while positioning it as a road map for technological development of energy efficiency, work to develop, assist practical utilization of, and promote widespread use of advanced technologies. In addition, regarding assistance for investment in energy efficient facilities, etc., GOJ will robustly encourage energy efficiency while combining regulations and assistance. Regarding assistance to small and medium-sized enterprises, etc., which do not necessarily possess enough energy efficient knowhow, GOJ will continue to develop a support system by, for example, building a platform in each region that can provide integrated support for planning, execution, and review of the energy efficiency measures, while encouraging them to undergo the energy efficient diagnosis and leading to investment in energy efficiency.

In addition, GOJ will provide energy conservation assistance, etc. through optimization of production activities through DX.

(b) Commercial and residential

In the residential and commercial sectors, improving high energy efficiency of buildings and houses are expected. For non-residential buildings, so far, in addition to realizing ZEB for newly constructed public buildings, including national public buildings, by 2020, GOJ has aimed to achieve ZEH for more than half of the ordered detached houses newly constructed by house builders, etc. by 2020 and conducted demonstrations or taken assistance measures for introduction. Although the target of 2020 was achieved for non-residential buildings, the ZEB rate in newly constructed buildings is less than 1%, and for houses, the ZEH rate in ordered detached houses newly constructed in FY2019 is approximately 20%, which shows the situation in which achievement of the target of 2020 is difficult. In light of such a situation, GOJ will work to further strengthen regulations and assistance while taking into account insulation performance to be

required and challenges to introduce solar photovoltaic power generation that vary depending on a region or building type toward 2030.

For buildings and houses of medium or larger size, the Building Energy Efficiency Act requires buildings to conform with the energy efficiency standard and houses to notify, that they satisfy the energy efficiency standard when they are newly constructed. For small-sized buildings and houses, the act requires an architect to explain whether they meet the energy efficiency standard to a client. In addition, through the Top Runner Program for housing that requires housing suppliers above a certain size to supply houses with higher performance than the energy efficiency standard, GOJ is promoting energy-efficient houses. Through these efforts, the rate of conformance with the energy efficiency standard of newly constructed houses and non-residential buildings increased to 81% and 98%, respectively, in 2019. On the other hand, on the supply side of houses and buildings, improvement of an organization or capability and proficiency of small- and medium-sized builders involved in construction of energy-efficient houses remains an issue. In addition, on the consumer side cost burden associated with improvement of the energy efficiency performance including renovations of existing houses and buildings, and insufficient consumers' awareness or understanding of advantages are pointed out as issues.

In view of these issues and results of the study by the "Study Group on Principles of Energy Efficiency Measures for Houses and Buildings toward Decarbonized Society" aimed at realizing carbon neutrality by 2050 or the target of reducing greenhouse gas emissions in FY2030, GOJ will promptly strengthen the regulatory measures in the Building Energy Efficiency Act in the future. Specifically, GOJ will revise the Building Energy Efficiency Act, and houses and small-sized buildings, are required with the energy efficiency standard, to conform with the energy efficiency standard, by FY2025. In addition, aiming to ensure[8] the energy efficiency performance of houses and buildings which will be newly constructed after FY2030 to meet the level of the ZEH and ZEB standard, GOJ will increase the level of the consistent guiding standard and the Top Runner standard for housing or implement phased upgrades of the energy efficiency standard at least by FY 2030. In addition, GOJ will not only strengthen regulations, but also take initiatives in public building, and provide assistance including demonstration project to promote or further adoption of ZEH or ZEB. Moreover, GOJ will promote the energy efficiency measures comprehensively, for example, providing assistance for renovations and rebuilding of existing houses and buildings, developing and popularizing construction materials and construction methods, that have high energy efficiency performance and are easily applicable to renovations, and aiming to make it obligatory to indicate the energy efficiency performance when selling or renting a newly constructed house, among others.

It is also important to improve the performance of energy efficient equipment or construction materials such as heat insulation materials. In addition to equipment such as air conditioners, water heaters, etc., GOJ has positioned windowpanes, sashes, and heat insulation materials as the target of the Top Runner Program, defined target criteria by referring to products and building materials with the best energy consumption

8 For houses, GOJ aims to reduce the primary energy consumption volume, excluding conformance with the reinforced casing standard and renewable energy, 20% from the current value of the energy efficiency standard. For buildings, it aims to reduce the primary energy consumption volume, excluding the renewable energy, 30% or 40% from the current value of the energy efficiency standard, depending on the intended use (20% for small-sized buildings).

efficiency at the time of establishment of the target, and requests manufacturers, etc. to ensure that products shipped by them will meet said criteria by the target year. Regarding the energy consuming equipment subject to the Top Runner Program, GOJ reviews the criteria on the basis of status of immediate improvement of the energy consumption efficiency for each equipment, as needed. In recent years, GOJ has reviewed the criteria for lighting, passenger cars, television receivers, magnetic disk devices, gas/oil water heaters, electric water heaters, etc. as well as the labeling scheme of the energy efficiency performance of equipment for consumers. In addition, for water heaters, GOJ has reformed the system so that the energy efficiency performance of gas, oil, and electricity can be evaluated and displayed in a cross-sectorial manner. While continuously reviewing the criteria for the target equipment of the Top Runner Program or studying the possibility of expanding the target equipment, GOJ will strengthen enforcement, including review of measures for business operators that have not satisfied the criteria. For construction materials as well, GOJ will consider enhancement of the criteria in the Top Runner Program for construction materials, with the aim of ensuring the energy efficiency performance of houses and buildings which will be newly constructed after FY2030 to meet the level of the ZEH and ZEB standards. In addition, to implement to raise the energy efficiency standard GOJ will improve the performance of and construction building materials and equipment, popularize them and reduce those cost.

Energy efficiency in the operational stage is also important. In the benchmark system of the Act on the Rationalization etc. of Energy Use, while nine industries are targeted in the commercial sector, in FY2020, GOJ has decided to review benchmark index and target values for the tenant office industry and convenience store industry, and requested these industries to make further efforts to achieve energy efficiency. In addition, recently, with the advancement of digitalization, volume of data circulation in Japan has been growing, and it is estimated that energy consumption volume in domestic data centers will substantially increase. Therefore, GOJ will study the possibility of adding the data center industry to the benchmark target to facilitate popularization and increase of data centers of the energy efficient type. In the future as well, GOJ will also work to review the benchmark or expand target industries, in light of the energy consumption trend.

In the residential sector, while the Act on the Rationalization etc. of Energy Use requires the energy retailers to make efforts to provide the general consumer with information on energy efficiency, it is likely that information is not adequately provided as there are few institutional incentives. Therefore, GOJ will review "Energy Efficiency Guideline for Energy Retailers" based on the Act on the Rationalization etc. of Energy Use to create a scheme that encourages effective provision of the information on energy efficiency, and visualizes and evaluates status of the efforts made by business operators. In addition, GOJ will provide and promote measures for third parties such as energy suppliers, etc. to further encourage the general consumer or small- and medium-sized companies to make energy conservation repairs or introduce energy efficient equipment.

In addition, through demonstrations, for promoting the next-generation energy management system that can control the usage of energy based optimally with AI and IoT on the power supply-demand situation and status of energy utilization in buildings, GOJ will push forward with more efficient energy consumption in houses and buildings.

(c) Transport

In the transport sector, it is important to achieve energy efficiency for automobiles that account for a major part of energy consumption or to introduce carbon neutrality of fuel and energy. GOJ will pursue the diverse options towards decarbonization and take comprehensive measures such as expansion of the introduction of electric vehicles and infrastructure, technologies related to electric vehicles such as batteries, or strengthening of the supply chain and value chain.

Regarding the fuel economy regulation for automobiles, under the fuel efficiency standard based on the Top Runner Program, the fuel economy has been significantly improved. In March 2020, GOJ defined a new fuel efficiency standard for passenger cars, the target year of the standard being FY2030, which also targets electric vehicles and plug-in hybrid vehicles by "Well to Wheel" evaluation.

To aim for carbon neutrality in the future, it is necessary to continue to use both regulatory approaches and incentive measures in parallel. GOJ will effectively promote reduction of CO_2 emissions by leveraging technically-neutral fuel economy regulation and combining all kinds of technologies.

To this end, GOJ will encourage auto manufacturers, etc. to improve fuel economy in new vehicles by achieving the new fuel efficiency standard. Then, by reviewing operation of recommendations and public announcements, GOJ will study the possibility of strengthening enforcement toward compliance with the fuel efficiency standard.

It is also important to work on the demand side as well as on the supply side. The Energy Conservation Act requires consignors or freight and passenger business operators to report if the business operator has a volume of commodity distribution or transport capacity which is above a certain size, and requests them to make a 1% improvement per year in the energy consumption intensity, as with the case of the regulation for factories and business establishments. On the other hand, regarding regulations on consignors or freight and passenger business operators, due to a difference in the methods of calculating energy usage which serves as an index, etc., energy conservation efforts have not been properly evaluated as in the regulations on factories and business establishments. Therefore, in the future, GOJ will strengthen incentives for consignors and transport operators by appropriately evaluating and visualizing their efforts to improve energy efficiency.

To increase energy efficiency in the transport sector, it is also important that consignors, transport operators, consignees, etc. cooperate to achieve optimization of freight transportation as a whole. To this end, these business operators collaborate, demonstrate that the entire supply chain will become efficient through standardization and formalization of the logistics system and introducing new technologies such as AI and IoT, etc., and laterally develop the best practices which are obtained as this result will be going to widely utilize. In addition, for coastal shipping, technological development and demonstrations for introduction of advanced energy efficiency measures and improvement for logistics efficiency will be conducted, and of energy efficient vessels will be promoted through operation of the system that "visualizes" and evaluates the vessels' energy efficiency performance, etc.. For ports, a study will be conducted on a size and location, etc. of port facilities that allow for import of a large amount of stable and inexpensive hydrogen or fuel ammonia, etc. GOJ will also push forward with measures such as promoting idling stop of vessels through introduction of supply of onshore power to vessels at anchor in a port, promoting introduction of self-supporting hydrogen power sources that can be used even in case of emergency, and facilitating hydrogen fuel for port cargo

handling machines or large trucks, etc. that enter and leave ports.

2) Demand-side efforts to expand introduction of non-fossil energy

In order to accelerate efforts towards carbon neutrality in the future, it is necessary to build a framework that encourages new efforts on the demand side toward S+3E, in addition to the conventional energy efficiency policy. Specifically, GOJ will consider institutional responses with a view to the revision of the Act on the Rationalization etc. of Energy Use, for 1/ rationalization of all energy uses including non-fossil energy (reviewing the definition of energy in the Act on the Rationalization etc. of Energy Use), 2/ expansion of introduction of non-fossil energy (sophistication of demand), 3/ optimization of demands for effective use of renewable energy electricity, and 4/ enhancement of resilience to contribute to system stabilization corresponding to expansion of the introduction of variable renewable energy.

The current the Act on the Rationalization etc. of Energy Use aims to rationalize and make efficient domestic use of fossil energy, and use of non-fossil energy such as electricity derived from solar power, biomass, hydrogen and ammonia, etc. is not subject to the rationalization. On the other hand, for example, hydrogen and ammonia will be procured from overseas for the time being, and thus, rationalizing use of non-fossil energy including these will contribute to realization of carbon neutrality by 2050 and to securing of stable supply of energy and higher economic efficiency. Therefore, GOJ will review the definition of "energy" in the current the Act on the Rationalization etc. of Energy Use, include all energy uses including non-fossil energy in the target of rationalization, and aim to improve the overall energy consumption efficiency. Along with this, by changing the primary energy efficiency coefficient of the grid electricity, which is now considered being derived from thermal power generation, to a coefficient that appropriately reflects immediate power generation mix, status of use of non-fossil energy for power sources will also be reflected appropriately in the evaluation of energy usage on the demand side.

Moreover, towards expansion of the introduction of non-fossil energy on the demand side with an eye on 2050, it is necessary that in addition to some efforts, such as the low carbon society action plan or RE100, that are led by the private sectors, the entire industry set a medium- to long-term goals and promptly launch immediate measures. To this end, while noting that there are still cost barriers or technical restrictions, GOJ will push forward with building of a framework that encourages business operators to increase the introduction ratio of non-fossil energy to expand the introduction of non-fossil energy by electrification and hydrogenation on the demand side, in light of decarbonization on the supply side.

In addition, in recent years, due to the increase of the variable renewable energy such as solar photovoltaic power generation, etc., surplus electricity may be generated in some regions, as seen in implementation of output control of renewable energy electricity, etc. Nevertheless, shifting demand (DR for increasing electricity demands) at this timing will result in rationalization of energy use when looking at the supply and demand combined together. In addition, in the event of strained supply-demand situation, etc. attributable to extreme heat or severe winter, unplanned shutdown of power generation facilities, etc., reduction in demand (DR for decreasing electricity demands), such as a request for electricity saving, becomes one of the effective measures. On the other hand, the current the Act on the Rationalization etc. of Energy Use uniformly requests consumers to equalize demands for electricity during daytime in summer and winter, and the framework is

not such that it flexibly creates or reduces demands in accordance with the supply and demand situation. Therefore, GOJ will push forward with building of a framework that optimizes demands in accordance with changes on the supply side.

Furthermore, with the increase in the variable renewable energy, it is also necessary to take countermeasures on the demand side to contribute to enhancement of resilience such as stable maintenance of the system, etc. Specifically, measures are needed to introduce equipment (air conditioners, etc.) on the demand side that autonomously controls load when frequencies of the system drop, or to encourage use of resources on the demand side such as EV or cogeneration in the event of a temporary shortage of supply capacity due to extreme heat or severe winter. Such efforts will also contribute to enhancement of resilience of the entire system.

GOJ will promptly deepen its study on the institutional framework that positions comprehensive measures that go beyond the energy efficiency on the demand side, take necessary measures such as revision of the act, and contribute to carbon neutrality by 2050 and the goal of reducing greenhouse emission gases in FY2030, while aiming for S+3E.

(4) Sophistication of the secondary energy structure including effective use of distributed energy resources such as storage batteries

In accordance with lowered renewable energy cost or upgraded energy management attributable to improvement in the digital technology, increasing interests in enhancement of resilience, etc., it is expected that the introduction of the distributed energy resources including renewable energy will make progress in the future. In response, it is expected that functions of the distributed energy resources will extend in utilization as the supply capacity for electricity retailers or balancing power for general electricity transmission and distribution utilities, in addition to the functions for own use in the past, such as responses to consumers' resilience, peak cutting, energy conservation by combined heat and electricity, etc. To this end, a smart meter that acquires data on the distributed energy resources or power consumption, etc. of consumers will be introduced to, in principle, all consumers by 2024. In addition, types of data to be acquired by electricity meters or frequency of measurements, etc. will be increased. A next-generation smart meter system capable of acquiring data of a special meter based on the specific metric institution of the Electricity Business Act or data of a gas or water meter will be developed and replace by early 2030s the smart meters which are currently introduced, by early 2030s. The next-generation smart meter will be utilized in enhancement of resilience, stabilization of the supply and demand of the entire system, upgrading of the energy management, etc.

In addition, among the distributed energy resources, storage batteries are of special importance in provision of the balancing power or effective use of variable renewable energy. In recent years, against a backdrop of the increasing interests in enhancement of resilience or improved economic efficiency of own use of electricity generated by residential solar photovoltaic power generation, a purchase period of the FIT system of which has expired, introduction of storage batteries has progressed for residential use. The market size of household storage batteries in Japan has reached the highest level in the world, and growth of the market is expected to continue in the future. From the viewpoint of promoting further introduction of renewable energy, continued expansion of the introduction of not only storage batteries for residential use but also those for commercial and industrial use or for systems, which are expected to be utilized as the balancing power for the system, is expected.

To further increase the widespread use of storage batteries for residential, commercial, or industrial use, it is necessary to address the issue that when compared with other countries, cost of introducing electricity storage systems remains high[9]. To further reduce cost, as the level of investment that can be recovered from profits obtained from electricity storage systems, the target prices of FY2030[10] of 70,000 yen/kWh and 60,000 yen/kWh will be set for electricity storage systems for household use and those for commercial and industrial use, respectively. These will be leveraged as price targets in assistance for introduction by the government, which will thus promote price reduction. In addition, it is estimated that used in-car storage batteries will increase in the future. Thus, promotion of their reuse in stationary storage batteries is expected

9 The estimated price of electricity storage systems including construction cost in 2019 is 187,000 yen/kWh for residential use and 242,000 yen/kWh for commercial and industrial use.

10 The system price including the construction cost, for both residential use and commercial and industrial use.

to contribute to cost reduction of the stationary storage batteries. Therefore, through promotion of international standardization regarding safety, etc. of electricity storage systems when reused storage batteries are used or assistance for demonstration projects, the government will encourage assurance of safety and improvement of performance reliability, and facilitate conversion of in-car storage batteries to stationary storage batteries. In addition, since expansion of the domestic production scale is necessary for further cost reduction, the government will set the outlook for introduction, which will be approximately 24 GWh (approximately 10 times of the cumulative total in 2019) as a total of the residential, commercial, and industrial use in 2030, to promote investment in manufacturing equipment. The government will provide assistance for enhancement of manufacturing equipment of stationary storage batteries in Japan, while sharing the outlook for future market with the industries. In addition, towards smooth introduction of storage batteries to consumers, the government will study the streamlining of paperwork for the grid connection, and introduction and popularization of a performance evaluation index which is easy to understand from the users' viewpoint.

Against a backdrop of utilization in the balancing market or the growing importance of storage batteries associated with integration of renewable energy into the electricity market, some business operators intend to enter the electricity storage business that provides services to avoid imbalance of renewable energy or provides the balancing power, etc., as a new business that takes advantage of storage batteries by utilizing the characteristics (quick response performance, bi-directionality of output, etc.) of large storage batteries that directly connect to the grid. In order to improve the economic efficiency and expand the introduction of stationary storage batteries, which are currently at a high cost, it is also important to make values of storage batteries apparent, by promoting such a new business, and allowing for diverse uses (multi-use) such as the own use, balancing power, or provision of supply capacity. Therefore, the government will address various institutional issues, such as clarification of positioning of storage batteries for systems under the Electricity Business Act, improvement of the environment whereby such a value of storage batteries as quick responsiveness is evaluated and storage batteries are utilized in the market including the supply-demand adjustment market, etc. In addition, the government will encourage diverse use of storage batteries on a business level through demonstrations, etc. of a new business model that utilizes storage batteries, including guiding of charging peak-shifts of EV users by setting electricity prices (dynamic pricing) in tandem with the wholesale electricity market prices.

To promote utilization of the distributed energy resources, active participation of aggregators is necessary. Aggregators can bundle various types of distributed energy resources such as storage batteries or renewable energy, and trade the value of the distributed resources at appropriate prices on the market. At present, main businesses of aggregators are the services which aggregators instruct large consumers such as factories, etc., to reduce demands (DR for decreasing electricity demands) and provide the reduced demand to general electricity transmission and distribution utilities, etc. In these businesses, in a public offering for the balancing power (power source I'[11]) of general electricity transmission and distribution utilities, successful bids by DR of the aggregators increases to approximately 1.8 GW (approximately slightly more than 1% of

11 The general electricity transmission and distribution utilities procure reserve capacity for responding to extreme heat or severe cold that happens roughly once every 10 years, through public offering.

approximately 150 GW of the domestic peak demand) across the country in FY2021. Even during the strained supply-demand situation in January 2021, the demand reduction was carried out multiple times and effectiveness of DR in the event of shortage of electricity was confirmed to some extent. Further utilization of the demand reduction as the decarbonized balancing power is now expected while the business predictability for large-size power sources will decline in the future. It is to be noted that the power source I' is scheduled to shift to the capacity market (activation order power source) in and after FY2024. The amount of successful bid for the activation order power source (including DR) in the main auction for FY2024 is approximately 4.2 GW, and utilization of DR tends to increase.

In addition, from FY2021, the balancing markets will be sequentially established, and from FY2022, the FIP scheme will start, and the aggregators will be positioned in the Electricity Business Act. As such, taking into account the progress in the improvement of related schemes, GOJ will promote further vitalization of the aggregation businesses[12]. To this end, GOJ will push forward with improvement of the market environment so that the distributed energy resources will be evaluated as the balancing power or supply capacity in the balancing market or wholesale electricity market, etc. Moreover, GOJ will promote demonstrations of technology to facilitate the aggregation businesses, including the aggregation business of renewable energy, which bundles generated electricity while predicting output of renewable energy such as solar photovoltaic, etc., with high precision, thereby leveling off fluctuations thereof and restraining any imbalance, or utilizes storage batteries to sell electricity in accordance with the market trends, etc. Furthermore, GOJ will take measures to avoid output control of renewable energy or mitigate grid conjugation through control, etc. to shift the electricity demand when having surplus renewable energy, by shifting the electricity demand (DR for increasing electricity demands) using the distributed energy resources. As described above, a combination of different distributed energy resources will contribute to sophistication of S+3E.

To utilize the distributed energy resources such as renewable energy or cogeneration in a region, construction of a self-sustained and distributed energy system including microgrid is expected that contributes to efficient use of energy through local production for local consumption in the region, enhancement of resilience, etc. In addition, efficient adjustment of the energy supply-demand in the microgrid is expected to lead to avoidance of cost burden or time associated with enhancement of the electricity network equipment when the electricity flowing to the grid level decreases, and improvement of the efficiency of system operation. On the other hand, construction of the microgrid involves issues from technological and economic viewpoints. In addition, when renewable energy is introduced in the region, there arise local concerns about, for example, future disposal of equipment or harmony with landscape for solar photovoltaic power generation. Thus, measures for local production for local consumption that contribute to revitalization of the region while co-existing with the region are also important.

12 The potential DR focused on the demand restraint by aggregators on the electricity market in 2030 is temporarily calculated to be approximately 9 GW with respect to the domestic peak power (currently: approximately 150 GW), assuming that it becomes the same level (corresponding to 6% of the peak power) as the United States where initiatives of demand restraint have advanced. It is also assumed that approximately 12 GW of residential solar photovoltaics that has been introduced by FY2020 will not be subject to FIT by FY2030. In addition, automatically assuming that approximately 11 GW of solar photovoltaic power generation that will be introduced in and after FY2022 will be all subject to FIP or not subject to FIT, the DR potential would be temporarily calculated to be approximately 23 GW (for the electric energy, approximately 30 TWh: approximately 3% of the current electricity demand) if the aggregators could integrate all of those.

Therefore, through assistance for construction of regional microgrids, GOJ will construct the infrastructure technology necessary for business operators to adjust demand in a microgrid and supply by the distributed energy resources. In addition, GOJ will increase business feasibility and profitability of the microgrid by reducing cost of storage batteries that are important as a supply-demand adjustment function or promoting measures to effectively use the distributed energy resources in normal times, etc. Furthermore, GOJ will steadily push forward with construction of regional microgrids, etc. and by accumulating knowledge and experience related to the business feasibility or coordination with related parties and promoting awareness through guidelines, etc. and sharing in the distributed energy platform, GOJ will facilitate more efficient business operations or smooth coordination among related parties such as local governments, etc. In addition, to promote true local production for local consumption that contributes to enhanced resilience in the region or revitalization of the regional economy, GOJ will commend an excellent business operator that co-exists with the region and contributes to construction of the industrial infrastructure of the region and promotes popularization. In addition, the GOJ will improve a mechanism that allows for development of facilities that utilize land of unknown owners, for introducing renewable energy that contributes to the local production for local consumption, etc.

(5) Efforts for utilization of renewable energy as the major power source

A rapid decrease in generating costs is making renewable energy more cost-competitive with other power sources and causing a sharp rise in the amount of renewable energy that is being introduced around the world. In Japan as well, the ratio of renewable energy has increased to 18% in FY2019 from 10% in in July 2012 when the FIT was introduced. The introduction of renewable energy is progressing steadily as Japan ranks sixth in the world for installed capacity of all renewable energies, and Japan has increased the amount of electricity generated from renewable energy about 3-fold since 2012 at a pace far surpassing both Europe and the world average. In fact, Japan has installed the most solar photovoltaic capacity per flat area in the world, showing how the country has cleverly used the limited space it has to promote the introduction of renewable energy.

Going forward as well, with the aim of realizing carbon neutrality by 2050 and reduction targets for greenhouse gas emissions in FY2030, based on the S+3E principle of energy policy, GOJ will continue to fully promote making renewable energy the main power source for decarbonization of the power sector, make efforts on the top priority to renewable energy, and promote the maximum introduction of renewable energy while managing excessive national burden and harmonizing with local communities. Specifically, GOJ will steadily promote the ensuring optimal siting while living in harmony with local communities, project implementation, cost reduction, overcoming power grid constrains, rationalization of regulations, and promotion of technological development, and will work to expand the introduction of electric power while securing a stable supply of the entire electric power system.

The generating costs of renewable energy in Japan have steadily come down, but, because of construction costs, zoning restrictions and other factors, they are still high in comparison to international standards. Moreover, because surcharges for renewable energy are already projected to reach 2.7 trillion yen in FY2021 alongside its increased introduction, it is necessary to manage excessive national burden while continuing to increase its introduction. For this reason, renewable energy costs should be quickly reduced to a level that is competitive with other power sources and allows it to be introduced for its own merits. Moreover, one important step towards renewable energy's establishment as a viable energy source will be to encourage renewable energy electricity producers to take action on their own in response to the supply and demand situation of the power market. Therefore, lower costs and integration into the power market need to be constructively promoted in order to quickly establish renewable energy as a viable energy source.

Another fact that must be considered is that the rapid increase in renewable energy that was spurred by the start of the FIT scheme has also brought various businesses into the picture, which is increasing concerns amongst local communities that host infrastructure over the impact to landscapes and the environment, future abandonment, safety and disaster prevention. Therefore, in order for these local communities and society to accept renewable energy as a stable power source over the long term, efforts to promote a proper understanding, ensure proper business conduct and dispel any fears over safety will be needed.

Furthermore, it is extremely important towards getting the most out of renewable energy to ensure grid

capacity between areas of high renewable energy potential and large consumption areas, deal with the output fluctuations of natural variable energy sources like solar photovoltaic and wind, and overcome system constraints, i.e., maintaining grid stability in outages and other emergencies.

Getting fully behind actions like these and other actions predicated by the characteristics of each power source will be essential to maximizing the introduction of renewable energy with managing excessive national burden and living in harmony with local communities. Let it be clear that, in order to effectively introduce the most renewable energy possible, the progress of various related strategies will have to be watched and evaluated, and those strategies changed as often as needed.

1) Cost reduction and independence from FIT scheme

Both the FIT and FIP schemes are mechanisms designed to reduce the costs of renewable energy by buying renewable energy over the long term at fixed prices or making up the difference from market prices with a premium so that it increases the investment incentive and spreads the use of renewable energy. Based on the objective of this system, in order to reduce the cost of renewable energy power generation and to minimize the increase in the burden on the people associated with the mass introduction of renewable energy, GOJ takes actions that lower the cost of renewable energy by using a bidding system in the FIT/FIP schemes and setting mid to long-term price targets, setting purchase prices and standard rates based on these targets and actual cost reduction trends, and providing support for research and development into lower costs.

Moreover, with regards to inactive power facilities that have not been in operation for an extended period of time but whose procurement price has remained unchanged since its FIT approval, a series of measures have been taken to date to prompt the power producer to reengage in business, because procurement prices are based on costs from the time of approval and do not reflect cost reductions like the yearly fall in solar panel prices. Otherwise, it could lead to consumers bearing a larger burden in the future, disincentivize businesses from developing new business and put pressure on grid capacity. Therefore, a system for nullifying approvals was newly created under the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities (Amended Act on Renewable Energy Special Measures) that was amended by the Act of Partial Revision of the Electricity Business Act and Other Acts for Establishing Resilient and Sustainable Electricity Supply Systems in 2020, which, through proper implementation, should streamline the introduction of renewable energy and minimize the burden borne by people.

It is additionally important towards turning renewable energy into a viable power source that the FIP scheme and other measures be used to stimulate the creativity of power producers so that they integrate renewable energy into the power market. The FIP scheme that was introduced under the Amended Act on Renewable Energy Special Measures of 2020 allows power producers to sell power on wholesale markets or through bilateral transactions just like any other power source and receive a premium based on market price. In market transactions, the scheme encourages power producers to effectively generate and sell electricity in wake of the supply and demand situation and market price, and allows them to foresee the likelihood of them recovering their investment because it guarantees them support in the form of a premium that is calculated by a method that ensures foreseeability. Moreover, the applicability of the FIP scheme will be gradually

expanded to compensate for circumstances peculiar to each power source and business environment, and power producers who have business under the FIT scheme are allowed to transfer that business to the FIP scheme if they so desire. Measures like these will fuel the integration of renewable energy into the power market, which in turn is expected to lower costs of the power system as a whole, improve the accuracy of forecasts of power generation from renewable energy, and lead to business opportunities such as applications that utilize storage batteries to time power generation and sales, and aggregation business.

Moreover, local production for local consumption is important for areas that have renewable energy resources and infrastructure from the perspectives of ensuring a stable supply of power in a natural disaster and activating the local economy and jobs market. For this reason, eligibility for the FIT scheme should include a "local use requirement" that encourages local production for local consumption and use of community-wide power sources, rather than allowing communities to just introduce the system, as this would enhance resilience and spur communities to produce power for themselves.

2) Agreements from local communities / strengthening business discipline

It is absolutely indispensable towards a harmonious introduction of renewable energy into local communities to guarantee that a renewable energy power development project will be implemented properly throughout the entire process from start to finish, and to gain the trust of the local community that hosts the project.

For those reasons, the Amended Act on Renewable Energy Special Measures in 2016 made observing all related laws and local ordinances a new approval standard for projects. Moreover, it was added to project planning guidelines under this same Act that developers were required to make every reasonable efforts to communicate with local residents. In addition, the operation of the Act has also been reviewed from time to time, taking into account the concerns of local communities.

However, community concerns about safety, disaster prevention, impacts to landscapes and the environment, disposal of solar panels in the future and other matters still exist from before particularly with regards to solar photovoltaic power generation projects implemented by businesses of differing size and affiliation that have sprung up rapidly since the launch of the FIT scheme. These fears and concerns need to be dispelled and an environment that ensures responsible safe project management and operation over the long-term must be built.

(a) Efforts to promote local understanding

One way that information on renewable energy power generation projects is made available to local communities is, based on 2016 Amended Act on Renewable Energy Special Measures, to publicly disclose identifying numbers, output and other data of power generation equipment, names of developers and other information about approved projects on the website of the Ministry of Economy, Trade and Industry. Under the Amended Act on Renewable Energy Special Measures, more information will be publicly disclosed beginning in FY2022, in order to better ensure that developers implement projects properly and with the understanding of the local community by providing local residents and others with information. More specifically, the new information will include whether the power generating equipment is running or not, etc.

It should also be noted that, since the start of the FIT scheme, large quantities of renewable energy equipment

have been introduced, prompting an increasing number of local governments to enact restriction ordinances and issue guidelines. For example, amongst the municipal ordinances regarding renewable energy, those that restrict or prohibit the installation of renewable energy power generating equipment in certain areas increased about 4-fold from FY2016 to FY2020. Given these circumstances, the Act on Renewable Energy Special Measures makes it mandatory to observe all related laws and ordinances, and specifies that a violation of an ordinance that reflects the will of a local community can result in government oversight, improvement orders and, if necessary, rescission of approvals. Therefore, as an added push and encouragement to local governments to enact ordinances and the like that reflect the will of local residents, a comprehensive study and analysis should be done of the status and content of ordinances on renewable energy equipment enacted by local governments all across Japan, that information compiled into a database of local ordinances, and good practices, e.g., ordinances that reflect the will of the local community or that produces good results, identified and highlighted therein.

Furthermore, as part of enforcing the Act on Renewable Energy Special Measures, it is important for like-minded local governments that understand what their communities want to coordinate and collaborate with each other. For that purpose, regional liaison meetings that gather all prefectures were launched in October 2018 and have met four times to date. This format should be continued and cooperation between local governments strengthened to encourage more governments to enact ordinances and share good practices.

In addition, the Act on Promotion of Global Warming Countermeasures was amended in 2021 to smoothly form agreements with local communities and create mechanisms that promote the introduction of renewable energy in ways that appropriately consider the environment and contribute to the communities that host them. The Ministry of the Environment and all other concerned governmental ministries and agencies should work together to promote the use of these mechanisms and, from the perspective of human resources, information and capital, the central government should build schemes that continuously and comprehensively support the efforts of local communities in order to promote the introduction of renewable energy in ways that address environmental impacts and communication with local communities, and is agreeable and beneficial to the concerned local community.

(b) Ensuring consistent and appropriate project implementation from start to finish

To ensure that renewable energy power generation projects take firm root as a community-based stable long-term business and gain the trust of local communities, they need to ensure consistent and proper operations from start-up to the end of the business. The Amended Act on Renewable Energy Special Measures, enforced in April 2017, requires licensed business operators to install signs, fence walls, etc. at their power generation facilities. In November 2018, a reminder was issued regarding the obligation to install signs, fence walls, etc. If business operators fail to install such signs, etc., the Agency for Natural Resources and Energy provides verbal guidance and conducts on-site inspections as necessary, each time when such a case is reported. Nevertheless, the Agency is still receiving reports today about the non-installation of signs, fences, etc., thus they will reinforce the response team so that more cases can be handled if reported.

Regarding solar photovoltaic power generation projects, it is necessary to reduce the risk of abandonment and illegal dumping of facilities and equipment after completion of the project. The Amended Act on

Renewable Energy Special Measures and its related laws and regulations have incorporated a new rule that requires operators to set aside disposal costs as a reserve fund in advance to secure reliable financial reserves for disposal. Specifically, for all commercial solar photovoltaic power generation facilities with an output of 10 kW or more, business operators are required to deposit a reserve for disposal costs at an external financial institution using a withholding method, as a general rule. However, exceptionally, if it is confirmed that the operator has the ability to reliably ensure stable power generation over the long term and is also able to reliably secure disposal costs, they are allowed to reserve disposal costs internally. To ensure steady implementation of this rule, GOJ will continue to disseminate and publicize necessary information and improve the system so that licensed solar photovoltaic power business operators and other related parties will correctly recognize the purpose of this rule and act accordingly.

(c) Ensuring safety

In recent years, natural disasters such as typhoons and heavy rains are occurring more frequently and severely, causing accidents involving renewable energy power generation facilities. As a result, people are becoming more interested in the safety of these facilities. Accordingly, it is critical to promote safety measures while appropriately considering these changes in the social environment.

Among various types of renewable energy power generation facilities, solar photovoltaic power generation facilities have seen a particularly significant increase in the number of installations and also the number of accidents. Conventionally, technical requirements for solar photovoltaic power generation facilities have been governed by the technical standards for electrical equipment (e.g., the strength of supporting objects, countermeasures against landslides on slopes, etc.). However, in consideration of the social situation described above, and to respond to the diversification of equipment types and to enable flexible linkage with private sectors' standards and specifications, GOJ has enacted a new and specialized technical standard dedicated to solar photovoltaic power generation only (enforced on April 01, 2021).

Also, for small-capacity power generation facilities, operators are now required to submit a proper report in the event of an accident under the revised Electricity Business Act. While requiring proper business operations through these measures, GOJ will strive to understand the actual status of safety management for small-capacity power generation facilities.

3) Efforts to overcome grid constraints

To maximize the introduction of renewable energies, it is essential to deal with grid constraints. Currently, the demand for decarbonization is becoming stronger, and we must also be prepared for large-scale disasters such as a near-field earthquake directly hitting the Tokyo metropolitan area. Considering these backgrounds, it is important to transform the power transmission network throughout the country into a next-generation network by drastically strengthening its resilience while adapting to massive introduction of renewable energies. In step with further introduction of natural variable energies (solar photovoltaic and wind), greater balancing power will be needed. However, at present the balancing power relies on thermal power generation, etc. as adjusting power sources, thus it is essential to have the balancing power more decarbonized while promoting diffusion of the next-generation network. Conventionally, grid stability has been maintained by

synchronous power sources (thermal, hydro, nuclear, etc.), but in the future, non-synchronous power sources (solar photovoltaic, wind, storage batteries, etc.) will account for greater portion in the grids, thus it is important to take steps to maintain grid stability while adapting to such a change of situation. To foster renewable energies into main power sources of the future, it is necessary to resolve these grid constraints.

(a) Addressing grid constraints toward a large-scale introduction of renewable energies

Conventionally, Japan's electricity system has not always considered potential locations for renewable energies, and grid constraints have become apparent in step with the increase of renewable energies introduced. Therefore, to further introduce a large amount of renewable energy in the future, it is important to fundamentally change the methods of reinforcing, connecting, and utilizing the grids from a viewpoint of securing sufficient transmission capacity.

Toward reinforcement of bulk systems such as cross-regional interconnection lines, GOJ will formulate a master plan to form cross-regional networks on a national scale in a planned manner to improve regional resilience by facilitating mutual power dispensing, while also considering the nationwide potential of renewable energy. In that process, GOJ will seek to steadily understand the potential of each power source, including candidate sources for future connection, and thereby advance the grid reinforcement efficiently and in a planned manner. In addition, GOJ will accelerate the studies for planned and efficient development and deployment of a direct current (DC) transmission system designed to transmit electricity from Hokkaido and other areas that have a large potential for renewable energies, including offshore wind, to large consumption areas. In doing so, GOJ will also consider measures to promote domestic capital investment, while considering the magnitude of economic benefits and the perspective of economic security.

As for the local and distribution grids, from the perspective of ensuring reliable reinforcement of transmission and distribution facilities, GOJ will aim for planned and efficient reinforcement. To that end, GOJ will examine the content of investment plans that will be formulated by each general electricity transmission and distribution utility to verify that necessary amount of investment can be expected. In addition, to optimize those plans, GOJ will study the desirable state of the reinforcement discipline by referring to the master plan for the backbone system. Regarding cost burden for the reinforcement, GOJ will study, in an integrated manner, how to allocate the burden according to the structure of local grid connections and promptly determine a certain direction but expects that it will be the public burden for at least local grids, in principle. On the other hand, since it takes a certain amount of time to reinforce the grids, it is necessary to maximize the use of existing grids in parallel with the reinforcement efforts. For this reason, as a "Japanese Connect & Manage," GOJ has been increasing the operational capacity by probabilistic evaluation of power flow, by opening the quota for emergencies, and by introducing a non-firm access that allows new connection on the condition that output is controlled when transmission lines are congested.

To continue to increase the available space in the operational capacity, GOJ will expand the scope of the application of non-firm access to the local grids as soon as possible. Also, for the distribution grids, GOJ will start development and verification of elemental and other technologies by FY2022 at the latest at NEDO projects utilizing distributed energy resources. Based on the results of those activities, GOJ will determine the direction toward social implementation, aiming for prompt deployment. Furthermore, GOJ will aim to

expand the available capacity of the grids by introducing the dynamic rating system that dynamically handles grid capacity based on weather conditions and other factors. In addition, the number of non-firm-connected power sources is expected to increase, but under the first-come-first-served rule being used at present, non-firm-connected power sources that newly enter will become subject to output control before coal-fired and other power sources that are already connected to the grid, during times when the grit does not have sufficient available capacity. In the days ahead, to enable renewable energies to use bulk system with priority over coal-fired power and other types of electricity, GOJ will review the status quo and work on the prompt realization of a new mechanism that utilizes markets and pursues the merit order (a market-driven mechanism: the zone system and the nodal system). To that end, while studying necessary measures about possible rules and systems, from the perspective of S+3E and considering costs for CO_2 countermeasures, plant start-up, grid stabilization, etc., as well as the easiness of operation, for the time being, GOJ will continuously review the grid-usage rules toward the future introduction of a re-dispatch system that can control the output of power supply by order or command of electricity transmission and distribution utilities. In addition, as a measure to address capacity constraints in upper grids, GOJ will promote effective use of the demand response system and other distributed energy resources in the same region.

(b) Measures to address output fluctuations of natural variable renewable energies

In step with the expansion of the introduction of natural variable renewable energies (solar photovoltaic and wind) in the future, output fluctuations are expected to increase. To maintain stable grid operation, it is necessary to strengthen measures to ensure that supply and demand of electricity are always matched. In addition to its geographical characteristics as an island nation, Japan has a particular need to address output fluctuations in a more sophisticated manner at certain times of the day, because among the options of natural variable energies, Japan has been mainly introducing solar photovoltaic, which shows a large fluctuation in electricity generated between day and night. To promote the further introduction of natural variable energies while ensuring their stable supply, it will be necessary to increase the flexibility of the power system by efficiently and effectively securing the ability to adjust various types of fluctuations, ranging from short- to long-cycle fluctuations, and by strengthening measures to maintain the supply-and-demand balance.

For the time being, while utilizing thermal and pumped hydropower generation, GOJ will facilitate further diffusion of storage batteries. At the same time, GOJ will seek to acquire more broad-based and efficient balancing power by creating a supply and demand balancing market, while also working on studies to promote further utilization of the market.

In addition, to expand the introduction of renewable energy while maintaining the balance of supply and demand ensuring a stable supply during the daytime when solar photovoltaic and other power sources reach their generation peaks, mainly during low-demand seasons, it will be important to control the power output appropriately by considering the characteristics of each power source. As the introduction of renewable energies progresses in the future, output control may become necessary in wider geographical areas or in larger amounts. To minimize the amount and maximize the efficiency of output control for renewable energies, GOJ will promote various measures: for example, reinforcing the grid connection to enable mutual dispensation of available surplus power between districts; encouraging consumers to utilize the demand

response system; introducing the FIP scheme as a measure to raise renewable energy power generators' awareness about supply and demand of electricity; and sophisticating output control by utilizing digital technologies. Furthermore, to prepare for circumstances where it becomes necessary to restrain output due to supply and demand constraints, GOJ will consider rules for the prioritized supply of electricity by thoroughly pursuing the merit order from the perspective of S+3E and considering other factors, such as costs for CO_2 countermeasures, plant start-up, grid stabilization, etc., as well as the easiness of operation. As part of such consideration, GOJ will also study the possibility of lowering the standard for minimum output operation of thermal power plants after carefully examining the status of minimum output and other factors. In addition, while considering the social trend that flexibility and decarbonized balancing power are increasingly desired of power systems, GOJ will make efforts to put storage batteries and water-electrolysis devices into practical use through cost reduction, etc. At the same time, regarding storage batteries used for power grids, GOJ will seek to clarify their positioning in the Electricity Business Act and to develop a market for them.

Furthermore, in anticipation of future integration of renewable energies into the electricity market, GOJ will promptly start studies on additional measures to be taken when output control becomes necessary for renewable energies, including a certain level of financial settlement for output control of non-FIT renewable energies such as post-FIT and FIP power sources.

Besides, to improve the predictability of the amount of output control and to facilitate business operators' investment decisions and smooth financing, GOJ will review the current system so that grid information will be updated for each power source on virtually a real-time basis and disclosed in a visualized form and in 30-minute increments. Also, for thermal power, GOJ will promptly consider disclosure of information for each fuel type.

(c) Maintaining grid stability

In step with the further introduction of natural variable energy power source generating direct current, the non-synchronous power sources (solar photovoltaic, wind, storage batteries, etc.), which transform DC-waveform electricity into an AC waveform by electronic inverter devices, will increasingly account for a greater proportion in the grid. To prepare for that situation, it is necessary to sophisticate the grid operations by utilizing digital technologies in order to ensure grid stability at the foundation level. Specifically, while maintaining stability by operating synchronous power sources, for the time being, GOJ will promote technological development and institutional studies to install synchronous phase regulators and to adopt inverters equipped with a pseudo-inertial function. By doing so, GOJ aims to reduce the risk of widespread power outages that may occur in the event of sudden grid trouble caused by technical factors such as inadequate inertia by a decrease in the number of synchronous generators.

Especially, in power distribution systems, when a large amount of variable renewable energy is introduced locally, even on a small scale for each unit, it will become more difficult to maintain and manage power quality such as voltage. To prepare for that situation, it is necessary to take measures such as sophistication of methods and procedures of collecting, examining, and managing various data. To that end, GOJ will promote sophistication of technologies to predict expected currents and data-analysis technologies to reduce

power loss during transmission. At the same time, GOJ will also work on studies and initiatives to develop a mechanism to collect real-time data necessary for monitoring the grid conditions from natural variable energies, storage batteries, and various power equipment, to be analyzed and integrated to enable optimal management and control of grids according to changes in their conditions.

4) Efforts considering the characteristics of different types of power sources

(a) Solar photovoltaic

Solar photovoltaic power generation is the leading renewable energy in Japan. It has grown to have the world's third largest cumulative installed capacity and the largest installed capacity per land area, as a result of efforts to expand the introduction despite the limited land available where the ratio of flat area is relatively small compared to other major countries. Also, as a distributed energy resource for own use and local production for local consumption, and from the perspective of regional resilience, further utilization of solar photovoltaic is expected and further expansion of its installation is essential.

On the other hand, the annual installation amount of solar photovoltaic power generation has been declining compared to the start-up period of the FIT scheme. As its primary reasons, it can be pointed out that rapid expansion of installation has caused troubles with local communities, and recently there has been an increasing number of enactments of local ordinances that virtually discourage installation of renewable energy power generation facilities in order to preserve the natural environment and landscape. As a result, business operators are faced with growing constraints that prevent the expansion of installation as well as a shortage of locations suitable for the implementation of projects at a low cost and in coexistence with local communities. Another major reason would be that after the introduction of the FIT scheme, GOJ has implemented a reduction of purchase prices and enforcement of stricter business disciplines, considering the immatureness of the industry that was not keeping up with the rapid expansion, as well as the increased burden on the public caused by the surcharge.

In terms of grid connection, the solar photovoltaic power generation can generate power only during daytime and their generation amount is affected by weather conditions. On the other hand, however, they can be installed relatively easily and in a shorter time compared to thermal and other power plants. As a result of these characteristics, their grid constraints have become apparent due to the time lag between power source installation and grid development.

Under these circumstances, to further expand their installation, it is important to encourage, before securing suitable locations, that the projects should be implemented by appropriate business operators in coexistence with the local communities while forming positive consensus with them. In addition, it is desired that costs will be further reduced to a level competitive with other power sources and that solar photovoltaic will mature as a stable power source over the long term by combining them with storage batteries.

Therefore, from the perspective of promoting the introduction of solar photovoltaic in coexistence with local communities, for example, under the revised Act on Promotion of Global Warming Countermeasures, local governments will work on securing suitable locations by setting numerical goals for introducing renewable energy and subsequently by specifically designating renewable energy introduction promotion zones (positive zoning). Regarding farmlands, on the premise that "superior farmlands should be secured for

agriculture," GOJ will promote the expansion of installation of renewable energy facilities in abandoned farmlands not expected to be used for farming, will provide advice on speeding up non-farmland decision and facilitating exclusion from agricultural land areas of devastated farmland that is difficult to regenerate, and will also promote the expansion of the farm-compatible solar photovoltaic power generation that can be installed in active farmlands. In addition, GOJ will also seek to expand the introduction of solar photovoltaic power generation by utilizing infrastructure space such as airports. As for houses and buildings, considering the study results of the "Study Group on Energy Conservation Measures for Houses and Buildings for a Decarbonized Society," GOJ aims that a solar photovoltaic power generation system will be installed at all residences and buildings reasonable for solar photovoltaic power generation by 2050 as common practice and 60% of newly constructed detached houses by 2030. To achieve these goals, GOJ will take the lead by, for example, ensuring that newly constructed government buildings and other new buildings established by the government will be equipped with solar photovoltaic power generation systems to the maximum extent possible at the time of construction, and by also promoting the installation of solar photovoltaic power generation systems on existing government-owned buildings and publicly owned lands to the maximum extent possible. In addition, GOJ will consider all possible support measures also for private sectors to familiarize them with the concept of ZEH and ZEB and to reinforce measures for existing houses and buildings.

Besides, since the power generation cost remains high in Japan compared to international standards, it is necessary to promote further cost reduction while also facilitating their self-reliance from supports through the FIT scheme, etc. Accordingly, to reduce the cost of power generation, GOJ will encourage and facilitate cost reduction efforts of power generation companies and other business operators by utilizing the bidding system under the FIT and FIP schemes and by showing mid- to long-term price targets. In addition, toward effective utilization of solar photovoltaic as a distributed energy source for own use and local production for local consumption, while paying sufficient attention to ensuring fairness of the burden, GOJ will work on development of the business environment by promoting new introduction models such as own use models that do not rely on the FIT and FIP schemes and a new mechanism that allows consumers to install power generation equipment in remote areas and receive electricity based on long-term contracts, as well as by also promoting reduction of prices of storage batteries to facilitate their self-reliant diffusion toward own use by users. Furthermore, by utilizing the FIP system and residential solar photovoltaic power generation whose FIT purchase period has expired, GOJ will promote revitalization of the aggregation business that handles natural variable energies and develop the business environment to achieve self-reliance of solar photovoltaic power generation.

Besides, the existing solar cells, which are currently the mainstream of solar photovoltaic power generation, are lowering their prices, but they have technical constraints for installation. They are difficult to install on the roofs of existing buildings that have only small load-bearing capacity and are also difficult to install on the walls of any building, whether new or existing. To develop next-generation solar cells that can overcome these technical constraints, and put them into practical use, and create new markets including overseas, GOJ will work on research and development activities and demonstration projects toward social implementation of next-generation solar cells and related products.

The installation of solar photovoltaic power generation equipment began to accelerate after the launch of the FIT scheme in FY2012. Since then, there have also been growing anxieties and concerns among local communities: for example, the equipment may be left abandoned or illegally thrown away after the expiration of the operating period, or the power station may make or is making an adverse impact on the landscape and environment. To respond to these voices, GOJ will strengthen the cooperation with local governments in step with the enforcement of the Act on Renewable Energy Special Measures. In addition, GOJ will continue to promote efforts to ensure the proper disposal and treatment of used panels in the future by applying the disposal expenses reserve fund scheme under the Amended Act on Renewable Energy Special Measures.

(b) Windpower

When introducing wind power generation, business operators need to find a suitable location by considering Japan's geographical characteristics and constraints: for example, for onshore sites, suitable locations are decreasing in the plain regions that are easy to develop, and for offshore sites, Japan generally has steep and deep coasts and complex geological strata, compared to generally shallow coasts in Europe. In addition, even after finding a location and forming a project plan, there are additional things to do before the introduction, which takes considerable time: for example, coordinating with the local community, completing an environmental assessment, and ensuring compliance with various regulations and restrictions applicable to the site location. Furthermore, there are opinions that recently the suitable locations for wind do not necessarily match the room for connection to the power grids available now.

To make the most efficient use of suitable areas for wind power generation, including those in Hokkaido, Tohoku and Kyushu regions, GOJ will continue its efforts to streamline the regulations and systems so that wind power generation infrastructure can be introduced more smoothly and in a shorter period, while also aiming for harmonious and symbiotic land use with agriculture and forestry areas. Specifically, for onshore wind, under the revised Act on Promotion of Global Warming Countermeasures, local governments will work on securing suitable locations by setting numerical goals for introducing renewable energy projects and subsequently by specifically designating renewable energy introduction promotion zones (positive zoning). Besides, currently, wind power plants with an output capacity of "10,000 kW or more" are classified as Class 1 Projects that need an environmental assessment, but GOJ will take measures to raise this threshold to "50,000 kW or more." At the same time, GOJ will consider the desirable state of various rules and systems to enable effective and efficient assessments that take into consideration the environmental characteristics of each region. GOJ will also work to speed up and simplify the administrative procedures required to revoke the designation of Protected Forests.

Another issue is that it is necessary to promote cost reduction because the cost of wind power generation remains high in Japan compared to international standards. Accordingly, aiming to achieve the mid- to long-term price targets under the FIT scheme, GOJ will encourage and facilitate cost reduction efforts of power generation companies and other business operators through the public solicitation system and technological development under the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities (the Act on Promoting Utilization of Sea Areas for Renewable Energy Generation).

In particular, in the domain of offshore wind power generation, cost reduction and expansion of installation are both progressing rapidly worldwide. Also in Japan, the same can be expected in the future by establishing a competitive environment through the public solicitation system pursuant to the Act on Promoting Utilization of Sea Areas for Renewable Energy Generation. Furthermore, this business field has a market size of several hundred billion yen and uses tens of thousands of parts and components, making it an industry with a broad base, thus it is expected to have an economic ripple effect on related industries. On the other hand, to build a competitive supply chain that can capture the rapidly expanding Asian market, it is also necessary to collaborate with overseas companies and ensure predictability of the market to attract domestic and foreign investment, after summarizing lessons learned from the withdrawal of domestic wind turbine manufacturers. To this end, GOJ and private sectors will aim to realize a "virtuous cycle" of mass installation of offshore wind and strengthened competitiveness of related industries in line with the "Vision for Offshore Wind Power Industry (1st)" formulated in December 2020 at the Public-Private Council on Enhancement of Industrial Competitiveness for Offshore Wind Power Generation.

As the first step, GOJ will make a commitment as the government to the creation of an appealing domestic market to attract domestic and foreign investment. Specifically, GOJ will continue to designate candidate zones (for site locations) for ten years, which represents forming of approx. 1 GW projects per year and will amount to 10 GW by 2030 and 30 GW to 45 GW[13] including floating power plants by 2040 in accumulated total. To achieve these goals, it is essential to form projects one after another steadily under the Renewable Energy Marine Use Act. Accordingly, GOJ and local governments will be involved in this initiative from the initial stage and will work on studies to establish a mechanism (Japanese version of a centralized model) designed to investigate wind conditions more quickly and efficiently and ensure grid connection in a timely manner, including studies on the appropriate division of roles between the public and private sectors. In parallel, GOJ and local governments will also promote the maintenance and development of infrastructures, such as power grid systems and port facilities, in a planned manner. Specifically, a GOJ-led "push-type" reinforcement will be started by formulating a master plan for grid maintenance that will contribute to the achievement of the introduction goals. Such reinforcement activities include, for example, 1/ studies on laying long-distance direct current transmission lines on the seabed to carry electricity from suitable locations of offshore wind power generation to large demand areas, 2/ development of technologies necessary for nationwide deployment of a mechanism that enables as much renewable energy as possible to be connected to local and distribution grids, and 3/ continuous review of the grid-usage rules toward the future introduction of a re-dispatching system that can control the output of power supply by order or command of electricity transmission and distribution utilities, so that renewable energies can use backbone grids with priority over coal-fired and other types of electricity. For the time being, while pursuing the merit order, this review /3 will be conducted from the perspective of S+3E and considering costs for CO_2 countermeasures, plant start-up, grid stabilization, etc., as well as the easiness of operation. In addition, GOJ will steadily develop base ports necessary for installation and maintenance of large wind turbines, while also studying functions required of

13 Approved amounts based on the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities

Japan's base ports in the future.

Through all these initiatives, GOJ will seek to create an attractive domestic market and thereby support forming of competitive and robust supply chains, which is important from the perspective of stable power supply and economic ripple effects. In this regard, although there is no domestic manufacturing base for wind turbines at this time, Japan has domestic component manufacturers who have potential technological capabilities with experience in onshore wind turbines, as well as other domestic manufacturing bases. To support these initiatives, the industrial circles have set goals for cost reduction and for strengthening industrial competitiveness and are making efforts to achieve them. The government, too, will drive forward various measures to support the formation of supply chains: for example, providing incentives for capital investment; promoting business matching on a global basis; improving the business environment by regulatory reform through collaborative efforts among multiple ministries; and developing human resources.

Another important issue is to expand the projects to Asian countries where the weather and ocean conditions are similar to Japan’s and the market is expected to expand. To this end, based on the “Offshore Wind Power Technology Development Roadmap” formulated in April 2021 for the purpose of identifying elemental technologies necessary to strengthen the competitiveness, GOJ and private sectors will work to develop next-generation technologies by considering domestic and international trends of bottom-fixed and floating offshore wind power generation and Japan's characteristics and strengths. In particular, regarding wind turbines that are indispensable for building supply chains, and regarding floating offshore wind power generation that is expected to expand in the medium and long term, GOJ and private sectors will accelerate the development of elemental technologies and provide support for long-term technological development, demonstration projects, etc. in a comprehensive manner. In addition, GOJ will promote cooperation with foreign governments as well as inter-company collaboration between domestic and foreign companies, while conducting FS, demonstration, and financing to support Japanese companies that consider participation in the offshore wind business in overseas countries, and while also working on international standardization of safety assessment methods for floating offshore wind.

(c) Geothermal

Japan’s geothermal resource potential is the third largest in the world, but it is not being fully exploited compared to other countries, because of various issues involved with the development of geothermal power generation. For example, it takes considerable time and money; there are constraints on suitable development sites and grid connections due to the uneven distribution of promising geothermal resource areas, which are located only in certain regions; and there is a need to coordinate with local communities and comply with various regulations for development. It is necessary to overcome these issues in order to utilize the value of geothermal power generation as a base-load power source and foster it to be a competitive, self-reliant power source in the mid- to long-term.

For this reason, to achieve the introduction of geothermal power generation in a shorter period, at a lower cost, and more smoothly, GOJ will proceed with a range of activities: for example, efforts to promote the understanding of local communities through study sessions held by local governments and through monitoring of hot-spring operators; fund supply as risk money to reduce investment risks and costs; and

enhancement and development of exploration and other technologies that will contribute to improving the success rate and efficiency of drilling.

In addition, in order to accelerate the geothermal development, Japan Oil, Gas and Metals National Corporation (JOGMEC) itself will conduct surveys of geothermal resources, mainly in natural parks where about 80% of geothermal resources exist, and provide survey data and other information widely to business operators. At the same time, JOGMEC will hand over drilled wells to business operators if requested by them, to further reduce business operators' burden of development risks and costs. In addition, JOGMEC will cooperate with relevant government authorities to review the operation of applicable laws and regulations, including the Natural Parks Act, the Hot Springs Act, and the Forest Act, on the premise that consideration should be given to the natural environment and hot spring operators. In parallel, based on the "Geothermal Development Acceleration Plan" announced in April 2021, the Ministry of the Environment will proceed with the designation of the promotion zones pursuant to the revised Act on Promotion of Global Warming Countermeasures, as well as the efforts to collect and survey scientific data such as hot spring monitoring and to ensure smooth coordination with local communities. Through these activities, the Ministry aims to shorten the lead time by up to two years and, by the year 2030, double the number of geothermal power generation facilities nationwide.

In addition, looking toward the year 2050, GOJ will work on the development of innovative new technologies in order to achieve a drastic expansion in the introduction of geothermal power generation. By utilizing supercritical hydrothermal resources located further deeper (about 5 km) underground compared to those used in conventional geothermal power generation, it will enable geothermal power generation on a larger scale than before. Supercritical geothermal resources are characterized by ultra-high temperatures and pressures, as well as higher acid concentration than conventional geothermal resources, thus it is necessary to take measures to prevent corrosion of equipment such as wells and turbines. In order to utilize these deep underground hydrothermal resources, GOJ will develop technologies for ultradeep drilling and elemental technologies for components and materials such as casing and piping. In addition, regarding a new system for the appropriate management of finite hot springs and geothermal resources, GOJ will clarify the current situation and then summarize and review issues to be discussed.

Geothermal power generation is also expected to have multi-stage energy utilization, such as hot water usage after power generation. For example, geothermal power plants provide warm water generated from steam for use by neighboring hotels, agricultural greenhouses, etc., thereby playing a role in stabilizing regional energy supply. While continuing this kind of sustainable development in coexistence with local communities, GOJ will select local municipalities that are active in utilizing geothermal resources to support agriculture, forestry, fisheries, tourism, and other industries and designate them as "geothermal model districts" to make them known widely to the public.

Furthermore, GOJ will conduct geothermal resource surveys and power generation projects in overseas volcanic belts similar to Japan's, such as in Asia, to accumulate knowledge, experience, and insights to be applied to the exploration and development of geothermal resources in Japan. While doing so, GOJ will also consider strengthening the policy support, including JOGMEC's roles, from the perspective of promoting the global expansion of geothermal power generation technologies by making effective use of the strength of the

Japanese companies that maintain approximately 70% of the global market share of geothermal turbines.

(d) Hydropower

Hydro power generation is important as a decarbonized power source that can maintain a stable power output for a long period of time. There is growing international momentum to re-evaluate the value of hydro power generation and promote utilization of hydro power generation in response to the recent climate changes and the carbon neutralization movements. On the other hand, hydropower generation entails various issues to be addressed: for example, high development risks; difficulties in finding new development sites; agreement with local communities required concerning the watershed environment; and power grid constraints. It is necessary to overcome these issues in order to realize self-reliance while reducing costs and coexisting with local communities. To that end, to encourage the market entry of new operators and to promote the achievement of the cost reduction in the industry, GOJ will provide them with a range of support, including support for flow surveys, support for the preparation of basic and detailed designs, and support for obtaining understanding of local communities that are necessary at the stage of consideration of introduction small to medium-sized hydropower generation. In doing so, since certain data have already been collected by parties concerned, GOJ will ensure that such data will be shared among multiple parties concerned and will facilitate further cooperation with local government agencies from the perspective of collaborating with local communities. Moreover, GOJ will consider establishing a framework of initiatives led by local governments to actively utilize information on promising locations and water systems to facilitate the installation of new hydropower stations.

In Japan, many of the existing hydro power generation facilities located around dams and water conduits were built during the high economic growth period to the 1990s. In those days, design, analysis, and fabrication technologies were still under development, and in particular, the digital technologies available today were not fully utilized. Therefore, those facilities use a sufficiently generous safety factor (available margin of equipment capacity) to protect the equipment. Through the effective use of digital technologies and other means, GOJ will seek to reduce the environmental impact and costs of power generation at dams and water conduits while ensuring the safety of facilities and local communities. In that process, while strengthening the cooperation with the ministries and the agencies in charge of the existing infrastructure such as dams and water conduits, GOJ will work to optimize and improve the efficiency of existing equipment by replacement and other means and will install generators at existing dams and other facilities that are not being used for power generation, to facilitate an increase of the amount of electricity generated. In addition, GOJ will also work on the effective use of hydropower energy through efficient operations of water storage by utilizing digital technologies such as long-term inflow forecasting that is currently under scientific study. When implementing all these actions, in order to enable all the parties concerned to work together under clear schedules and division of roles, GOJ will provide directions toward improvement of the usage and utilization of hydropower generation.

(e) Biomass

Biomass power generation is an energy source which has diverse values as a locally-distributed, locally-

produced, and locally-consumed energy source such as improving resilience in times of disaster and having a large ripple effect on the economy and employment through the revitalization of local industries.

On the other hand, biomass power generation has a distinctive characteristic that, unlike other renewable energies, it requires fuel and, the fuel costs account for the majority of the power generation costs. Therefore, to expand the introduction of biomass power generation, it is necessary to ensure the stable procurement and sustainability of the limited biomass fuel, while reducing the fuel costs. It is expected that these issues will be overcome and the effort will be made to promote the utilization of this energy source in a multifaceted manner in conjunction with local agriculture and forestry industries.

Under these circumstances, to expand the supply of domestic woody biomass fuels, in particular, the government ministries and agencies involved with biomass will work together to promote various initiatives: for example, selecting tree species suitable for fuelwood, such as fast-growing trees and broad-leaf trees; demonstrating forest-raising methods suitable for each region; and revitalizing market transactions by establishing quality standards for woody biomass fuels. Through these efforts, GOJ aims to achieve two primary purposes: to reduce fuel costs, and to stabilize the management of forestry companies where fuelwood is increasingly becoming an important income source.

Moreover, to ensure the sustainability of biomass fuels, the FIT/FIP schemes will intend to require the use of fuels that meet sustainability criteria that will be formulated based on expert and technical s discussions from the perspectives of competition with food and lifecycle greenhouse gas emissions, in addition to environment, society, labor, and governance perspectives. In addition, after obtaining certification, if it turns out that a business operator has failed to conduct that business in accordance with the applicable business plan, GOJ will issue a guidance or improvement order to require the practice of that business, or revoke the certification if necessary, pursuant to the Act on Renewable Energy Special Measures.

Furthermore, with regard to biomass power generation and heat utilization, GOJ will actively promote policies and measures for heat utilization and combined heat and power supply by woody biomass while ensuring the preservation of forest resources through enforcement of the Act on Promoting the Generation of Electricity from Renewable Energy Sources Harmonized with Sound Development of Agriculture, Forestry and Fisheries, etc. to drive forward the introduction of renewable energy in harmony with the sound development of the agricultural, forestry and fisheries industries. In addition, measures will be taken to promote the use of biomass materials, such as domestic animal waste, sewage sludge, food waste, etc., and the introduction of crop plants for biofuel in deserted arable lands, while seeking to reduce costs.

In particular, for large-scale biomass power generation where certain cost reduction can be achieved through competition, cost-efficient introduction will be encouraged through a bidding system based on the FIT/FIP schemes, on the premise of stable and sustainable fuel procurement.

(f) Renewable heat

Since renewable heat is an important energy source with region-based characteristics, it is important to promote the use of biomass heat generated from sewage sludge and waste wood, the use of biofuels that can partially replace petroleum products used as fuel for transportation, and the recovery of heat during waste processing, while considering energy source’s economic efficiency and the characteristics of each region.

GOJ will support the introduction of heat supply facilities that use renewable heat, including solar heat, geothermal heat pump, snow ice storage, hot spring heat, seawater heat, river heat, and sewage heat. As another measure to expand the introduction of renewable heat, GOJ will support the schemes where multiple consumer groups mutually share surplus heat in a wide area.

(6) Re-establishment of the nuclear power policy

1) Starting point of the nuclear energy policy – Sincere reflection on the TEPCO's Fukushima Daiichi Nuclear Power Station accident

Regarding TEPCO's Fukushima Daiichi Nuclear Power Station accident, the government and nuclear power sectors must continue their efforts to make sure nothing like that accident happen again. We do not forget the fact we fess into the so-called "myth of safety" invited to the disastrous situation, even for a moment. It is also needed to learn lessons from the various experiences, including those at the Onagawa, Tokai Daini and other nuclear power stations that fortunately did not end up with a serious accident.

GOJ, in cooperation with TEPCO and many other parties involved, has been making its utmost efforts toward the restoration and reconstruction of Fukushima, including by lifting the evacuation order for almost all areas except the Difficult-to-Return Zones. On the other hand, however, even after a lapse of ten years after the accident, about 22,000 people still remain subject to the evacuation order, leaving the government only halfway through its efforts toward restoration from the accident.

Furthermore, there are still anxieties over nuclear power and a sense of distrust and opposition against the government and nuclear power sectors that have been promoted the nuclear power policy. Social confidence in nuclear power has yet to be fully obtained. Despite being in such a situation, there occurred incidents that may damage public trust again, such as the incident related to inadequate protection of nuclear materials at TEPCO's Kashiwazaki-Kariwa Nuclear Power Station.

GOJ and operators must take such a situation seriously and squarely, and continue their maximum efforts toward obtaining social confidence in nuclear power. In addition, keeping in mind the lessons learned from the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, they must take all possible measures to minimize risks of similar accidents. Even after all such efforts, if by any chance an accident occurs, GOJ must deal with it responsibly in accordance with relevant laws and regulations.

2) Untiring pursuit of safety and establishment of a stable business environment for nuclear power operations

While coping with social demands for addressing long-term issues such as a stable supply of electricity at low cost, global warming, etc., in order to gain public trust and to stably promote the use of nuclear energy on the premise of ensuring safety as the top priority, GOJ must make comprehensive and responsible efforts to deal with a variety of issues surrounding the nuclear power industry, including the resumption of nuclear power plant operations, measures to deal with spent fuels, the nuclear fuel cycle, final disposal of spent fuels and the decommissioning of nuclear power reactors.

On the premise that safety always is the top priority, GOJ and operators will make every effort to resolve the public's concerns. Thus, GOJ entrusts matters regarding the safety of nuclear power plants to the expert judgment of the Nuclear Regulation Authority (NRA). If NRA confirms that the nuclear power plants conform with the regulatory requirements that are of the most stringent level in the world, GOJ will respect the judgment and will proceed with the restart of the nuclear power plants. In this case, GOJ will stand at the

front and make efforts to obtain the understanding and cooperation of relevant parties including host municipalities.

Industries, including nuclear power operators, need to set up business schemes to pursue safety voluntarily and persistently and make efforts to foster a safety culture that places top priority on the safety of nuclear facilities. GOJ will play necessary roles such as developing a stable business environment that make these activities possible.

Each nuclear power operator, with a firm resolve of never letting another nuclear accident happen, should establish a system to manage risks appropriately, sophisticate objective and quantitative risk assessments methods such as probabilistic risk assessment (PRA), develop a foundation for risk-informed decision-making (RIDM) and practice it on work sites. Nuclear power operators also need to strive toward the persistent enhancement of safety through competing with each other, for example by accumulating the experiences of peer review activities about their safety management systems. As a core organization to lead the continuous safety improvement activities of the industries, coping with the other parties and academia, a cooperative organization among industries including manufacturers, will present the policy of efforts on the common technical problems by formulating guidelines etc., and continuously check the implementation status with the commitment of industries

. For these efforts to improve safety, it is necessary to have proactive discussions with NRA so that the efforts are consistent with the regulations and what such regulations should be in the mid- and long-term.

As ensuring nuclear security is the basis of operating nuclear power, it is required to foster a culture of nuclear security and to protect nuclear materials thoroughly. Not only complying with regulatory standards, but operators should also build a scheme to strengthen their protection measures voluntarily by mutual feedback about their respective nuclear material protection system, with the management of sensitive information. In addition, thorough measures for cyber security must be taken at each power station based on industry guidelines.

Under these policies, nuclear industries including operators will set up the “Task Force for Acceleration of Restart of Nuclear Power Plants” as a new collaborative structure. In this task force, they will correspond accurately and smoothly to the review of “changes in reactor installation” by the Nuclear Regulatory Commission, etc. and pre-service inspection by a nuclear operator at Tomari, Shimane, Hamaoka, Higashidori, Shika, Ohma, and Tsuruga Nuclear Power Plants that are currently under review. The task force also maintain and improve the on-site technical skills. In addition, in order to build a relationship of trust with the local communities where the plants are located, the nuclear power operators themselves will conduct a series of community-based risk communication on a daily basis. At the same time, GOJ will also stand at the forefront and provide detailed and careful explanation about the current state and issues surrounding energy and nuclear power, based on scientific knowledge and data, to gain understanding and cooperation of those local communities and other stakeholders.

On the other hand, considering that the shutdown periods of the nuclear power plants have been prolonged after the Great East Japan Earthquake, cooperative organizations among nuclear power industries, including manufacturers, will take the lead in proceeding with various initiatives, such as enhancement of maintenance activities, countermeasures anti-aging designs, management of discontinued products, and so on. At the same

time, both the public and private sectors will consider various issues maintaining long-term operations with safety.

It should also be noted that technical discussions have already been started mainly by cooperative organizations among nuclear power industries, including manufacturers. The current agenda include the establishment of a system to study common technical issues to reduce troubles; continuous expansion of knowledge on aged degradation such as irradiation embrittlement; effective and efficient conduct of periodic operator inspections; and measures to achieve longer operating cycles. These discussions and initiatives will be continued.

Nuclear power operators are also required to i) maintain high-level nuclear technologies and human resources, ii) smoothly go through decommissioning work, which will increase in the future, iii) quickly take the best safety measures in response to regulations reinforced after TEPCO's Fukushima Daiichi Nuclear Power Station accident and iv) contribute to global warming countermeasures and stable electricity supply base-load power. Accordingly, the government will continue to study the desirable state of the business environment, by referring to overseas examples, so that nuclear power operators can cope with these issues even in an environment where competition has progressed due to the electricity system reform. In addition, the government will also continue to establish a stable business environment, including the back-end, while considering the progress of the electricity system reform.

Maintaining and developing high-level nuclear technologies and human resources is imperative for smoothly decommissioning including TEPCO's Fukushima Daiichi Nuclear Power Station. In addition, even after the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, the international utilization of nuclear power is expected to expand continuously. In particular, such expansion will progress on a massive scale in China, India and other emerging countries where energy demand is rapidly increasing. As an advanced nation in the utilizing nuclear power with the experience of the accident, Japan is expected to make contributions in nuclear safety, nonproliferation, and security as well as from the perspective of countermeasures against global warming. Furthermore, as the enhancement of nuclear safety in neighboring countries directly means the securing of safety of Japan, Japan should maintain and reinforce high levels of human resources, technologies and industrial foundation for nuclear power through the development of technologies considering varied social demands, and should also maintain and strengthen on-site capabilities through the resumption of operations of suspended nuclear power plants and the decommissioning of stale nuclear power plants.

Regarding the disposal of waste from the decommissioning of nuclear power plants, it is basically the responsibility of nuclear power operators to steadily proceed with efforts to secure the locations of disposal sites, including the disposal of low-level radioactive waste, under the principle that the waste generators are responsible. In order to facilitate the smooth disposal, GOJ will promote measures to ensure the safety, including promotion of necessary research and development activities.

In order to proceed with decommissioning safely and smoothly, it is also necessary to optimize the waste processing. It is important to utilize abundant experience and technologies of overseas operators for our domestic work. For large components that are difficult to be processed in an appropriate and reasonable way in Japan, GOJ will review the existing export regulations as necessary so that such components can be exceptionally exported only when they meet certain criteria, such as export for safe recycling as a useful

resource, and only with the consent of the importing country's authority, taking into consideration relevant international conventions and overseas examples of recycling of similar components. As for clearance object, from the perspective of ensuring smooth decommissioning and effective utilization of resources, GOJ will promote further expansion of recycling destinations, while making efforts to familiarize the clearance system in the society looking ahead future free releases.

Regarding the nuclear damage compensation system, in order to take all possible measures to protect victims in the event of a nuclear accident, the "Act on Compensation for Nuclear Damage" was partially amended in 2018. This revision included preparatory measures to enable prompt and appropriate compensation for damages and a mechanism that allows for early compensation through settlement between the parties before formal compensation is provided. Regarding the review of the compensation system, in view of the actual situation of compensation related to the accident at TEPCO's Fukushima Daiichi Nuclear Power Station as well as progression of the electricity system reform, and on the premise that adequate compensation should be provided promptly, the government will continue its comprehensive study and take necessary measures by considering the division of roles between nuclear power operators and the government and in light of the perspectives of minimizing the public financial burden related to compensation for people affected by the nuclear accident and ensuring the predictability for nuclear power operators.

Regarding establishment and enhancement of the nuclear disaster prevention system, all government agencies will make united efforts to promote various measures, including securing of evacuation routes through road maintenance and improvement, etc. Regarding regional disaster prevention plans and evacuation plans formulated on the basis of the basic disaster prevention plan and the nuclear emergency preparedness guidelines and pursuant to the previsions of the Basic Act on Disaster Management and the Act on Special Measures Concerning Nuclear Emergency Preparedness, GOJ and relevant local government agencies will work together under the framework of the "Regional Nuclear Emergency Preparedness Council" to examine specific issues that need to be resolved in each region and make those plans more specific and appropriate. Regarding local communities' emergency response plans, including the disaster prevention and evacuation plans mentioned above, the Council will review them according to the criteria of the nuclear emergency preparedness guidelines and confirm that the content is specific and reasonable, and then submit such plans to the Nuclear Emergency Preparedness Council (NEPC), chaired by the Prime Minister, for approval. Even after formulation of such plans, while actively adopting the latest knowledge and insights, and in cooperation with local governments and other stakeholders, GOJ will continue to improve those plans through training and other means and develop human resources who can be engaged in nuclear disaster prevention and emergency response. Also, for personnel already engaged in disaster prevention work, GOJ will provide training to improve their ability to respond to a nuclear disaster.

3) Efforts to steadily promote measures without postponing them to the future

As a result of the past use of nuclear energy, currently there are about 19,000 tons of spent fuel, which is already about 80% of the management capacity. As spent fuels are sure to be produced through the use of nuclear energy, it is essential to implement measures steadily to resolve this challenge as a responsibility of the current generation so that the burden is not passed on to future generations. Therefore, GOJ will

drastically reinforce and comprehensively promote efforts to resolve the challenge of how to manage and dispose of spent fuels.

GOJ will take the initiative in dealing with high-level radioactive waste and proceed with measures toward final disposal. In July 2017, GOJ released the Nationwide Map of "Scientific Features" relevant for geological disposal of high-level radioactive waste in Japan. Following the release, while promoting the nationwide dialogue activities, literature surveys in Suttsu Town and Kamoenai Village in Hokkaido the. GOJ will continue its efforts to help deepen the understanding of the Japanese people and relevant local communities about the radioactive waste disposal.

Safely managing spent fuels until their final disposal is an important process in the nuclear fuel cycle. Therefore, GOJ will reinforce its efforts to expand the capacity of storing spent fuels. Furthermore, GOJ will promote development of technologies for reducing the volume and harmfulness of radioactive waste in order to secure a wide range of options in the future.

Regarding the nuclear fuel cycle policy, GOJ will promote reprocessing and "pluthermal" (i.e., using plutonium in form of mixed oxide fuel in Light Water Reactors (LWRs)) while taking into consideration the background to date and seeking the understanding of the relevant municipalities and the international community, and it will flexibly address measures on the mid- to long-term basis.

(a) Drastic reinforcement and comprehensive promotion of efforts to solve the spent-fuel problems

(i) Drastic reinforcement of measures for final disposal of high-level radioactive waste

Toward the realization of the final disposal of the high-level radioactive waste, recognizing that it is the responsibility of the current generation that has generated the waste, GOJ decided to take leadership to proceed with necessary efforts in accordance with the Basic Policy on the Final Disposal of Designated Radioactive Wastes (Cabinet Decision in May 2015) so as not to leave the burden to future generations. In doing so, it is important to ensure that based on recognition that the final disposal project will benefit the whole society, a wide range of citizens have a sense of respect and gratitude for the local communities that contribute to the realization of the final disposal project, and share the awareness that such benefits should be returned to the community in an appropriate manner. In July 2017, GOJ released the Nationwide Map of "Scientific Features" relevant for Geological Disposal. Following the release, while conducting nationwide dialogue activities jointly with the Nuclear Waste Management Organization of Japan (NUMO), NUMO started literature surveys in November 2020 in Suttsu Town and Kamoenai Village in Hokkaido. Along with conducting the surveys, GOJ and NUMO will actively promote dialogues with these local communities including neighboring municipalities through every opportunity such as the "Place for Dialogue" while listening to voices of local people. These dialogues will include the concept of how to ensure the safety in the geological disposal project, the future of the region, and so on. GOJ and NUMO will make utmost efforts to discuss these topics carefully so that local people will consider these issues more deeply. In parallel, considering the importance of coexistence with local communities, GOJ will actively work on collecting and analyzing necessary information that will contribute to future community development, while promoting the appropriate use of supporting systems. GOJ will also continue dialogue activities while asking for understanding and cooperation of local communities, so that people will become interested in the geological

disposal project and willing to accept the surveys in as many communities as possible throughout the country. In doing so, considering the status of communication activities in local communities, GOJ will proactively propose implementation of the survey to the relevant local governments.

With regard to high-level radioactive waste, each country has been making efforts toward the realization of geological disposal based on international recognition that: i) methods for final disposal that do not depend upon long-term institutional management (human management) should be used as far as possible to minimize the burden on future generations, and ii) geological disposal is currently the most promising method of disposal. Japan has also decided to adopt geological disposal, after continuous consideration based on accumulated scientific knowledge. NUMO has compiled the NUMO Pre-siting SDM-based Safety Case that summarized concepts and methodologies for ensuring the safety of disposal projects taking the latest technological developments into consideration. On the other hand, it is important to continue the efforts to resolve the situation where the professional assessment of the technical reliability of geological disposal is not fully shared with the public. To address this issue, GOJ, NUMO, JAEA and other relevant organizations will take a bird's eye view of the whole situation and steadily promote technological development in a comprehensive, planned, and efficient manner. In this process, the research outcomes obtained at the Horonobe Underground Research Center, etc. will be fully utilized. Furthermore, while working toward geological disposal assuming that it is the best option, GOJ will also ensure reversibility and retrievability, so that future generations will be able to select the best disposal method when a better option is put into practice in the future.

Based on this concept, the latest scientific knowledge related to the technical reliability of geological disposal will be periodically and continuously evaluated and reflected in the policy. At the same time, from the perspective of ensuring a wide variety of options for the future and allowing flexible responses, GOJ will steadily promote surveys and researches on alternative disposal options including direct disposal of spent fuels. Additionally, GOJ will also proceed with surveys and researches on the impact to be produced if retrievability is maintained without closing a disposal site in order to specifically identify a desirable method to manage the high-level radioactive waste for the period until closure of the disposal site.

From the standpoint of securing the expertise and knowledge necessary to realize the disposal of high-level radioactive waste, GOJ will work on the development of research outcomes and the succession of human resources and will promote collaboration with related organizations in Japan and abroad including mutual utilization of each other's research infrastructure while gaining the understanding of local communities. Also, regarding the dialogue activities, GOJ will seek to share knowledge and experiences with other countries that share the same challenges with Japan, and utilize them in Japan's domestic efforts.

In addition, the nuclear power operators, which bear the basic responsibility for having generated the radioactive waste, are required to undertake their own community-based activities for local understanding voluntarily and actively, and explain the necessity of the final disposal site to the whole nation, building upon the efforts of GOJ and NUMO.

(ii) Expanding storage capacity of spent fuels

As the current generation that has produced radioactive waste, GOJ will reinforce measures toward final

disposal of high-level radioactive waste and take the initiative in solving this problem, but these processes will take a long time. In the meantime, spent fuels produced by nuclear power generation must be safely managed. It is therefore necessary to expand the capacity for storing the spent fuels and is urgently important to broaden the range of choices for managing the spent fuels while ensuring safety. Such efforts will enhance the flexibility of policies and response, and contribute to medium and long-term energy security.

Based on this concept, the storage capacity of spent fuels will be expanded. Specifically, while studying a wide range of locations as possible sites, regardless of whether they are inside or outside the premises of a power station, GOJ will strengthen its effort for facilitating construction and utilization of new intermediate storage facilities and dry storage facilities.

In October 2015, at the meeting of the Inter-Ministerial Council for Final Disposal, the government adopted the "Action Plan on Measures for the Disposal of Spent Fuel." Based on this Plan, nuclear power operators formulated plans to promote the measures for the disposal of spent fuel and have been proceeding with their efforts accordingly. As a result, since the autumn in 2020, specific progress has been made toward the expansion of the storage capacity: for example, pursuant to the regulatory standards, NRA Japan approved the installation plan of dry storage facilities on the premises of Ikata and Genkai Power Stations, and the construction plan of the Mutsu Interim Storage Facility. In addition to these efforts, further reinforcement of cooperation among business operators is also necessary as an issue for all business operators, which has significant meaning in ensuring flexibility of the spent-fuel measures. GOJ will also stand on the front lines and respond proactively to these spent fuel issues and will make best efforts to ensure the understanding of all parties involved, while considering the intentions of the local governments.

(iii) Promotion of technology development for volume reduction and mitigation of degree of harmfulness of radioactive waste

Regarding spent fuels, including those which have already been produced, appropriate measures must be taken by carefully considering that the fuels must be safely managed and appropriately processed and disposed of on a long-term basis, and that volume reduction and mitigation of degree of harmfulness of radioactive waste are important for lowering long-term risks. Efforts to develop technologies that can rightly respond to these issues and enhance the safety, reliability and efficiency of the measures have the potential to become one of the pillars of countermeasures for spent fuel in the future, and promotion of such efforts has important meaning from the perspective of securing a wide range of options.

Therefore, GOJ will promote technology development on volume reduction and mitigation of degree of harmfulness of radioactive waste. Specifically, the development of technologies for decreasing the radiation dose remaining in radioactive waste over a long period of time and enhancing the safety of processing and disposal of radioactive waste, including nuclide transmutation technology using fast reactors and accelerators, will be promoted by utilizing global networks of personal contacts. Also, while the government examines the situation of study and progress in terms of final disposal, it will continue to study the feasibility of integrated implementation of the research and development for final disposal and reduction of volume, international research cooperation and development of human resources for research.

(b) Promotion of the nuclear fuel cycle policy

(i) Promotion of reprocessing and plutonium use in LWRs

The basic policy of Japan is to promote a nuclear fuel cycle that reprocesses spent fuels and effectively utilizes the plutonium etc. retrieved, from the viewpoint of effective utilization of resources and reduction of the volume and harmfulness of high-level radioactive waste.

Regarding the nuclear fuel cycle, many issues have arisen, including delays in completion of the Rokkasho Reprocessing Plant. Regarding the Monju prototype fast breeder reactor, the government decided to change course to its decommissioning. It is important to take this situation seriously and resolve, one at a time, the issues that may arise in our efforts to safely carry out operations. In order to resolve the issues related to the reprocessing and disposal of spent fuels and mitigate the risks for and the burden on future generations, GOJ will make efforts towards a nuclear fuel cycle that contributes to the reduction of the volume and harmfulness of high-level radioactive waste and effective utilization of resources while adequately taking the past history into consideration and continuing to gain the understanding of relevant municipalities and the international community, and will promote reprocessing and plutonium use in LWRs.

The Rokkasho Reprocessing Plant and MOX fuel plant, the core facility of the nuclear fuel cycle, have just obtained permission based on regulatory standards from the Nuclear Regulation Authority in 2020. And based on the premise of ensuring safety, the public and private sectors, with support from related businesses, will work together to complete and prepare for the operation of these facilities.

GOJ remains committed to the policy of not possessing plutonium without specific purposes on the premise of peaceful use of plutonium and work to reduce of the size of plutonium stockpile, thereby contributing to nuclear nonproliferation and steadily proceeding with such efforts while gaining international understanding. In order to make this policy effective, plutonium will be appropriately managed and utilized through the involvement of GOJ based on the framework of the Spent Nuclear Fuel Reprocessing Fund Act that was newly introduced in 2016 while fully considering the balance between plutonium recovery and utilization in keeping with the “Basic Principles on Japan’s Utilization of Plutonium” (decided by the Atomic Energy Commission in 2018). Based on their understanding of local communities, nuclear power operators are considering the introduction of plutonium use in LWRs in all operating nuclear power plants. Operators plan to implement plutonium use in LWRs at least twelve nuclear power plants by FY2030, and will further promote plutonium use in LWRs while they continue to deepen their mutual collaboration and cooperation.

Along with this, by taking into account the conditions of spent MOX fuel generation and their storage, developments in reprocessing technologies, and the intentions of relevant municipalities, we will study measures for the processing and disposal of spent MOX fuel while continuing R&D with the aim of establishing the technology by the late 2030s. Furthermore, under the “Policy on Fast Reactor Development” (decided at the Inter-Ministerial Council for Nuclear Power Introduction in December 2016), and “Strategic Roadmap” (decided at the Inter-Ministerial Council for Nuclear Power Introduction in December 2018) we will carry out research and development of fast reactors while proceeding with international cooperation with the United States and France.

With respect to the Monju fast breeder reactor, GOJ will address the steady and systematic decommissioning of Monju by giving top priority to safety pursuant to the “Basic policy on Monju decommissioning” (the

decision by Monju decommissioning promotion team). In doing so, GOJ will continue its efforts to gain the understanding of residents of the host community and the general public. In tandem with the decommissioning, the government will develop the Tsuruga area of Fukui Prefecture as the core research and development base for nuclear power and energy while obtaining the cooperation of local communities. In addition to the human resources and various knowledge and technologies that had been cultivated in the Monju project, knowledge and technologies to be obtained during the Monju decommissioning will be used as effectively as possible in fast reactor research and development in the future.

(ii) Flexibility of mid- to long-term approaches

Issues related to the nuclear fuel cycle cannot be solved in a short period but require a mid- to long-term approach. Moreover, it is important to adopt a flexible approach, since it is necessary to respond to various uncertainties, including the technological trend, energy supply-demand balance and the international situation. Since these activities are closely related in particular to the outlook of the future operating situation of nuclear power plants, the amount of nuclear fuel required and the quantity of spent fuels generated, they will be conducted while taking into consideration all of these factors, as well as other factors including the reduction of the volume and harmfulness of high-level radioactive waste, effective utilization of resources and its costs, and the intentions of relevant municipalities, and ensuring strategic flexibility in accordance with the development of the situation.

4) Establishing relationships of trust with citizens, nuclear host municipalities and the international community

(a) Public hearing and public relations activities based on the TEPCO's Fukushima Daiichi Nuclear Power Station accident

Even after a lapse of ten years since TEPCO's Fukushima Daiichi Nuclear Power Station accident, distrust of and concern about nuclear power have yet to be dispelled, and the level of people's trust in administrative agencies and operators involved in energy remains low. Some people are urging the government to provide accurate and objective information on nuclear power.

It is necessary to take the situation seriously and promote polite public hearings and public relations in order to establish relationships of trust. For this reason, GOJ will take the lead and strengthen efforts to gain the understanding of a wide range of communities, including not only nuclear power host communities but also consuming regions that have benefited from the power supply. In doing so, we will devise ways, based on scientific grounds and objective facts, to meet the needs of recipients and facilitate communication on various themes including the risks of nuclear power and the effects of accidents, the state of affairs of regulatory standards and safety measures that were prepared with accidents in mind, disaster management measures for severe accident scenarios, the economic efficiency of nuclear power, back-end such as the disposal of radioactive waste, as well as the current state of energy policies, contribution to global warming countermeasures, and international developments. At the same time, in addition to holding briefing sessions and lectures nationwide, we will also disseminate information by utilizing interactive dialogue formats and public relations methods, such as the web and social networking services (SNS), and promote activities that

are effective in conveying understanding, such as organizing conscientious dialogue activities with regional opinion leaders and stakeholders. Regarding the decommissioning of the Fukushima Daiichi Nuclear Power Station, we will proceed by gaining the understanding of residents of the region through conscientious mutual communication during opportunities such as inspections of the decommissioning site and roundtable discussions with local residents.

Furthermore, we will improve our nuclear power education in order to convey a better understanding of nuclear power by peoples across generations.

(b) Establishing relationships of trust with nuclear power host municipalities and other parties

Japan's use of nuclear energy has been supported by the understanding and cooperation of stakeholders in nuclear power host communities regarding the stable supply of power. In order to continue to use of nuclear power, it is essential that we make efforts to coexist with host communities.

Host communities are faced with unique issues of their own, including regional economic development measures such as the development of regional resources and attracting more tourists, as well as the development of evacuation roads and improvement of disaster prevention schemes. We will seriously deal with these problems, and relevant ministries and agencies will work together to implement efforts to solve these issues, such as through the implementation of budgetary measures and the utilization of the Act on Special Measures concerning Development of Areas around Nuclear Power Plants and Other Facilities to develop local businesses, improve the welfare of local residents, and implement disaster prevention plans.

Meanwhile, the economic and social impacts that are being felt in these regions due to the changing state of affairs, such as the suspension of operations, prolongation of suspensions, suspension of construction work, resumption of operations, extension of operations, and decommissioning are making it difficult to envision a future outlook for these regions. To dispel concerns about the future of host communities, GOJ will work to share awareness and deepen relationships of trust through careful dialogue with these communities, establish a framework based on which to jointly draw a "future vision" for host communities according to their respective needs—including the multi-tracking of industry, creation of new industries, and creation of jobs—and provide support according to the actual situations that each community faces.

For example, in the Reinan region of Fukui prefecture where operations have been ongoing for over 40 years, we have set up a "Co-creation Conference" to study and realize a future vision. Within this Conference, in collaboration with Fukui Prefecture's "Reinan E Coast Plan," GOJ will proactively coordinate efforts with related ministries and agencies to support the nuclear recycling business, conduct research and development, and human resource development through the preparation of the new test and research reactor that is being developed at the "Monju" site, and attract related companies to the region.

In addition, the "multi-tracking of industry" which leverages the strengths of regional resources—such as by creating more added value and strengthening brands in agriculture, forestry, and fisheries through the introduction of ICT, increasing tourism and workcation draw, and utilizing natural energy—is also moving forward in various regions.

As we share these progressive cases and know-how, and deepen discussions on a nationwide level, we will also refine the ideal form of support such as by proposing combinations of various policy tools according to

the actual conditions of different regions. In addition, we will ask nuclear power operators, as members of their local communities, to take sincere actions that contribute to resolving various issues that their host communities may be faced with, as well as make proactive contributions towards examining and realizing future visions.

(c) Contribution to peaceful use of nuclear power and nuclear non- proliferation/nuclear safety in the world

Because the TEPCO's Fukushima Daiichi Nuclear Power Station accident has raised concerns in the countries surrounding Japan, GOJ will promote dialogues with the international community on such occasions such as the meetings of the IAEA etc. to disseminate prompt and accurate information. While some countries have decided to abolish nuclear power in the future, it is also true that many countries have made it clear to continue to utilize nuclear power. Particularly in emerging economies surrounding Japan, including China, Southeast Asian nations and India, nuclear power generation is expected to increase. Considering these situation and the perspective of maintaining and developing Japan's high level of technology and human resources in nuclear, it is Japan's responsibility and the world's expectation to make a contribution to the improvement of global nuclear safety, peaceful use of nuclear energy, non-proliferation and security, as well as to contribute to the fight against global warming. It is imperative for Japan to proactively contribute to formulating international standards of nuclear safety, such as IAEA standards. In addition, when granting public finance for nuclear technology, Japan will contribute to the worldwide improvement of nuclear safety by sharing enhanced safety and the safety culture based on experiences and lessons learnt from the past accidents, while considering for ensuring safety with reference to the Nuclear Safety Convention and IAEA standards etc..

As a non-nuclear armed country, Japan will proactively contribute to nuclear nonproliferation via the reinforcement of the IAEA safeguards and stringent export control as well as to the strengthening of international nuclear security through the beneficial results of the nuclear security summits and IAEA-led continuous efforts. In particular, in the non-proliferation field, it is important to intensify the efforts toward the nuclear non-proliferation by promoting international collaboration in enhancing proliferation resistance of nuclear fuel, and research and development to strengthen technology of nuclear forensics, detection and safeguards, etc. Japan will go through these efforts in cooperation with the countries such as the U.S. and France. GOJ will also support the development of human resources, institutional infrastructure and others for countries that will newly introduce nuclear power in an integrated manner while cooperating with international organizations such as the IAEA.

(7) Future position of thermal power generation

Thermal power generation was a strong driver of the rapid economic growth in postwar Japan, and having undergone the shift from coal-fired to oil-fired power brought on by the liberalization of crude oil imports in the 1960s, and growing utilization of LNG-fired power generation from the oil crisis and environmental issues in the 1970s, it has remained active as a valuable power source for many years. It represented an important supply capacity that provided a stable supply of electricity in the aftermath of the Great East Japan Earthquake and has supported electricity resilience in times of disaster. Thanks to its functions, such as balancing power that adjusts the supply-demand balance by absorbing fluctuations in the output of solar photovoltaic and wind, and inertial response that reduces the possibility of blackouts by mitigating sudden drops in frequency caused by sudden power loss, thermal power generation contributes to the stable supply of electricity, and with the growing introduction of renewable energy, it is also needed for the time being as balancing power and supply capacity to compensate for the variability of renewable energy. Meanwhile, in order to realize the ambitious new greenhouse gas emissions reduction target for FY2030, our basic aim, grounded in the premise of ensuring stable supply, will basically be to secure installed capacity with enough supply capacity to respond to instantaneous and/or continuous drops in electricity generated by renewable energy, and at the same time reduce the proportion of thermal power generation in the power generation mix. In doing so, we must, based on the premise of ensuring stable supply, tackle issues such as strengthening the competitiveness of thermal power generation and improving its economic efficiency while implementing environmental measures to decarbonize thermal power generation.

Regarding stable supply, there is an increasing risk of supply capacities potentially becoming insufficient in the near future as the capacity factor in thermal power plants drops, equipment age, and service suspensions or discontinuations stemming from declining profitability become more frequent while the widespread implementation of technologies (storage batteries, hydrogen, etc.) that are slated to replace the functions of thermal power generation remains insufficient. We will conduct studies aimed at boosting efforts to prevent power source exits and efforts to secure fuel, and at the same time secure installed capacities that will be required in the capacity market over the medium to long term in order to secure supply capacity needed to ensure stable supply amid a deteriorating business environment brought on by declines in installed capacity and capacity factor in thermal power as well as rising fuel shortage risks. In addition, in advancing the shift toward decarbonized thermal power while ensuring a stable supply, it is important to secure an appropriate portfolio based on the advantages and disadvantages of different types of fuels used in fossil-fired operations. As the suspension or discontinuation of oil-fired and the fade-out of inefficient coal-fired proceeds, raising the possibility that our thermal power portfolio may become more heavily weighted on LNG-fired, we will maintain an appropriate thermal power portfolio based on the perspectives of procurement risks associated with sea lane risks that may result from shifting conditions in the Middle East and intensifying procurement competition from growing fuel demand in China and other Asian countries, CO_2 emissions per electricity generated, as well as the perspective of degree of contribution in improving resilience such as stockpiling, and ease of storage.

Regarding environmental measures, we must steadily reduce CO_2 emissions from thermal power generation, and accelerate the development and dissemination of technologies that replace the functions of thermal power generation and technologies for decarbonization. To this end, efforts to reduce CO_2 emissions will be steadily advanced through conventional ongoing voluntary efforts by the electric power industry to reduce CO_2 emissions whose aim is to fulfill the CO_2 emission factor target based on the "Low Carbon Society Action Plan in the Electricity Business," as well as regulations for retailers based on the "Act on the Promotion of Use of Non-fossil Energy Sources and Effective Use of Fossil Energy Materials by Energy Suppliers (Sophistication Act)" that sets targets on the ratio of non-fossil power sources to the amount of electricity sold, and regulations for power generation operators based on the Energy Conservation Act, which sets power generation efficiency targets for thermal power generation. Furthermore, as we build an appropriate thermal power portfolio with an eye on realizing carbon neutrality by 2050, efforts will be taken going forward to steadily fade out inefficient thermal power while making the transformation to next generation and higher efficiencies; promote measures to reduce CO_2 emissions from thermal power generation (abatement measures) such as co-firing of decarbonized fuels such as ammonia and hydrogen, and CCUS/carbon recycling with the aim of replacing existing thermal power with decarbonized thermal power; and promote technological development and improve the environments to which these technologies will be introduced to improve the efficiency and sophistication of thermal power operations.

Specifically, targets benchmarked to generation efficiencies (per provider) equivalent to the latest USC (ultra super critical) will be set for inefficient thermal power, particularly inefficient coal-fired, by tightening regulations under the Energy Conservation Act. In doing so, the co-fired portions of ammonia and other fuels will be made deductible for power generation efficiency calculations as a way to promote the introduction of decarbonization technologies. With respect to the capacity market, starting in the FY2025 auction, we will steadily promote the fade-out of inefficient coal-fired by introducing measures, in addition to the above regulatory measures, to reduce the amounts that inefficient coal-fired power generation operations that exceed a certain availability factor receive from the capacity market. In addition, while we look ahead to decarbonization, we will promote the development of technologies such as Integrated coal Gasification Combined Cycle (IGCC) and Integrated coal Gasification Fuel Cell Combined Cycle (IGFC), both of which are next-generation high-efficiency coal-fired power generation technologies.

Regarding the utilization of decarbonized fuels such as ammonia and hydrogen for thermal power generation, with the goal of introducing and popularizing 30% hydrogen co-firing in gas-fired power generation, hydrogen-only firing, and 20% ammonia co-firing in coal-fired power generation by 2030, we will promote demonstrations of co-firing and dedicated firing using actual equipment, establish the technology, and then implement in existing power plants and other facilities, combustors that are compatible with the combustibility of hydrogen and co-firing burners that suppress NO_x. Through these efforts, the annual demand for hydrogen in 2030 is expected to grow to up to 3 million tons, of which the annual demand for ammonia is expected to be 3 million tons (about 500 thousand tons in terms of hydrogen). It is also assumed that hydrogen and ammonia will cover about 1% of the power generation mix in FY2030. Regarding CCUS/carbon recycling, it is essential that we overcome technical issues and reduce costs as we move forward to 2030. We will promote the development of an environment for the commercialization of

CCUS/carbon recycling through efforts such as developing suitable sites, technological development, transportation demonstrations, and improving the business environment that will be necessary for considering the introduction of CCS by 2030 premised on its commercialization, and considerations for introducing CCS Ready as soon as possible. Through these efforts, we will steadily reduce CO_2 emissions from thermal power generation while maintaining the equipment necessary for stable supply.

Regarding improvements to economic efficiency as the introduction and expansion of renewable energy continue to advance under electricity deregulation, there is a possibility that the capacity factor of thermal power will continue to decline, the equipment will age, and the business environment will continue to deteriorate. In order to enhance the competitiveness of thermal power in this competitive environment going forward, it is essential that we take decarbonization action to realize carbon neutrality by 2050, and we will need to introduce new power sources that support decarbonization that will also be competitive under the environmental actions that will be taken. To this end, we will accelerate detailed studies on ways to promote new investment that contributes to realizing both carbon neutrality and stable supply. And also with respect to existing equipment, while they have been run proportion of thermal power generation in the power generation mix. Under fastidious operation management based on the many years of experience of field engineers, they have been placed in a competitive environment brought on by electricity deregulation in recent years and more efficient business management is required. Furthermore, for the purposes of decarbonization, flexible operation from a balancing power perspective (responding to a wide range of load fluctuations) will be required, and we will need to strengthen efforts that enable these operational advancements. For this reason, with the aim of reducing costs and making operations more flexible by improving the efficiency of operations and maintenance, we will optimize and automate thermal power generation operations using AI/IoT, and promote efforts to develop thermal power technologies with excellent load fluctuation response and mobility.

The perspective of coexistence with host communities will be important when tackling these issues, in particular with respect to the fade-out of inefficient coal-fired. Given the fact that coal-fired is responsible for local tax revenue (property tax, corporate tax, etc.), creates employment in areas such as transportation, operation and maintenance, and contributes to local economies through outsourcing to local companies, studies will need to be carried out to ensure that transitions, such as energy switching aimed at decarbonization, are made according to the actual conditions of these regions and by taking into account the potential future impact on local economies and employment.

Additionally, at the “Infrastructure System Overseas Promotion Strategy 2025” decided at the Management Council for Infrastructure Strategy of December 2020, the basic policy of the Government was to promote effective decarbonization in developing countries. Based on a deep understanding of the needs of partner countries, Japan will offer all available options for reducing CO_2 emissions including renewable energies such as wind, solar and geothermal energy, hydrogen, energy management techniques and CCUS/Carbon Recycling. Japan will support developing policies such as a long-term strategy under the Paris Agreement with a view to attaining decarbonization. Regarding export support for coal-fired power generation, the Government will end to new direct government support for unabated international thermal coal power generation by the end of 2021, including through Official Development Assistance, export finance,

investment, and financial and trade promotion support, based on the G7 Summit communiqué in Cornwall in June 2021.

By deepening our engagement with partner countries in their energy and climate change policies, we will promote efforts based on this basic policy of encouraging decarbonization and lead the realization of decarbonized societies.

(8) Drastic enhancement of efforts towards realizing the hydrogen society

In order to realize a society where hydrogen is used in our everyday lives as well as in industrial activities, in other words a "hydrogen society," we must position hydrogen as another resource, and involve a wide range of players to implement this resource in our societies. In December 2017, Japan formulated the world's first national strategy for hydrogen, the "Basic Hydrogen Strategy" (decided at the Ministerial Council on Renewable Energy, Hydrogen and Related Issues), and has since been steadily implementing efforts toward the realization of a hydrogen society. In recent years, many countries and regions have positioned hydrogen as an indispensable energy source for realizing carbon neutrality, and are formulating strategies and strengthening their efforts. Looking ahead to the carbon-neutral era, in order for Japan to maintain its lead in the field of hydrogen internationally, we must further strengthen our efforts in this area because hydrogen is expected to make positive contributions in a diverse range of areas including the decarbonization of heat utilization where electrification is difficult, zero emissions for power sources, decarbonization of the transport and industry sectors, manufacture of synthetic fuels and synthetic methane, and efficient use of renewable energy, and also because hydrogen's role is expected to expand further in the future. Furthermore, new uses are being considered for ammonia, which is produced from hydrogen, in addition to its conventional use as a feedstock for fertilizers and other products. Such uses include its co-firing or dedicated firing in thermal power generation, and new uses in ships and other forms of transportation as well as in industry.

In order to realize carbon neutrality through the realization of a hydrogen society, we will need to reduce hydrogen supply costs and create demand in a diverse range of fields in an integrated manner. To this end, our aim is to reduce the supply cost of hydrogen, which is currently sold at 100 yen/Nm^3 at general hydrogen stations to 30 yen/Nm^3 (CIF price) in 2030, and 20 yen/Nm^3 or less in 2050, and to eventually reduce costs to the same level as fossil fuels over the long run. At the same time, we aim to increase the hydrogen supply, which is currently estimated to be about 2 million tons/year, to up to 3 million tons/year in 2030 and to about 20 million tons/year in 2050.

Meanwhile, with multiple power companies planning to co-fire fuel ammonia with thermal power generation by 2030, annual domestic demand for fuel ammonia is presumed to be about 3 million tons (about 500 thousand tons in terms of hydrogen) in 2030, and about 30 million tons (about 5 million tons in terms of hydrogen) in 2050. In order to achieve this growth in utilization, it is important to secure the required volumes in a stable manner while keeping the market price from rising. Therefore, by reducing costs in areas such as the procurement, production, transportation/storage, utilization, and financing of fuel ammonia, and by building a system capable of providing a stable supply of necessary fuel ammonia, we aim to supply fuel ammonia at a price in the upper teens of yen per Nm^3 (in terms of calorific value equivalent hydrogen) in 2030.

In order to provide a stable supply of cheap hydrogen and ammonia, etc. in large amounts over the long term, it is important that we proceed with utilizing cheap hydrogen produced overseas and at the same time establish a hydrogen production base utilizing domestic resources. Therefore, with the aim to commercialize hydrogen production by 2030 through the use of international hydrogen supply chains and water electrolyzers

that utilize surplus renewable energy, etc., we will upscale the various transportation and supply facilities including hydrogen carrier ships, improve the reception conditions at ports, provide support for technological development related to the upscaling and modularization of water electrolyzers, consider utilizing and preparing financing schemes provided by public financial institutions and JOGMEC to help reduce the risks associated with resource development and originating port development for hydrogen and ammonia, as well as develop a system to promote the utilization of surplus electricity and other cheap electricity. In addition, we will proceed to support the development of innovative hydrogen production technologies and basic research, including hydrogen production using photocatalysts or high-temperature heat sources such as high-temperature gas-cooled reactors to further reduce hydrogen supply costs and efficiently produce large amounts of hydrogen. Regarding fuel ammonia, we will proceed with technological developments for achieving higher efficiencies in its processes, and once fuel ammonia reaches widespread use, proceed with technological development and environmental improvements to enable more efficient control of CO_2 emissions during its production.

To grow hydrogen demand, we will need to accelerate efforts being made at all sectors. Firstly, in the transport sector, with the aim of further expanding the introduction of FCVs, we will take a two-pronged approach of supporting the introduction of FCVs and strategically developing hydrogen stations. Meanwhile, we will also develop and demonstrate technologies aimed at developing fuel cell trucks and achieving direct combustion of hydrogen and ammonia, developing ships that are equipped to also utilize fuel cells, and extending applications to fuel cell railroad rolling stock and other vehicles, as well as provide support for the development and introduction of stations with large-scale filling capacities. In the area of aircrafts, we will proceed with decarbonization in the aircraft sector by supporting not only the direct use of hydrogen, but also the development of manufacturing technologies for airframes and synthetic fuels as we expect to see the use of synthetic fuels produced from hydrogen in the area of SAFs.

Because we can expect to see a large amount of hydrogen demand in the power generation sector, hydrogen use in the sector is positioned as a driving force for growing hydrogen demand. For this reason, we will proceed steadily with advancing the technological development of combustors for dedicated firing and demonstrations of actual power generation using large-scale combustors. Meanwhile, we will also appropriately evaluate hydrogen's non-fossil value together with ammonia in accordance with the Sophistication Act and other laws to accelerate efforts to achieve social implementation by 2030.

In the industry sector, both hydrogen and ammonia are expected to be used as industrial feedstocks and high-temperature heat sources required in industrial processes. That being said, large-scale conversion of hydrogen reduction iron making and other manufacturing processes must be undertaken, and technological development and demonstrations must be carried out for factory equipment used in industries that use hydrogen, and for burners that match the combustion characteristics of hydrogen and such, as well as for large-scale, high-performance boilers.

In the buildings sector, the selling price of household fuel cells, the first in the world to be commercialized, have dropped in the case of PEFCs (polymer electrolyte fuel cell) from over 3 million yen at the time of their launch to levels below 1 million yen. And since they also contribute to enhancing resilience, the cumulative number of units introduced has exceeded 400,000, entering a stage where they can be now be expected to

independently reach widespread use in the market. In order to promote their further spread going forward, we will promote improvements to conditions so that the potential of fuel cells, including stationary fuel cells for business and industrial applications, can be utilized to their fullest by further reductions in cost enabled by further technological development, and also promote support for demonstrations for utilizing them as supply capacity and balancing power in the power grid. Looking ahead to the carbon-neutral era, we will also support the introduction of pure hydrogen fuel cells going forward, keeping in mind the direct use of hydrogen in stationary fuel cells which can be used even in emergencies.

While Japan has been a world leader in fuel cell technology—fuel cells being key devices that enable decarbonization with the use of hydrogen in a diverse range of areas such as transport and buildings sectors—competition for technological development is intensifying as many countries are now working toward the utilization of hydrogen, so we must accelerate our efforts to strengthen competitiveness with an eye on future market expansion. For this reason, from the perspective of maintaining Japan's competitive advantage and realizing social implementation through the reduction of fuel cell costs, the public and private sectors will work together to 1) strengthen research and development of elemental technologies including basic research, 2) utilize economies of scale through capacity building accompanied by support for expansion into multiple applications and promotion of capital investment, and 3) build further cooperative relationships between FC manufacturers, including standardization in areas of collaboration.

In order to produce a synergistic effect, it is important to carry out these efforts not only individually but also in an integrated manner. In addition, in order to expand hydrogen supply in the face of uncertainties regarding the long-term demand for hydrogen and difficulties in taking the first step in large-scale infrastructure investments, it is desirable to develop model communities in locales where supply can be expanded while maximizing the use of existing infrastructure, and demand and supply are located adjacent to each other as much as reasonably possible, with the first objective being to promote the use of hydrogen. For this reason, the Green Innovation Fund will also be utilized and, by taking into account the results from technological developments for the construction of international hydrogen supply chains and demonstrations of large-scale hydrogen production in Fukushima and Yamanashi using renewable energy, we will create models of social implementation that make the best use of regional characteristics where existing infrastructure and supply can be found adjacent to each other, including 1) large-scale hydrogen supply through international hydrogen supply chains and large-scale utilization in coastal areas, and 2) self-consumption and their utilization in surrounding areas using water electrolyzers, etc. to accumulate knowledge efficiently and increase hydrogen utilization. In creating these models, we will also work with private organizations such as the Japan Hydrogen Association and private sector initiatives that seek to achieve social implementation of hydrogen in their regions.

Regarding the utilization of hydrogen, which can contribute to decarbonization in a wide range of fields in our pursuit of carbon neutrality, "local production for local consumption" type efforts are underway in Fukushima and other local municipalities which take advantage of the characteristics of hydrogen, i.e., how it can be produced from various resources such as by-product hydrogen and renewable energy available in these regions. These efforts are important not only for the contribution they make to the realization of decarbonization at the regional level, but also in improving the degree of energy self-sufficiency in these

regions and enabling regional revitalization. As such, in our pursuit of building advanced models of hydrogen societies at the regional level, we will support hydrogen supply schemes that utilize regional resources and efforts to achieve their wide-area utilization.

With respect to hydrogen regulatory reforms, while we have been steadily implementing reforms aimed at introducing fuel cell vehicles and hydrogen stations, we will continue to steadily proceed with reviews such as on the unification of regulations for fuel cell vehicles as well as expand the scope of reviews in various other fields, in addition to the transport sector, in line with the progress of social implementation of hydrogen, and review the rationalization of regulations based on the premise of ensuring safety. Similarly, from the viewpoint of securing Japan's technological superiority and promoting expansion into overseas markets at a time when advancements are being made in the development of a variety of technologies with an eye on the growing number applications for hydrogen—including developments in hydrogen filling technology for international hydrogen supply chains and commercial vehicles—we will be strengthening our efforts in pursuing international standardization along with the practical application of hydrogen-related technologies such as fuel cell vehicles and hydrogen station-related equipment.

In addition, against the backdrop of increasing momentum toward the realization of carbon neutrality in countries around the world, we will revise the Basic Hydrogen Strategy in accordance with the role of hydrogen in the carbon neutral era.

(9) Promotion of securing stable energy supply and mineral resources looking ahead to the carbon neutral era

Even under the circumstances where various uncertainties exist in the process to realize carbon neutrality, no compromise is acceptable to ensure energy security, and it is the obligation of a nation to continue securing necessary energies and resources stably. In the light of recent changes in Middle East situation, demand expansion in emerging countries, destabilization of sea lanes, growing international strains over strategic material, and others, securing the stable supply through acquisition of oil and natural gas, metallic mineral resources, and other overseas interests as well as domestic resources development is important from the viewpoint of the lives of Japanese citizens and economic activities, and must be achieved continuously and definitely.

To introduce and expand hydrogen, ammonia, and other decarbonized fuels as well as CCS and other technologies, which will serve as keys to realize a carbon neutral society, it is assumed that networks with Middle East, Russia, and other countries with plentiful supplies of natural resources as well as with Asia and other consumer countries, which we have built up through resource diplomacy of oil and natural gas, will serve as important bases. It, therefore, becomes important for us to think of beginning active efforts from now with our eyes fixed on the future. In addition, oil and natural gas developers of Japan continue to be expected to work as leading players in the supply of these decarbonized fuels and technologies, too.

In view of these situations, we will reconsider 1/ more stable securing of immediately needed oil, natural gas, etc., 2/ more stable securing of rare metal and other metallic mineral resources, whose demand is increasing owing to electrification, and 3/ introduction and expansion of decarbonized fuels and their technologies in an integrated manner as natural resources and fuel policies, and pursue a comprehensive policy for realizing smooth shift to carbon neutrality, while making doubly sure of stable natural resources and energy supply.

Furthermore, investigation will be made on roles of JOGMEC and strengthening of its functions of risk money supply, technological demonstration, and other functions in order to contribute to achievement of carbon neutrality, such as introduction and expansion of hydrogen, ammonia, CCS and other decarbonized fuels and their technologies, in addition to stable and inexpensive supply of oil, natural gas, metallic mineral resources, and others.

We will promote comprehensive efforts to make contributions to SDGs and other common philosophy of international community while pursuing these policies.

1) Promotion of comprehensive resources diplomacy

Natural resources diplomacy has been pursued primarily for securing the stable supply of oil and natural gas as well as metallic mineral resources. The world natural resources and energy situations have become more complex and opacified to realize carbon neutrality. Japan with scarce fossil resources must continue to be committed to natural resources diplomacy to the maximum in order to ensure the stable supply of oil and natural gas, metallic mineral resources, and others. Furthermore, we must begin now our efforts to actively work on introduction and expansion of decarbonized fuel and technology in the future. Keeping this in mind, we will roll out “comprehensive resource diplomacy” in order to secure the stable supply of oil and natural

gas and metallic mineral resources, and furthermore, to secure decarbonized fuels and technologies of the future. In such event, we will be actively involved with forming international opinions, such as needs of energy transition and strengthening of resilience, formulating specific cooperation projects concerning decarbonized fuels and technologies, cooperating innovation with the countries concerned for decarbonization of fossil fuels, and forming international rules for countermeasures against methane, carbon credits, and others.

2) Further implementation of independent development of oil and natural gas, and others

Japan depends on imports for almost all of oil and natural gas, and has structural problems, such as limitations to bargaining power in procurement due to the high dependence on imports or susceptibility to the Middle East situation. Under such circumstances, in order to secure stable supply of oil and natural gas, it is extremely important to carry forward independent development through securing upstream interests, which Japanese companies are directly engaged in the development and production, and developing domestic resources. To achieve this, Japan has implemented independent development by Japanese companies through natural resources diplomacy from Prime Minister down, supplying risk money by JOGMEC, and others.

In the meantime, the domestic and international situation surrounding oil and natural gas has been greatly changed, such as decreased upstream investment caused by the low oil price starting from COVID-19 infection spread, increased sea lane risks associated with the destabilization of the situation in the Middle East and growing tensions in the South China Sea and the East China Sea, and furthermore, Japan's 2050 Carbon Neutrality Declaration announced in October 2020 and manifestation of the new greenhouse gas emission reduction target for FY2030 in April 2021, and others.

Even under such circumstances, importance of ensuring the supply of oil and natural gas never changes, but rather, importance of increasing the ratio of independent development to the extent possible still more grows as a foundation for flexibly keeping up with any kind of change in the situation, with enhanced global environmental awareness taken into account. Consequently, the independent development continues to be encouraged, and an increase of the independent development ratio of oil and natural gas (34.7% in FY2019) to 50% or more in 2030 and to 60% or more in 2040 is aimed at by continuously advancing natural resources diplomacy, supplying risk money by JOGMEC, and implementing other measures to ensure a stable supply of oil and natural gas. In addition, while we continue to aim at creating "core companies" with international competitiveness who survive resource acquisition competition including hydrogen, ammonia, CCS and other decarbonized fuels as well as technologies, we will also aim at encouraging these companies to achieve innovative changes to the "comprehensive energy industry" and to become leading players who realize a carbon neutral society. In addition, investigation will be made on whether or not hydrogen and ammonia should be included in the independent development targets on the basis of the launch status, etc. of future domestic demand. The coal independent development ratio (55.7% in FY2019) is aimed to be maintained at 60% in 2030.

3) Creation and expansion of LNG market in Asia

Since it is difficult to hold LNG stockpiles in the same manner as crude oil, it is important to diversify

suppliers and expand the LNG market. Consequently, we have relaxed and abolished destination clauses that prohibit reselling, etc. to third parties and diversified the suppliers on the basis of the "Strategy for LNG Market Development" formulated in May 2016 (formulated by Ministry of Economy, Trade and Industry in May 2016) for the purpose of stabilization of LNG supply and demand as well as prices through market liquidity enhancement. From the viewpoint of strengthening LNG security and building up a market with still higher liquidity, at the LNG Producer-Consumer Conferences 2017 and 2019, we committed ourselves to a twenty billion dollar-level financing initiative from the public and private sectors in Japan and to human resources development assistance for 1,000 people. Furthermore, in the "New International Resource Strategy" formulated in March 2020 (formulated by Ministry of Economy, Trade, and Industry in March 2020), the Japanese Government set out the goal to achieve volume of LNG traded by Japanese companies to reach 100 million tons in FY2030, including offshore trading. Through these activities, the LNG market liquidity has been consistently improved.

Under these circumstances, from the end of 2020 to the beginning of 2021, the LNG price on spot surged temporarily and was destabilized because LNG demand increased in North-East Asia associated with cold wave, LNG supply was lowered due to frequent occurrence of troubles of LNG supply facilities around the world, LNG transport days were prolonged due to congestion at the Panama Canal, etc. Furthermore, it was predicted that China would get ahead of Japan and become the world's largest LNG importing country as early as 2021, and it is feared that the presence of Japan in the international LNG market would be weakened. Taking these circumstances into consideration, from the viewpoint of strengthening security by improving further liquidity of the international LNG market and maintaining Japanese influence in the international LNG market, we will continue promoting activities for creating and expanding a deep Asian LNG market with high liquidity through our involvement in diversifying supply sources by increasing flexibility for destination clauses and supplying risk money by JOGMEC as well as creating and expanding LNG demand in Asian countries, with the aim of achieving volume of LNG traded by Japanese companies to reach 100 million tons in FY2030, including offshore trading.

We will renovate our "LNG market strategy" and formulate a new LNG strategy and put it into motion promptly to further increase international LNG market liquidity and strengthen its resilience, effectively secure LNG amid liberalization of gas and electricity and stabilize procurement prices, and decarbonize the full LNG value chain.

4) Support of CCS, etc. by our upstream development companies and value-added credits created overseas

There are cases in that the governments of resource countries request implementation of CCS at the time of upstream development because of global increase of environmental awareness. Global oil and natural gas development companies carry out upstream development and simultaneously reinforce their various activities for decarbonization, including renewable energies, tree planting, CCS and others. The implementation of CCS in upstream development incurs a great amount of additional cost on a scale of 100 billion to hundreds of billion yen but CCS itself does not generate any income. Unless any support to the implementation of CCS or some kind of economic potential is added to the CSS project itself, the Japanese companies with smaller

company size as compared to those from other countries cannot assume the project risks and cannot participate in upstream development, and as a result, they may damage the Japanese energy security. Consequently, we will back up CCS and other decarbonization action plans in upstream development of Japanese companies through supplying risk money by JOGMEC, technological development, demonstration, human resources development, and others.

In addition, in order to provide added value to CCS and other decarbonization technologies associated with overseas upstream development, it is assumed that the Joint Crediting Mechanism (JCM) in which credits are obtained from the projects implemented in conformity to the rules prescribed in the bilateral framework and voluntary credit transactions which private certification authorities issue to corporate greenhouse gas emissions reduction activities. Meanwhile, currently, it has become an issue that the methodology of greenhouse gas emissions reduction by CCS projects has not yet been established in any case. The voluntary credit has a problem in that credits which Japanese companies created overseas through CCS and other decarbonization activities cannot contribute to the Japan's greenhouse gas emissions reduction targets. Consequently, we will create the environment to increase partner countries in the Joint Crediting Mechanism (JCM) through forming CCS projects, etc., improve international environment to include CCS in credit targets in the voluntary credit market, and investigate and clarify the position of the credits in the domestic system, which Japanese companies created overseas.

5) New development and acquisition of human resources in the oil and natural gas industry

As Japan is poor in natural resources, it is not a matter of course to ensure energy security but public and private people involved have made a ceaseless effort at ensuring energy security to the maximum. These activities are not clearly visible to the public, and we must dispatch information to the public as a country together with the industry in a proactive manner.

Meanwhile, the network and experience which the oil and natural gas industry has accumulated over years continue to serve as an important basis for us to concurrently promote to secure immediate stable supply of oil and natural gas and securing future decarbonized fuels and technologies such as hydrogen, ammonia and CCS, which are required for smooth shift to the carbon neutral society. Furthermore, the oil and natural gas industry is expected to become leading players to aggressively carry forward decarbonization activities, to make a transformation to the "comprehensive energy industry" by themselves, and to realize a carbon neutral society.

Based on the foregoing, we will transmit information on public and private activities to ensure energy security for shifting to carbon neutrality in a manner easily understandable for the public, establish an examination framework in cooperation with the industry in order to back up acquisition of diverse and highly motivated human resources who support the radical transformation of the industrial structure, and formulate specific policies for developing and acquiring new human resources, including transmission of information to students, etc.

6) Securing stable supplies of mineral resources

Mineral resources are important to support people's lives and economic activities as raw materials of all industrial products, and are essential to manufacture renewable energy-related equipment and electrified vehicles, etc. whose demand is expected to increase for carbon neutrality. In particular, securing of stable supply of copper, rare metal, and other mineral resources is fundamental to manufacture storage batteries, motors, and semiconductors, etc. which serve as keys for effective use of energy. Meanwhile, mineral resources vary in conditions of uneven distribution of deposit sites and production sites, degree of oligopoly of midstream process, price stability, etc. according to the kind of mineral resources, and diverse supply risks exist from upstream mine development to downstream end product production.

To date, Japan has rendered assistance to securing of stable mineral resources supply by Japanese companies through risk money supply and resource exploration for securing overseas interests via JOGMEC. At the same time, resources development risks tend to continuously increase due to rising resources nationalism and worsened development conditions, etc. Part of rare metals have a problem of advancing oligopolization by specific countries not only in the upstream process but also in the midstream process. Consequently, we will collect and transmit accurate information related to ongoing resource exploration and development through JOGMEC, and at the same time, we will reinforce support of risk money for mineral ores whose demand is assumed to sharply rise and whose supply is feared to be stopped.

The Japanese domestic non-ferrous smelters play important functions as the core of mineral resources supply chain to supply high-quality metal ingots, restore rare metals which are byproducts of ores, circulate resources by recycling used products, etc. In the meantime, circumstances surrounding the non-ferrous smelters grow increasingly severe with degraded ores or intensified international competition resulting from demand expansion of emerging countries as background. Consequently, we will be committed to building a strong supply chain that does not depend on any specific country by reinforcing support for reducing procurement risks of ores, etc. or risks of sudden demand fluctuations in the non-ferrous smelters. In addition, we will promote investment to maximize the use of recycled resources making the best of specialty area of each non-ferrous smelter, increase the collection rate by refining process improvement and technological development, and increase productivity by collaboration among companies and equipment introduction. Moreover, we will provide further support for activities of developing technologies to reduce rare metal use as well as new materials that can substitute for the rare metal functions in order to greatly reduce supply risks from abroad.

With respect to the stockpiling system to take measures against short-time supply disruption of rare metal, necessary stockpile will be secured on the basis of changes of consumer needs and supply trends of ore types, and at the same time, the system will be consistently improved to enable us to take flexible and prompt actions, such as flexibly changing the type of ore stock.

In addition to these measures, we will roll out comprehensive resource diplomacy in a multilayered way, including the top level as well as the ministerial level. By this, we will continue to aim at achieving 80% or more base-metal self-sufficiency rate by 2030 (50.1% in FY2018). We will aim at maintaining the base metal quantity equivalent to that required domestically by 2050, by combining base metal procured from our own mines overseas, in which Japanese companies own interests, with those obtained by encouraged circulation of resources by recycling. With respect to rare metal, any uniform self-sufficiency rate goal will not be established, but efforts will be made to ensure stable supply by each ore type, because rare metal is frequently

a by-product of base metal production and off-take rights are frequently set irrespective of the rate of interests.

7) Promotion of energy and mineral resources measures in the domestic sea, etc.

Domestic resources development enables us to secure stable energy supply without being susceptible to geopolitical risks. It is, therefore, important for us to continue promoting domestic resources development including methane hydrate with the use as a feedstock for hydrogen and ammonia taken into account. Consequently, technological development and others will be promoted so that we could obtain results as early as possibly in the goal of "aiming at launching a commercialization project on the initiative of a private company taken between FY2023 to FY2027," which was set up in the "Plan for the Development of Marine Energy and Mineral Resources" (formulated by Ministry of Economy, Trade and Industry in February 2019) formulated in conformity to the "Basic Plan on Ocean Policy" (Cabinet Decision in May 2018).

As to oil and natural gas, we will continue to search domestic oil and natural gas (about 50,000 square kilometers by FY2028) using the 3D seismic survey vessel "Tansa," and at the same time, test-drill promising marine waters flexibly and promptly. In addition, "Tansa" is used for the suitable site investigation for CCS and exploration of oil and natural gas performed by private companies at home and abroad to achieve still more effective exploration and to increase market competitiveness. For sea-floor polymetallic sulphides, cobalt-rich crusts, manganese nodules, rare-earth yttrium rich mud, and other domestic marine mineral resources that exist in Japan's territorial waters and exclusive economic zone, activities of getting hold of the resources quantity and establishing production technologies will continue to be promoted in accordance with the "Basic Plan on Ocean Policy" and the "Plan for the Development of Marine Energy and Mineral Resources" with our eyes set on the international situation.

8) Activities for securing decarbonized fuels, etc. (hydrogen, ammonia, synthetic fuels, CCS, carbon recycling, etc.)

The activities implemented in the fuel field for carbon neutrality by 2050 fall into following two broad general categories: 1/ decarbonized fuels such as biofuels, hydrogen, ammonia, synthetic fuels, and synthetic methane which do not increase CO_2 in the atmosphere even when they are burned and 2/ decarbonization technologies such as CCS and carbon recycling, which do not increase CO_2 in the atmosphere even though fossil fuels are being used. For 2030, too, with our eyes fixed on 2050, all of them need to achieve innovation for social implementation and expansion, and systematic approaches are important for securing of them.

Specifically, development of cost reduction technologies must be promoted in line with the progress schedule, etc. decided on "Green Growth Strategy" for social implementation and expansion of decarbonized fuels, etc., and at the same time, it is necessary to organize the concept of CO_2 capture and emissions counting, and to establish rules internationally. In particular, for hydrogen and ammonia, the environment will be improved to ensure investment predictability of business operators through a manifestation of non-fossil fuel energy value or others. In such event, from the viewpoint of expanding the hydrogen and ammonia market, it would be also important to take strategic approaches to carry forward our efforts to expand the use without waiting for the sufficient price fall of hydrogen and ammonia derived from renewable energy fall. With respect to CCS, we will formulate a long-term roadmap, perform the suitable site investigation at home and abroad for

CO_2 storage, and at the same time, investigate environmental improvement for commercialization.

(10) Future position of supply system of fossil fuels

1) Securing of oil and liquefied petroleum gas storage

Though domestic demand of oil tends to decrease, oil storage still has an important role when the Middle East situation and an increase of oil demand in Asia are taken into account, and the oil stockpiling level is maintained. Accordingly, we will continue enhancing the partnerships with oil refinery and oil wholesale companies, changing oil types according to the situation, conducting oil release training and tabletop exercise, and repairing and updating the necessary facilities in oil storage stations in Japan to further improve mobility in releasing the oil stockpiling so that oil stock can be released still more quickly and smoothly for emergency. In keeping with the conditions of fuel shift, we will investigate what the fuel storage should be, including effective use of tanks, and promote cooperation in stockpiling with oil-producing countries and Asian oil-consuming countries for ensuring energy security of the Asian countries.

With respect to liquefied petroleum gas stockpiling, too, the stockpiling level combining the present national stockpile and private stockpile in preparation for wide-scale disasters. For further improving mobility at times of crisis, we will cooperate with the liquefied petroleum gas industry and JOGMEC, and do detailed simulation for a release of national stockpile in relation to the transportation means from national storage stations to various locations by the use of tankers, coasting vessels, and others in accordance with assumptions in emergencies. Furthermore, from the viewpoint of maintaining the supply system at the time of disaster, we will work to construct newly core filling stations equipped with self power generation facilities, and others and to strengthen facilities, and at the same time, to reinforce storage on the demand side, such as fuel storage at emergency shelters, medical and welfare institutions, and other important facilities. Furthermore, we will constantly review the “Petroleum gas supply cooperation program in case of a disaster” for smooth supply cooperation for emergency and conduct training based on the cooperation program.

2) Maintenance and shift of oil supply system

For 2030, too, it is important to maintain a strong oil supply system which can meet all the requirements not only in peacetime but also in an emergency. To achieve this, in order to maintain locations of national oil refinery facilities, we will continue to back up cooperation between companies inside and outside industrial complexes, still greater use of digital technology, effective use of crude oil through upgrading the heavy oil cracking capabilities, increased productivity through business development to Asia and other overseas markets with demand increase anticipated, and activities to enhance competitiveness. Incidentally, the oil refinery industry has made efforts for comprehensive energy corporatization by shifting to petrochemical production or developing a business of renewables, but it is important for them to carry out more proactive new business deployment and encourage to rebuild their operating bases.

For further improvement of capabilities of oil refineries and oil terminals to respond to large-scale disasters, we will promote reinforcement of the refinery drainage system with measures to combat emergency warning level heavy rains and high tides taken into account, in addition to measures against earthquakes and tsunami which have been implemented to date. Furthermore, in order to ensure the stable supply of oil under the

spread of infectious diseases, we will back up the activities of enhancing continuity of refinery operation, including introduction of digital technologies to achieve operator labor saving.
In addition, we will back up structural reform and innovation to enable the oil refinery industry to make the best of the existing fuel infrastructure and networks and human resources the industry has developed, and take on the challenge of supplying biofuel, hydrogen, synthetic fuels, and other new fuels. We will advance further the measures to conserve energy for clean oil refinery process, and at the same time, promote decarbonization activities of refineries, including the use of CO_2-free hydrogen.

3) Activities for securing the supply system by service station

(a) Securing of energy supply system in the region

Service station (SS) is the important and essential social infrastructure that plays an important role to supply petroleum products through fueling, delivery of kerosene, and others and is expected to bear the responsibility to supply energy to EV and FCV or synthetic fuels and other new fuels.
Meanwhile, maintenance of the supply system by SS within the region poses an issue because of decrease of petroleum product demand resulting from future depopulation or vehicle electrification and aggravated shortage of workers. It is therefore necessary to reinforce activities for maintaining SS functions as social infrastructure to meet local conditions where each SS is located.
While further decrease of petroleum product demand is anticipated, SS needs to expand their profits other than by sales of petroleum products. It is also important to use the digital technology as a tool for measures against shortage of workers or for new business development. For this purpose, we will back SS up to diversify their business lines and reconstruct their businesses, and to take actions against shortage of workers making the best of digital technology so that SS could target the development as a “multifunctional SS” which provides carsharing and other mobility services and daily-life-related services such as laundry, etc. or as a “digital transformation SS (SS that is compatible with DX and digitization)”.
It is important for SS to be able to fill electrified cars with energy smoothly as in the case of gasoline-fueled vehicles for their popularization, but charging service for EVs and hydrogen stations for FCVs have not yet been popularized in SS because they have problems of business potential and installation cost. Consequently, we back SS up to find solutions to these issues and at the same time to attach battery chargers for EVs and a hydrogen station so that SS could aim at development as a “comprehensive energy base” that assumes a role of energy supply to EVs and FCVs while continuing the supply of petroleum products. In addition, we will advance energy saving of facilities and introduction of renewable energies at SS.
Furthermore, depending on regions, SS within the area may face business difficulties due to further decrease of petroleum product demand in the area or the successor problem. We therefore need to investigate necessary measures to secure the oil supply system within the area on the basis of the speed and scale of decrease of petroleum product demand in the future. In particular, in the regions other than urban areas, not only supporters of petroleum product supply but also supporters to meet social needs, such as services for elderly people, are not sufficiently available. We therefore support SS activities to work as a “local community infrastructure” which assumes the responsibility for such services. In the meantime, in the case where private business operators find it difficult to continue SS business independently, first of all, it is necessary to carry

forward “collaboration,” “business merger,” and “consolidation” between private business operators, but if it is difficult to maintain SSs by the management effort of private business operators, it is appropriate to secure the oil supply system within the area in a form of succession of SS by municipalities or construction of new SS “built by the public sector but operated by the private sector.” Consequently, we will also support activities for enhancing the partnerships between municipalities and SSs within the area in peacetime and activities for municipalities to succeed SS, in addition to streamlining of the oil supply system within the area by integration, etc. associated with business change of SS.

Close coordination of the government and companies is essential when we support forward-looking activities of SS centering on the foregoing.

(b) Strengthening of SS resilience

Based on the lessons learnt from the Great East Japan Earthquake and 2016 Kumamoto Earthquake, we have proceeded with upgrading of core SSs (SSs that perform priority fueling to emergency vehicles) and SSs for residents (SSs that assume responsibility for fueling general vehicles) equipped with emergency generators to cope with a power failure risk in a time of disaster. At the same time, we have built a system where SSs play a role of “last resort” that responds to requests for fuel supply in a time of disaster in each area by the fuel supply cooperation agreement in case of a disaster, which is executed between petroleum association of each prefecture and municipalities of forty-seven prefectures. Meanwhile, in view of disasters that frequently occurred recently, we will further reinforce capabilities to cope with disasters of SS and enhance cooperation with municipalities and other organizations concerned for responding to fuel delivery stoppage risk of SS due to heavy snow or landslide disasters, risk of losing SS due to tsunami, and risk of damage to weighing machines and other equipment due to flood damage, as well as to respond requests for fuel supply from municipalities.

(c) Ensuring fairness and transparency in the oil product trading structure

It is difficult to differentiate the quality of petroleum product and competition tends to focus on prices. It has been pointed out that the competition would increase along with further decrease of petroleum product demand. We need to take measures ongoingly to establish a fair and transparent petroleum product transaction structure. Based on the wholesale price difference and opacity of price deciding method pointed out in March 2017, we have formulated the Guidelines for Appropriate Trade Practices designed to build a fair and transparent transaction environment and have made efforts to optimize the customary practice of transactions through penetration of the guideline. We will, however, continue to review the guideline as needed in accordance with the progress.

It is necessary to rigorously deal with cases where direct oil sales companies, which generally hold a superior position in business transactions, are committing violations of the Antimonopoly Act, such as imposing competitively disadvantageous terms of transactions on SS operators unfairly in light of normal trading practices, in cooperation with the Fair Trade Commission(FTC).

4) Securing of liquefied petroleum gas supply system

Though the domestic demand of liquefied petroleum gas may decrease due to electrification of the residential sector and depopulation in rural areas, or popularization of energy-saving equipment in the long term, it is essential to keep securing a strong supply system that can accommodate needs not only in peacetime but also in an emergency. We need to seek ways to increase the Japan's energy security by diversifying suppliers including Canada and Australia. In addition, we will support activities such as streamlined delivery by introducing a smart meter that contributes to energy conservation, with the aim of reducing greenhouse gas emissions and improving earning power of liquefied petroleum gas industry.

We will proceed with the activities of fuel switching from oil to liquefied petroleum gas by boilers, generators, etc. from the viewpoint of reduction of greenhouse gas emissions. In cogeneration, too, we will carry on our efforts to increase the use of liquefied petroleum gas cogeneration, such as household fuel cells and others that achieve greater energy conservation and gas engine heat pump (GHP) that can contribute to the cut in peak demand for electricity. Furthermore, we will support activities of the industry who tackle research and development as well as social implementation of bio-liquefied petroleum gas, synthetic liquefied petroleum gas (propanation and butanation), etc. for decarbonization of liquefied petroleum gas.

To optimize liquefied petroleum gas transaction, we will proceed with official announcement of standard prices by liquefied petroleum gas dealers through the website or the environment to which consumers can easily gain access, in addition to continuation of the retail price survey and provision of information by the government. In particular, to achieve transparency of liquefied petroleum gas prices in apartment houses for rent, we will promote activities to work in close cooperation with the real estate industry and other related industries.

5) What the gas supply should be

(a) Strengthening of gas resilience

Gas piping is buried and is not easily susceptible to rain and wind. The most part of gas piping is provided with earthquake resistance. Ongoing activities to improve the earthquake resistance have been performed, too. Consequently, the gas piping has a low risk of supply disruption in times of typhoons, big earthquakes, and other natural disasters of recent years, and early restoration could be anticipated in the light of reinforced measures taken against disasters up to this point. In addition, gas cogeneration with black-start operation can jointly supply electricity and heat continuously and stably even at the time of power failure, and is expected to be diffused as a regional distributed energy system that contributes to strengthening of gas resilience and energy conservation.

It is important to secure diversity of energy sources and energy networks from the viewpoint of stable energy supply, and it is necessary to continuously strengthen resilience of gas infrastructure. In addition, in recent years, part of gas business operators have begun activities for improving security and resilience by considering smart meters that enable remote meter reading, opening and closing cocks, etc. and by using a new safety technology utilizing the digital technology. We will be committed to reinforcement of resilience through further increasing earthquake resistance etc., including promotion of the use of these digital technologies.

(b) Shift to natural gas and decarbonization of heat

The heat demand accounts for about 60% of consumption energy of industry and consumer sectors of Japan, and in particular, in the industrial field, there exists a high-temperature area which is difficult to handle by electrification. Therefore, decarbonization of gas that supplies heat energy to the demand side will play a big role for achieving decarbonization of heat demand and at the same time, the fuel switching to natural gas and increased efficiency of natural gas utilization equipment on the demand side are one of the alternatives for decarbonization of heat demand.

Since natural gas emits the least amount of CO_2 among fossil fuels, it can make contribution to low-carbon heat demand by fuel switching to natural gas, etc., and at the same time, if methanation and other technologies are established on the supply side, synthetic methane, etc. that can use existing infrastructure and facilities can be substituted for natural gas. Therefore, the demand side that has conducted fuel switching, etc. can receive the supply of synthetic methane, etc. in the future and can expect the smoother shift to decarbonization while suppressing the cost for 2050. It is essential for both demand side and supply side to proceed with their activities that contribute to low-carbon heat and decarbonization of heat.

Synthetic methane synthesized (methanation) from hydrogen and CO_2 can use city gas piping and other existing infrastructure and facilities, and therefore, has a big potential as a pillar of gas decarbonization. On the other side, for its practical use and cost reduction, technological development such as increasing the size of the methanation facilities and improving the efficiency must be performed. In part of the regions, the efforts of supplying electricity and heat utilizing hydrogen have been initiated, and in the future, it is can be considered that hydrogen is supplied in the region where hydrogen piping are developed, such as coastal areas. Introduction of LNG with carbon offset by credits and technological development concerning CCUS/carbon recycling such as CO_2 separation, recovery and reuse is promoted, too. It is important to pursue various alternatives including synthetic methane as alternatives of energy switching on the demand side.

It is aimed that in 2030, synthetic methane is injected 1% into the existing infrastructure to make 5% of gas carbon-neutralized with other means added, and in 2050, synthetic methane is injected 90% to make gas carbon-neutralized with other means added. It is essential for private companies, government, and other various stakeholders on the supply side and the demand side to cooperate to work hard for carbon neutralizing the gas. Therefore, we will promote examination of issues and response directionality including the viewpoints of technological development and formulation of overseas supply chains in the Public-Private Sector Council for the Promotion of Methanation Promotion.

In addition, when the use of renewable energies as the main power sources takes place in the future and hydrogen and synthetic methane are manufactured from surplus electricity and others, the electricity is able to be stored and utilized by injecting them into gas piping (Power to Gas: PtoG), and at the same time, the synthetic methane, etc. are utilized to generate power while effectively using heat by gas cogeneration (Gas to Power: GtoP). Through this process, their roles as backup power sources for short power sources in case of emergency and balancing power sources can be expected, too. Consequently, in the distributed energy system, we will carry forward integration of electricity and gas while using digital technology, properly carrying out PtoG and GtoP by data cooperation between electricity and gas, and optimizing supply and demand. To advance this electricity-gas amalgamation, we will strive to build a distributed energy system

through technological development of manufacturing synthetic methane and hydrogen etc. to achieve PtoG and widened introduction of gas cogeneration to achieve GtoP.

(11) Further promotion of the energy system reform

The energy system reform has been carried out for electricity, gas, and heat in three stages with a goal of securing the stable supply, maximum restraints in prices, and an expansion of customers' options and business chances of business operators.

Five years on from liberalization of electricity and heat and four years on from liberalization of gas, new entry from telecommunication, oil, and other industries has increased and cooperation has taken place beyond the business category such as electricity and gas or the barrier of area. At the same time, new service menus come on stage and customers' options are expanded, consistently exhibiting the result of energy system reform.

By the legal separation of pipeline business division scheduled to be carried out in April 2022, a series of system reform process will be fundamentally completed, but for realization of carbon neutrality by 2050, actions against unprecedented changes of energy supply and demand structure will be requested to be taken. Under these circumstances, we need to make our further efforts to build a stable and sustainable energy system, in addition to ongoing pursuit of the results of system reform.

1) Activities for building an electricity system to achieve the stable supply under decarbonization

With the separation of power generation sectors and transmission sectors implemented in April 2020, a series of electricity system reform processes have been fundamentally completed with the pillars of reform being an expansion of the cross-regional system operation, full liberalization of retail sales of electricity and full liberalization of power generation, and ensuring of neutrality of power transmission and distribution sectors through legal unbundling.

After the launch of full liberalization of retail sales of electricity in April 2016, increase of new entry, provision of a variety of price menus, and lowering of prices have taken place, and some positive results have been achieved.

In the meantime, we are facing new challenges associated with the environmental changes surrounding the electricity system, such as uncertainties of stable supply resulting from frequent occurrence and intensification of natural disasters as well as declining trends of supply capabilities, need of realizing a next generation network to achieve mass introduction of renewable energies, and others. Above all, in recent years, operations of thermal power plants have been suspended or discontinued one after another due to worsening of business environment involving power generation. The tight supply and demand relationship that occurred from December 2020 to January 2021 is assumed to be primarily attributed to great increase of power demand caused by intermittent cold weather and operation suppression of LNG thermal power plants due to decrease of LNG inventory arising from troubles of LNG supply facilities. The declining trend of supply capabilities, however, exists as the structural background, and maintaining and securing the supply capabilities in the liberalization of electricity has become the most urgent issue. It continues to be the most important issue to enhance the fair competition environment in a still deeper form, including the competitive relationship between existing electric power companies and newcomers.

In addition, to achieve the FY2030 new greenhouse gas emissions reduction goal and furthermore, realize carbon neutrality by 2050, the electricity sector is requested to accelerate more its activities for decarbonization, and it is important to promote not only conventional activities but also decarbonization of the entire electricity system.

The electricity system reform has been promoted for the purpose of securing the stable supply, restraining electricity prices at a maximum, and expanding customers' options and business chances of business operators with the Great East Japan Earthquake on the background. After the Great East Japan Earthquake, Japan's electricity prices tend to rise because of shutdown of nuclear power plants, and the surcharge for renewable energy may possibly build up cumulatively in the future, too. This heightens concern that the Japan's international competitiveness would be subordinated in the aspect of the energy cost. Consequently, efforts must be made to restrain an electricity price burden of the people by reduction of renewable energy cost, promotion of competition by electricity system reform, and restarting of nuclear power plants with the safety set as the overriding prerequisite, and all these efforts must be connected to securing of international competitiveness of the industry by achieving internationally competitive electricity prices.

In the future, based on these new challenges, too, it is essential to build the electricity system for achieving the stable supply amidst of decarbonization.

We will, therefore, be committed to the following activities including the measures of Act for Establishing Energy Supply Resilience enacted in 2020.

(a) Investigation on strengthening measures and framework for securing the supply capabilities

Before the liberalization, former general electricity utilities, whose cost recovery was guaranteed by regional monopolies and regulated charges, systematically secured power-generating facilities (kW) and fuel (kWh), which are required in accordance with demand. As liberalization progressed and wholesale market transaction increases, withdrawal of unprofitable power sources advances and new investment stagnates in the competition based on the short-term wholesale electricity market. In actuality, suspension or discontinuation of aged thermal power plants is advancing, and oil-fired decreased by about 10 GW in five years from FY2014 to FY2019. Furthermore, risks to the stable supply resulting from lowered supply capabilities have begun surfacing, for example, in the most recent supply-demand forecast, securing of the electricity reserve margin minimally required for the stable supply is unclear. Under these circumstances, foreign countries, too, face the similar issues and introduction of a system for securing the supply capabilities under liberalization has advanced[14]. In Japan, too, in order to achieve the ambitious FY2030 new greenhouse gas emissions reduction goals, we need to grapple with securing of supply capabilities necessary for stable supply in a form that could solve the problem of instantaneous and continuous drop of electricity generated by renewable energies while maintaining sustainable competition and market environment.

In the light of securing plant capacity (kW), we will investigate countermeasures for securing additional supply capabilities and prevention of excess withdrawal of power sources, and at the same time, we will make constant review for further increasing the efficiency while carrying out steady operation of the capacity

14 In the United States, at present, it is thirteen states and Washington D. C. that implement full liberalization of retail selling.

market in which the supply capabilities required four years later are efficiently secured by prior auction.
With respect to the non-fossil value trading market in which the environmental value which the electricity generated from non-fossil power sources, we will undertake a radical overhaul of the whole system, including great increase of non-fossil fuel certificate with tracking information, making accessible to the customers to purchase, and creation of the renewable energy value trading market where renewable energies are able to be traded in a global-standard form.
From the viewpoint of securing the balancing power (ΔkW), we will seek to steadily streamline the supply and demand balancing market to increase efficiency of supply and demand balancing through the wide-area procurement and operation of adjustment capabilities, as introduction of natural variable power sources (solar photovoltaic and wind) has increased and an increase of output fluctuation is foreseen.
In addition, while the new investment to power sources stagnates, at the present moment it is necessary to cover the supply capabilities and balancing power with thermal power generation, but in future years, we must secure the supply capabilities and balancing power by hydrogen, ammonia, CCUS/carbon recycling, hydro, geothermal, storage battery, demand-response, and other decarbonized power sources. In view of the lead time related to construction of power sources, it is essential to urge new investment in Japan. Therefore, for the new investment that contributes to both realization of carbon neutrality by 2050 and stable supply, we will accelerate detailed investigation on the methods of adding long-term income predictability to the initial investment by securing the capacity income for multiple years.
From the viewpoint of securing stable supply of electricity (kWh), we will evaluate the amount of electricity (kWh) conditions, in addition to the installed capacity (kW) in confirming the supply-demand balance, based on the tight supply-demand balance in the FY2020 wintertime, and at the same time, we will seek to investigate encouragement of activities of securing fuels by electricity generation utilities.
Furthermore, with respect to the framework for securing the supply capabilities, we have pursued the electricity system that can secure stable supply efficiently through the broad-based operation of electricity and market mechanism in the electricity system reform under the circumstances in which there is no main body who secures the supply capabilities primarily like former general electricity utilities before the liberalization, and at the same time, we have imposed a duty of securing supply capabilities to retailers and have carried forward environmental improvement so that the cost required for power generation can be appropriately covered through market, etc. We will investigate anew how such responsibilities and roles should be to secure the stable supply on the basis of changes of the competition and market environment from the beginning of designing the electricity system reform to the present as well as changes in the power generation mix.

(b) Development of fair and sustainable competition and market environment

It is essential to develop a fair and competitive environment in a still deeper form, in addition to measures taken to date for promoting new entry in order to further pursue the aim of electricity system reform in that electric utilities may exert their originality and ingenuity, competitions that generate new additional values are actively performed, and the stable power supply is provided efficiently.
After the full liberalization of retail, new entry was rapidly increased, and a large number of retail specialists

who aim at securing the supply capabilities primarily through market transactions have entered markets. The present market has a structure in which these retail specialists and business operators who possess power generation facilities themselves and secure the supply capabilities are mixed. Since these structural changes are observed, it is important to enable electricity generation utilities, including who run both power generation and retail businesses, to secure power generation facilities essential for stable supply within the overall electricity system, and at the same time, to enable all the business operators including retailers who do not possess any facilities to compete under the practically common environment. Therefore, we will investigate comprehensively all the issues (sell bid system, account separation, separation of electricity retailing and generation, etc.) to enhance the effectiveness of nondiscriminatory wholesale inside and outside of major power companies and to secure transparency of in-house and in-group transactions from the viewpoint of investigating the way of being the power generation business and retail business of dominant business operators who own power generation facilities predominantly.

We have been committed to revitalization of electricity wholesale market for smoother power source procurement for newcomers and for achieving an economically rational procurement system. In the electricity wholesale market, with the expansion of renewable energies with natural variability on the background, the event that hours when the market price reaches the lowest price (0.01 yen/kWh) increase while the price rises sharply occurs, causing risks of price fluctuations to increase. In actuality, in the sharp rise in market price in the FY2020 wintertime, the situation in which retailers were unable to secure the supply capabilities occurred. The primary cause was the tight electricity supply-demand balance, followed by intermittent occurrence of out-of-stock condition, resulting in the spirally increased buy bid price. In the background, retailers who were market players were unable to make efforts for securing the supply capabilities beforehand because appropriate price signals that reflected the supply-demand conditions were not issued before prices rose sharply. Consequently, we will work to release power generation information and other pieces of market-related information in more satisfactory manner to increase predictability on formation of market prices, and at the same time, transmit the electricity value at that moment as the price signal, and investigate how the bidding system in which the value of electricity at that point is transmitted as a price signal to encourage appropriate actions by system users should be. In order to make nondiscriminatory power wholesaling of former general electric utilities more effective, we will investigate the state of voluntary activities (gross bidding, compulsory delivery of all surplus electricity to market on the marginal cost basis) of former general electric utilities related to wholesale electricity market including its necessity.

Along with this kind of development of competition and market environment, it is also important for the business operators themselves to make a contribution to the stability of whole electricity system, and business operators need to take appropriate actions including demand management and risk hedging from the viewpoint of continuance of stable services for customers and stabilization of their businesses. Consequently, we will seek to revitalize the futures and forward markets as well as the baseload market and promote risk management of business operators through these markets.

The environment that surrounds the electricity market would vary in the future, too. We will hold constant discussions to achieve the purpose of electricity system reform and make efforts to design sustainable markets.

(c) Building next-generation electricity network and distributed electricity system that contribute to decarbonization and stable supply

We need to implement activities to build a next-generation electricity network and distributed electricity system that contribute to decarbonization and stable supply in addition to the activities for promotion of competition and securing of the supply capabilities. We will put forth efforts steadily and quickly to formulate a master plan concerning improvement of the power distribution network including investigation of submarine high-voltage, direct current power transmission and others, for the purpose of systematically carrying forward the formation of a wide-area interconnected power system on a national basis to take measures for mass-introduction of renewable energies and further smoother power interchange. We will review nationwide rollout of a non-firm access in the bulk system, introduction of a re-dispatch system, and other rules on system use, and at the same time will take measures that contribute to the effective use of existing systems, such investigation on extended application of a non-firm connection in local and distribution systems and market-driven rules on system use and introduction of dynamic rating system, in addition to the formulation of an improvement plan of local and distribution systems. Furthermore, we will focus effort on promotion of building a distributed electricity system, such as improvement of market environment to promote entry of electricity distribution business or to vitalize aggregation business. Since the use of new technologies is expected for building the system, we will proceed with increase of efficiency by digital technologies and promotion of rolling out new businesses, including the use of electricity data, from the viewpoint of achieving sophistication of the whole electricity system.

We will secure the necessary cost in a fair manner while promoting improvement of efficiency with respect to augmentation of these networks. For this purpose, we will review the wheeling rate system in FY2023 to introduce a revenue cap system, and grapple with renewable energies on the top priority on the major premise of S+3E. Under the foregoing policy, we will continue investigation including need or no-need of the introduction in order to smoothly introduce the power-generator-side billing system. We have taken measures against the burden related to preparation for compensation involved in nuclear accidents and the accounting system concerning reactor decommissioning through the wheeling charge mechanism. We will surely put forth efforts to recover the cost of public interests after the liberalization, too.

(d) Development of business and market environment that can meet the increased procurement needs of renewable energies and other decarbonized power sources

In the midst of global acceleration of a move of carbon neutrality, decarbonization of business activities and the whole supply chain becomes important from the viewpoint of international competitiveness, and needs of procurement and marking of renewable energies and other decarbonized power sources grow from customers centering on the industry. To meet these needs, it is requested that renewable energies and other decarbonized power sources should be still more expanded, a business environment that enables customers to gain direct access to renewable energies and other decarbonized power sources should be developed, and customers themselves should appropriately get hold of attribute information of electricity which customers themselves use.

Consequently, with respect to the non-fossil value trading market where the environmental value which the

electricity generated from non-fossil power sources, we will undertake a radical overhaul of the overall system, including a great increase of non-fossil fuel certificate with tracking information, accessibility of the customers to purchase, and creation of the renewable energy value trading market where renewable energies are able to be traded in the globally valid manner, with consideration given to the consistency in obligations and burdens of electricity retailers of procuring decarbonized power sources under the current Act on Sophisticated Methods of Energy Supply Structures. Moreover, we will investigate a system in which the cost incurred in association with obligations of electricity retailers is fully understood and properly borne by the customers. We will undertake environmental improvement to promote power interchange with other companies by the off-site power purchase agreement (PPA) (direct procurement of renewable energy electricity, etc. from remote locations by customers). Furthermore, we will carry forward market improvement that promotes integration of renewable energies to the power market through the FIP scheme and aggregators to encourage the use of renewable energies.

(e) Formulation of a hazard-resistant power supply system

In recent years, things that affect the electricity supply occur under frequent occurrence and intensification of natural disasters, such as the blackout in Hokkaido Eastern Iburi Earthquake in 2018 or long-term power outagein Typhoon No. 15 and Typhoon No. 19 in 2019. For that, the activities for increasing power resilience gain importance in power policies.

Therefore, we will enforce the following measures.

- Strengthen cross regional interconnection lines.
- Promote the entry to power distribution business.
- Build microgrids and other distributed electricity systems that enable smooth power supply in an independent power system.
- Promote installing electric wire in the ground to contribute to keep stable supply of electricity at the time of disaster.

In addition, we will also grapple with the activities for completing preparations and enhancing the partnerships in time of disaster among the people concerned based on action plans on the collaboration in disaster, and taking action for fallen trees.

There is no end to these actions as any unexpected situation would always occur in natural disasters. We will proceed with our efforts to strengthen resilience of power supply based on the lessons learnt from disasters.

Furthermore, threats of cyber attacks which get complex and increase sophistication rise daily. We will carry forward the ceaseless approach for improving cybersecurity in the electricity field, too. Especially, in view of the progress of electricity system reform and spread of distributed power sources, the importance of securing cybersecurity at new entrant business operators increases, in addition to the measures taken for major electric power companies as in the past. Therefore, we prescribed grid codes in October 2020 for cybersecurity measures related to power generation equipment installers including small-scale power-generating facilities. At the same time, we formulated a guideline on cybersecurity measures related to electricity retailers in February 2021. In addition to these activities, we will formulate cybersecurity measures requested for specified wholesale suppliers (aggregators) and a cybersecurity standard requested for the next-

generation smart meter. In view of the progress of digitization of the electricity system, we will further promote the strengthening of cybersecurity measures in the electricity system.

2) The progress of gas system reform and initiatives toward deepening the system

As for the gas system reform, in order to establish a gas system which ensures safe and stable supply of gas at low cost and which provides various options, including new services, to consumers, along with the electricity system reform, the Gas Business Act was revised to implement reforms regarding full liberalization of the retail market. As a result of these reform efforts, some achievements have already been noticed, including the increased number of new entries into the gas market and the emergence of new gas rate and new services menus (new entrants' share of gas sales increased from approximately 8% to 15% [April 2017 – March 2021]). Going forward, the government will steadily implement the legal separation of the pipeline business divisions of major gas companies (Tokyo Gas, Osaka Gas, and Toho Gas) to enhance the neutrality and fairness of the pipeline business sector, in April 2022.

(a) Sustainable competition and the improvement of the market environment

Gas system reform was intended to secure a stable supply, maximize price control, expand consumer options and business opportunities, strengthen industrial competitiveness, and develop/acquire international markets. Sustainable competition and the improvement of the market environment are important not only to further promote competition to further elevate the outcomes of gas system reform but also to promptly respond to changes in the environment surrounding the gas system (e.g., realizing carbon neutrality by 2050, frequent and intensified natural disasters, and changes in the international LNG supply and demand structure) and the emergence of new issues that accompany it and to strengthen industrial competitiveness.

In order to further promote competition, the government will consider measures to facilitate entries into areas which have no new entrants by making it easier to receive wholesale supply so that gas can be supplied at lower prices; measures to revitalize gas transactions including the promotion of the use of LNG terminals by third parties; and efforts to reduce raw material procurement costs, taking into account the progress of full gas retailing liberalization.

(b) The construction of a gas system that contributes toward decarbonization

It is also important to promote efforts toward constructing a gas system that will contribute toward decarbonization. To this end, we aim to make gas carbon neutral while working in innovative technological development centered on methanation, which is considered to be a promising means of decarbonization. It is apparent that there are various consumer needs that seek value beyond the fees, such as carbon-free menus that supply carbon-offset LNG via carbon credits. Accordingly, we will respond to new customer needs and develop an environment that could lead to further demand stimulation by promoting the utilization of J-credit and so on; and examining and clarifying the position of voluntary carbon credits in the domestic system.

Achieving carbon neutrality with gas requires establishment of an optimal network and supply based on the transition of gas body energy the amount/distribution of demand, and so on. Specifically, it is important to proceed by developing infrastructure including natural gas pipelines while considering the "Guidelines for

development trunk line network" formulated in 2016 as well as judgments on the economic efficiency and business feasibility of private businesses based on the amount/distribution of demand and so on.

Synthetic methane by methanation (approximately 40 MJ/m^3) is a promising means of decarbonization; furthermore, with regard to optimal calorific value system for achieving carbon neutrality in gas, we can comprehensively consider the costs and transition period of the measures necessary for system change, low carbonization effects, progress of decarbonization technology/price, and so on. Considering these aspects, it is optimal to shift the standard calorific value system (40 MJ/m^3) from 2045 to 2050, with a transition period of 15–20 years. The optimal transitional calorific value system will be confirmed in 2030 after verification is conducted around 2025, as needed, based on the position of city gas businesses in overall energy policy as well as future technological development trends, response status of household combustion equipment, and so on.

Promoting usage pattern diversification and sophistication is key to promoting gas system reform, but promoting natural gas usage in each field is important during the transition period until decarbonization. The social implementation of technologies such as methanation would enable the replacement of natural gas with synthetic methane which, could utilize existing infrastructure such as gas pipelines. Therefore, synthetic methane etc. will be supplied to the demand side, which has conducted fuel switching, and we can anticipate a smoother transition to decarbonization in 2050 along with low cost maintenance.

We can expect such a transition to play a role in the following examples: utilization of highly efficient LNG-fired power plants, contributions to the fade-out of inefficient coal-fired power plants; boilers with excellent environmental friendliness; industrial furnaces with excellent energy efficiency; natural gas co-generation that achieves energy efficiency by using and combined heat and power; gas-based air conditioning to ease peak supply and demand of grid power; expansion of fuel use in transportation fields such as shipping; and use as a feedstock for supplying hydrogen to fuel cells.

(c) Constructing a gas system that contributes to stable energy supply

It is important to comprehensively promote efforts at each stage of the value chain toward the construction of a gas system that contributes to stable supply.

In addition to diversifying procurement sources, there are entities that also work on procuring LNG in a stable and flexible manner and reducing its costs by building cooperative relationships in terms of procurement and transportation with other gas/electric utilities. Therefore, it is also important to consider cooperation between these utilities, as required, from the perspective of ensuring a stable energy supply.

The efforts that contribute to the stable supply of energy, including electric power are considered in order to response to concerns about stable supply such as the need to secure adjustment capabilities due to the expansion of the introduction of renewable energy, and the frequent and intensified natural disasters, starting with the expansion of co-generation, which has functions including promotion of decentralization, balancing power, and backing up of power supply during emergencies such as natural disasters.

As comprehensive energy companies, gas suppliers provide various energy supply services required by the demand side, strengthen their management base by diversifying their businesses, and open up international markets where energy demand is increasing by expanding new businesses internationally and strengthening

competitiveness through collaboration with companies in various fields. As gas suppliers rooted in the region, these businesses are also expected to not only provide the energy and services demanded by local consumers but also to contribute to regional revitalization and achievement of SDGs by securing a stable energy supply in the region, collaborating with local governments and local companies, and contributing toward decarbonization by utilizing local resources (e.g., renewable energy, hydrogen, and biogas).

3) Promotion of efficient heat supply

Amid the rising interest in the effective use of heat, service formats for supplying cooling and heating air are diversifying, as shown by the introduction of regional supply of heat through region-wide installation of heat pipes and combined supply of heat and electricity pinpointed at specific buildings in ways that secure business and life functions as part of urban redevelopment projects..

Under such circumstances, it is important to promote the development of manufacturing process technologies, introduction of energy- efficient equipment, use of co-generation, and the use of waste heat cascades for industrial applications mainly under high temperatures. Additionally, it is important to first reduce heat demand itself by popularizing energy-conserving houses and buildings and promote the dissemination of energy-conserving equipment (e.g., household fuel cells and heat pumps) in consumer applications mainly under low temperatures. In addition to these initiatives, we will continue to promote efficient heat use through regulations in the Act on Rationalizing Energy Use.

Given that system reforms regarding the heat supply business can advance the environment for heat supply combined with electricity, the government will promote to use the energy such as co-generation and waste heat in certain regions. This will contribute toward the realization of regional energy conservation, strengthen resilience in the event of disasters, and support local production for local energy consumption.

4) Ensuring appropriate and fair business operations

Energy companies that support citizens' lives and industrial activities need to advance their businesses after building a trust-based relationship with society according to the role they play in the public interest. Meanwhile, some cases have involved questionable legal compliance; for example, the Electricity and Gas Market Surveillance Commission provided business improvement recommendations and guidance to major electricity/gas companies and new entrants. It will be necessary to continue conducting appropriate and fair business operations based on a sound organizational culture that emphasizes compliance.

(12) Global harmonization and global competition

Global energy demand is expected to continue increasing, especially in Asia, which continues to develop, and there is growing global interest in responses to climate change issues. Under such circumstances, many countries, including Japan, have announced carbon neutrality; these decarbonization trends are accelerating not only in developed economies but also in developing countries. As such, the international circumstances regarding resources and energy have change significantly in recent years.

Given these changing circumstances, Japan, as a nation deficient in fossil fuel resources, will maintain a bird's-eye view of the entire international supply chain and continue to work on securing stable energy supply and stabilize/improve the efficiency of the energy supply/demand structure; it will also actively respond to climate change issues. Therefore, considering the importance of a stable supply of oil/natural gas and metal/mineral resources, we will need to continue making maximum efforts in resource diplomacy and develop a "comprehensive resource diplomacy" that is integrated with the securance of stable supply of resources and energy that we have worked on to date, with the aim of introducing and expanding decarbonized fuels and technologies (e.g., hydrogen, ammonia, and CCS) in the future.

It is also important that we lead the international trend toward carbon neutrality and promote innovative technological development, societal implementation, and the establishment of rules in order to realize carbon neutrality by 2050. To this end, we must acquire not only the domestic market but also international markets including those in emerging economies; strengthen domestic industries' competitiveness through cost reduction utilizing economies of scale; and incorporate international funds, technology, markets, and management.

Therefore, we will further strengthen and develop bilateral relationships with developed economies such as the United States and Europe, emerging economies in Asia, and resource-rich countries such as those in the Middle East. We will also actively contribute to organizations like the IEA, which has abundant expertise in a wide range of energy policy fields including emergency responses and energy transitions; multilateral frameworks such as the IAEA; and international and regional forums such as the G7, G20, and Asia-Pacific Economic Cooperation (APEC).

Additionally, the 2030 Agenda for Sustainable Development adopted in 2015 sets out the Sustainable Development Goals (SDGs) relating to energy, economic growth/employment, climate change, and so on; therefore, it is important to contribute not only to climate change countermeasures but also the achievement of the SDGs.

Based on the above, we will promote cooperation with each region and make efforts in each field as follows.

1) Collaboration and cooperation with developed economies like the United States and Europe with the aim of realizing carbon neutrality

By working toward realizing carbon neutrality in collaboration with developed economies such as the United States and Europe, we will promote innovations in the energy and environmental technology fields and support efforts toward decarbonization in third-party countries including emerging economies. For example,

regarding the United States, in the "U.S.–Japan Global Partnership for a New Era" compiled at the U.S.-Japan Summit Meeting held in April 2021, we agreed to address climate change and promote the recovery of a green and sustainable world economy by maximizing both countries' technological capabilities in clean energy and other related areas.
Specifically, we will promote the following forms of cooperation:

- Collaboration and support for the innovation, development, and dissemination of clean energy technologies including renewable energy/energy-conservation technology, next-generation grids, energy storage (e.g., storage battery and long-term storage technology), smart grids, hydrogen, CCUS/carbon recycling, decarbonization in industry, and innovative nuclear energy
- Promoting the development and utilization of climate change/environment-friendly and adapted infrastructure relating to grid power optimization, demand response, smart grids, and renewable energy/energy conservation
- Supporting developing economies, including those in the Indo-Pacific region, through the Japan-U.S. Clean Energy Partnership (JUCEP) and other national-level activities conducted collaboratively between the two countries with regard to climate change and clean energy in order to rapidly disseminate renewable energy, promote economy decarbonization, and accelerate diverse and ambitious, yet realistic, transition paths in the region toward achieving a net zero emissions on a global scale by 2050

2) Support for realistic energy transitions in Asia

To achieve worldwide decarbonization, it is essential to decarbonize not only developed economies but also emerging economies such as those in Asia, which depend on fossil fuels for most of their energy requirements. As fossil fuel business divestment continues worldwide, the simultaneous achievement of sustainable economic growth and realistic energy transitions in emerging Asian economies, where energy demand will grow in the future, with an aim to realizing carbon neutrality worldwide will require utilization of various forms of energy and technologies based on each country's circumstances. Based on these concepts, Japan proposed and included the Asia Energy Transition Initiative (AETI) in its joint statement at the Special Meeting of ASEAN Ministers on Energy and the Minister of Economy, Trade and Industry of Japan in June 2021; this included the following elements: 1/ support for formulating an energy transition road map based on each country's needs and actual circumstances; 2/ support for the formulation and dissemination of the concepts of Asian transitions and finance; 3/ support for financing individual projects; 4/ utilization of the results of research and development/demonstration of support through a Green Innovation Fund; 5/ support for human resource development relating to decarbonization technologies; 6/ dissemination and development of low carbon technologies through NEDO demonstration projects, JCM system, and so on; and 7/ sharing of CCS knowledge in Asia through the "Asia CCUS Network". In the future, we will cooperate with ASEAN countries and strengthen cooperation with other Asian countries, the United States, Canada, Australia, Middle Eastern countries, and so on in order to promote AETI and spread these concepts worldwide.
In particular, Japanese companies have strengths in LNG, which will be an important energy source even

after the realization of carbon neutrality. Japan aims to take the lead in improving resilience and promoting realistic energy transitions throughout Asia by continuously hosting LNG Producer–Consumer Conference, providing financial support through JOGMEC, strengthening collaboration with LNG-producing/consuming countries through human resource development, and establishing and expanding the LNG market.

3) Forming international standards and rules for fossil fuel decarbonization

Considering the worldwide decarbonization trend, it is also important for Japan to be involved in the formation of international rules. For example, the European Commission announced EU Methane Strategy in October 2020 in order to address methane leaks from oil, natural gas (LNG), coal, and so on, under which they have begun to develop methane emission controls and international MRVs (measurement, reporting, and verification of greenhouse gas emission amounts). Japan's implementation of all efforts to realizing carbon neutrality is very likely to be extremely expensive if implemented only domestically; therefore, it is important to utilize international resources, including credits, based on Japan's technological superiority.
Based on these aspects, we will be actively involved in the formation of international standards and rules, starting with the fields in which Japan is a leader, such as the decarbonization of fossil fuels (e.g., methane countermeasures) and the addition of credits created by CCS in international upstream development.

4) Promoting international cooperation in order to expand hydrogen/ammonia use

It is important to promote international collaboration and cooperation relating to hydrogen/ammonia, which have received international attention as new energy sources, not only in terms of efforts toward social implementation in Japan but also in terms of strengthening energy security through the formation of a stable, flexible, and transparent international market in the future; promote international expansion (including to Asia) of technologies in which Japan is a leader; and strengthen relationships with oil-producing countries, gas-producing countries, and renewable energy resource countries that can newly supply hydrogen/ammonia. By doing so, we will conduct resource diplomacy for securing resources such as hydrogen and ensure stable procurement; furthermore, in terms of expanding the international market. We will also strengthen relationships with consuming countries that have limited resource potential and are expected to import hydrogen in the future and promote the international expansion of Japan's superior hydrogen utilization technology. Regarding ammonia, we expect that fuel ammonia will become widespread in use in Southeast Asia as well as worldwide in the long-term, and to this end, we aim to construct a worldwide procurement supply chain (that will include Japan) with Japanese companies on the scale of 100 million tons by 2050.
Additionally, increasing the hydrogen market's liquidity, which is important for the formation of the international market, not only requires an internationally consistent definition for clean hydrogen and fuel ammonia that is not limited to being derived from renewable energy, but also the promotion of international standardization for transportation equipment and combustion equipment. To this end, we will consider some steps forward while maximizing the use of bilateral cooperation as well as multilateral cooperation frameworks such as the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). Furthermore, we will continue to lead international collaboration while utilizing the Hydrogen Energy Ministerial Meeting, which is a Japan-based platform for dialogue between each country's overseeing

hydrogen ministers; it aims to expand the utilization of hydrogen worldwide.

5) Promoting international cooperation in order to improve nuclear safety and peaceful use of nuclear energy worldwide

The international use of nuclear energy is expected to continue expanding, and many countries look to Japan for nuclear energy technologies. In response to this, Japan can contribute toward worldwide decarbonization. Therefore, Japan will continue to provide support regarding human resources, infrastructure and technology development, to countries that have newly introduced nuclear power through multilateral cooperation frameworks such as the International Atomic Energy Agency (IAEA) and the Organisation for Economic Co-operation and Development Nuclear Energy Agency (OECD/NEA) as well as bilateral cooperation frameworks with the United States, United Kingdom, France, etc.

We will also expand options for meeting various social demands by actively supporting Japanese companies' efforts in collaboration with international demonstration projects including those in the United States, United Kingdom, France, and Canada as we advance research and development of innovative technologies such as fast reactors, small modular reactors, and high-temperature gas-cooled reactors.

6) Disseminating Japan's efforts through the Tokyo "Beyond-Zero" Week

In the form of the Tokyo "Beyond-Zero" Week, we will intensively host a series of international conferences regarding energy and environment such as the Asia Green Growth Partnership Ministerial Meeting, ICEF, RD20, TCFD Summit, Hydrogen Energy Ministerial Meeting, International Conference on Carbon Recycling, LNG Producer–Consumer Conference, and International Conference on Fuel Ammonia; and use these as a platform for leading international discussions and cooperation in important fields in order to create a virtuous cycle of the economy and the environment with the aim of promoting transitions and innovation and realizing carbon neutrality.

(13) Outlook for energy supply and demand in FY 2030

The new energy supply and demand outlook in FY 2030,by regarding climate change as an urgent issue that is shared by all humankind, and taking into consideration the extremely ambitious greenhouse gas emission reduction targets for 2030, mainly set by developed economies, as well as Japan' aim to reduce its greenhouse gas emissions by 46% in FY 2030 from its FY 2013 levels, setting an ambitious target which is aligned with the long-term goal of net-zero by 2050 together with its further challenge to continue strenuous efforts to meet the lofty goal of cutting its emissions by 50%. This outlook shows energy supply and demand on the ambitious assumption that various challenges in both aspects of supply and demand in promoting thorough energy conservation and expansion of non-fossil fuel energy will be overcome as we aim for 46% reduction. A stable energy supply has also become an indispensable factor in our consideration of the energy supply and demand outlook, given the major power outages caused by the Hokkaido Eastern Iburi Earthquake (2018) and Typhoon Nos. 15 and 19 (2019).

For example, this outlook significantly reduces the ratio of fossil fuel-fired power sources in power generation. If fossil fuel power sources are immediately curtailed at a stage prior to full introduction of non-fossil fuel power sources, stable supply of electricity can be impaired. Therefore, in implementing the measures towards this ambitious outlook, degree and timing of implementation of the measures need to be carefully considered for stable supply of energy not to be impaired.

Furthermore, energy costs support the foundation of industrial activities and significantly impact business strategies including corporate location and business activities. Therefore, reducing energy costs as much as possible is an important issue in maintaining and strengthening Japan's industrial competitiveness and achieving further economic growth.

Thus, energy demand in FY2030—which is the premise of this discussion—is expected to increase going forward because of economic growth, and the thorough energy conservation promotion is expected to significantly improve energy efficiency such that it will exceed levels following an oil crisis.

Specifically, we used the economic growth rate of the Economic Revitalization Case in "Economic and Fiscal Projections for Medium to Long Term Analysis (July 2021)" published by the Cabinet Office, latest population estimates (medium estimate) by the National Institute of Population and Social Security Research, activity estimates in major industries, and so on. We then estimated the demand prior to the implementation of additional energy conservation measures and accumulated as many technically possible and realistic energy conservation measures as possible in the industry, commercial, residential, and transport sectors. Using these estimates, we expect energy demand in FY2030 to be approximately 280 billion L because of implementing energy conservation measures of approximately 62 billion L in final energy consumption.

The primary energy supply that meets this energy demand is expected to be approximately 430 billion L, of which approximately 31% for oil, 22–23% for renewable energy, 18% for natural gas, 19% for coal, 9–10% for nuclear, and 1% for hydrogen/ammonia.

Regarding electricity supply and demand structure, electricity demand is expected to increase because of factors such as economic growth and electrification rate improvements. However, electricity demand in

FY2030 is expected to be approximately 864 TWh, and the total electricity generated is expected to be approximately 934 TWh due to the thorough promotion of energy conservation (electricity savings).

Furthermore, regarding the power sector, on the major premise of the principle of S+3E, we will make efforts under the basic policies of energy conservation promotion, address maximum introduction of renewable energy as major power sources in 2050 on the top priority, reduce fossil fuel-fired power source ratios and decarbonize thermal power generation to the greatest possible extent based on the premise of stable supply, and reduce the dependence on nuclear power as much as possible.

First, we aim to achieve approximately 313 TWh of renewable energy by anticipating the maximum formation of new projects through each ministry's strengthening of measures while considering the current status of introduction and certification. We will also make further efforts to strengthen measures in order to reduce greenhouse gas emissions by 46% in 2030; we anticipate the introduction of 336–353 TWh at around 36–38% of total power generation mix as an ambitious goal where the effects of strengthening such measures are realized. Note that this level is not an upper limit or cap. If certain efforts, which cannot be imagined currently, progress in the future, these levels are reached at an early stage, and the amount of renewable energy introduced is increased, we will aim for even higher goals. In these cases, other power sources will be adjusted beyond this level in consideration of CO_2 emissions and cost-efficiency.

Related ministries and agencies will work together to expand the introduction of renewable energy in order to steadily respond to issues such as securing suitable sites, co-existence with the region, overcoming system constraints, and cost reduction.

Nuclear power generation is regarded as a power source that contributes to CO_2 emission reduction, and we prioritize safety above all circumstances and make efforts to resolve public concerns. The safety of nuclear power stations is left to the expert judgment of the Nuclear Regulation Authority, and if cases that meet the strictest regulatory standards worldwide are set by the Nuclear Regulation Authority, we will respect that judgment and restart nuclear power plants. GOJ will also take the lead in working to gain the understanding and cooperation of local governments and other related parties. Given all these aspects, we expect nuclear power to compose approximately 20–22% of the total power generation mix[15].

For the time being, we will continue to use thermal power generation as a major supply capacity and as a balancing power to supplement the variability of renewable energy during the process of maximizing renewable energy introduction. We will promote efforts, including the fade-out of inefficient coal, while considering the status of non-fossil fuel power source introduction on the premise of securing a stable supply, and we will reduce the ratio of thermal power generation to the greatest extent possible. By doing so, we will maintain a thermal power portfolio centered on natural gas and coal in terms of energy security. Regarding power generation mix, LNG-fired is expected to comprise approximately 20%; coal-fired approximately 19%; and oil-fired, a minimum required amount of approximately 2% as a last resort. Furthermore, we anticipate anew hydrogen/ammonia-fired of approximately 1% in power generation mix in order to accelerate the social implementation of hydrogen/ammonia, which is expected to form an important new energy source

15 The ratio of nuclear power generation also shows the outlook for power generation mix as of FY2030, and this does not affect inspection by the Nuclear Regulation Authority regarding the safety of individual nuclear power stations.

in the future.

If this energy supply and demand outlook is realized, then energy-related CO_2 will be reduced by approximately 45% compared to levels in FY2013[16]. The energy self-sufficiency rate[17], which is an index for measuring stable energy supply, is anticipated to be at around 30%[18], which exceeds the 25% assumed in Long-term Energy Supply and Demand Outlook formulated in 2015. Additionally, the electricity cost[19], which is an index for measuring economic efficiency, is expected to be around 8.6–8.8 trillion yen, which is lower than the previously assumed electricity cost (9.2–9.5 trillion yen) if introduction and expansion of cost-reduced and price decline of fossil fuels as IEA's outlook, which is the basis of fuel cost[20], are achieved (FIT purchase costs increase from 3.7–4.0 trillion yen to approximately 5.8–6.0 trillion yen, fuel cost decreases from 5.3 trillion yen to 2.5 trillion yen, and grid stabilization costs increase from 0.1 trillion yen to 0.3 trillion yen). Additionally, because of decreases in electricity demand due to thorough energy conservation promotion (electricity savings), we expect electricity costs per kWh to be approximately 9.9–10.2 yen, which exceeds the previously assumed figure of 9.4–9.7 yen[21]. The outlook for fossil fuel prices may continue to fluctuate in the future, and electricity cost may increase further due to increased integration cost[22] because of expanded renewable energy introduction. Therefore, we will maximize our efforts to reduce renewable energy costs and achieve early realization of a state where renewable energy introduction can progress independently.

16 The amount of greenhouse gas emission reduction in our country is the sum of the non-energy related CO_2 emission reduction and measures for sink, in addition to the energy-related CO_2 emission reduction.

17 The ratio of domestic production to primary energy supply is calculated based on the Comprehensive Energy Statistics. As mentioned above, in addition to resource self-sufficiency rate, it is also important to improve the "technology self-sufficiency rate" (the degree to which energy supply is covered by the country's own technology against domestic energy consumption) through securing core technologies in the supply chain in the country and leading the innovation of such technologies in the world.

18 It is about 31% based on Comprehensive Energy Statistics and about 30% based on the IEA "World Energy Balances".

19 The total amount of fuel cost necessary for thermal and nuclear power generation, the total purchase amount under the FIT scheme (FIT purchase cost), and grid stabilization cost (This refers to the sum of the costs associated with the deterioration of power generation efficiency due to a decrease in the operating rate of thermal power generation and the costs associated with increases in the suspension and start of thermal power generation. The same shall apply hereinafter.) is estimated mechanically. Fossil fuel prices are based on the World Energy Outlook published by the IEA and assume that all electricity generated using renewable energy sources in FY2030 is covered by the FIT scheme. Grid stabilization costs may increase depending on actual system conditions.

20 The World Bank and the U.S. Energy Information Administration (EIA) expect fossil fuel prices to rise in the latest forecast.

21 This is calculated by mechanically dividing the "electricity cost" by the "electricity demand, which is the amount of electricity generated excluding the amount of electricity lost through transmission, etc.", which is different from the electricity rate. It is difficult to accurately project the actual electricity rate because it includes the wheeling charge and is greatly affected by the operation status of the power source, fuel price and electricity demand.

22 This refers to the cost of grid stabilization, 1) the cost of generating demand with pumped hydro when natural variable power sources generate electricity, and 2) the cost of securing power generation facilities for natural variable power sources.

6. Promotion of strategic technological development, and its societal implementation and so on, integrated with industrial, competition and innovation policies for realization of carbon neutrality by 2050

Resolving the issue of climate change is difficult to achieve through conventional efforts alone; global efforts and disruptive innovation are essential.

Calculations have shown that additional costs of $7 trillion per year will be required to achieve a 70% reduction in greenhouse gas emissions worldwide by 2050, which is IPCC scenario of limiting the temperature increase to 2°C[23], and the costs will be much higher to limit it to 1.5°C. The manner in which these costs can be reduced is the biggest challenge in making the necessary investments to meet the goals of the Paris Agreement, especially for developing economies where greenhouse gas emissions are expected to increase in the future.

Japan has been working on innovative interventions for over 30 years through the Sunshine Project, etc., and has contributed to reducing the cost of solar cells to 1/250th of their original cost (equivalent to a cost reduction of 17 trillion dollars worldwide). As a result, solar cells are being introduced worldwide, including in developing economies, and have become an important means of combating climate change. Therefore, achieving socially implementable costs through disruptive innovation as soon as possible is crucial for reducing greenhouse gas emissions worldwide.

Making the best use of the influence of businesses with massive capital and technological capabilities is important in achieving these goals. As competition intensifies among businesses to lead the way toward a carbon-free society worldwide, it is important to support private investment, encourage utilization of 240 trillion yen in cash and deposits held by private companies and thereby attract an estimated US$35.3 trillion (approx. 3,500 trillion yen) in global environment related investment funds to Japan, identify the fields in which Japan can be competitive internationally, and prioritize efforts on the technological development and social implementation of decarbonization technologies at an early stage. We have formulated the “Green Growth Strategy” from this perspective, setting lofty goals in 14 important fields where future growth is expected through technological innovation. The ways in which energy is used are closely related to not only energy-related industries such as offshore wind and hydrogen industries but also non-energy-related industries, so we will work on technological development and social implementation based on the Green Growth Strategy.

Additionally, for each of the 14 fields where growth is expected, the Green Growth Strategy has formulated “Execution Plans” that include 1/ time-bound goals, 2/ research and development / demonstration, 3/ system development such as regulatory reform / standardization, and 4/ international cooperation; these are further divided into the four stages of “research and development,” “demonstration,” “introduction and expansion,” and “independent commercialization,” with the path to 2050 outlined and concrete measures and innovative elements for achieving the goals organized for each field.

Additionally, we will mobilize budgets, tax systems, finances, regulatory reform / standardization, etc., as

23 Calculations according to a model by the Research Institute of Innovative Technology for the Earth (RITE)

cross-sectoral policy tools. In terms of the budget, we have created an unprecedented two trillion yen fund (Green Innovation Fund) in order for the government to take a big step forward in environmental investment. Over the next 10 years, we will continue to support aspects of research and development / demonstration of innovative technologies to social implementation for companies that show specific goals and commitment to efforts in priority areas where an execution plan has been formulated under the Green Growth Strategy, particularly in areas where policy effects are large and long-term continuous support is needed until social implementation. Accordingly, we will promote the significance and goals of the projects implemented by the Fund in a form that is easy for citizens to understand and constantly endorse the transformation of society as a whole in order to arouse widespread interest among the people and society. With regard to the tax system, we will stimulate private investment through the Investment Promoting Tax Systems, research and development tax systems, and the use of special provisions that raise the deduction limit for loss carryforwards in companies engaged in business restructuring and reorganization in order to realize carbon neutrality.

Regarding finance, we will aim to attract financing for green, transitional, and innovative initiatives through the creation of financial market rules, such as guidelines for evaluating steady efforts to shift to decarbonization (e.g., information disclosure, steady low-carbon efforts).

With regard to innovative technologies that will be the key to future growth, following the “demonstration phase”, which will be promoted through joint public-private investment based on the premise of inducing private investment, we will 1/ tighten regulations to create demand for new technologies and 2/ develop domestic regulations and systems, including streamlining of regulations that did not anticipate new technologies (regulatory reform related to hydrogen stations, review of system operation rules so that renewable energy is prioritized, utilization of fuel efficiency regulations to promote the electrification of automobiles, assessment of public procurement of CO_2-infused concrete, etc.). Furthermore, as competition for the formation of international rules regarding global warming countermeasures intensifies, Japan will 3/ actively work on international standardization that facilitates the utilization of new technologies worldwide. We will create an environment in which Japan’s superior new technologies are evaluated correctly and ensure that the nation’s interests and social circumstances are reflected in these international rules

We will also promote “comprehensive resource diplomacy” that is integrated with securing a stable supply of resources and energy.

Simultaneously, we are very aware of the fact that there are various environmental differences (e.g., energy situation, technological trends) in the expansion of innovative technologies according to each country and region, and we will promote collaboration between regions like Asia and others when implementing these cross-cutting policy tools.

By improving the institutional environment in Japan and overseas, we will expand demand as well as green investments and aim for mass production and price reduction.

<Fourteen Green Growth Strategy fields where growth is expected>

1) Offshore wind, next-generation solar photovoltaic, geothermal industries

Offshore wind is a trump card for making renewable energy the main power source because of the possibility

of mass introduction and cost reductions as well as anticipated economic ripple effects. First, we will stimulate domestic and foreign investment by having the government commit to the creation of an attractive domestic market. Specifically, we are aiming for 10 GW by 2030 and 30–45 GW (including floating power generators) by 2040[24] we will systematically proceed with project development based on the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities and with the development of infrastructure such as grids and ports. Additionally, we will construct a competitive and robust domestic supply chain by providing incentives for capital investment, promoting domestic and international corporate collaboration, and boosting investment by improving the business environment. Furthermore, with a view to expanding into Asia, we will work on the development of next-generation technologies and international collaboration based on the "Technological Development Roadmap for Strengthening the Industrial Competitiveness of Offshore Wind Power" in order to create next-generation industries that could survive international competition.

With regard to solar photovoltaic power generation, we will work on creating new markets for the practical application of next-generation solar cells such as perovskite, which could be installed on walls where technical restrictions are present for existing solar cells, and developing international markets. Specifically, industry, academia, and government will collaborate to develop basic technologies to improve the performance of next-generation solar cells and conduct the necessary demonstrations for social implementation in collaboration with user companies; we will also accelerate the market launch of next-generation solar cells. We will promote the expansion of the availability of solar photovoltaic power generation through these efforts, and foster and reconstruct industries and secure suitable sites that can co-exist within the region by revitalizing associated markets.

Geothermal power generation is a form of renewable energy and is a base load power source capable of stable power generation, so GOJ will conduct surveys on the amount of resources available in suitable development areas, supply risk money to businesses, review the operation of related laws and regulations such as the Natural Parks Act and Hot Springs Act, and promote local understanding.

Furthermore, as we work toward realizing carbon neutrality by 2050, we will be the first in the world to achieve next-generation geothermal power generation technologies such as supercritical geothermal power generation, develop geothermal resources that could not be developed to date, and promote the introduction of radical geothermal power generation in Japan. We will also work on further expanding Japan's geothermal business globally by selling entire power generation systems (including supercritical geothermal resource exploration technologies, deep excavation technologies, above-ground and underground piping, and turbines) to international buyers as a package.

2) Hydrogen/fuel ammonia industries

Hydrogen is a key carbon-neutral technology that would be widely used in power generation, industry, and transport sectors. We aim to reduce the selling price to less than one-third of its current price (30 yen/Nm^3) by 2030 and to a level that is sufficiently competitive with fossil fuels by 2050; in other words, the cost of

24 Approved amounts based on the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities

hydrogen-fired power generation would be lower than that of gas-fired power (less than approximately 20 yen/Nm^3). We plan to do this by positioning hydrogen as a new resource for a wide range of players that also include passenger car applications and expanding the amount introduced in society. For the target supply amount, we aim to introduce up to 3 million tons by 2030 and approximately 20 million tons by 2050.

To that end, we will need to work on both supply cost reductions and demand expansion in an integrated manner. Supply side initiatives include increasing the scale and modularizing water electrolysis units, and constructing an international hydrogen supply chain that can transport hydrogen on a large scale. Demand expansion includes the development and demonstration of technologies relating to the combustion stability of hydrogen-fired power generation, support for the introduction of fuel cell vehicles and strategic development of hydrogen stations, expanding dissemination of stationary fuel cells (including pure hydrogen fuel cells), and establishment of technology for hydrogen-reduced iron manufacturing. As part of cross-thematic initiatives, we will also efficiently accumulate knowledge through the construction of a hydrogen society model that maximizes existing infrastructure and characteristics of neighboring regions of supply and demand as well as work on regulatory reform, international standardization, etc.

Fuel ammonia is a zero-emission fuel that does not emit CO_2 when burned.

On the demand side, we will develop technologies in anticipation of dedicated firing (e.g., high-level co-combustion burners that suppress NO_x emissions) while proceeding with the demonstration of an actual machine with 20% co-firing technology for coal-fired power. Additionally, we will clarify the legal status of fuel ammonia in order to promote the use of ammonia as fuel. Furthermore, we will continue to develop co-combustion technology in Southeast Asia, where a considerable amount of coal-fired power is expected to be used, while also working on the international standardization of fuel ammonia specifications and NO_x emission standards for combustion equipment, with the aim of promoting the international distribution and utilization of fuel ammonia.

On the supply side, we will consider strengthening financial support by public financial institutions and JOGMEC while advancing technological development for improving manufacturing efficiency. Assuming an annual demand of 3 million tons in Japan in 2030, we aim to supply this at a price in the upper 10 yen range per Nm^3 (equivalent to hydrogen calorific value). Furthermore, we expect annual domestic demand to be 30 million tons by 2050.

Japan will take the lead in quickly building an international supply chain for fuel ammonia through these supply- and demand-side initiatives.

3) Automotive/storage battery industries

In the automotive field, we will aim for carbon neutrality throughout the supply chain and take comprehensive measures such as promoting the introduction of electric vehicles/fuel cell vehicles, etc.; developing rapid charging equipment, hydrogen stations, etc.; promoting the development of next-generation battery technologies and manufacturing locations; and supporting part suppliers, automobile dealers, maintenance companies, SS, etc., which support the local economy. These will be conducted alongside the decarbonization of energy to promote electrification. Based on these basic ideas, we will proceed with the following specific efforts:

- We will take comprehensive measures to achieve 100% of new passenger car sales are electrified vehicle by 2035. With regard to commercial vehicles, for small vehicles weighing eight tons or less, we aim to have electrified vehicles account for 20–30% of new vehicle sales by 2030; electrified vehicles and vehicles suited for the use of decarbonized fuels such as synthetic fuels should account for 100% of new vehicle sales by 2040; to that end, we will take comprehensive measures such as the introduction of vehicles. For large vehicles weighing more than eight tons, we will aim for advanced introduction of 5,000 units by the 2020s while proceeding with technological demonstrations aimed at developing and promoting the use of electrified vehicles suitable for commercial applications such as freight and passenger businesses; additionally, we will set a dissemination target for 2040 by 2030 based on the progress of technological development and dissemination efforts to reduce the prices of hydrogen and synthetic fuels.
- Insufficient charging/filling infrastructure hinders the dissemination of electrified vehicles. Therefore, with regard to the charging infrastructure, we will update aging equipment as well as install 150,000 new charging stations (including 30,000 public quick chargers, of which 10,000 will be SS quick chargers that can effectively utilize existing infrastructure) as we aim to achieve the convenience experienced with gasoline-powered vehicles by 2030 at the latest. In so doing, we will promote optimal placement and business feasibility by promoting the dissemination of charging infrastructure and deregulation, and support the introduction of charging equipment at apartments where dissemination of charging equipment has been delayed. Additionally, with regard to the filling infrastructure, we will focus on establishing approximately 1,000 hydrogen stations by 2030 in anticipation of the spread of fuel cell vehicles, fuel cell buses, and fuel cell trucks, and aim for optimal placement of these stations by considering the flow of people and physical distribution; we will also focus on regulatory reforms. We will promote the development of charging equipment and hydrogen stations for commercial vehicles such as buses and trucks, including charging and filling equipment dedicated to business establishments.
- We will support aggressive business format conversion and business restructuring alongside the electrification of automobiles (e.g., engine parts suppliers take on the challenge of manufacturing electric parts; SS and maintenance bases develop into new human resources, physical distribution, and service bases in the region, as well as EV stations).

Storage batteries are a “new energy base” that is the key to the progress of digitalization and greening initiatives such as the electrification of automobiles and decarbonization of the balancing power required for dissemination of renewable energy. From this perspective, we will increase the production capacity of domestic in-vehicle storage batteries to 100 GWh as soon as possible by 2030 in order to strengthen the domestic manufacturing base of storage batteries; we will also encourage large-scale investment, including in storage battery materials, in order to strengthen the storage battery supply chain. Furthermore, we aim for a cumulative total of approximately 24 GWh in 2030 for household and commercial/industrial storage batteries.

4) Industry and material industry related to Carbon Recycling

Carbon Recycling is a technology that effectively utilizes CO_2 as a resource, and is an important cross-cutting field for the realization of a carbon-neutral society. Japan has a competitive edge in Carbon Recycling, and aims to expand globally after cost reduction and social implementation.

Specifically, CO_2 absorption type concrete will be priced at the same level as existing concrete (= 30 yen/kg) in 2030 through increased demand, and the new products with rust prevention performance will be available for architectural application in 2050. For cement, we aim to develop plants that could recover nearly 100% of CO_2 emitted from limestone by 2030, and introduce this technology both in Japan and internationally in order to gain and expand market share by 2050.

In the field of carbon-recycled fuel, we will promote technological development for the practical use of synthetic methane; for SAF such as bio-jet fuel, we will develop manufacturing technologies and engage in large-scale demonstrations with the goal of commercialization by around 2030. With regard to CO_2 and hydrogen-based synthetic fuels for transportation equipment, etc., we will intensively develop and demonstrate technologies over the next 10 years and aim for independent commercialization by 2040.

In the field of carbon-recycled chemicals, we will conduct large-scale demonstrations of plastic feedstock production for artificial photosynthesis, and we aim to achieve a price point for general-purpose plastics that is the same as that of existing products (= 100 yen/kg) by 2050. With regard to functional chemicals produced from CO_2, we will establish manufacturing technologies in 2030 and aim to achieve an equivalent price point as that of existing products by 2050, and also upgrade naphtha cracking furnaces through the decarbonization of heat sources (research and development of burners and decomposition furnaces).

Furthermore, in the CO_2 capture and storage fields, we will develop highly efficient technologies that result in lower costs, and we aim to achieve a 30% share of the global carbon capture and storage market (worth 10 trillion yen annually) by 2050.

Material industries, which supply materials for products that form the basis of society, are expected to grow further as they play a leading role in the process management of overall manufacturing with an eye toward carbon neutrality. However, one issue is to emit a large amount of CO_2 during the manufacturing process, so we will expand the spread of materials with high environmental performance and aim to capture new markets through decarbonization at the manufacturing stage (e.g., decarbonization of heat sources and radical changes in the process itself) and contributions to energy conservation in downstream processes.

Specifically, in the reduction and melting processes of the iron and steel industry, we intend to effectively utilize current energy-efficient blast furnaces to reduce iron ore using hydrogen, while separating and capturing the CO_2 contained in blast furnace exhaust gas and converting it into a reducing agent for utilization. With an eye toward the realization of CO_2 emission-reducing technologies and “zero-carbon steel” by 2050, we aim to be the first in the world to develop and supply zero-carbon steel technologies, such as basic technology for the realization of “direct hydrogen reduction methods” that could reduce iron ore only with hydrogen. Furthermore, we aim to capture the green steel market, which is expected to reach a maximum of approximately 500 million tons and 40 trillion yen on an annual basis by 2050. Additionally, we will expand the resource recycling rate of wrought aluminum materials to 50% in order to achieve global

decarbonization and to alleviate resource constraints through advanced recycling and resource conservation. Furthermore, in the paper and glass/ceramics manufacturing industries, we will work on converting manufacturing equipment necessary for fuel switching, with the aim of eliminating fossil fuels in high-temperature heat sources. At petrochemical complexes as well, we will advance decarbonization through technological development of naphtha cracking furnaces and introduction of CO_2-free hydrogen, etc., into the petroleum refining process.

Through these efforts, we aim to establish carbon neutrality and also promote further growth/development of the material industries in Japan.

5) Housing and building industry/next-generation electricity management industry

The housing/building field is a key field toward achieving carbon neutrality in the residential/commercial sector and is a field that should be addressed immediately from the view point that houses and buildings become a long-term stock, once they are built.

Specifically, GOJ will improve energy efficient performance by strengthening regulatory measures to comply with energy efficiency standards for housing, etc; promoting ZEH/ZEB; enhancing the measures for existing houses/building measures, including expansion of energy efficient renovation; reviewing certification criteria for superior long-term housing; setting higher grades in the housing performance indication system and operating them from FY2022; extending the life of houses and buildings; and requiring the indication of energy efficient performance when selling or renting new houses.

Additionally, GOJ will promote the introduction of solar photovoltaic power generation and storage batteries, and in order to maximize power generation GOJ will establish a system to encourage the introduction of renewable energy such as solar photovoltaic power generation and provide assistance to expand power generation in houses and buildings by introducing next-generation solar cells on the walls of buildings.

Simultaneously, GOJ will also utilize home/building energy management systems (HEMS/BEMS) in order to promote energy management that contribute to the balancing of power supply and demand according to the amount of power generated by the solar photovoltaic power generation system.

Through these efforts, we will simultaneously create a market environment to promote advanced energy efficiency/energy management technologies in Japan and expand those technologies into international markets.

There are concerns that grid congestion and power quality problems will become more serious with the changes in the power supply structure represented by the massive introduction of renewable energy. In order to achieve a carbon-neutral society while curbing the burden on public, it is important to not only maintain and review the necessary regulations that effectively respond to these issues, but also develop “next-generation electricity management industry” that utilizes ever-advancing digital technology and uses more advanced methods for forecasting, operating, and controlling electricity management for business development.

Specifically, the public and private sector will work together to consider and promote efforts such as institutional and support measures, including the development of various markets (e.g., spot market, hourly ahead market, supply and demand balancing market, forward market, capacity market, renewable energy

value trading market) where values of supply capacity and balancing power of distributed energy resources (DERs), or environmental values can be traded. These efforts are conducted with the aim of developing businesses that utilize and provide value to DERs such as renewable energy, fuel cells/co-generation, storage batteries, and demand-side resources, next-generation grid businesses that aim to improve the operation of power transmission and distribution systems and form facilities based on the premise of increasing and utilizing DERs, and microgrid businesses as a form of fusion of the two in specific regions, as well as, businesses that provide platforms such as systems, equipment, and databases that make these businesses possible.

6) Next-generation heat energy industry

Heat demand accounts for about 60% of the energy consumption of the industry and consumer sectors in Japan. From this point of view, it is important to decarbonize gas, which is a source of heat energy, in order to realize carbon neutrality by 2050. In order to decarbonize gas, it is important to utilize next-generation heat energy such as synthetic methane synthesized（methanation） from renewable and other energy-derived hydrogen and CO_2 and directly used hydrogen. To that end, we will promote the technological development and social implementation of next-generation heat energy from both the supply and demand side.

As for supply side initiatives, by 2030, we aim to inject 1% synthetic methane into existing infrastructure and combine this with other means to carbon-neutralize 5% of gas; by 2050, inject 90% synthetic methane and combine this with other means to achieve carbon neutralization of gas. To that end, we will work on technological development such as increasing the size of methanation equipment and improving the efficiency. We will also promote to study CO_2 counting methods in a direction that contributes to carbon neutrality, and to build international supply chains. The public and private sectors will work together at the Public-Private Sector Council for the Promotion of Methanation to advance discussions on the form these efforts should take; additionally, we will aim to supply 25 million tons of synthetic methane and establish a price point for synthetic methane that is at the same level as current prices of LNG (40–50 yen/Nm^3) by 2050. Additionally, we will work on the direct use of hydrogen, introduction of LNG offset by credits, and the promotion of CCUS/carbon recycling.

Additionally, gas companies will provide optimal regional energy supply and management etc. as a comprehensive service while utilizing digital technology based on demand-side needs. We will also encourage the conversion of these companies into comprehensive energy service companies through the implementation of various energy supply services such as decarbonization menus and the business development to develop new markets in Japan and abroad.

As for demand-side initiatives, we will promote fuel switching from coal/oil to natural gas in industrial fields and improve the efficiency of natural gas-utilizing equipment, etc. Substituting synthetic methane for natural gas will enable a smooth transition to decarbonization on the demand side. We will formulate a road map for each field, including gas, by the end of FY2021 in order to promote transition finance. Gas companies will collaborate with local governments and businesses to study ways to form a regional network for the direct supply of hydrogen and resolve associated issues, promote the introduction of credit-offset LNG, and work on the practical application of CCUS/carbon recycling. In doing so, these companies will be better able

to meet decarbonization needs on the demand side.
Additionally, we will continuously strengthen the resilience of gas infrastructure. We will promote efforts to improve security/resilience through smart meters and digital technology, and build a distributed energy system by supporting the introduction of gas co-generation. In so doing, we will achieve optimal regional energy control through the utilization of digital technology.
Additionally, local gas companies rooted in local communities will promote proactive efforts to supply next-generation heat energy to regional demand side as well as promote local contributions and management base strengthenings through the support by industry groups and governments, etc. Through these measures, we will contribute to solving regional issues and ensuring a stable regional energy supply.

7) Nuclear power industry

With regard to nuclear power, we will continue to reduce the risk of accidents by promoting the development of technologies that contribute to further improving the safety, reliability, and efficiency of light water reactors, including measures against severe accidents. Simultaneously, we will respond to various social demands such as reducing the harmfulness and volume of radioactive waste, improving resource recycling through the effective use of resources, promoting co-existence with renewable energy, and ensuring carbon-free hydrogen production and heat utilization.
Backed by government finance, China and Russia currently dominate the market for light water reactors; meanwhile, developed economies such as the United States, the United Kingdom, and Canada have found a way forward with small reactors and innovative reactors and are investing large-scale government budgets to accelerate research and development, with the aim of achieving commercialization by around 2030. Given these international trends, we will also participate in international development projects in collaboration with Japanese companies that have high manufacturing capacity. At the domestic level, we will also promote the development of new technologies and human resources that will radically improve the safety, reliability, and efficiency of nuclear power utilization for the future, such as pursuing reactors with excellent safety records (e.g., high-temperature gas-cooled reactors where various industrial applications including hydrogen production are expected and which are inherently safe). In order to support such initiatives, we will strengthen human resources, technology, and industrial bases, which transcend the boundaries of industry, academia, and government, including the maintenance of test/research reactors needed for human resource development, research and development, etc. To that end, related ministries and agencies will collaborate to conduct horizontal development/discussion of advanced initiatives and research results regarding collaboration between universities and local communities, human resource development, etc., and promote the social implementation of such knowledge and technologies.
We will advance specific research and development with strategic flexibility that involves competition between diverse technologies and selection of those technologies by domestic and international markets. Simultaneously, we will take into account the efforts of the United States and Europe in promoting the development of innovative reactors (e.g., small modular reactors, molten salt reactors). In this framework, GOJ will develop a long-term development vision, and the private sector will make use of its ingenuity and wisdom. With regard to the tokamak-type ITER project and a wide range of approaches being promoted

through international cooperation for the realization of fusion energy, site construction and equipment production are progressing; we will continue to steadily promote these efforts from a long-term perspective. In tandem with these efforts, we will promote research on the helical/laser methods and other innovative concepts in order to ensure diversity in technology. We will also promote the development of technologies necessary for volume/harmfulness reduction and stable final disposal of radioactive waste.

Through these efforts, by 2030, we aim to steadily promote fast reactors utilizing international collaboration while making use of the ingenuity and wisdom of the private sector, demonstrate small modular reactor technology through international collaboration, promote the establishment of elemental technologies related to hydrogen production in high-temperature gas-cooled reactors, and steadily promote fusion research and development such as the ITER project through international collaboration.

8) Semiconductor/information and communication industries

As rapid progress is being made in the utilization of information and digitalization, carbon neutrality will be achieved by societies where electrification and digitalization have progressed in various fields such as manufacturing, services, transportation, and infrastructure. Therefore, the semiconductor and information and communication industries, which are the foundation of digitalization and electrification, are the key to simultaneously promoting green initiatives and digitalization.

Policies for realizing carbon neutrality in the semiconductor and information and communication industries can be divided into two categories: (a) streamlining energy demand and promoting CO_2 conservation through digitalization ("Green by Digital"), and (b) energy conservation and greening of digital equipment and the information and communication industry itself ("Green of Digital"). We will use these two approaches in tandem to promote various initiatives and aim for carbon neutrality in the semiconductor and information and communication industries by 2040.

Specifically, from the perspective of (a) streamlining energy demand and promoting CO_2 conservation by digitalization ("Green by Digital"), it is important to promote DX, support the domestic establishment of green data centers, and develop next-generation information and communication infrastructure. To that end, we aim to make Japan the premier green and digital power worldwide by expanding the market scale as well as investigating and implementing various support measures for those objectives.

Additionally, from the perspective of (b) energy conservation and greening of digital equipment and the information and communication industry itself ("Green of Digital"), we aim to build a green and digital society by promoting energy conservation, CO_2 conservation, and high performance through research and development, practical application, and dissemination and expansion of power semiconductors used in a wide range of fields; supporting the development and demonstration of various technologies for the promotion of green data centers; facilitating expansion of edge computing technology; advancing the development of ultra-distributed computing software; and promoting research and development for the advancement of optoelectronics.

In particular, in order for Japan to be a world leader in building a sustainable society in which both green initiatives and digitalization are compatible, we will need to accurately grasp the needs of the changing times and enhance competitiveness of the digital industry and semiconductors, which are the "rice of the industry"

(things that play a central role in industry) and are deeply related to all social and economic activities, playing a key role in data communication, processing, etc. Given this background, the Ministry of Economy, Trade and Industry hosted the Semiconductor and Digital Industry Strategy Review Conference, which has experts as members who received various opinions. In June 2021, the "Strategy for Semiconductors and the Digital Industry" was compiled to outline measures for strengthening the competitiveness of semiconductors, reinforcing digital infrastructure such as data centers and ensuring their optimal placement, and fostering the digital industry, which supports the digital society. Going forward, we will steadily implement this strategy alongside the Green Growth Strategy.

9) Shipping industry

Green ships and shipping services are Japanese maritime industries' strength, mainly in the shipbuilding and shipping industries. The more global interest in measures for tackling global warming people have, the more market value of such ships and services has been increasing. This means that the time has come for a game change. If Japan's shipbuilding and shipping industries succeed in developing the technologies relating to zero-emission ships ahead of other countries, they will be able to capture this demand. In addition, towards net-zero by 2050, shipping is expected to play a major role in import and export including the import of decarbonized fuels such as hydrogen, carbon neutrality in the entire supply chain is also required.

In order for Japan to secure stable marine transportation as well, we will strengthen the international competitiveness of its shipbuilding and shipping industries and strive for carbon-neutral maritime transportation by acquiring technical competence relating to the development of greener ships, such as gas-fueled ships powered by LNG[25], hydrogen, ammonia and others, which are essential to achieve zero emissions, and establishing production infrastructures, and by leading the establishment of related international regulations at the International Maritime Organization (IMO). By technology development by supported by the Green Innovation Fund and other policy tools, we aims to start a demonstration project for zero-emission ships by 2025, realize the commercial operation of zero-emission ships before the conventional previous target year of 2028 and further spread zero-emission ships towards 2030., In 2050, the fuel used for ships is expected to be converted into alternative fuels, such as hydrogen and ammonia.

Specifically, considering the current limitation of output, weight, and size, we will promote the development and practical use of core technologies such as hydrogen/ammonia-fueled engines, which have yet to exist in the world, for the use in long-distance and large ships, while facilitate the broader use of hydrogen fuel cell systems and battery propulsion systems for short-distance and small ships. We will also work to establish production infrastructures of required equipment such as high-quality fuel tanks steadily and efficiently.

In parallel with efforts to develop and implement these technologies, in order to diffuse zero-emission ships, it is necessary to establish international frameworks including safety standards for hydrogen/ammonia-fueled

25 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 gas fuels such as hydrogen, ammonia, and clean methane from recycled carbon dioxide. 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-fueled 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.

ships. Japan has been leading the establishment of international regulations to improve energy efficiency of ships and others, we will continue to play the leading role in developing international frameworks for energy saving and decarbonization through the IMO. In addition, we will promote popularizing greener ships through the rating system for energy efficiency of coastal ships and other policy tools. By the end of 2021, we will formulate a roadmap for disseminating greener coastal shipping to achieve carbon neutrality, thereby implementing necessary measures.

10) Logistics/people flow, and civil engineering infrastructure industries

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

With regard to ports, we will try to develop Carbon-Neutral Port by upgrading port functions for decarbonization and improving the receiving environment to enable the import of large amounts of stable and inexpensive hydrogen and fuel ammonia.

In terms of smart transportation, we will promote the spread of MaaS to create an environment that facilitates movement without relying solely on private cars. We will re-organize the local transportation networks and promote barrier-free access (easy access), using the Act on Revitalization and Rehabilitation of Local Public Transportation Systems, in coordination with the town development to promote the use of such development by securing local public transportation, improving convenience, and introducing a means of transportation with low CO_2 emissions (e.g., LRT, BRT). Moreover, we will promote the creation of a safe and pleasant bicycle user environment based on the Second Bicycle Use Promotion Plan.

For the promotion of green physical distribution, we will work to promote modal shifts and improve transportation efficiency throughout the supply chain utilizing new technologies. In addition to promoting measures for road traffic flow, we will promote the efficiency of logistics will be improved by promoting the use of double-trailer trucks. We will promote the development of fuel-cell railway vehicles. Moreover, we will promote the reduction of CO_2 emissions from airport facilities and vehicles, the conversion of airports to renewable energy hubs, and the improvement of flight operation methods by upgrading air traffic control.

To achieve zero emissions in the infrastructure and urban space, we will promote energy saving in road lighting and investigate the introduction of renewable energy for the electricity required for road management.

In sewerage systems, we will develop new technologies to promote further energy conservation saving in water and sludge treatment. We will promote urban compactness, area-based decarbonization in cities, and the introduction of renewable energy in urban parks. We will develop technologies for green infrastructure that utilizes various functions of the natural environment and support its regional introduction and will promote the utilization of green finance through green bonds.

In the construction fields, we will promote the use of construction machinery with superior fuel efficiency. Moreover, we will establish and promote the introduction and use of a certification program for innovative construction machinery with a radical review of power sources.

Based on the “MLIT’s Green Challenge” (the summer of 2021), the government will strategically promote cross-sectoral decarbonization and other initiatives in the field of livelihood, urban development, transportation, and infrastructure through the acceleration of technological innovation and its implementation in cooperation with the private sector.

11) Food/agriculture, forestry, and fishery industries

Based on the “Strategy for Sustainable Food Systems, MeaDRI” (May 2021), we will promote the development and social implementation of innovative technologies and production systems throughout the supply chain, including production, processing, distribution, and consumption, in order to achieve zero CO_2 emissions in the agriculture, forestry, and fishery industries by 2050.

We will promote the use of electricity and hydrogen in agricultural and forestry machinery and fishing boats, and efforts to reduce greenhouse gas emissions from agriculture and the livestock industry, and efforts to create carbon sinks such as long-term and mass storage of carbon in agricultural land and oceans, and food loss reduction. With regards to forests and timber, we will implement forest maintenance measures such as the appropriate thinning of planted forests and reforestation using elite trees; develop and expand the use of building materials that contribute to using wood for construction of high-rise buildings; and secure and strengthen forest carbon absorption.

12) Aircraft industries

ICAO (the International Civil Aviation Organization) set a goal of not increasing CO_2 emissions in and after 2020 and IATA (the International Air Transport Association) set the goal of reducing the CO_2 emissions to half of the 2005 levels by 2050. Given these circumstances, we aim to establish Japan’s technological superiority in the aircraft manufacturing industry, with the goal of reducing carbonization in the aircraft industry by using electrification and hydrogen technologies, SAFs such as bio-jet fuels, and carbon fiber composite materials for airframes.

The current limited applications of aircraft electrification technologies, such as the installation of storage batteries for auxiliary power or power supply while on the ground, are expected to expand to include applications relating to power during flight and the operation of internal systems. Therefore, in line with the timing of introductions to the future aircraft market, we will accelerate our research and development with the aim of incorporating core technologies for aircraft power (e.g., aircraft batteries, motors, inverters) from 2030. We will also promote international standardization through domestic collaboration between industry, academia, and government collaboration.

The use of hydrogen fuel, in addition to electrification technologies, is expected to help reduce carbon emissions in the aircraft industry. Moreover, in September 2020, Airbus announced that it is aimed to introduce hydrogen-powered aircraft by 2035. Japanese companies have started specific initiatives relating to hydrogen-powered aircraft. Along these lines, we will promote the development of core technologies such as liquefied hydrogen fuel storage tanks and engine combustors for hydrogen-powered aircraft, which will be necessary for achieving hydrogen-powered aircraft in and after 2035.

The main manufacturing technologies of SAFs include gasification FT synthesis technology, ATJ technology,

and microalgae culture technology. However, each of these technologies has technical issues and remains in the small-scale demonstration stage. We will conduct research, development, and large-scale demonstration in order to establish the technology and achieve cost reductions. By around 2030, we will achieve cost reductions to those of current jet fuels and applications. Synthetic fuels made from CO_2 and hydrogen as feedstocks are also expected to be one of the SAFs capable of stable supply since they can be mass-produced industrially without resource restrictions. Therefore, during the next 10 years, we will intensively develop and demonstrate the technology, aiming for independent commercialization by 2040. Additionally, we expect that the production and supply of SAFs in other countries will progress in and after 2025. Therefore, we aim to expand the national and international supply of competitive SAFs according to the international SAF market trends.

Due to weight reductions, energy conservation during operation is higher in carbon fiber composite materials for airframes than in conventional metal materials. However, energy consumption during manufacturing is higher in carbon fiber materials than in metallic materials. Therefore, in order to enhance emission reduction effects of the entire manufacturing cycle while coordinating with other fields, such as the automotive industry, we aim to establish medium to long-term recycling technology. Additionally, we will collaborate with domestic material manufacturers, aircraft and engine manufacturers, and national research and development agencies, such as the Japan Aerospace Exploration Agency, to promote necessary technological development, including database maintenance and production technology related to advanced materials. We aim to meet the technical levels required by domestic manufacturers whose technologies are selected to be installed in future aircraft.

13) Resource recycling-related industries

Regarding the goals of 3R+Renewable, the Government is supporting technology development and social implementation through laws and planning. Waste power generation, heat utilization, biogas utilization, etc. have already entered the commercial phase and are becoming more widespread and sophisticated. In the future, these efforts will be further promoted by advancing and optimizing technology, improving equipment, lowering costs, advancing digitalization, etc. and then, Japan will reduce GHG emissions to net-zero by 2050 while advancing the transition toward the Circular Economy.

(a) Reduce and renewable

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 circulation and CO2 saving. In respect of the goal of Renewable (biomass conversion, utilization of recycled materials, etc.), the Government will promote technology development/demonstration, development/sophistication of recycling technology, equipment maintenance, and demand creation for higher functionality of biomass materials and expansion/cost reduction of applications for further expansion of recycling.

(b) Re-use, recycle, and utilization of exhaust gas

The Government will develop and advance high-performance recyclable materials and recycling technology,

optimize collecting routes, expand installed capacity, and further expand reusing, and recycling.
In particular, based on the "Act on Promotion of Resource Circulation for Plastics" and other relevant laws and regulations, the Government will take measures to promote efforts for resource circulation for plastics by all stakeholders throughout the lifecycle of them, from designing products to disposing waste. Similarly, promotion of resource circulation for other materials than plastics will be further considered.
Regarding the utilization of exhaust gases and other materials from incineration facilities, while considering the use of the Green Innovation Fund, the Government will promote efforts toward practical use and social implementation of those gases by developing and scaling up innovative technologies, reducing costs of them, etc. through demonstration projects such as combustion control to facilitate the recovery of CO2 from waste treatment facilities as well as separation, recovery, and utilization of CO2 from low-concentration exhaust gases containing various impurities.

(c) Waste power generation, heat utilization, biogas conversion fixation of exhaust gas
As regards waste power generation, 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), there is a concern that the power generation efficiency will decrease. The Government will proceed with technological development to ensure high-efficiency energy recovery.
In addition, as a measure to mitigate climate change, in order to promote the use of trees generated in the ongoing maintenance and management of rivers (felled trees, driftwood, etc.) as a renewable energy resource for biomass power generation, the Government will examine the possibility to improve efficiency in the maintenance and management and effectively utilize general waste treatment facilities.
As for heat utilization, the Government will promote the improvement and cost reduction of heat storage and transportation technologies to supply heat to distant facilities.
With regard to biogasification, the Government will promote technical demonstration projects in anticipation of the need for large-scale methanization facilities in line with major changes in the quality of waste in the future In order to expand the use of sewage biomass, the Government will make intensive efforts until FY2025 to promote the formation of projects among local governments, including the enhancement of the "Sewage Energy promoting Concierge Program."
As for the fixation of exhaust gases from incineration facilities, the Government will develop the technology at the lab level to fix CO2 which is separated and recovered from the exhaust gases from waste incinerators, etc.

14) Lifestyle-related industries
In order to make our live carbon-neutral while maintaining resilience and comfortability by 2050, the Government will put effort in decarbonization of our lifestyle in consideration of the discussion in the Council for National and Local Decarbonization.

(a) Total management of housing and transportation
The Government will work on establishing the methods for total management of housing and mobility

including by facilitating practical use of ZEH, ZEB, demand side equipment (home appliances, boilers and etc.), local renewable energy and EV/FCVs in a combined manner. The Government will also promote the demonstration and the social implementation of technologies, such as networking houses and buildings by using renewable energy electricity and heating that is close to demand side and DC power supply, ensuring flexibility consistent with the mainstreaming renewable energy utilizing hydrogen, and sector coupling of electricity, heating and mobility.

(b) Behavior change by means of nudge, digitalization, and sharing, etc

In order to materialize the concept of fusion of behavioral insights such as nudge and cutting-edge technologies (BI-Tech) in social implementation, the Government will further accelerate the efforts to digitalize that behavioral information, which is to be aggregated and analyzed. The Government will pursue the development, implementation and standardization of further advanced system technology which supports personalized eco-friendly and comfortable lifestyle.

Furthermore, we will use the demonstration results to digitalize application procedures of the J-credit Scheme and simplify monitoring process automate credit certification procedures. Simultaneously, we will continue to investigate the construction of a blockchain-based trading market, aiming to start operations from FY2022 at the earliest.

The Government will also promote the construction of smart cities equipped with a decentralized energy system nationwide, while ensuring security.

What is more, the Government will promote the establishment of business models related to decarbonized mobility by car-sharing of EVs utilizing local renewable energy, and community-serving decarbonized logistics utilizing battery exchange type EVs and battery stations, and then horizontally diffuse on a nationwide base).

(c) Enhancement of scientific infrastructure related to observations and models

In order to estimate CO_2 emissions more accurately, the Government will improve spatiotemporal resolution, further elucidate the mechanisms of climate change, improve the accuracy of climate change projection information, continue observations and monitorings, promote further utilizations of GHG observation data and climate change projection information through the Data Integration and Analysis System (DIAS), and enhance the scientific infrastructure.

Furthermore, the observation network and the analysis system will be integrated and upgraded to improve spatiotemporal resolution and estimation accuracy, and to quantify the GHG balance in whole area including natural ecosystem.

The Government will promote cross-disciplinary R&D including from humanities and social sciences to natural sciences. To enrich the fundamental knowledge related to the methods of introducing effective technologies and measures, as well as to promote the social implementation of such knowledge, the Government established “University Coalition for Carbon Neutrality 2050” to strengthen the cooperation between universities and between industry, academia and government.

<Carbon pricing>

As for economic instruments that use market mechanisms such as carbon pricing, we will introduce without hesitation those that contribute to growth, so as to strengthen industrial competitiveness and promote innovation and investment.

Given the accelerating expansion of the international voluntary credit trading market led by the private sector, we will take concrete measures to increase the depth of the domestic market (carbon credit market) in Japan in which carbon reduction value can be traded and promptly respond to the needs of companies that are leading the way in climate action, in light of the growing corporate demand for credits with carbon reduction value, such as J-credits and Non-fossil Fuel Energy Certificates, we will first review the existing systems for these credits and promote voluntary and market-based carbon pricing.

In terms of carbon taxes and emissions trading systems, we will proceed with specialized and technical discussions on whether it is possible to design a system that will promote investment and contribute to growth in terms of both price signaling and revenue generation, while taking into account the added cost borne by companies. In doing so, it is necessary to have specialized and technical discussions based on international trends and the situation in Japan, including the fact that many companies are willing to decarbonize, the efforts of leading local governments, and the impact on the international competitiveness of industry including the impact on corporate R&D and capital investment.

Japan will fully display its leadership as the flag-bearer of free trade by taking the lead in creating fair international rules to balance these aspects with global warming countermeasures. At the same time, we will pay close attention to the trends of discussions with the European Union, and respond strategically based on Japan’s basic concepts of carbon border adjustment measures.

Based on the domestic and international circumstances, we will review the Environment Innovation Strategy, which was formulated with the aim of establishing innovative technologies that enable “Beyond-Zero,” reducing CO_2 on a prior-stock basis, by 2050, in a timely and appropriate manner and promote this together with industry, academia, and government.

Forest sink countermeasures and the utilization of negative emissions technologies such as DACCS and BECCS, which fix CO_2 from the atmosphere, will be required in fields where decarbonization is difficult. We will advance technical development and social implementation of these negative emissions technologies, with the aim of practical application by 2050.

We will do our utmost to create disruptive innovations in order to achieve a “virtuous cycle in the economy and the environment”.

7. Enhancement of communication with all levels of society

(1) Enhancement of understanding of energy at all levels of society

Choosing among energy sources is choosing among possible futures. The government must remember that information disclosure and thorough transparency by the government are the most important elements for citizens to make informed energy choices.

Since the Great East Japan Earthquake and the Fukushima Daiichi Nuclear Power Station accident, the public has been increasingly interested in energy aspects as a whole, including nuclear power generation, accident response, and the reconstruction of Fukushima. For example, concerns about the reliable supply of electricity have prompted initiatives to save electricity, and there has been increased interest in distributed energy systems to enhance disaster response capabilities. Furthermore, public awareness has grown about issues affecting the energy supply and demand structure, such as problems with the treatment of spent fuel in nuclear power generation and the disposal of radioactive waste, persistent high dependence on foreign resources, a low energy self-sufficiency rate, and increasing electricity fees.

In response to the announcement of carbon neutrality by 2050 and new greenhouse gas emission reduction targets for FY2030, the public has become interested in the feasibility of innovative technologies such as hydrogen and CCU, which are necessary elements for these goals.

Furthermore, the challenge of carbon neutrality by 2050 is accompanied by transformations in the industrial structure, economy, and society, and there is a long way to go. In order to achieve these ambitious goals, all industries and citizens need to resonate and sympathize with the future of a carbon-free society and take personal responsibility for their actions.

Under such circumstances, it is essential to provide the overall picture of the energy situation in Japan so that everyone, regardless of their own level of interest or background knowledge, can understand and take an interest in interacting with the information. The government will also proactively implement public relation campaigns that will lead to public understanding of the energy situation in Japan, with efforts of making continuous improvements.

The existence of the “safety myth” in government and businesses has been a major obstacle in the enhancement of opportunities for public awareness of the energy situation. The “safety myth” gives the impression that there is no risk and no further awareness is required, if the standards and conditions set by the government and businesses are met. Energy-related public relations campaigns could not improve this perception prior to the Fukushima Daiichi Nuclear Power Station accident. After the accident, the government and businesses were often criticized for their information dissemination method and lack of awareness of issues relating to communication with the local community. The government must conduct a self-examination of the fact that it has reduced public confidence.

To improve this situation and help the public select and utilize properly organized information based on their own interests, a continuous effort must be made to establish a system that expresses policy-related information (such as basic energy terms and the latest trends and topics in an easy-to-understand manner),

and provides objective and diverse information based on scientific knowledge and data as clearly as possible. Specifically, this information should be carefully disseminated using various media such as “Special Contents” on the Agency for Natural Resources and Energy website and pamphlets. An English version of the pamphlet will also be created to disseminate information on the energy situation and policy of Japan to foreign countries.

We will also create an environment where discussions on energy can be widely held as a country by actively providing information to the media, private research organizations, and non-profit organizations; having a third party organize information from a unique and independent perspective; and providing the energy information to the public in various formats.

In order to broaden and deepen the understanding of the energy situation of Japan, it is important that basic knowledge relating to energy be taken up as part of the educational programs in school education. Choosing among energy sources spans various subjects including science, social studies, technology, and home economics and is also an issue with no “correct” answer, so it is a topic that would deepen children’s own thoughts and allow them to take personal responsibility for energy. Furthermore, providing opportunities for energy-themed education and discussions with children, faculty members, and local individuals will contribute to broadening thinking and advancing inquiry in relation to children’s future career development. Developing the understanding of Japan’s current state of energy from childhood through such efforts will help the child make suitable decisions when the child becomes an adult and gets actively involved in energy policy. Furthermore, it is expected that more people will study energy as a specialized field in higher education and more people will be trained to support the future energy supply and demand structure. Based on these aspects, we will develop and improve content such as lesson development examples relating to energy education, supplementary teaching materials, and games that allow individuals to think about electricity balance, and will provide these lesson plans through our websites and paper media. Additionally, we will support the ingenuity and voluntary efforts of teachers working on energy education in Japan.

We will broaden public understanding of energy by carefully implementing these initiatives. As a result, we expect that each citizen will thoroughly implement energy conservation, participate in the energy supply structure as a renewable energy supplier, and develop interest in locating radioactive waste disposal sites; and that this will lead to the dissemination of independent efforts for energy by the public.

(2) Transparency of policymaking process and enhancement of interactive communication

It is essential that every effort improves understanding of the overall picture of the energy situation in Japan, while increasing the transparency of the energy policy planning process and gaining trust in policy. We will increase the transparency of the policy-making process as much as possible through councils and meetings of experts.

We will strengthen two-way communication in order to promote public dialogue. Various energy-related issues, particularly nuclear power, have specialized and complicated content, including difficult-to-explain safety, risk, and cost aspects, which could make them difficult to understand. Therefore, we will not only unilaterally communicate this information but also invite various stakeholders to participate, including local governments, businesses, non-profit corporations, and citizens. We will enhance polite dialogue and two-way communication across the country, including the ways to use local energy, and build opportunities for individuals to take personal responsibility for energy-related matters in each activity.

Furthermore, we will build a mechanism for young people, such as university students and young adults, to learn from each other, exchange opinions, and start businesses that will lead to solutions for various energy issues. Simultaneously, we will encourage communication with youths who will be responsible for realizing carbon neutrality by 2050.

We will proceed a variety of initiatives to establish an interactive policy-making and implementation process in society.