Strategic Energy Plan

February 2025

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I. Introduction

Japan is limited in its readily accessible natural resources and is geographically constrained by its mountainous land and being surrounded by deep oceans. Japan has faced several energy supply crises in the past, and each time mobilized collective expertise to secure a stable energy supply.

In the wake of the 1973 oil crisis, Japan not only diversified fossil fuel types and procurement sources, but also promoted energy conservation through government-led initiatives such as the Moonlight Project, and development and utilization of alternative energy sources to oil, such as solar photovoltaic, nuclear energy, and LNG, through the Sunshine Project. Since then, we have continued efforts to build a well-balanced energy supply system.

However, after the Great East Japan Earthquake and the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi Nuclear Power Station in 2011, many nuclear power plants were shut down, resulting in increased dependence on fossil fuels, with the majority of supply relying on imports from overseas. This led to the re-emergence of vulnerabilities in Japan’s energy supply-demand structure.

Against this backdrop, in February 2022, Russia's aggression against Ukraine completely changed Japan’s energy landscape. Global energy sector inflation became evident, and in Japan, tight electricity supply-demand conditions and soaring energy prices raised concerns of an energy crisis reminiscent of the oil crisis. The following year, military tensions escalated in the Middle East, a region from which Japan imports more than 90% of its crude oil, leading to greater uncertainty in fossil fuels procurement and highlighting once again the challenges Japan faces in its energy supply-demand structure.

These challenges are also having a significant impact on Japan's balance of trade. In 2023, a substantial portion of revenue from exports, such as automobiles and semiconductor manufacturing equipment, was used to import mineral fuels such as crude oil and natural gas, with the total reaching approximately 26 trillion yen. In addition, Japan’s digital services trade balance is currently worsening, and if deficits continue to grow in the digital sector, which is expected to drive future economic growth, further outflow of Japan's national wealth will be inevitable. Therefore, energy policy plays an important role in securing domestic investment in the digital sector, including data centers.

As energy is the foundation of people's lives and economic activities, the stability of energy supply must never be undermined. In order to break away from excessive dependence on fossil fuels and to promote transitions to a resilient energy supply-demand structure that can withstand energy crises, it is imperative that Japan's technological and intellectual resources be brought together once again to rebuild its energy policy, with an emphasis on energy security.

In the midst of extreme weather events and large-scale natural disasters worldwide, many countries and regions around the world have announced time-bound carbon neutrality

targets[1]and momentum toward decarbonization is high. Under these circumstances, Japan has been working to simultaneously realize stable energy supply, economic growth, and decarbonization. In May 2023, it enacted the GX Promotion Act[2]and the GX Decarbonization Power Source Act[3], followed by the Hydrogen Society Promotion Act[4]and the CCS Business Act[5]in May of the following year. In addition, to further strengthen GX-related measures, the GX Promotion Strategy[6]was formulated to outline the direction of efforts to realize Green Transformation (GX). Promoting GX through these efforts will contribute to breaking away from excessive dependence on fossil fuels, and will also help to secure a stable energy supply in the medium to long term.

While many countries in Europe and the United States have set ambitious targets for decarbonization, some are shifting to a more realistic path that strikes a balance between economics and stability of supply, and the gap between targets and reality appears to be widening. Japan has so far been advancing emission reductions in line with its goal of achieving carbon neutrality by 2050, in terms of greenhouse gas emissions and absorptions, demonstrating strong national commitment to addressing climate change, a common challenge for all humankind.

In Japan, although electricity demand has been on a downward trend since FY2007 due to a declining population and the spread of energy efficiency improvement, it is expected to turn upward in the future due to the progress of Digital Transformation (DX) and GX.

Future growth industries such as data centers, which are expected to expand with the advent of generative AI, semiconductors, a key strategic resource, and materials industries, such as steel and chemicals, all require a stable supply of decarbonized energy at internationally competitive prices.

Increasing demand for electricity and the need for decarbonized power sources are becoming increasingly evident worldwide. In particular, major ICT companies in the United States are strategically and rapidly expanding investment in innovative technologies such as next-generation advanced reactors and next-generation geothermal technologies, in addition to securing renewable energy, to ensure that the decarbonized power sources required to operate data centers and other facilities do not constrain their business growth. In Europe, the expansion of renewable energy is also underway, and according to a report published by the European

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[1] Since the Declaration of Carbon Neutrality by 2050, the term "carbon neutrality" has been used in a number of Cabinet-approved documents, and this plan will, in principle, use the term "carbon neutrality" as well. In international contexts, the term "net zero" is more commonly used, but this plan adopts the term "carbon neutrality" with the recognition that both expressions share the same fundamental meaning.

[2] Act on Promotion of Smooth Transition to a Decarbonized, Growth-Oriented Economic Structure (Act No. 32 of 2023).

[3] Act for Partial Revision of the Electricity Business Act and Other Acts for Establishing Electricity Supply Systems for Realizing a Decarbonized Society (Act No. 44 of 2023).

[4] Act on Promotion of Supply and Utilization of Low-Carbon Hydrogen and its Derivatives for Smooth Transition to a Decarbonized, Growth-Oriented Economic Structure (Act No. 37, 2024).

[5] Act on Carbon Dioxide Storage Business (Act No. 38 of 2024).

[6] Strategy for Promoting Structural Transition based on Decarbonization (approved by the Cabinet in July 2023).

Commission in September 2024, wind power generation has overtaken gas-fired power generation, and renewable energy accounted for half of Europe's power generation in the first half of 2024. Regarding nuclear energy, concrete steps are being taken to expand nuclear power, including a policy shift in Sweden to lift the ban on the construction of new nuclear power plants and new projects in Eastern Europe.

While the world is undergoing a dynamic shift, accelerating investment in decarbonization sectors to leverage them for economic growth, Japan's ability to sustain domestic industry and achieve economic growth will depend on securing sufficient decarbonized power sources. A lack of sufficient decarbonized power sources would result in missed opportunities for domestic investment and economic growth. It would also hinder job creation and wage increases, which would significantly affect people's lives. For this reason, it is essential to expand and maximize the use of decarbonized power sources.

In particular, from the perspective of Japan's industrial location and competitiveness, a stable supply of high-quality energy at internationally competitive prices is indispensable. Based on the policies outlined in the GX2040 Vision, the Government should take the lead in developing the business environment to secure decarbonized energy, while adopting an integrated approach to energy and economic policy.

Given the urgency of the situation, the Seventh Strategic Energy Plan, from the viewpoint of promoting investment to secure a stable energy supply, outlines policy issues to be addressed in the future and directions under the principle of S+3E, while taking into account the energy supply-demand structure in 2040 and beyond toward the realization of carbon neutrality.

In order for Japan to remain a prosperous country in the future and to realize a society in which all citizens can live with hope, it is necessary to simultaneously achieve stable energy supply, economic growth, and decarbonization. This new Strategic Energy Plan is presented to be used in conjunction with the "GX2040 Vision" and the "Plan for Global Warming Countermeasures," and to provide a long-term vision for Japan's energy policy and ensure long-term energy stability.

II. Progress after the accident at TEPCO's Fukushima Daiichi Nuclear Power Station

1. General remarks

Almost fourteen years have passed since the Great East Japan Earthquake and the accident at TEPCO’s Fukushima Daiichi Nuclear Power Station. The experiences, reflections and lessons learned from this accident remain the starting point for Japan’s energy policy.

Without the reconstruction of Fukushima, there is no reconstruction of Tohoku, and without the reconstruction of Tohoku, there is no revitalization of Japan. The reconstruction and revitalization of Fukushima should be carried out with full recognition of the Government’s social responsibility, having promoted nuclear energy policy. In the process of reconstruction and revitalization, we face a number of critical challenges, including technically demanding decommissioning of nuclear reactors and the final disposal of removed soil, which require medium- to long-term responses. The memory and lessons of the accident must never be forgotten. Without forgetting the reflection and lessons learned, we must acknowledge and respond to the emotional pain of those still displaced, and through a field-oriented approach, the Government will take the lead in fully supporting the recovery and revitalization of Fukushima.

Having experienced the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, Japan will introduce renewable energy as its major power source to the maximum extent possible, taking into account the aforementioned changing circumstances surrounding the country.

That said, in continuing to utilize nuclear energy in the future, we must place the highest priority on ensuring safety, and must never forget the lessons learned from the remorse of having fallen into the "myth of safety" and failed to prevent a disastrous situation.

2. Status of efforts for the reconstruction of Fukushima

(1) Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station: On-site

The decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station, which is a major prerequisite for the reconstruction of Fukushima, is an unprecedented in the world and extremely challenging undertaking. Rather than leaving the task solely to the operator, the Government has taken the lead, establishing the "Mid- and Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station" (decided by the Inter-Ministerial Council for Contaminated Water, Treated Water and Decommissioning Issues, in December 2019. Hereafter referred to as the "Mid- and Long-Term Roadmap"). Based on this Mid- and Long-Term Roadmap, the Government is working with unwavering determination to implement each measure safely and steadily, drawing on collective expertise from Japan and abroad.

The current Mid- and Long-Term Roadmap reaffirms the principle of "coexistence of reconstruction and decommissioning" with early risk reduction and safety assurance as the first priority. Under this principle, the amount of contaminated water generated has been significantly reduced through measures such as frozen soil walls.[7]Fuel removal from spent fuel pools has been completed in Unit 3 and Unit 4. With the start of trial retrieval of fuel debris from Unit 2 in September 2024, the process entered "Phase 3," the period from the start of fuel debris retrieval to the completion of decommissioning, in the Mid- and Long-Term Roadmap. The decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station is a task with challenges that are difficult to foresee, and we will review the decommissioning process appropriately based on the progress of measures, newly identified on-site conditions, new insights obtained from analysis of fuel debris, trends in research and development, and the feasibility of decommissioning methods. The Government will continue implementing measures in a safe and steady manner towards complete decommissioning. Regarding ALPS treated water, after the 6th Inter-Ministerial Council for Contaminated Water, Treated Water and Decommissioning Issues, and the 6th Inter-Ministerial Council for Steady Implementation of the Basic Policy on Handling ALPS Treated Water in August 2023, we started discharging ALPS treated water into the sea on the 24th of the same month. Monitoring has confirmed the safety of ALPS treated water, and the International Atomic Energy Agency (IAEA) has verified that the discharge into the sea is being conducted safely.

(2) Reconstruction and revitalization of Fukushima: Off-site

By March 2020, the evacuation order was lifted for all areas except for the Restricted Area. Regarding the Restricted Area, the evacuation orders for all Specified Reconstruction and Revitalization Base Areas were lifted by November 2023. The population subject to evacuation

[7] Decreased from 540 m^3/day (May 2014) to 80 m^3/day (FY2023 average).

orders decreased from 81,000 in August 2013 to 8,000 in April 2024, a decrease of approximately 90%. On the other hand, some areas are only at the initial stage of recovery. In the Restricted Area outside of the Specified Reconstruction and Revitalization Base Areas, a system referred to as the Specified Living Areas for Returnees was established in June 2023 to enable residents wishing to return to do so over the course of the 2020s. By April 2024, restoration and revitalization plan for Specified Living Areas for Returnees were approved in Okuma, Futaba, Namie, and Tomioka Towns, and efforts toward lifting of evacuation orders, including decontamination and infrastructure development, have begun.

In areas where evacuation orders have been lifted, efforts have been made to support the rebuilding of affected businesses and livelihoods, and to promote new industry creation through the Fukushima Innovation Coast Framework. In December 2019, the "Blueprint for Industrial Development Based on the Fukushima Innovation Coast Framework" (hereafter referred to as the "Blueprint") was formulated, fleshing out the Framework to show the independent and sustainable industrial development that the Hamadori area, etc., is aiming for. In June 2024, key discussion points for further development of the Framework were presented.

Through individual support provided by the Public-Private Joint Teams, approximately 2,600 business operators resumed their activities as of the end of December 2024, and approximately 80 robot-related companies have clustered, through practical development utilizing the strengths of the Fukushima Robot Test Field, and other facilities. In April 2023, the Fukushima Institute for Research, Education and Innovation (F-REI), the core and command centers of the Fukushima Innovation Coast Framework, was established to industrialize research outcomes and foster and to train, and secure the human resources to support these initiatives. In addition, based on the "Action Plan for Expansion of Exchange Population" compiled in May 2022, efforts are being made to expand the exchange and related population. Based on "the Fukushima Plan for a New Energy Society," projects such as woody biomass-fired power generation and shared transmission line development is progressing. In September 2024, the "Fukushima Acceleration Plan for a New Energy Society 2.0" was formulated to further accelerate the introduction of renewable energy and the social implementation of hydrogen.

3. Future efforts for the reconstruction of Fukushima

The reconstruction and revitalization of Fukushima is the most important issue for the Government. Until the day Fukushima achieves full reconstruction, the Government will continue to address each difficult challenge one by one, including the decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station, the lifting of evacuation orders for the Restricted Area, and the realization of self-sustained industrial development.

The decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station is important to further promoting the return of local residents to their homes, and it is essential to take all possible measures to ensure safety in conducting extremely difficult tasks, such as the removal of fuel from the spent fuel pools of Unit 1 and Unit 2 and retrieving fuel debris. Therefore, more than ever before, the Government will take measures with a clear focus on the principle of the "coexistence of reconstruction and decommissioning." In doing so, the Government will continue to provide necessary support for technically demanding research and development efforts that require national leadership under the Mid- and Long-Term Roadmap. In addition, the Government will share its technical expertise and knowledge on decommissioning with the international community through multilateral cooperation frameworks and bilateral partnerships with the United States, the United Kingdom, and France, to contribute to enhanced safety and disaster prevention capabilities at nuclear facilities in each country. Furthermore, with the aim of leveraging global expertise to complete the decommissioning process, Japan will actively promote international technical cooperation in this field. The Government will also steadily develop the facilities at the Okuma Analysis and Research Center of the Japan Atomic Energy Agency (JAEA), establish a technological basis for decommissioning and promote research and development at the Okuma Analysis and Research Center, the Naraha Center for Remote Control Technology Development, and the Collaborative Laboratories for Advanced Decommissioning Science. At the same time, efforts will be made to foster the clustering of decommissioning-related industries and develop human resources, such as analytical specialists, to ensure the long-term sustainability of these decommissioning works. In particular, the Government will promote the active participation of local companies in decommissioning-related industries and ensure that the economic benefits of decommissioning are shared with surrounding areas by providing clear and concrete explanations of decommissioning projects to local companies and improving their technical capabilities. In addition, the Government will engage in careful interactive communication through site visits to decommissioning facilities and roundtable discussions, thereby advancing the project while gaining the understanding and trust of local residents. In order for TEPCO to implement decommissioning work responsibly with necessary funding remaining available, the Government will ensure that the rationalization of the power transmission and distribution business, which is under regulated rates, can continue to be used to fund the decommissioning, while the power network is being strengthened from the perspective of responding to disasters and ensuring a stable supply of electricity.

Moreover, TEPCO must fulfill its responsibility to Fukushima by further promoting the discontinuous management reforms and efforts to improve corporate value that have been undertaken based on the Government-approved special business plan, in preparation for the full-scale retrieval of fuel debris and other decommissioning activities.

Regarding the discharge of ALPS treated water into the sea, the Government will continue to take all necessary measures to ensure safety, and will strive to disseminate clear and transparent information domestically and internationally, including evaluations conducted by the IAEA. In response to import restrictions imposed by certain countries and regions, the Government will call for the immediate lifting of measures that are not based on scientific evidence. It will also maintain its policy that the Government will take full responsibility until the completion of ALPS treated water disposal, and will make every possible effort to support the fisheries industry nationwide.

With regard to the Restricted Area, even if it will take many years, the Government is firmly committed to lifting all evacuation orders in the futures and taking full responsibility for reconstruction and rehabilitation. The government as a whole will work toward the earliest possible recovery of the Restricted Area. In the Specified Reconstruction and Revitalization Base Areas, all evacuation orders were lifted by November 2023, and the Government will continue to improve the living environment, including housing, shopping, medical and nursing care, child-rearing, and education. In the Restricted Area outside the Specified Reconstruction and Revitalization Base Areas, efforts will be made to lift the evacuation orders, including decontamination and infrastructure development in the Specified Living Areas for Returnees, so that residents who wish to return can do so during the 2020s. At the same time, careful efforts will be made to confirm residents' intentions to return. In addition, a mechanism has been established to allow the lifting of evacuation orders in areas outside the Specified Reconstruction and Revitalization Base Areas where local governments have strong interest in land utilization. This mechanism will continue to be implemented with full respect for the intentions of each local governments. Furthermore, in the Restricted Area, the Government will consider how to resume activities in line with local needs, including the easing of entry restrictions in areas without physical barriers such as barricades, the resumption of activities such as forest maintenance, and utilization of biomass-fired power generation facilities in conjunction with such activities. The handling of remaining land, houses, and related assets will continue to be discussed in close consultation with local governments.

In addition to steadily transporting removed soil to interim storage facilities, we will promote its recycling and conduct activities to foster understanding nationwide for the final disposal of removed soil outside Fukushima Prefecture, under the Council for Promotion of Recycling, etc. for Realization of Final Disposal of Removed Soil and Waste outside Fukushima Prefecture, which was established in December 2024. We will continue to make every effort toward the environmental restoration of Fukushima.

With regard to the "Fukushima Plan for a New Energy Society," based on the "Fukushima Acceleration Plan for a New Energy Society 2.0" formulated in September 2024, we will further accelerate efforts toward the expansion of renewable energy and the social implementation of

hydrogen. In addition, wind power plants and other facilities will be gradually connected to the shared transmission lines, which were completed in July 2024 with a total length of approximately 86 km. At the same time, we will promote the early deployment of distributed renewable energy systems and perovskite solar cells. To establish a hydrogen supply chain in Fukushima, related ministries and agencies will collaborate to explore solutions to cost and other challenges from the perspectives of both supply and demand sides, and to utilize various support measures and systems, including the Hydrogen Society Promotion Act, which came into effect on October 23, 2024. We will promote initiatives such as the commercialization of the Fukushima Hydrogen Energy Research Field (FH2R) by the private sector, the expansion of hydrogen mobility, and the development of industrial clusters.

For independent and sustainable industrial development in the Hamadori area etc., we will rebuild and sustain the "daily lives of residents," which serve as the foundation for all initiatives. In addition to supporting the return of former residents and encouraging new migration, we will expand the exchange and related population, including individuals and businesses. At the same time, we will promote rebuilding communities and creating local vibrancy and innovation, and link these efforts to enhancing "regional earning capacity." By sharing the story of the region’s transformation into a leading hub for solving social challenges, we aim to create a virtuous cycle that attracts people and businesses, continuously gathers, and innovation flourishes. In the upcoming revision of the "Blueprint", we will incorporate the direction of these initiatives and make every effort to realize self-reliant and sustainable economic growth.

III. Changes in the situation since the Sixth Strategic Energy Plan

1. General remarks

In just over three years since a Cabinet decision was made on the Sixth Strategic Energy Plan in October 2021, the energy situation surrounding Japan has changed significantly.

Regarding energy, in addition to increasing demand for economic security following Russia's aggression against Ukraine and soaring tensions in the Middle East, the situation in Japan is expected to increase in electricity demand due to the progress of DX and GX.

Regarding decarbonization, there is a trend, particularly in Europe and the United States, to adopt diverse and realistic approaches in response to the instability of energy in terms of both quantity and price, while maintaining ambitious goals toward realizing carbon neutrality by 2050. In particular, major countries are increasingly integrating climate change measure with industrial policy to promote the structural transition of the energy system, for example, by strengthening domestic industrial competitiveness while linking climate change measures with industrial policy. Promoting GX in this way will contribute to breaking away from excessive dependence on fossil fuels and help ensure a stable energy supply over the medium to long term.

In developing and implementing the Seventh Strategic Energy Plan, it is necessary to fully consider such changes in domestic and international circumstances.

2. Increased requirements for economic security due to Russia's aggression against Ukraine

Around 2021, energy prices began to rise due to a combination of economic recovery from the COVID-19 pandemic and increased energy demand caused by cold waves and other factors. Furthermore, in February 2022, Russia's aggression against Ukraine began, and the global energy situation was dramatically changed.

At the time, European countries and others, which were increasing their energy dependence on Russia, indicated their intention to move away from Russian gas. This caused a major short-term energy supply-demand imbalance, resulting in a natural gas supply shortage, and the price of natural gas reached record highs not only in Europe but also in the Asian LNG market.

Against this backdrop, inflation in the energy sector triggered international inflation in various fields, including foodstuffs. Japan, too, experienced a period of acute energy stress, as the supply-demand balance for electricity tightened and energy prices soared, raising concerns over a potential energy crisis not seen since the oil crisis. In the face of this crisis, we were reminded of the vulnerability of Japan's energy supply system and the persistent challenges to ensuring energy security.

Tensions in the Middle East are escalating, due to the worsening Israeli-Palestinian situation and rising military friction between Israel and Iran. For Japan, which depends on the Middle East for more than 90% of its crude oil imports, the deteriorating situation in the Middle East, where critical choke points are concentrated, has a direct impact on energy security and could have a significant impact on Japan's industrial competitiveness.

In addition, the adoption of the Paris Agreement at the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2015 has triggered a growing global trend toward decarbonization. Under these circumstances, while upstream investment in fossil fuels is on a downward trend, energy demand is increasing due to economic growth in Asian countries and other factors. As a result, the uncertainty of energy supply and demand is increasing. Moreover, while investment in clean energy sources such as renewable energy and nuclear energy continues to grow, investment in fossil fuels is steadily declining. These changes may result in heightened volatility in fossil fuel prices in the future.

Japan lacks readily accessible natural resources and is geologically restricted by its mountainous land and being surrounded by deep oceans. Ensuring a stable energy supply has always been and will continue to be a top priority for Japan. We must take all possible measures to ensure energy security so that energy supplies, which form the basis of people's lives and economic activities, are not interrupted in terms of either quality and quantity.

3. Potential increase in electricity demand due to progress in DX and GX

The demand for electricity is expected to increase globally with the progress of DX and GX.

The International Energy Agency's (IEA) World Energy Outlook 2024, released in October 2024, forecasts that global electricity demand will increase at an annual rate of approximately 3% from 2023 to 2035 under the Stated Policies Scenario (STEPS). The main drivers of electricity demand include data center expansion, rising average temperatures, improvements in the energy efficiency of electrical equipment, and increased demand for EVs.

A similar trend is observed in Japan. According to the "Demand Projections for the Entire Nation and Each Supply Area" (FY2025) published by the Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO) in January 2025, electricity demand had been on a downward trend until FY2023 due to population decrease, electricity conservation, and energy efficiency improvements. However, from FY2024 onward, despite the continued impact of conservation efforts, electricity demand is expected to increase due to economic growth and increased demand associated with the construction of new data centers and semiconductor factories, with growth projected through FY2034.

To address this anticipated increase in electricity demand, it is important to strengthen efforts to improve the energy efficiency of data centers by utilizing advanced information processing technologies, such as cutting-edge semiconductors and photoelectric fusion technologies, along with supporting infrastructure such as liquid cooling systems. Some countries have already introduced information disclosure and regulations on the energy consumption and efficiency performance of individual data centers.

Even with significant efficiency improvements, electricity demand is likely to increase due to electrification driven by GX initiatives, such as the shift from blast furnaces to electric furnaces, and the increase in data centers and semiconductor factories associated with the spread and expansion of generative AI. While it remains difficult to precisely forecast future electricity demand, given the likelihood of increased electricity demand, it is important to make thorough preparations to ensure the stable supply of necessary decarbonized power sources will be secured.

In particular, future increases in electricity demand will need to be met by expanding decarbonized power sources, and a failure to secure sufficient capacity must not lead to the loss of investment opportunities for data centers, semiconductor factories, and other facilities in Japan, nor to the loss of opportunities for economic growth and to strengthen competitiveness of domestic industry. In addition, Japan is currently facing a worsening trade deficit due to fossil fuel imports, along with a deteriorating digital balance of payments. Under such circumstances, it is essential that necessary investments in data centers and others be made domestically in order to maintain Japan's national wealth and ensure its economic security.

4. Maintaining ambition against climate change, and realistic and diverse measures

In response to the changing international energy landscape, realistic efforts are underway, particularly in the United States and Europe, to ensure a stable energy supply while maintaining ambitious decarbonization targets.

With regard to climate change, European countries, as represented by the European Commission's "REPowerEU" plan, have been promoting the deployment of renewable energy, strengthening energy efficiency, and diversifying energy sources, such as nuclear energy and hydrogen in order to reduce their dependence on Russian energy following its aggression against Ukraine. In February 2024, the European Commission, in line with the advice of the European Scientific Advisory Board on Climate Change, put forward a highly ambitious decarbonization proposal to reduce greenhouse gas emissions by 90% from 1990 levels by 2040, which is currently under consideration.

At the same time, Western countries are also taking practical measures to secure a stable energy supply. While European countries have been moving forward to increase natural gas storage since Russia’s aggression against Ukraine, the United States, the world's largest LNG exporter, has been expanding LNG exports to Europe. At COP28, held in November and December 2023, in addition to ambitious goals such as tripling the global installed capacity of renewable energy and doubling the global average rate of improvement in energy efficiency by 2030, the decision document also includes a commitment to accelerate the deployment of zero and low emission technologies, including nuclear energy, carbon dioxide capture, utilization and storage in hard-to-abate sectors, and low-carbon hydrogen production and indicates the direction to utilize all available technologies to achieve carbon neutrality.

Thus, while major countries continue to uphold ambitious targets for achieving carbon neutrality by 2050, they are also shifting toward more realistic approaches that balance economic efficiency and stable energy supply, taking into account each country’s unique circumstances. As a result, there is a growing tendency for the gap between ambitious decarbonization targets and reality to widen.

Against this backdrop, with regard to the approaches to decarbonization, the G7 Hiroshima Summit held in May 2023 clearly stated to address energy security, the climate crisis, and geopolitical risks in an integrated manner, while recognizing the various pathways, taking into account different national circumstances, and aiming at the common goal of achieving net zero emissions. This policy was reaffirmed at the G7 Puglia Summit in June 2024, and was also agreed upon by partner countries of the Asia Zero Emission Community (AZEC) as the "AZEC Principles."

5. Integration of energy policy and industrial policy

Countries around the world, particularly in Europe and the United States, are strengthening their policies to link climate change measures with industrial strategies, leveraging domestic and international energy transitions toward carbon neutrality to enhance the competitiveness of their industries.

In the United States, the Inflation Reduction Act of 2022[8], which was enacted in August 2022, outlines measures to promote investment in energy security and climate -related sectors, and allocates $369 billion (approximately 52 trillion yen[9]) in government support over 10 years for clean electricity, mainly from renewable and nuclear energies.

In Europe, the "REPowerEU" plan was announced in May 2022, followed by the "Green Deal Industrial Plan" in February 2023. In addition to promoting reduction of energy dependence on Russia, the region has been actively supporting green industries to remain competitive with the United States and China.

Against this backdrop, in September 2024, Mario Draghi, former President of the European Central Bank (ECB) and former Prime Minister of Italy, published "The future of European competitiveness" (the Draghi Report), which is aimed at strengthening the European Union's industrial competitiveness. The report maintains the goal of decarbonization, but emphasizes the need for industrial policy, noting that the ambitious goal has brought additional short-term costs to industry and placed a heavy burden on European industry. The report states that industrial policy has lagged behind the ambition of decarbonization, and calls for up to €800 billion (120 trillion yen[10]) in additional annual investment.

Japan positions the GX as a transformation of its entire economic and social systems, shifting from a fossil fuel-based economy, society, and industrial structure, rooted since the Industrial Revolution toward one centered on clean energy. Japan aims to simultaneously achieve a stable energy supply, economic growth, and decarbonization, and will continue to promote these efforts.

[8] Enacted August 16, 2022.

[9] Amount based on an exchange rate of 140 yen to the USD.

[10] Amount based on the exchange rate of 150 yen to the EURO.

IV. Basic perspectives on energy policy (S+3E)

1. General remarks

The foundation of Japan's energy policy lies in the principle of S+3E, which places safety as a fundamental prerequisite, energy security as the first priority, while improving economic efficiency and environmental suitability.

In particular, since Japan lacks readily accessible natural resources and is geographically constrained by its mountainous land and being surrounded by deep oceans, the basic perspective of energy policy is to pursue an optimal balance among the three Es (energy security, economic efficiency, and environment), with safety as a fundamental prerequisite.

In addition to the principle of S+3E, future energy policy must also incorporate international perspectives and a focus on maintaining and securing supply chains.

The growing international geopolitical risks, such as Russia's aggression against Ukraine and the escalating tensions in the Middle East, have reaffirmed that Japan’s energy security cannot be considered in isolation from the global energy situations. With an increasing number of challenges, such as climate change, which are difficult for a single country to resolve adequately on its own, a global perspective becomes even more important.

In promoting energy policy, it is also important to take a comprehensive view of the entire energy supply chain, from production and procurement to distribution and consumption, and to engage in medium- to long-term to maintain and secure the supply chains necessary for a stable energy supply.

While taking these perspectives into account, the principle of S+3E is reaffirmed as follows.

2. Ensuring safety (Safety)

Ensuring safety is a fundamental premise of energy policy. Particularly with regard to nuclear energy, safety must take precedence over all other consideration, and every effort must be made to address public concerns.

In addition, there are concerns about future personnel shortages due to the aging of specialized safety personnel and other factors, as well as the increasing frequency and severity of natural disasters and the growing complexity and sophistication of cyber attacks. Continuous efforts are required to ensure the safety of all energy sources, not only nuclear energy but across the entire energy sector.

3. Stable energy supply (Energy security)

Japan lacks readily accessible natural resources and is geographically constrained by mountainous land and being surrounded by deep oceans. Japan's energy self-sufficiency rate was approximately 12.6% in FY2022, the lowest among the G7 countries, highlighting its vulnerabilities in terms of energy security.

In light of this situation, Japan has been striving to ensure a stable energy supply by promoting diversification of the countries form which it imports fossil fuels and avoiding excessive dependence on specific energy sources, in addition to thorough energy efficiency improvement. Going forward, it will be necessary to improve the energy self-sufficiency rate by making maximum use of renewable energy, nuclear energy, and other power sources that contribute to energy security and have high decarbonization effects. If the "FY2040 energy supply and demand outlook" is realized, the energy self-sufficiency rate in FY2040 is expected to reach approximately 30–40%.

In addition, in securing a stable energy supply, it is also necessary to take into account the increasing frequency and severity in recent years, as well as the growing risks such as cyber attacks targeting energy infrastructure. From this perspective, strengthening resilience is essential.

Given the evolving international energy landscape, Japan must rebuild its energy policy with a renewed focus on securing a stable energy supply. It is also necessary to enhance the resilience of the multi-layered energy supply system so that it can function properly not only in normal times, but also in times of emergency.

4. Economic efficiency

It is important to ensure the supply of energy at internationally competitive prices by improving economic efficiency.

Energy is the foundation of people's lives and economic activities, and its cost, in particular, has a significant impact on daily life and business activities. As further decarbonization proceeds, energy costs are expected to rise. A key factor for the manufacturing sector, particularly for energy-intensive industries, will be whether energy can be supplied at prices that remain competitive on a global scale. In recent years, countries in Europe and the United States have been strengthening government support for GX-related investment in order to link their own economic growth with efforts to decarbonize their economies. The ability to supply energy at internationally competitive prices is a prerequisite for Japan to retain domestic business operations, stimulate capital investment within Japan, and achieve further economic growth.

In particular, as emission reductions progress toward carbon neutrality by 2050, it will be necessary to address measures with relatively high marginal abatement costs for greenhouse gas emissions. Therefore, in order to minimize the overall cost increase to society due to decarbonization, it is essential to prioritize the introduction of economically rational measures, and thereby to improve the economic efficiency.

5. Environmental suitability (Environment)

With regard to environmental compatibility, in Japan, energy-related CO_2 accounts for more than 80% of greenhouse gas emissions, so it is important to address this issue in energy policy. In particular, as climate change becomes a common issue for all humankind, an increasing number of countries and regions are declaring carbon neutrality targets, and momentum for decarbonization is growing worldwide. In line with the global 1.5ºC target[11], Japan aims to reduce greenhouse gas emissions by 60% and 73% in FY2035 and FY2040, respectively, from FY2013 levels, as an ambitious goal on a linear path toward achieving net zero emissions by 2050. The country as a whole has expressed a strong commitment to tackling climate change.

In decarbonizing the energy sector, it is expected that the social costs associated with decarbonization will increase. Therefore, it is necessary to promote the cost reduction of decarbonization technologies to the maximum extent possible, while carefully obtaining the understanding of the public and industries that use decarbonized energy, based on a balance between a stable energy supply and economic efficiency.

[11] It is consistent with the pathway presented in the IPCC's Synthesis Report for the Sixth Assessment Report, which limits warming to 1.5°C (>50%) with no or limited overshoot.

V. Policy directions for 2040

1. General remarks

(1) Basic approach to energy policy

Energy is the foundation of daily life and economic activities, and is indispensable to our lives. In particular, as the demand for electricity is expected to increase due to DX and GX, energy policy must be developed along with industrial structure and siting policies. Considering the lead time for the constructing of power generation facilities, it is necessary to develop energy policies toward 2040 starting now, integrated with the GX2040 Vision, in order to ensure a stable energy supply. In doing so, it is important to make utmost efforts to improve economic efficiency and environmental suitability under the principle of S+3E, with safety as a prerequisite and a stable energy supply as the first priority.

As an ambitious goal that is consistent with the global 1.5ºC target and on a linear path toward achieving net zero by 2050, Japan aims to reduce greenhouse gas emissions by 60% and 73% in FY2035 and FY2040, respectively, from the FY2013 levels, but it is difficult to accurately predict the status of innovation in energy-related technologies, trends in energy policy in each country, and progress in DX and GX in 2040 given the many uncertainties involved.

Under these highly uncertain circumstances, in considering energy policy for 2040, it is necessary to pursue all options under the policy of utilizing all available technologies to achieving net zero by 2050.

Given Japan‘s unique circumstances, such as a lack of readily accessible natural resources, mountainous land and being surrounded by deep oceans, from the perspective of achieving both stable energy supply and decarbonization, we will maximize the use of renewable energy as our major power source and we will aim for a balanced power generation mix that does not excessively depend on specific power sources or fuel sources.

On the supply side, it is essential to make maximizing the use of renewable energy, nuclear energy, and other power sources that contribute to energy security and have a high decarbonized effect, while promoting thorough energy efficiency improvement, and fuel switching within the manufacturing sector on the demand side, in order to break away from excessive dependence on fossil fuels.

In particular, as demand for electricity is expected to increase due to the progress of DX and GX, Japan’s industries and economy depend on whether or not we can provide enough decarbonized electricity that matches the demand at competitive prices. If we cannot expand decarbonized power sources and achieve economic growth and industrial competitiveness, it will be difficult to maintain employment and raise wages. Therefore, it is extremely important to maximize the use of both renewable energy and nuclear power, rather than engaging in dichotomous discussions on whether to use renewable energy or nuclear power.

In addition, toward 2040, decarbonization must be promoted in Hard-to-Abate sectors, such as those where electrification is difficult. In these areas, in addition to fuel switching to natural gas, it is necessary to advance measures using hydrogen and its derivatives (hydrogen, ammonia, e-fuels, e-methane) as well as CCUS.

In implementing these decarbonization efforts, it is important to focus on minimizing the overall societal costs associated with decarbonization. Especially, as emission reductions progress, it will be necessary to address measures with relatively high marginal abatement costs for greenhouse gases. Therefore, it is essential to prioritize the introduction of economically rational measures. Based on the principle of S+3E, we will work to minimize cost increases associated with decarbonization to the greatest extent possible.

At the same time, although further innovation is required to achieve carbon neutrality by 2050, it is necessary to consider a risk scenario in which the development of renewable energy, hydrogen and its derivatives, CCS, and other decarbonization technologies does not progress as much as expected and cost reductions remain insufficient by 2040. Even in such a case, from the perspective of protecting people's livelihoods from energy constraints while achieving economic growth, it is important to take all necessary measures to ensure a stable energy supply, such as securing long-term LNG contracts, while also taking into account the responses of other countries.

Energy policy toward 2040 needs to be formulated with full consideration of these factors. First, specific measures outlined in the Outlook for Energy Supply and Demand in FY2030, and other relevant materials should be steadily implemented. Then, while monitoring the progress of these measures, and comprehensively considering the level of technological innovation, international situation, and the progress of DX and GX, the measures should be promoted based on the direction toward 2040 as indicated below. In addition, it is necessary to further refine, and revise required measures.

(2) Alignment with GX2040 Vision

Around the world, there is a growing movement to link the transition in energy supply and demand structure associated with decarbonization to domestic economic growth, and countries are actively working to attract decarbonization-related investment. Against this backdrop, a new "GX2040 Vision" has been formulated in Japan to develop integrated policies for GX industrial structure, GX industrial location, and energy from a long-term perspective.

With the expected increase in electricity demand due to the progress of DX and GX, Japan’s industries and economy depend on whether or not we can provide enough decarbonized electricity that matches the demand at competitive prices and energy policy and industrial policy are inseparably interconnected.

By implementing this plan together with the "GX2040 Vision" in an integrated manner, we will accelerate efforts to simultaneously achieve a stable energy supply, economic growth, and decarbonization.

2. Energy efficiency improvement and shift to non-fossil energy on the demand side

(1) Basic concept

In Japan, in order to break away from excessive dependence on fossil fuels and to promote a transition to the resilient energy supply-demand structure that can withstand energy crises, we have been promoting efforts for thorough energy efficiency improvement.

In Japan, which relies heavily on imports for the majority of its fossil fuel supply from overseas, the importance of thorough energy efficiency improvement remains unchanged. However, to further promote emission reduction measures toward carbon neutrality by 2050, electrification and shift to non-fossil energy will account for a larger proportion of demand-side efforts, in addition to thorough energy efficiency improvement. In particular, the decarbonization of heat demand will become increasingly important, as non-electric energy accounts for approximately 70% of total demand.

Therefore, in areas where electrification is possible, decarbonization of power sources should be promoted along with electrification, while ensuring the balance of S+3E. At the same time, in order to achieve carbon neutrality by 2050, decarbonization must also be promoted in sectors that are difficult to electrify. In addition to switching to natural gas and other fuels, measures utilizing hydrogen and its derivatives, as well as CCUS, should be advanced.

Emission reduction measures include those with relatively high marginal greenhouse gas abatement costs. Therefore, it is essential to prioritize the introduction of economically rational measures in order to minimize cost increases associated with decarbonization to the greatest extent possible. It will be necessary to proceed with policies using cost-optimal measures, comprehensively considering options such as energy efficiency, electrification, and shift to non-fossil energy, from the perspective of how much can be reduced by each measure.

(2) Energy efficiency

Since the enactment of the Energy Efficiency Act[12] in 1979, triggered by the oil crisis, Japan has consistently promoted efforts toward thorough energy efficiency improvement by taking regulatory and supportive measures in an integrated manner. As a result of these efforts, Japan's energy efficiency has improved by 40% since the oil crisis of the 1970s, thanks to the efforts of the public and private sectors, and is at a globally high level.

From a global perspective, in addition to the strengthening of climate change countermeasures to achieve carbon neutrality by 2050, mainly in Europe and the United States, there is a growing interest in energy security, such as that triggered by Russia's aggression

[12] At the time of enactment, it was officially named the "Act on the Rational Use of Energy" (Act No. 49 of 1979). After the act was revised, it is now called the "Act on Rationalization of Energy Use and Shift to Non-fossil Energy" (Act No. 49, 1979).

against Ukraine, as well as rising international prices for fossil fuels. These developments have led to efforts to enhance energy efficiency in countries around the world.

Under these circumstances, at the G7 Hiroshima Summit in May 2023, energy efficiency was positioned as the "first fuel" and "an essential element of the clean energy transition." The importance of energy efficiency has been reaffirmed globally, as evidenced by the fact that the GST (Global Stocktake) decision document at COP28 includes a target of doubling the global average rate of improvement in energy efficiency by 2030.

Although Japan's final energy consumption has been on a downward trend since 2005, due in part to the results of thorough energy efficiency improvement efforts, not a small portion of the recent decline is due to a decrease in economic activity. Japan has adopted a policy to simultaneously achieve a stable energy supply, economic growth, and decarbonization through GX, and therefore must promote improvements in energy efficiency while maintaining economic activity.

Currently, the demand for electricity is expected to increase due to the progress of DX and GX, and it is necessary to secure decarbonized power sources such as renewables and nuclear power. At the same time, energy consumption efficiency should be improved by enhancing the energy-saving performance of semiconductors and utilizing cutting-edge technologies such as photoelectric fusion. For data centers, in addition to promoting technological development, institutional and support measures should be implemented together, such as setting efficiency standards for operators and ensuring transparency of their efforts, while taking into account the initiatives of other countries. In addition, evaluation indicators will be developed to more effectively encourage efficiency improvements in data centers.

In the future, since discontinuous technological development and strengthened efforts will be necessary for further energy conservation, innovation in high-efficiency equipment, digital technologies, and other areas will be promoted through the New Energy and Industrial Technology Development Organizations (NEDO) projects, while reviewing the "Technology Strategy for Energy Efficiency and Transition to Non-Fossil Energy" jointly formulated by the Agency for Natural Resources and Energy and the NEDO, among others. Furthermore, it is important for small and medium-sized enterprises (SMEs), which are estimated to account for 10–20% of Japan's greenhouse gas emissions, to advance decarbonization. For SMEs, GX initiatives are expected to bring benefits such as lower electricity and fuel costs, enhanced brand value for their products, and expanded business opportunities. For SMEs and households, the "first step" in decarbonization efforts is often energy efficiency improvement, which should work as the catalyst for decarbonization initiatives.

It is important to promote support measures and regulations in an integrated manner. The support system will be enhanced, while the Top Runner Program and Benchmark Program under the Energy Efficiency Act will be continuously reviewed in terms of targets, indicators, and other factors, taking into account the status of business initiatives.

(3) Shift to non-fossil energy

To achieve carbon neutrality by 2050, the first step is to promote electrification and the decarbonization of power sources while ensuring the balance of S+3E. Following that, fuel switching to natural gas and the use of hydrogen and its derivatives and CCUS will be promoted, especially in areas where electrification is difficult.

The revision of the Energy Efficiency Act in FY2022 changed the official name of the law to the Act on Rationalization of Energy Use and Shift to Non-fossil Energy and expanded the definition of "energy" under the Act. It requires energy consumers to submit mid- to long-term plans regarding their goals for shift to non-fossil energy, along with periodic reports on their use of non-fossil energy. As a result, in addition to improving the energy efficiency of fossil fuels, the revised Energy Efficiency Act has established a framework to promote the shift to non-fossil energy and the efficient use of non-fossil energy.

Electrification and shift to non-fossil energy often require fundamental changes in manufacturing processes, especially in energy-intensive industries. In these sectors, it is necessary to systematically promote capital investment and the establishment of supply chains. Therefore, it is essential for the public and private sectors to work together for promoting such efforts through a combination of regulations and support, which is crucial for maintaining and enhancing Japan's industrial competitiveness.

Toward 2040, while focusing on electrification and the shift to non-fossil energy, efforts will also be made to promote demand response (DR) and the rationalization of energy use, including more efficient heat supply through technologies such as heat pumps and cogeneration. These initiatives will be advanced in an integrated manner, with efforts made in each sector through both regulation and supportive measures.

(4) Efforts required in the industry, business, household, and transport sectors

(i) Industry

In addition to the promotion of thorough energy efficiency improvement, heat demand and the manufacturing process itself will need to be transformed toward 2040, especially in the manufacturing industry. Therefore, fuel switching, electrification, and shift to non-fossil energy must be boldly promoted in conjunction with supply-side efforts for decarbonized power sources such as renewables and nuclear energy, as well as decarbonized energy sources such as hydrogen and its derivatives.

It is necessary for the public and private sectors to work together to promote initiatives in order to strengthen Japan's industrial competitiveness, with particular consideration of the following factors, especially in energy-intensive industries: the high cost of equipment and facilities associated with the change of production processes; the timing of equipment replacement considering the durability of existing equipment; the relative deterioration of energy efficiency of production equipment, including machine tools, which have been used for many years while energy-saving technologies have been improving; and the need to improve

electrical infrastructure such as receiving equipment and piping, in addition to production equipment.

To promote investment in facility renewal, we will provide seamless support for multi-year investment plans. In particular, we will encourage the introduction of high-efficiency equipment, significant energy savings across factories and business sites, electrification and shift to non-fossil energy, and optimization of operations using digital technology. Regarding SMEs, in order to uncover potential needs for decarbonization, energy audits will be strengthened, and a system will be established to support their efforts to improve energy efficiency in the region in cooperation with financial institutions and energy efficiency support organizations. In order to enhance the support system, we will also work to secure human resources who can provide advice on energy efficiency.

We will consider institutional measures to encourage the use of digital technology, taking into account the progress of DX, including AI to promote further energy efficiency by using digital technology to visualize energy consumption.

With regard to periodic reporting under the Energy Efficiency Act, efforts will be made to expand the number of businesses that actively disclose information. In addition, from the perspective of expanding energy efficiency efforts, the regulatory targets of the Energy Efficiency Act will be appropriately reviewed. Furthermore, in order to strongly promote shift to non-fossil energy and DR, we will advance studies, including institutional measures, while paying attention to the potential for adopting non-fossil energy in factories and other sites.

(ii) Business & housing

In the business and housing sectors, it is necessary to promptly improve energy efficiency of homes and buildings, as well as promote shift to non-fossil energy and DR, as homes and buildings become long-term assets once constructed.

The Government has set a goal of ensuring average performance across the building stock by 2050 at the level of the ZEH (Net Zero Energy House) and ZEB (Net Zero Energy Building) standards, and of ensuring energy efficiency at the same level for new houses and buildings constructed in FY2030 and beyond. The Government will promote the improvement of energy efficiency and expansion of renewable energy introduction while integrally utilizing regulations, such as the Act on the Energy Efficiency of Buildings[13], and support measures.

In terms of regulations and systems, energy efficiency standards for homes and buildings will be raised in stages by FY2030 at the latest, in order to be consistent with these goals. Regarding the "ZEH," which aims to achieve a net-zero energy balance, the definition of "ZEH" should be revised to promote photovoltaic power generation for self-consumption, as well as to substantially increase energy efficiency from the perspective of further promoting zero-energy consumption. In addition, a framework will be established to encourage the supply of homes with a higher level of energy efficiency, and the standards in the Housing Performance Indication System will be enhanced. Furthermore, in order to support such improvements in energy efficiency from the viewpoint of building materials and equipment, we will revise the

[13] Act on the Improvement of Energy Consumption Performance of Buildings (Act No. 53 of 2015).

target standard values for windows and other components under the Top Runner Program and expand the scope of the program.

In addition to the above, from the perspective of promoting shift to non-fossil energy and DR in the household sector as well, institutional measures will be taken, such as accelerating energy efficiency and shift to non-fossil energy of water heaters, which account for approximately 30% of energy consumption in the household sector, promoting the provision of functions necessary for DR, and strengthening efforts by energy suppliers through disclosure.

Regarding support measures, combined with these regulatory standards and institutional methods, support will be provided for the introduction of homes with energy efficiency that far exceeds the level of the ZEH standards. In addition, in order to improve energy efficiency in existing houses and buildings, support will be provided for the renovation of houses and buildings to improve higher energy efficiency, including installation of insulated windows and high-efficiency water heaters.

Support will also be extended to include high-efficiency water heaters such as heat pump water heaters, hybrid water heaters, and residential fuel cells, as well as condensing-type water heaters for rental housing complexes where it is difficult to install high-efficiency water heaters due to installation space and other constraints.

(iii) Transport

In the transport sector, we will promote efforts to reduce CO_2 emissions throughout the life cycle in the automobile sector, improve energy efficiency in the logistics sector, and adopt next-generation fuels in the shipping, aviation, railway, and port-related sectors.

The automobile sector accounts for 86% of the transport sector's CO_2 emissions (as of FY2022), and we are pursuing a variety of options toward carbon neutrality, aiming to achieve zero CO_2 emissions throughout the life cycle of automobiles by 2050.

For passenger cars, the goal is to achieve 100% of electrified vehicle sales (electric vehicles, fuel cell vehicles, plug-in hybrid vehicles, and hybrid vehicles) by 2035. As for small commercial vehicles of 8 tons or less, we aim to achieve 20–30% of electrified vehicle sales by 2030 and 100% electrified and decarbonized fuel vehicles such as those using e-fuels by 2040. For large commercial vehicles over 8 tons, aiming to introduce 5,000 vehicles in the 2020s as a first step, and set the 2040 electrification target by 2030, taking into account the progress in technology development and cost reductions for hydrogen, e-fuels and other alternatives.

To this end, comprehensive measures will be taken, including promoting the introduction of electrified vehicles and the development of charging infrastructure with a target of 300,000 plugs by 2030. Regarding fuel efficiency regulations for passenger cars, a system will be introduced to evaluate off-cycle technologies that are not reflected in WLTP tests, while further improving energy efficiency under fuel efficiency standards with a target for FY2030. With regard to storage batteries, which are essential for electrification, the Government will provide support for the domestic localization and technological development of manufacturing infrastructure for storage batteries, components/materials and manufacturing equipment, aiming to establish a domestic production base of 150 GWh/year by 2030 at the latest. In

addition, the reuse of vehicle-mounted storage batteries and the development of facilities for supplying electricity from vehicles will be promoted to contribute to the effective use of renewable energy.

For commercial vehicles, support will be provided for the introduction of vehicles to transport businesses and consignors that have established plans in conformity with the targets set by the Government for the ownership and use of non-fossil energy vehicles. Moreover, consideration will be given to expanding the targets set by the Government. In order to promote the spread of fuel cell vehicles with emphasis on commercial vehicles, with a focus on commercial vehicles, additional support will be provided to priority areas where fuel cell vehicles will be intensively introduced. In addition, to further improve fuel efficiency, the Government will consider new fuel efficiency standards for heavy-duty vehicles with a view to promoting the spread of electrified vehicles.

To promote the low carbonization and decarbonization of gasoline used in internal combustion engines toward achieving carbon neutrality by 2050, we aim to begin supplying low-carbon gasoline with a maximum bioethanol concentration of 10% by FY2030 and strive to begin supplying low-carbon gasoline with a maximum bioethanol concentration of 20% from FY2040. In addition, development and expansion of compatible vehicles will be undertaken. The introduction of biodiesel will be promoted. Furthermore, e-fuels will be utilized with the aim of achieving commercialization within the first half of 2030s.

In the logistics sector, we will promote a new modal shift utilizing various modes of transportation such as rail, ship, aviation, and double articulated trucks, as well as the decarbonization of logistics facilities.

In the shipping sector, the Government will work to support the development of domestic production systems for zero-emission ships and related vessels, and promote their deployment, taking into account international trends, including those led by the International Maritime Organization (IMO), as well as technological developments.

In the aviation sector, public-private partnerships will be advanced for the introduction of sustainable aviation fuel (SAF), improving flight operations through further sophisticated air traffic control, introduction of new technologies into aircraft and equipment, energy efficiency improvements in airport facilities and vehicles, and development of airports as renewable energy hubs.

In the railway sector, efforts will be made toward social implementation of fuel cell railcars and the introduction of biodiesel fuel.

In the port sector, decarbonization will be advanced by introducing hydrogen-fueled cargo handling equipment and by using certification system to objectively assess decarbonization progress.

3. Expansion of decarbonized power sources and grid development

(1) Basic concept

(i) General remarks

Toward carbon neutrality by 2050, it will be necessary to replace thermal power generation, which currently accounts for approximately 70% of the power generation mix, with decarbonized power sources, and to promote decarbonization of thermal power generation. In addition, electricity demand in Japan is expected to increase with the progress of DX and GX, and this future increase in electricity demand will need to be met by expanding decarbonized power sources. Insufficient decarbonized power sources could lead to missed investment opportunities in data centers, semiconductor factories, and other facilities, undermining Japan's economic growth and industrial competitiveness. Such outcomes must be avoided at all costs, and we are entering an era that requires large-scale investment in power infrastructure. These changes in circumstances were not necessarily envisioned at the time of electricity system reforms, and unless the supply capacity of decarbonized power sources is fundamentally strengthened, the future prospects for a stable supply of electricity will be uncertain.

The basic approach in the power generation mix should be to maximize the deployment of renewable energy as a major power source, while aiming for a balanced power generation mix that does not excessively depend on specific power sources or fuel, from the perspective of simultaneously achieving a stable energy supply and decarbonization. This is based on the idea that there is no single perfect energy source at this moment, and that a diverse power generation mix is important because excessive dependence on specific energy sources increases risk. In order to realize a transition to the resilient energy supply-demand structure that can withstand energy crises, it is necessary to realize a multi-layered supply structure under the principle of S+3E, with a combination that maximizes the strengths of each energy source and ensures that weaknesses are appropriately complemented by other energy sources.

In the face of the risk of fossil fuel price fluctuations due to Russia's aggression against Ukraine, conflicts in the Middle East, and other factors, it is essential to maximize the use of power sources that contribute to energy security and have high decarbonization potential such as renewable energy, and nuclear energy, rather than dichotomous discussions on whether to use renewable energy or nuclear power, given that the current composition of decarbonized power sources is approximately 30%.

(ii) Necessity of securing supply capacity and grid maintenance

In addition, during the transition period, it will be necessary to take initiatives such as fade-out of inefficient coal-fired power generation and new construction or replacement of LNG-fired power plants on the premise of future decarbonization, as well as efforts to secure stable supply of necessary fuels, on the basic premise of stable electricity supply. From this perspective, it is also necessary to continue efforts to ensure stable supply, such as steady operation and review of capacity markets, including the Long-Term Decarbonized Capacity

Auction to secure necessary supply capacity, and continued consideration of a Reserve Power Plants system in case of emergency.

In addition, for power generation businesses, measures have been implemented to secure power sources through regulatory frameworks such as capacity markets and the development of various electricity trading markets, and they are expected to contribute through the supply of electricity. From this perspective, it is important to constantly assess the roles and responsibilities of power generation companies in accordance with the situation of the power system.

In order to expand decarbonized power sources and secure supply capacity during the transition period, it is necessary to enhance public understanding by providing appropriate information, and at the same time, it is necessary to make appropriate efforts toward coexistence with the local communities where the power sources are located, international negotiations, and cooperation with overseas partners.

Furthermore, it is essential to promote next-generation electricity networks in order to ensure a stable supply of electricity and promote decarbonization of the power system. To this end, it is necessary to steadily promote the development of inter-regional interconnection lines and the reinforcement of local backbone grids, based on the long-term policy for nationwide networks (the Master plan of Nation-wide Power Transmission Networks). In addition, a mechanism that encourages advance and strategic grid development should be considered in order to realize a stable supply of electricity by guiding large-scale demand, such as data centers supporting DX and GX, toward suitable locations near decarbonized power sources.

(iii) Improvement of business environment and market environment

Given the current environment surrounding investment in power sources, construction costs in the power sector are likely to increase due to factors such as inflation and rising interest rates. In particular, large-scale power sources require huge investment and a long project period, the risk of fluctuations in revenues and costs is significant. Under the current business environment, including the liberalization of electricity market, there is great uncertainty about future business revenues. These circumstances may discourage operators from making large investments that are expected to have a long project period, or for investments where the initial investment and cost fluctuations are expected to be large due to trends in technological development, system changes, inflation, and other factors.

To address these risks and concerns, institutional measures and a supportive market environment will be developed to manage changes in revenues and costs associated with fluctuations in market conditions and other factors during the project period. This aims to enhance the predictability of the return on investment in decarbonized power sources and to promote active new investment by operators, and achieve decarbonization and a stable supply of electricity.

In order to expand decarbonized power sources, it is necessary to continue to make large-scale investments over the long term in areas such as power generation, and transmission and distribution. However, due to the market environment changing dramatically, increased

business uncertainty, and large amounts of interest-bearing debt, it is not easy for operators to continue to raise large-scale, long-term funds in the future. Moreover, given the gap between the timing of investment and period of yielding return, the need to make proactive and concentrated investment in a forward-looking manner, while minimizing the impact on electricity prices, will make financing even more difficult. In addition, for financial institutions and institutional investors that support the financing of businesses, their loan and investment balances are growing significantly, and risk management is becoming more important than ever before. In this context, it has been pointed out that the hurdles to financing and investing in businesses are increasing due to the need to manage the scale of additional financing and investment. In the meantime, it is expected that large investments will be required globally to achieve carbon neutrality by 2050. Under such circumstances, other countries are providing financial support for investment in the power sector.

In Japan, it is necessary to improve the financing environment to secure stable funds for necessary investments in the power sector by maximizing the use of private funds, in conjunction with various reviews of the power business system. Specifically, the Government will consider measures to facilitate financing for decarbonization investment, such as loans backed by the creditworthiness of the Government as well as public credit enhancement for risks that private financial institutions are unable to cover.

In addition, while taking into account the situation where consumers and regions are seeking access to decarbonized power sources, we will also study appropriate rules for wholesale transactions, including non-discriminatory access between domestic and foreign entities.

(2) Renewable energy

(i) General remarks

A. Basic concept

Renewable energy is becoming a cost-competitive power source with its rapidly decreasing power generation costs worldwide, and the deployment of renewable energy is rapidly increasing. In Japan, since the introduction of the feed-in tariff (FIT) system in July 2012, the share of renewable energy in the country's power generation mix has expanded from 10% at the time to approximately 22% by FY2022. In particular, despite geographical constraints such as Japan's small flat land area and steep seafloor topography offshore, Japan has steadily expanded its use of renewable energy, ranking sixth in the world in terms of total installed capacity.

With the principle of S+3E as the major premise of our energy policy, we will actively promote renewable energy as a major power source for the decarbonization of the power sector and strengthen measures in cooperation with related ministries and agencies and local governments to encourage the maximum introduction of renewable energy while promoting coexistence with local communities and minimizing the public burden. In promoting renewable energy as a major power source, efforts will be made to integrate renewable energy into the electricity market, to minimize the social costs for integration associated with grid development and securing balancing power, and to make renewable energy a long-term stable power source. In addition, in order to expand the introduction of renewable energy, we will strategically

promote the acceleration of innovation and the establishment of supply chains to enhance technology self-sufficiency rate by expanding domestically produced renewable energy, and we will take measures to deal with used solar photovoltaic panels.

B. Coexistence with the local communities

(a) General remarks

As a result of the increased participation of various businesses in the rapid expansion of renewable energy as a result of the FIT system's introduction, there is growing concern in the local communities about the environmental impact, including safety, disaster prevention, landscape, and biodiversity, as well as future disposal issues. As for photovoltaic panels, disposal is expected to increase markedly from the late 2030s onward, requiring a planned response. It is important to promote local understanding and ensure proper business discipline so that renewable energy will be accepted by local communities and society as a stable power source over the long term.

(b) Strengthening of business discipline based on the revised Act on Special Measures Concerning Electricity from Renewable Energy Sources by Electricity Utilities, which came into effect in 2024, etc.

Based on the revised Act on Special Measures Concerning Electricity from Renewable Energy Sources by Electricity Utilities[14] that went into effect in 2024, in order to ensure appropriate communication with local residents, advance notice of the project to nearby residents by holding explanatory meetings was set as an approval criterion. To promptly address violations of laws and regulations related to renewable energy power generation projects, measures have been to temporarily suspend FIT/FIP[15] grants to non-compliant operators. At the same time, the Act on Special Measures Concerning Electricity from Renewable Energy Sources by Electricity Utilities has tightened the approval procedures for permits and approvals related to land development that could directly affect the risk of disasters, such as forest land development control system under the Forest Act[16], and made them a requirement for applications for FIT/FIP approval starting in October 2023.

Furthermore, in accordance with the revised Electricity Business Act[17], which went into effect in 2023, the regulations were strengthened by imposing the obligation to maintain conformity with technical standards on small-scale photovoltaic power generation equipment, among other measures.

In order to effectively implement these measures, we are strengthening our enforcement system by establishing a system to conduct on-site inspections of renewable energy power generation facilities nationwide starting in FY2024, and we will continue to respond appropriately.

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[14] Act No. 108 of 2011.

[15] Feed-in Premium, a system under which the difference between a reference price calculated based on the market price and a base price is granted as a premium, and the income level of the operator is linked to the market price.

[16] Act No. 249 of 1951.

[17] Act No. 170 of 1964.

(c) Efforts to promote local understanding/promotion of local decarbonization

We will strengthen cooperation with local governments by holding liaison meetings nationwide, and promote the formulation of ordinances by local governments for the introduction of renewable energy in the coexistence with the local communities.

In addition, through the Regional Decarbonization Promotion Project based on the Act on Promotion of Global Warming Countermeasures[18], the Government will strengthen support for local governments in terms of human resources, information, and funds to promote the establishment of promotion zones and the introduction of renewable energy in harmony with local communities, and will further promote the use of the system. The Government will select at least 100 regions as leading decarbonization areas by FY2025, and implement leading decarbonization initiatives that support regional revitalization by FY2030, as well as accelerate the introduction of the private and local consumption of renewable energy including rooftop photovoltaic power generation, storage batteries, ZEB/ZEH, and EVs on a priority basis, which implemented by local governments through multi-year integrated efforts, throughout Japan.

In the midst of increasingly severe natural disasters, from the perspective of national land resilience in each region, we will actively promote the installation of renewable energy and storage batteries in public facilities such as evacuation facilities and disaster prevention hubs, which contribute to strengthening disaster preparedness and resilience.

(d) Thorough implementation and institutionalization of disposal and recycling of renewable power generation facilities

In order to ensure the proper disposal of renewable energy power generation facilities, a system introduced in July 2022 that, in principle, requires external reserve funding for disposal costs of commercial photovoltaic power generation facilities. The system will continue to be implemented steadily.

In addition, in order to cope with the increase in the disposal of solar panels in the late 2030s onward, studies will be conducted to establish a new system, including a mandatory recycling system, to ensure proper reuse, recycling, and disposal of panels.

(e) Making long-term stable power sources

In order to ensure that the power sources introduced under the FIT/FIP system, funded by public contributions, continue stable operations over the long term into the next generation even after the end of the procurement period and the grant period, we will develop action guidelines for relevant operators. We will encourage reinvestment and repowering of renewable energy power generation projects based on the guidelines, by certifying responsible operators as qualified long-term photovoltaic power generation providers and promote project consolidation under these certified providers.

C. Curbing the national burden

The cost of renewable energy power generation in Japan is still high compared to international standards, although it has been steadily decreasing. In addition, the renewable

[18] Act No. 117 of 1998.

energy surcharge in FY2024 is expected to reach 2.7 trillion yen. In order to curb the burden on the public, renewable energy costs must be lowered to competitive levels, enabling self-sustained deployment as early as possible.

Specifically, the use of the bidding mechanisms in the FIT/FIP system and support renewable energy power generation projects based on business models independent of FIT/FIP system. In addition, in order to promote prompt implementation following FIT/FIP approval, the FIT/FIP approval revocation system will be steadily operated.

D. Integration into the electricity market

(a) General remarks

In making renewable energy a major power source, we will promote the integration of renewable energy with fluctuating output into the electricity market by securing balancing power through the use of pumped storage hydropower and storage batteries. Furthermore, we will promote the development of inter-regional interconnection lines that connect areas with large potential for the introduction of renewable energy with areas of electricity demand. In addition, from the perspective of maximizing the use of renewable energy, efforts will be made to curb the amount of output control.

When integrating renewable energy into the electricity market, it is important to minimize integration costs for society as a whole. From this perspective, through further utilization of the FIP system, renewable energy power producers will be encouraged to take actions (e.g., shifting supply using storage batteries) in response to supply and demand conditions in the electricity market, and local production for local consumption of renewable energy will be promoted.

(b) Further utilization of the FIP system

Since the FIP system is a key to the integration of renewable energy into the electricity market and contributes to reducing the cost of the entire power system and reducing renewable energy curtailment, further utilization of the system should be promoted. Specifically, the order of output control in the priority dispatch rule will be reviewed from the perspective of the degree of contribution to securing the balance between supply and demand of FIT and FIP power sources and ensuring fairness. At the same time, support for the use of storage batteries and power generation forecasts for FIP power sources will be strengthened.

(c) Local utilization of renewable energy

Local production and consumption of renewable energy is important for ensuring a stable energy supply during disasters and for revitalizing regional economies. In addition, the fluctuations in renewable energy output can be managed by decarbonized balancing power in close proximity to supply and demand, thereby reducing integration costs.

For this purpose, we will promote models in which renewable electricity is consumed by nearby factories and households as well as models that utilize surplus electricity within the region when it cannot be fully consumed at the demand site. We will also encourage self-consumption and the use of integrated regional power sources through "regional utilization requirements" under the FIT system.

E. Accelerating innovation/building supply chains

As renewable energy deployment continues to expand, suitable sites for efficient and community-friendly project development are becoming increasingly scarce. In this situation, further expansion of renewable energy in the future will require the development of new suitable sites, such as building rooftops and facades, and deep-sea areas. Accelerating technological innovation to support such development is critical. In this context, while some related industries such as solar panel production are currently highly dependent on foreign countries, it is important to build robust supply chains in Japan, strengthen the competitiveness of domestic industry, and promote human resource development, taking into account the ripple effect on the local economy, in addition to the expansion of renewable energy introduction.

F. Other issues

Renewable thermal energy from natural sources is an important energy source with strong regional characteristics, and it is important to promote it in consideration of economic viability and local conditions. To expand its use, the Government will support the installation of thermal energy system that utilize naturally derived sources such as solar heat, underground heat, snow and ice heat, hot spring heat, seawater heat, river heat, and sewage heat. Additionally, support will be provided for initiatives that enable area-wide heat distribution among multiple local users, thereby promoting broader adoption of renewable thermal energy.

In addition, the Government will promote research and development that will contribute to lower costs, higher efficiency, and the development of a variety of new applications of innovative technologies, such as ocean energy including wave and tidal energy.

(ii) Solar photovoltaic power generation

A. Basic concept

Photovoltaic power generation is making steady progress in Japan, with the country having the largest installed photovoltaic generation capacity per unit of national land among major countries in the world. Furthermore, it is expected to be utilized as a distributed energy resource for self-consumption, local production for local consumption, contributing to local resilience. In addition, as installation costs have been decreased to a certain extent, some projects are being implemented without relying on the FIT/FIP systems.

On the other hand, the annual installed capacity of solar photovoltaic power generation has declined compared to the time just after the introduction of the FIT system, due to a lack of suitable sites where the project can be conducted efficiently and in coexistence with the local communities. In addition, it is necessary to take into account that the amount of electricity generated depends on the time of day and weather conditions.

Under these circumstances, it is important to pursue effective use of roofs and walls of buildings where supply and demand are close proximity, based on the premise of coexistence with the local communities and minimizing the burden on the public, for further expansion of the introduction.

Regarding the production of solar panels, Japan's market share has decreased significantly since the late 2000s, as both the public and private sectors have not always been able to respond

with sufficient scale and speed in terms of demand creation and investment amidst the rapidly changing business environment. As a lesson from this experience, it is important to build a robust supply chain for next-generation solar cells in Japan to strengthen the competitiveness of Japan's solar industry.

B. Rooftop photovoltaic power generation

In expanding the introduction of photovoltaic power generation in the future, the potential of rooftop photovoltaic power generation, which relatively easily coexists with local communities and places a low load on the grid because it is introduced as a self-consumption type, will be used even more aggressively.

For the public sector, the Government will take the lead in aiming to install photovoltaic power generation equipment in approximately 50% of installable buildings by 2030, and furthermore, in 100% of installable buildings, by 2040. To achieve this goal, the Government will ensure maximum installation of photovoltaic power generation equipment in newly constructed buildings and will also promote installation in existing building stock and on publicly owned land. Furthermore, for the private sector, such as factories and offices, the Government will promote the spread of ZEBs and self-consumption projects, use of the periodic reporting system based on the Energy Efficiency Act, enhancement of measures for the existing building stock, and introduction of building-integrated photovoltaic systems. In addition, from the viewpoints of early return on investment and credit support for installers, the appropriate procurement and grant periods of FIT/FIP programs will be examined, and necessary support will be considered in cooperation with related ministries and agencies.

Regarding photovoltaic power generation for residential use, with the aim that by 2050, it will be common practice to have photovoltaic equipment installed in all houses and buildings where installation is reasonable, the goal is to have photovoltaic equipment installed in 60% of newly constructed detached houses by 2030. To achieve this goal, a certain percentage of homes will be expected to be equipped with photovoltaic power generation systems as part of the Top Runner Housing Standards for built-for-sale and custom-built detached homes, for further introduction of photovoltaic power generation systems in homes.

C. Ground-mounted solar photovoltaic power generation

Regarding ground-mounted photovoltaic power generation, local governments will be encouraged to set targets for the introduction of renewable energy. To achieve these targets, specific renewable energy promotion zones will be established (positive zoning) through the use of the Regional Decarbonization Promotion Project. In addition, with regard to farmland, on the premise that prime farmland is secured, the expansion of renewable energy will be promoted to abandoned farmland that is not expected to be used for farming. Furthermore, with regard to agriphotovoltaic power generation, where both power generation and farming are compatible, the expansion of the introduction of projects whose appropriateness is ensured through local government involvement, will be promoted on the premise that business integrity and appropriate farming operations are ensured. In addition, the introduction of photovoltaic

power generation using infrastructure spaces such as airports, roads, railroads, and ports will be expanded.

Moreover, the introduction of renewable energy power generation projects that are not subject to the FIT/FIP system, such as self-consumption models or systems in which users install power generation facilities remotely and receive electricity through long-term contracts, will be promoted.

D. Early social implementation of next-generation solar cells

Given the limited availability of suitable sites for photovoltaic power generation, and from the perspective of promoting installation on previously underutilized buildings with low load-bearing capacity, we will promote early social implementation of perovskite solar cells, which are lightweight and flexible, based on the "Next-generation Solar Cell Strategy" formulated in November 2024 by the public-private sector council to expand the introduction of next-generation solar cells and enhance industrial competitiveness. Specifically, technological development will be promoted with the aim of achieving a level of 20 yen/kWh by 2025, 14 yen/kWh by 2030, and as low as 10–14 yen/kWh by 2040. It is also important to establish a robust production capacity in Japan, with the aim of building a GW-scale production capacity before 2030. The public and private sectors will work together to establish mass production technology, develop the production system, and create demand on a globally competitive scale and timeline, with the goal of introducing approximately 20 GW by 2040. In addition, they will also aim for full-scale expansion into overseas markets, and will collaborate with the National Institute of Advanced Industrial Science and Technology (AIST) and other specialized organizations to formulate international standards including reliability assessment and certification.

(iii) Wind power generation

A. Basic concept

With regard to the introduction of wind power generation, suitable sites in easily developable plains are becoming scarce. On the other hand, there are offshore areas with high potential for wind power deployment, such as Hokkaido and the Tohoku Region. However, while large-scale offshore development is possible compared to onshore, Japan's geographical characteristics include steep terrain, complex geological conditions, and relatively low wind speeds compared to Europe. In this context, the challenge is to secure suitable sites while coexisting with the local communities. Furthermore, there is a long lead time before the introduction of a project due to coordination with local communities and addressing environmental assessments.

To further expands wind power deployment, it is important to develop power lines connecting suitable areas for wind power generation, such as Hokkaido, with demand centers. Based on the Master Plan of Nation-wide Power Transmission Networks, we will promote the development of inter-regional interconnection lines, including submarine high-voltage, direct current power transmission between Hokkaido and Honshu.

B. Offshore wind power generation

Offshore wind power generation is expected to account for a certain percentage of Japan's electricity supply as a power source for which costs are expected to be reduced in the future, and is a "key driver" toward making renewable energy a major power source in Japan, just as it is overseas where rapid cost reductions and project development are advancing. In addition, because of the large project scale and its broad industrial base, it is expected to have economic ripple effects, such as contributing to job creation through construction and O&M activities.

In light of this, we aim to form 10 GW of projects by 2030 and 30 GW to 45 GW by 2040, including floating projects, through the public solicitation and other systems, based on the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities[19]. To this end, the Government will remain actively involved from the initial stage to expand the areas covered by the “Centralized model,” which enables the Government to conduct seabed surveys more quickly and efficiently, ensuring timely grid connections. Additionally, the Government will consider establishing a system in which it conducts marine environment surveys when designating promotion zones. Furthermore, the Government will systematically promote the development of infrastructure such as inter-regional interconnection lines and ports. Since the investment is large and the total project period is long, we will promote a robust project structure that can cope with the risk of fluctuations in revenues and costs, and strengthen regulatory frameworks and improve the investment environment necessary to ensure the completion of power source investment in offshore wind power generation. In addition, the necessary institutional environment will be developed to enable the installation of offshore wind power generation facilities even in Japan's vast Exclusive Economic Zones (EEZ). We will steadily develop and efficiently operate base ports for large turbine installation and maintenance, and promote efforts to secure vessels related to offshore wind power generation facilities.

On top of this, in order to achieve a "virtuous cycle" of mass introduction of offshore wind power generation and strengthening the competitiveness of related industries, it is important to form a domestic supply chain that is competitive and robust. The industry has set a goal of increasing the domestic procurement ratio to 60% by 2040. In particular, with regard to floating offshore wind power generation, we will strengthen the domestic supply chain and promote international expansion by cost reduction and mass production through technological development, and the establishment of production and installation infrastructure as well as optimal offshore construction methods. We will also strongly promote human resource development through collaboration between industry and academic institutions.

C. Onshore wind power generation

With regard to onshore wind power generation, there are some projects that have not yet started operation due to local concerns regarding project implementation. These concerns will be appropriately addressed before promoting further development. Specifically, local governments will be encouraged to set targets for the introduction of renewable energy, and

[19] Act No. 89 of 2018.

specific renewable energy promotion zones (positive zoning) will be established through the use of the Regional Decarbonization Promotion Project to achieve these targets. In addition, while taking the perspective of national land conservation and environmental preservation as a premise, we will promote responses for protection forests based on the direction of positive zoning promotion, and take necessary measures for environmental assessment to ensure effective and efficient assessment based on the characteristics of projects.

(iv) Geothermal power generation

A. Basic concept

Geothermal power generation is a stable energy source that contributes to industrial development and local communities through the effective use of local resources, leading to regional revitalization. Although Japan has the world's third largest geothermal resource potential, there are challenges in developing geothermal power generation, including high development risks and costs, long lead times, constraints on suitable development sites and grid connections due to the uneven distribution of areas with promising geothermal resources, and the need to coordinate with local communities and comply with various regulations for development. These challenges will be addressed to make geothermal energy a competitive and independent power source in the medium to long term. The development of next-generation geothermal technologies, which could expand geothermal resource potential to more than four times the current level, will also be promoted.

B. Future issues and responses

To accelerate geothermal development, the "Geothermal Frontier Projects" will be launched in several promising areas, primarily within natural parks, as selected by the Ministry of Economy, Trade and Industry (METI), where approximately 80% of geothermal resources are located. In the selected areas, the Japan Organization for Metals and Energy Security (JOGMEC) itself will conduct geothermal resource surveys (including discharge tests), provide survey data to business operators, and transfer drilled wells to them upon request. These efforts aim to reduce development risks and costs for developers, while the Government will actively support coordination with local stakeholders. Toward implementing the "Accelerated Geothermal Development Package"[20], related ministries and agencies will work together to provide one-stop follow-up support. This includes fostering stakeholders' understanding, addressing soaring drilling costs and high drilling risks, and dealing with various licensing procedures such as the Hot Springs Act[21] as well as depending on location-specific conditions, the Natural Parks Act[22], and Forest Act, while ensuring consideration for the natural environment and hot spring businesses. The participation of various players in geothermal power generation will be encouraged, and rapid development will also be promoted by adopting

[20] Published at the 43rd session of the Natural Resources and Fuel Committee of the Advisory Committee on Natural Resources and Energy (November 13, 2024).
[21] Act No. 125 of 1948.
[22] Act No. 161 of 1957.

innovative approaches beyond conventional methods, such as using small and mobile drilling rigs and modular power plants.

Japanese companies are participating in the overseas demonstration projects, such as closed-loop and enhanced geothermal systems that can generate power even in areas without geothermal hot water. In Japan, organization such as NEDO and AIST are conducting research on supercritical geothermal energy, which utilizes high-temperature, high-pressure hydrothermal fluids deep underground. In order to realize a drastic expansion of geothermal power generation, R&D and demonstration of these next-generation geothermal power generation technologies will be promoted with the aim of commercialization in the early 2030s.

To facilitate the introduction of geothermal power generation quickly and cost-effectively, we will advance efforts such as promoting local understanding, providing risk capital, and technological development to improve success rates and efficiency of drilling, including upgrading exploration technologies.

Specific plans and targets will be formulated to accelerate the introduction of geothermal power generation toward 2040.

Furthermore, we will promote initiatives that position geothermal power as a key contributor to regional energy stability through multi-stage energy utilization, including the use of hot water after power generation. In collaboration with JOGMEC, we will promote the overseas expansion of geothermal power generation technology.

(v) Hydro power generation

A. Basic concept

Hydro power generation is important as a decarbonized power source capable of maintaining stable output over the long term. In addition, the establishment of a locally beneficial business model will contribute to the revitalization of local industries and regional development. However, hydropower projects face significant risks, including high development costs, regulatory challenges, reduced capacity from sedimentation, damage from intensifying natural disasters such as torrential rains, and the aging of facilities. It is also necessary to make hydropower projects self- sustaining while promoting coexistence with the local communities and reducing costs.

B. Future issues and responses

We will promote investment in hydropower generation through capacity markets, including the Long-Term Decarbonized Capacity Auction, and FIT/FIP schemes, in order to reduce development risk and promote utilization of hydro power generation through appropriate reinvestment, maintenance, and management.

Furthermore, we will provide support for flow rate surveys and efforts to build local understanding, which are necessary at the stage of considering the introduction of small- and medium-scale hydropower generation. In order to uncover the hidden development potential of small- and medium-scale hydropower generation, we will promote wide-area surveys of possible development sites in the river systems nationwide, and detailed surveys and project formulation of potential development sites under the leadership of local governments.

In addition, in order to maximize the use of hydropower, while taking into account the concept of the "Integrated Water and River Basin Management for All" and in cooperation with related ministries and agencies with jurisdiction over dams, conduits, and other infrastructure, we will advance hybrid dam initiatives that both strengthen flood control functions and promote hydropower generation. These initiatives include upgrading of dam operations, constructing and expanding power generation facilities at existing dams, modifying dams, and building multipurpose dams to increase power output. We will also promote the interconnection of multiple dams, including those used for power generation, the replacement of existing facilities to optimize and improve efficiency, and the installation of power generation facilities at existing dams that are currently not used for electricity generation. The above will be addressed in cooperation with related ministries and agencies, based on a clear division of roles among relevant measures.

(vi) Biomass-fired power generation

A. Basic concept

Biomass-fired power generation is an energy source with varied benefits as a regionally distributed, locally produced and consumed energy source that offers multiple benefits, including enhanced disaster resilience and revitalization of local industries, leading to positive ripple effects on the local economy and employment.

On the other hand, fuel costs for collection and transportation account for the majority of power generation costs. In addition, the supply and demand balance for fuel has been tightening recently, making stable operation of the business a challenge. For this reason, we will promote cost reduction and stable fuel procurement in collaboration with local agriculture, forestry, and related industries.

B. Future issues and responses

In order to expand the supply of domestic woody biomass fuels, related ministries and agencies will work together to build a system for further utilization of forest residues, to demonstrate afforestation methods using fast-growing and broadleaf tree species suitable for each region, and to promote appropriate reforestation. In addition, the Government will promote the use of biomass fuels that are sustainable in terms of the environment, society and labor, governance, competition with food, and life-cycle greenhouse gas emissions.

Furthermore, in collaboration with local agriculture, forestry, and related industries, we will promote high-efficiency heat utilization and combined heat and power systems for local use within the community, and actively promote local production for local consumption of energy through the Act on the Promotion of Renewable Energy Electric Power Generation Harmonized with Sound Development of Agriculture, Forestry and Fisheries[23] and other acts. We will also advance the effective use of livestock waste, sewage sludge, food waste, and other resources while maintaining harmony with the sound development of agriculture, forestry, and fisheries.

[23] Act on the Promotion of Renewable Energy Electric Power Generation Harmonized with Sound Development of Agriculture, Forestry and Fisheries (Act No. 81 of 2013).

For large-scale biomass-fired power generation, key challenges include securing a stable and sustainable fuel supply and assessing the potential for future self-sustainability based on cost structure. Under such circumstances, we will discuss how support under the FIT/FIP schemes should be structured and how to ensure the continuation of biomass-fired power generation projects after the procurement period and grant period have ended.

(3) Nuclear power generation

(i) General remarks

Sincere reflection on the accident at TEPCO's Fukushima Daiichi Nuclear Power Station is the starting point of nuclear energy policy that must never be forgotten. In utilizing nuclear energy, we must keep in mind the lessons that ensuring safety is a prerequisite and that we will never again fall into the "myth of safety". We must also take seriously the concerns that have been voiced about the safety of nuclear energy and the progress of the back end. Then, based on the Atomic Energy Basic Act[24], the Government should take the lead in fulfilling its responsibilities with respect to each of the items listed in the following section (ii).

Nuclear power, whose output per amount of fuel is overwhelmingly large, can continue producing power for several years only with domestic fuel stockpile. Nuclear power is a highly autonomous power source with superiority in stability of energy supply, and technology self-sufficiency rate as a quasi-domestic energy source, and cost levels comparable to those of other power sources with little fluctuations. It is also a decarbonized power source that can stably generate electricity at a constant output regardless of weather conditions.

These characteristics of nuclear power generation will meet the demand for electricity, which is expected to increase due to the development of DX and GX, in particular from the needs of new GX-related demand in the manufacturing industry, and data centers and semiconductor plants and others that operate on a rated basis. Given these characteristics, the Government will continuously utilize the necessary amount of nuclear power with safety and public trust as the foremost priority.

(ii) Future issues and approaches

A. Starting point of nuclear energy policy—Untiring pursuit of safety based on lessons learned from the accident at TEPCO's Fukushima Daiichi Nuclear Power Station

Regarding the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, with sincere reflection on the situation, the Government needs to continue efforts to make sure that such an accident never happens again, based on the lessons learned from the various experiences. The Government does not forget the fact, that the Government and operators fell into the "myth of safety" which led to the disastrous accident, even for a moment.

Based on the new regulatory standards that take into account the lessons learned from the accident, safety measures are being strengthened. Specifically, those measures include tsunami countermeasures, installation of multiple power sources, strengthening anti-earthquake performance, tornado countermeasures, fire countermeasures, securing various cooling means,

[24] Act No. 186 of 1955.

and installation of filter vents. As a result of these strengthened safety measures, preparations for restarting, or actual restarts, are underway at nuclear power plants that have been certified as meeting the new regulatory standards, including Sendai, Takahama, Ikata, Oi, Genkai, Mihama, Onagawa, and Shimane.

It is essential for the industries, including nuclear power operators, to work together to pursue safety. The industry needs to reform safety management systems and foster an organizational culture of untiring safety improvement in order to pursue safety voluntarily and persistently, beyond regulatory fulfillment. The Government will guide the efforts of operators to make improvements through external evaluations and the sharing of good practices and lessons learned throughout the industry.

Each nuclear operator should continuously work toward risk-informed decision making (RIDM), including sophisticating risk assessment methods such as probabilistic risk assessment (PRA). In addition, nuclear power operators need to continue conducting peer review activities, pointing out each other's safety management systems, and to continuously improve safety through reviews by international organizations and other relevant institutions.

The Atomic Energy Association (ATENA), which is a cooperative organization among industries including manufacturers, will work with the academic community and overseas organizations to present the policy of efforts on the common technical issues 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 regulatory authorities so that these efforts foster a common understanding, and what such safety regulations should be in medium- and long-term.

An 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 the new regulatory standards, but operators should strengthen their protection measures voluntarily through 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. With regard to security at nuclear power stations, the security authorities, the Self-Defense Forces, regulatory authorities, and nuclear operators will cooperate closely, and related ministries and agencies and nuclear operators will work to strengthen cooperation through liaison meetings and other means.

Regarding establishment and enhancement of the nuclear disaster prevention measures, 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 provisions of the Basic Act on Disaster Management[25] and the Act on Special Measures Concerning Nuclear Emergency Preparedness[26], the government and relevant local

[25] Act No. 223 of 1961.
[26] Act No. 156 of 1999.

governments 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 host 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, the Government 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, the Government will provide training to improve their ability to respond to a nuclear disaster. Even after all such efforts, if by any chance an accident occurs, the Government must deal with it responsibly in accordance with relevant laws and regulations.

B. Coexistence with the host communities and communication with all levels of the public

Japan's use of nuclear energy has been supported by the understanding and cooperation of stakeholders in nuclear power host communities. In order to continue to use nuclear energy, it is essential that the Government makes efforts to coexist with host communities. On the other hand, host communities are faced with unique issues, such as regional economic development measures, as well as development of evacuation routes, and improvement of disaster prevention schemes. In addition, changes in circumstances such as prolonged suspension, suspension of construction work, restart, extension of operations, and decommissioning of nuclear power plants are having economic and social impacts. The Government will work to share awareness and deepen the relationship built on trust through careful dialogue with these communities. The government will sincerely address these issues and take measures to solve them, such as industrial development, improvement of residents' welfare, budget measures for disaster prevention, utilization of the Act on Special Measures for the Development of Areas Around Nuclear Power Generation Facilities[27]. The Government will also conduct study for the materialization of measures to secure the financial resources necessary to resolve issues, including expanding and fortifying evacuation routes. Related ministries and agencies will work together to promote sustainable development of these areas, taking into account the actual conditions in the areas, including the advanced approaches to addressing the issues. For example, efforts are being made to increase the added value of local resources and to utilize renewable energy. In the Reinan Region of Fukui Prefecture and the Shimokita Peninsula Region of Aomori Prefecture, local governments, the national government, and nuclear operators are working together to create a "future vision" for the area, including the creation of

[27] Act No. 148 of 2000.

new industries and employment, as well as the diversification of local industries based on local conditions and needs.

As the Government will share these progressive cases and know-how, and deepen discussions on a nationwide level, the Government 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. Nuclear operators will also be asked to take sincere actions and make proactive contributions to resolving various issues that their host communities may be faced with, as part of their responsibilities under the Atomic Energy Basic Act. In communication between the Government and the host communities, the Government will share the Government's understanding of the direction of nuclear energy policy and local issues through frank exchanges of opinions, and deepen and enhance policies for coexistence with the areas, based on discussions at the Nuclear Energy Policy Regional Conference, a forum for policy dialogue to realize policies and solve local issues together.

Even now, 14 years after the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, the distrust and concern about nuclear power have yet to be dispelled and there are still concerns about nuclear safety and progress on the nuclear back-end process. It is necessary to take the situation seriously, to provide accurate and objective information on nuclear energy and to promote public relations in order to establish relationship built on trust. For this reason, the Government 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, the Government 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, 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 interactive communication such as briefing sessions, the Government will constantly examine ways to promote more effective understanding activities, such as information dissemination using various PR methods including the web and SNS, and polite dialogue activities with opinion leaders and various sectors of public in each region, in order to deepen and enhance communication with various sectors of the public. The Government will take the initiative in this regard. In the event of a disaster, the public is highly interested in the status of nuclear power plants. Based on the experience and lessons learned from the 2024 Noto Peninsula Earthquake, the Government, nuclear operators, and industry will work on prompt, accurate, and polite information dissemination in accordance with their respective roles. In addition, education on nuclear energy will be enhanced to promote polite understanding across generations.

C. Acceleration of back-end processes

(a) General remarks

Addressing the back end, such as a nuclear fuel cycle, including reprocessing of spent fuel, smooth and steady decommissioning of nuclear power plants, and final disposal of high-level radioactive waste, are all important issues for the long-term use of nuclear energy.

(b) Promotion of the nuclear fuel cycle

The basic policy of Japan is to promote a nuclear fuel cycle that reprocesses spent fuel 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, it is important to take seriously the current situation, including repeated delays in the completion of the Rokkasho Reprocessing Plant, and to resolve one by one the challenges we face.

The completion of the Rokkasho Reprocessing Plant and the MOX Fuel Fabrication Plant, the core facilities of the nuclear fuel cycle, are the important tasks that must be accomplished, and the public and private sectors will work together to responsibly manage the progress of the review process and secure the necessary human resources to complete the construction of the plants. The public and private sectors will work to strengthen the necessary safeguard system in conjunction with the plants' operation. In addition, the public and private sectors will work on items that need to be addressed in the medium to long term, such as upgrading maintenance technologies and maintaining supply chains and technologies, in order to ensure the Rokkasho Reprocessing Plant's stable, long term use with safety after its completion. With regard to reprocessing of spent MOX fuel, R&D will be conducted to establish the technology by the latter half of the 2030s, including demonstration studies through international collaboration. On the assumption that the results of such R&D will be applied to the Rokkasho Reprocessing Plant, the necessary data for obtaining permits and licenses, and studying actual operation will be enhanced.

In addition, in order to remain committed to the policy of not possessing plutonium without specific purposes on the premise of peaceful use of plutonium thereby contributing to nuclear nonproliferation and steadily proceeding with such efforts while gaining international understanding, we will maintain the principle of not possessing plutonium without specific purposes, and will appropriately manage and reduce the size of plutonium stockpile, based on the "Basic Principles on Japan's Utilization of Plutonium" (decided by the Atomic Energy Commission in 2018). Furthermore, in the future, while ensuring stable operation of nuclear power plant and stable operation of the Rokkasho Reprocessing Plant and the MOX Fuel Fabrication Plant, we will promote steady utilization of plutonium extracted from the plant in addition to plutonium in foreign countries, and effectively implement the nuclear fuel cycle. To this end, the Government should be involved in cooperation and coordination among nuclear operators in relation to the utilization of plutonium and the delivery of spent fuel to the Rokkasho Reprocessing Plant, and will consider a framework to strengthen this function, and take necessary measures. Based on their understanding of host communities, nuclear operators are considering the introduction of plutonium use in all operating nuclear power plants.

Operators plan to implement plutonium use in at least twelve nuclear power plants by FY2030, and will further promote plutonium use in nuclear reactors while they continue to deepen their mutual collaboration and cooperation.

In order to use nuclear power plants stably and continuously, it is important to expand the storage capacity of spent fuel until it is reprocessed. Such efforts will enhance the flexibility of spent fuel measures, such as management and transportation, and contribute to medium and long-term energy security. We will strengthen its effort for facilitating construction and utilization of new intermediate storage facilities and dry storage facilities while studying a wide range of locations as possible sites, regardless of whether they are inside or outside the premises of a power plant. In addition, further reinforcement of cooperation among business operators also has significant meaning in ensuring flexibility of the spent fuel measures. The Government, together with the operators, will also stand on the front lines and respond proactively to these spent fuel issues and will make best efforts to promote understanding of nuclear energy policy, while considering the intentions of the local governments.

The Government 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.

In addition, the Government will promote the stable and long-term use of spent fuel stored in intermediate storage facilities and other sites under the policy that spent fuel stored in such facilities will be transported to the Rokkasho Reprocessing Plant, ensuring the safety of the plant, which is necessary for this purpose.

(c) Promote smooth and steady decommissioning

In Japan, with the exception of TEPCO's Fukushima Daiichi Nuclear Power Station, decisions have been made to decommission 18 nuclear reactors, and it is expected that decommissioning work will begin in earnest for each reactor in the future. The application for dismantling and removal of the reactor area of Units 1 and 2 of Hamaoka Nuclear Power Station was approved in December 2024, the first such application in Japan. Under these circumstances, in order to promote the smooth and steady decommissioning of reactors nationwide, a system has been introduced, under which the Nuclear Reprocessing and Decommissioning facilitation Organization of Japan (NuRO) conducts overall management of decommissioning as part of its decommissioning promotion work, and operators pay decommissioning contributions to NuRO. NuRO will continue to enhance its efforts to facilitate and improve the efficiency of decommissioning.

As for waste generated from decommissioning, the Government will consider business strategies for the smooth realization of treatment and disposal of low-level radioactive waste, including securing disposal sites, on the basis that nuclear operators should steadily proceed with such treatment and disposal under the principle of responsibility of the waste generator, and provide necessary support and guidance. In particular, with regard to clearance materials, from the viewpoint of facilitating decommissioning and effective utilization of resources, a roadmap for free release should be established, and with the cooperation of electric furnace steelmakers and other businesses, efforts should be made to process construction materials with

a larger demand scale and to further expand the number of reuse sites to achieve early free release. In addition, to improve the efficiency of verification of clearance materials, the Government will provide support for centralized processing projects and other initiatives, and will proceed in cooperation with related parties.

(d) Drastically enhanced efforts toward final disposal of high-level radioactive waste

Regarding high-level radioactive waste, in order to avoid deferring the burden to future generations as a responsibility of the current generation that produced the waste, (i) we aim for final disposal that does not depend on long-term institutional management (human management) as much as possible. As a means for final disposal, (ii) under the international recognition that geological disposal is the most promising method at present, efforts are underway toward geological disposal in many countries. The technical feasibility and reliability of geological disposal of high-level radioactive waste in Japan's geological environment was demonstrated in the "Technical Reliability of Geological Disposal of High-Level Radioactive Waste in Japan" (1999), and since then, geological experts assessed the feasibility of geological disposal in Japan in 2014 and 2024. The results of these assessments have reaffirmed that geological disposal is technically feasible in Japan, based on the latest scientific knowledge.

In order to realize final disposal, the Government will take the initiative in the lead in these efforts based on the Basic Policy for Final Disposal of Specified Radioactive Waste[28]. In doing so, it is important that the public widely share the recognition that the realization of the final disposal project is in the interest of society as a whole, and that society needs to give appropriate benefits to the communities that contribute to the realization of the project, as well as respect and gratitude to them.

A literature survey process for the selection of a disposal site is currently underway in three municipalities across Japan. Since the start of the study in 2020, Suttsu Town and Kamoenai Village in Hokkaido have held "dialogue forums" with the participation of local residents to deepen discussions on final disposal and the future vision of the region, in parallel with the study by the Nuclear Waste Management Organization of Japan (NUMO). In November 2024, NUMO began the statutory process of sending the literature survey report to the governor for public display, and holding public hearings and explanatory meetings.

In June 2024, a literature survey started in Genkai Town, Saga Prefecture. The Government will continue to promote activities for understanding, including neighboring municipalities, through every possible opportunities, such as "dialogue forums". Based on the importance of coexistence with the host communities, the Government will collect and analyze information that will contribute to future community development and promote the use of appropriate support systems in the survey areas.

The Government will actively engage in efforts to build public understanding so that as many communities as possible in Japan will be interested in the geological disposal projects and undertake the literature survey. Specifically, the Government will strengthen the government-led approach by holding nationwide interactive briefing sessions and by visiting local

[28] Cabinet Decision, April 2023.

governments individually throughout the country. In addition, the conducting the literature survey and preliminary investigation will serve as an opportunity to deepen discussion of the geological disposal project, and the Government will intensively engage in activities to obtain understanding throughout Japan in conjunction with the legal process in Hokkaido. In doing so, nuclear operators, who bear primary responsibility as waste generators, are expected to proactively conduct community-based activities to obtain understanding and explain the necessity of a final disposal site to the general public.

In order to further improve the technological reliability of geological disposal, it is important that the Government, NUMO, JAEA, and other related organizations continue to make steady progress in technological development from a holistic viewpoint, regularly reflect the latest findings, and ensure that their expert assessments are fully shared with the public. In doing so, the Government will fully utilize the research results obtained at the Horonobe Underground Research Center and other facilities. At the same time, from the viewpoint of securing a wide range of options for the future, while proceeding with efforts based on the assumption of geological disposal, research and studies on alternative disposal options such as direct disposal of spent fuel and on maintaining reversibility and recoverability should be promoted, so that future generations can select the best disposal method when better disposal options become feasible in the future.

In order to expand the knowledge necessary to realize the disposal project, the Government will work on the development of research results and the succession of human resources. In addition, while obtaining the understanding of the local community, the Government will collaborate with relevant domestic and foreign organizations to share knowledge and experience, in particular, with other countries facing common issues, and utilize this knowledge and experience in domestic efforts.

D. Maximum utilization of existing plants

The safety of nuclear power plants will be left to the expert judgment of the Nuclear Regulation Authority, and only those nuclear power plants that are deemed by the Nuclear Regulation Authority to be in compliance with the new regulatory standards formulated based on the lessons learned from the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, will be allowed to resume operations. In doing so, the Government will take a leading role and work to gain the understanding and cooperation of local municipalities and other concerned parties.

At present, in the Kyushu and Kansai areas, where the restart of nuclear power plants is progressing, the share of decarbonized power sources has increased, and electricity rates are up to 30% lower than in other areas. In addition, the effects of restarting nuclear power plants are being reflected in lower electricity prices and other benefits for consumers. Thus, from the perspectives of the vulnerability of the electricity supply structure, the effect of electricity rate reductions due to lower fuel costs, and the securing of decarbonized power sources that will determine future industrial competitiveness and economic growth, nuclear power generation is highly important for its contribution to people's lives and economic activities, and its utilization

should be promoted. Therefore, in order to accelerate the restart of nuclear power plants, the industry, including nuclear operators, will work together under the "Task Force for Acceleration of the Restart of Nuclear Power Plants" to ensure appropriate response to the Nuclear Regulation Authority's examination for amendment to the reactor installation license, appropriate implementation of pre-service inspection, and maintaining and enhancing on-site technical capabilities, at Tomari, Ohma, Higashidori, Onagawa, Kashiwazaki-Kariwa, Tokai Daini, Shika, Hamaoka, Tsuruga, and Shimane. The Government will also provide guidance to strengthen cooperation among operators. In particular, in view of the vulnerability of the electricity supply structure in Eastern Japan and the disparity in electricity rates between the east and west, the whole government will act in accordance with the policy presented at the Ministerial Meeting on Nuclear Energy to promote understanding of the need to restart the Kashiwazaki-Kariwa Nuclear Power Station. In addition, the Government will also work to promote understanding of other nuclear power plants that have not yet been restarted, while taking into account the progress of the Nuclear Regulatory Authority's examination and nuclear disaster prevention measures.

In accordance with the Act on GX Decarbonized Power Sources, the existing framework of capping the operating period of nuclear power plants at a maximum of 60 years was maintained. On the other hand, from the perspective of utilization policy, a new system was developed that allows periods of shutdown due to reasons beyond the nuclear operator’s control to be excluded from the counting of the 60-year permissible period. The Government will steadily operate this system by ensuring a stable supply of electricity, contribution to GX, and establishment of organizational and operational framework for ceaseless improvement of safety management and disaster prevention measures. Regardless of the decision based on the utilization policy, it is a basic premise that, a reactor cannot operate without approval based on a strict examination by the Nuclear Regulation Authority on the appropriate management to cope with the aging of a reactor. The Government will provide detailed explanations of the system and the results of the review. In addition to responding appropriately to the regulatory examination, the operators should cooperate within the entire industry and promote efforts to accumulate and expand technical knowledge and experience regarding aging degradation and its evaluation, while referring to examples of long-term operations in other countries. Furthermore, in order to improve the utilization rates, ATENA will take the lead and continue to strengthen efforts to reduce problems, conduct efficient periodic inspections by operators with safety assurance as a major premise, expand the introduction of in-service maintenance, and engage in discussions with regulatory authorities to identify technical challenges involved in lengthening the operation cycle.

E. Development and deployment of next-generation advanced reactors

More than 3 GW of existing reactors will reach 60 years of operation before 2040 and the supply capacity of existing reactors as decarbonized power sources will be significantly lost after that. Under such circumstances, it is necessary to proceed with measures while taking into account that a considerably long lead time of 10 to 20 years is needed to secure the decarbonized

power sources for achieving economic growth and improvement of people's lives in 2040 and beyond.

To materialize nuclear energy as a decarbonized power source, the Government will work on the development and deployment of next-generation advanced reactors with built-in new safety mechanisms to improve the safety of nuclear energy. With the aim of ensuring a well-balanced power generation mix, the Government will make concrete progress targeting the building of next-generation advanced reactors within the sites of operators with nuclear power plants that have been determined to be decommissioned, as long as it contributes to the maintenance and development of local industries and employment with the understanding of host communities, taking into account the progress in addressing back-end issues, such as the completion of the Rokkasho Reprocessing Plant. Other developments will be considered in the future based on the status of restart operations in each region, progress in securing local understanding, and other factors.

For advanced light water reactors, practical development will be promoted to enhance their safety with built-in new safety mechanisms from the design stage to control the risk of accidents and to enhance their ability to avoid or control the release of radioactive materials in the event of an accident. To enhance regulatory predictability, operators are taking action with a view to introducing such reactors, including the establishment of a working-level technical discussion between ATENA and the regulatory authorities. The operators will actively discuss with the regulatory authorities in order to clarify the relationship between the new safety mechanisms to be built into advanced light water reactors and regulatory standards for the purpose of further improving safety, and to foster a common understanding. In addition, technological development related to new safety measures will be promoted toward early implementation. The Government will continue to work on technological development for the practical application of other next-generation advanced reactors, such as fast reactors, high-temperature gas reactors, and fusion energy.

F. Creating an environment for sustainable utilization, maintaining and strengthening supply chains and human resources

In order to sustainably utilize nuclear energy as a decarbonized power source, it is necessary to improve the business environment so that the business can be stably operated even under the competitive environment created by the electricity system reforms, taking into account the characteristics of the nuclear industry, such as large-scale and long-term investment, long project period, regulatory standards, and back-end business. The Government will continue to study the necessary measures.

Regarding the nuclear damage compensation system, in take all possible measures to protect victims in the event of a nuclear accident, the Government has taken measures to realize early compensation to victims before the start of formal compensation under the system. With regard to the review of the compensation system, the Government will continue to conduct a comprehensive review and take necessary measures, taking into account the actual situation of compensation for the accident at TEPCO's Fukushima Daiichi Nuclear Power Station,

electricity system reforms, and other factors, based on the assumption that appropriate compensation will be promptly provided. In reviewing the system, including aspects such as minimizing the public burden, ensuring predictability of nuclear operators, and evaluating safety improvements should also be considered.

In addition, Japan's nuclear industry and human resource base boasts a high rate of domestic production and sophisticated technology and contributes significantly to the domestic economy and employment. It is also essential for restarting existing reactors and developing and installing next-generation advanced reactors such as advanced light water reactors and small modular reactors. Since the loss of new construction projects since the Great East Japan Earthquake, this foundation is being threatened. It is necessary to avoid prolonged construction periods and cost increases in the future, disruption of industrial infrastructure and technologies including equipment, materials, fuel fabrication, and decommissioning, and a shortage of nuclear human resources, including those to deal with regulatory issues. For this purpose, through the Nuclear Supply Chain Platform, in which industry and government agencies collaborate, support for business succession, including the commercial grade dedication, measures against supply disruptions of parts and materials, and support for human resource development and recruitment should be expanded. While utilizing the cooperative framework with related organizations such as the "Advanced Nuclear Education Consortium for the Future Society" (ANEC), related ministries and agencies will work together to promote human resource development measures, such as the introduction of skill standards, and exchanges between industry, academia, and government. In addition, a research infrastructure and human resource development system, including a new experimental research reactor, will be established. The public and private sectors will encourage participation in overseas projects where market expansion is anticipated, in the sense of maintaining and strengthening the industrial foundation for the development and installation of next-generation advanced reactors in Japan.

With regard to the uranium fuel supply chain, while strategically maintaining technologies related to uranium enrichment and fuel fabrication, and promoting cooperation among like-minded countries, the public and private sectors will work together to ensure a sustainable fuel supply system with a certain degree of autonomy, including the use of uranium retrieved at the Rokkasho Reprocessing Plant.

G. Contribution to solving common international issues

The use of nuclear energy is expected to expand globally in the future. Based on the lessons learned from the accident at TEPCO's Fukushima Daiichi Nuclear Power Station and the experience Japan has accumulated, it is both Japan's responsibility and the world's expectation for Japan to make positive contributions to improving nuclear safety, the peaceful use of nuclear energy, nuclear nonproliferation, and nuclear security, as well as to contribute to global warming countermeasures. From this perspective, Japan will contribute to the improvement of nuclear safety in the world, including Ukraine, through the formulation of international standards for nuclear safety such as the IAEA standards and the sharing of safer nuclear technologies and best practices in safety culture. In the area of nuclear security and nuclear

nonproliferation, it is important to intensify efforts in the international community by promoting international collaboration in research and development, such as improving the proliferation resistance of nuclear fuel, and research and development to strengthen safeguards technologies and nuclear forensics and detection. It is also important to strengthen efforts in the international community by continuing to enhance safeguards and promote effective export control by the IAEA. On the premise of ensuring nuclear safety, nuclear security, and nuclear nonproliferation, the Government will contribute to the expansion of appropriate nuclear energy use in the world, which is positioned as a means to address global warming at COP28 and is stated in the "Declaration to Triple Nuclear Energy ", by providing support for human resource development, institutional development, and nuclear technology for countries considering nuclear energy use. In these efforts, the Government will engage in bilateral cooperation with like-minded countries such as the United States, the United Kingdom, and France, as well as through multilateral frameworks such as the IAEA, the Organization for Economic Co-operation and Development Nuclear Energy Agency (OECD/NEA), and the G7.

(4) Thermal power generation and its decarbonization

(i) General remarks

While thermal power generation has the drawback of emitting greenhouse gases, it plays an important role as a supply source that meets electricity demand, currently accounting for approximately 70% of the power generation mix. It also serves as a balancing power source that stabilizes output and frequency fluctuations caused by renewable energy, and as an inertial and synchronous power to maintain grid stability.

Recently, with the expanding introduction of renewable energy, the operating rate of thermal power generation has been declining. Its stable operation is becoming increasingly difficult due to reduced profitability and growing challenges in securing stable fuel supplies, and the movement toward suspension and discontinuation is gradually progressing. However, it is thought to be difficult to completely replace thermal power generation with renewable energy and storage batteries, considering that there are times when the amount of variable renewable energy generation tends to remain low for extended periods, especially during adverse weather conditions in winter. It is also necessary to anticipate future increases in electricity demand due to the construction of new data centers and semiconductor factories. On the other hand, with the current electricity supply-demand situation remaining unpredictable, the fade-out of inefficient coal-fired power generation has not progressed sufficiently due to concerns about supply capacity shortages.

Therefore, while maintaining and securing the power generation capacity (kW) of thermal power necessary for stable supply, the actual electricity output (kWh) will be reduced, primarily from inefficient coal-fired power generation. Specifically, LNG-fired power generation will be secured as a transitional power generation will be secured as a transitional power source, along with LNG procurement contracts, and decarbonization of thermal power generation using hydrogen, ammonia, CCUS, and other technologies will be promoted. In advancing this strategy,

it is necessary to consider technological development, cost-effectiveness, and implementation timelines, while ensuring predictability for the operators and paying attention to emissions. The fade-out of inefficient coal-fired power generation will also be promoted. In doing so, to prepare for potential future increases in electricity demand and to ensure supply capacity during periods in coexistence with the further expansion of variable renewable energy, we will continue to consider institutional measures necessary to maintain low-utilization power sources and Reserve Power Plants system in case of emergency, while also ensuring the maintenance of power generation facilities and fuel supply chains. In addition, it is important to promote decarbonization efforts even for inefficient thermal power generation, through cooperative thermal power utilities and autoproducers.

At the same time, we will work to optimize and automate the operation systems of thermal power generations using AI and IoT. We aim to promote the technological developments for the high responsibilities and the flexibilities of the systems to load fluctuations, aiming to reduce costs and achieve more flexible management by improving the efficiency of the present operations and maintenance systems. In promoting these measures, attention should also be paid to maintaining supply chains necessary for construction, operation, and maintenance of thermal power plants, as well as to the potential future impacts on local economies and employment resulting from decarbonization, suspension and discontinuation of these plants. It is important to proceed with the transition toward decarbonization while taking into account regional circumstances and engaging with relevant stakeholders, for example, by clearly communicating the direction of transition from power generation companies to stakeholders.

(ii) LNG-fired power generation

LNG-fired power generation emits less greenhouse gas emissions than coal- and oil-fired power generation, and future decarbonization through the use of hydrogen and the introduction of CCUS and other sustainable fuels and technologies are possible. While the suspension and discontinuation of less economically efficient thermal power plants is progressing, demand for electric power is expected to increase. To maintain and secure the thermal power supply capacity necessary for a stable supply of electricity and to prepare for future uncertainty on both the supply and demand sides, the use of LNG-fired power generation is necessary as a means of transition toward power source decarbonization. In fact, there is a growing trend overseas to utilize LNG-fired power generation to ensure a stable supply of electricity.

Under these circumstances, Japan has been promoting the construction and replacement of LNG-fired power plants on the premise of future decarbonization through the Long-Term Decarbonized Capacity Auction. To further secure thermal power supply capacity, Japan will accelerate new construction and replacement of LNG-fired power plants on the premise of future decarbonization, while keeping an eye on future trends in the electricity supply-demand balance. In addition, decarbonization of LNG-fired power generation using hydrogen and CCUS and other technologies will be promoted through the Long-Term Decarbonized Capacity Auction and other means. With regard to power generation using hydrogen, technological development of combustors and power generation demonstrations are underway by also

utilizing the Green Innovation Fund, and social implementation will be aimed while keeping an eye on achieving domestic and international markets.

Despite its advantages, LNG is difficult to store for a long period, and there are risks associated with fuel procurement, such as fluctuations in the electricity supply-demand balance and price hikes due to geopolitical risks. Therefore, it is extremely important to ensure a stable supply of fuel for LNG-fired power generation. Since the tightening of electricity supply-demand balance in 2021, the Government and related businesses have been working together to establish a system to secure necessary fuels, including the preparation of guidelines for power generation fuels, regular monitoring of fuel inventories, establishment of national and regional coordination schemes, and introduction of Strategic Buffer LNG (SBL). On the other hand, it is becoming increasingly difficult for power generation companies to secure stable supplies of fuel through long-term contracts due to factors such as the decline in the predictability of electricity sales resulting from the liberalization of the electricity market, the resulting decrease in long-term PPAs, the seasonal fluctuations in fuel consumption due to the expansion of variable renewable energy, and the continuous decline in operating rates of LNG-fired power plants. Because of these factors, there is a growing concern about power generation utilities and consumers being exposed to the risk of fluctuating fuel spot prices.

Under these circumstances, there were some cases in which LNG inventories rapidly decreased due to a temporary increase in electricity demand and other factors, and some LNG-fired power plants experienced temporary fuel constraints. In light of this situation, as a preparation for the tightening of electricity supply and demand or a sharp rise in fuel spot prices due to a sudden change in the international situation, further consideration should be given to how to secure stable supplies of fuel both in normal times and in emergencies, such as by studying responses to promote the securing of long-term LNG contracts sufficient to ensure a stable electricity supply.

(iii) Coal-fired power generation

Coal-fired power generation currently accounts for approximately 30% of the power generation mix but emits more greenhouse gas emissions than other sources such as LNG-fired power generation. Therefore, the urgent issue is to steadily promote the fade-out of inefficient coal-fired power generation while maintaining a stable electricity supply as a fundamental prerequisite toward achieving carbon neutrality by 2050.

First, toward 2030, we will continue to promote the fade-out of inefficient coal-fired power generation through voluntary efforts by operators, utilizing institutional frameworks such as the Act on Rational Use of Energy and the Capacity Markets.

The fade-out of inefficient coal-fired power generation has not necessarily progressed sufficiently due to the emergence of supply capacity shortages. However, the emissions trading system that will be fully implemented in FY2026 from the perspective of GX promotion, and the GX-surcharge that is expected to be newly introduced in FY2028, may cause coal-fired power generation to lose its economic advantage over LNG-fired power generation. As a result, the fade-out of inefficient coal-fired power generation may progress. Electricity demand is

expected to increase in the future, raising further concerns about supply capacity shortages. In order to further promote the fade-out of inefficient coal-fired power generation, we will consider strengthening institutional measures, while also monitoring future electricity demand and the status of supply capacity, including decarbonized power sources.

Decarbonization efforts utilizing ammonia and CCUS will be promoted through the Long-Term Decarbonized Capacity Auction and other relevant mechanisms. With regard to power generation using ammonia, technological development of combustors and power generation demonstrations are underway by also utilizing the Green Innovation Fund, and social implementation will be aimed while keeping an eye on achieving domestic and international markets.

Furthermore, with a focus on decarbonization, we will promote the development of next-generation high-efficiency thermal power generation technologies, such as integrated coal gasification combined cycle (IGCC), with a view to integrating these technologies into existing thermal power generation facilities.

(iv) Oil-fired and other thermal power generation

The installed capacity of oil-fired power generation has been decreasing, following the transition to coal-fired power generation triggered by the oil crisis and the subsequent shift to LNG-fired power generation. Even at present, the use of oil-fired power plants has been declining with suspension and discontinuation in progressing, except for a temporary increase in operating rates immediately after the Great East Japan Earthquake and around 2021, when the electricity supply-demand balance became tight. Furthermore, as maintaining the oil supply chain becomes increasingly difficult, further progress is expected in the suspension and discontinuation of oil-fired power plants. On the other hand, oil-fired power plants are also expected to function as a backup supply source in situations where additional supply capacity needs to be secured, such as in the event of large-scale disasters causing power source outages or sudden surges in electricity demand.

(5) Construction of a next-generation electricity network

(i) General remarks

The development of next-generation electricity networks is essential for ensuring a stable supply of electricity and promoting decarbonization of the power system. In order to realize the timely and reliable supply of electricity while anticipating future demand, enhancing resilience against natural disasters, and maximizing the use of renewable energy, it is necessary to optimize the utilization of existing power grids, develop inter-regional interconnection lines based on the Master Plan of Nation-wide Power Transmission Networks formulated by the OCCTO, and steadily reinforce local backbone grids. In addition, as the maximum deployment of renewable energy is progressing, it is crucial to promote the construction of a next-generation electricity network that ensures flexibility to accommodate the variability of renewable energy sources. To address this, it is essential to secure sufficient balancing capacity and advance sophistication of grid and supply-demand operations, thereby enabling the construction of a

next-generation electricity network that ensures flexibility to accommodate the variability of renewable energy. In this context, OCCTO will play an important role not only in grid development, but also in supply-demand operation and investment in power sources. Moreover, promoting initiatives that utilize local distributed energy resources will also contribute to regional revitalization. Furthermore, in light of large-scale power outages caused by natural disasters such as the 2024 Noto Peninsula Earthquake, it is necessary to steadily implement measures to ensure stable supply. These include prompt restoration efforts, analysis of outage causes, and strengthening collaboration among power operators.

(ii) Reinforcement of the electricity network (grid)

A. Development of inter-regional interconnection lines and intra-regional backbone grids

To date, in order to utilize the existing grid efficiently, we have been expanding the available transmission capacity through the promotion of non-firm connection schemes and other measures. While continuing to promote these efforts, we will proceed with grid reinforcement to achieve the further expansion of renewable energy deployment and ensure a stable electricity supply. For inter-regional interconnection lines, in order to systematically accommodate the integration of renewable energy, we are proceeding with development based on the Master Plan of Nation-wide Power Transmission Networks, and have introduced a system in which costs are borne through renewable energy surcharges and nationwide wheeling charges. Under this system, we aim to develop transmission infrastructure over the next 10 years on a scale of more than 10 GW, which is over eight times the scale of the past 10 years (approximately 1.2 GW). This includes projects such as the development of submarine high-voltage, direct current power transmission between Hokkaido and Honshu, and the enhancement of interconnection facilities between the Chugoku and Kyushu (Kanmon interconnection lines), and we will consider necessary institutional measures to address challenges such as financing.

In addition, as the further deployment of renewable energy and the localized concentration of large-scale electricity demand are expected in the future, it may become necessary to review the approach to developing inter-regional interconnection lines. Therefore, we will review the Master Plan of Nation-wide Power Transmission Networks, taking into account the future situation of renewable energy deployment and the location of large-scale electricity demand.

Furthermore, in order to maximize the use of renewable energy, strengthen resilience in the event of natural disasters, and ensure a stable energy supply, it is also important to efficiently develop local backbone transmission networks. Until now, these networks have been developed by General Electricity Transmission and Distribution Utilities within each area. However, to enable more systematic development, it has been decided that those networks integrated with inter-regional interconnection lines or those contributing to wide-area electricity transactions will be developed by the General Electricity Transmission and Distribution Utilities under the involvement of the OCCTO. Under these circumstances, it is necessary to develop the local backbone transmission networks that contribute to renewable energy deployment more efficiently than before. For this purpose, mechanism will be considered to enable the General

Electricity Transmission and Distribution Utilities in each area to proceed with the development in a more efficient and planned manner. In addition, a cross-regional and cost-sharing mechanism will also be studied, taking into account both the burden on regions hosting renewable energy sources and the benefits to the nation as a whole. Alongside these efforts, measures such as promoting the undergrounding of power lines will also be advanced.

B. Development of the power transmission and distribution network in response to localized large-scale demand

In order to promote decarbonization of manufacturing processes through domestic investment and electrification, which will lead to the maintenance and enhancement of high value-added industrial activities such as data centers, it is necessary to supply electricity promptly and reliably to meet new large-scale demand. To this end, the Government will ensure appropriate procedures for grid connection applications by data centers and other users, and promote location guidance through the "Welcome Zone Map" which indicates areas where the General Electricity Transmission and Distribution Utilities can begin supplying electricity at early stage. In addition, to guide large-scale demand to suitable locations from the perspective of efficient grid development, a mechanism will be studied in which the General Electricity Transmission and Distribution Utilities, in cooperation with local governments and other related organizations, to carry out advance and planned grid development in appropriate areas. Furthermore, to ensure fairness for electricity consumers while steadily promoting grid development, a mechanism will be considered to ensure that costs associated with advance and planned grid development by the General Electricity Transmission and Distribution Utilities are securely recovered. In cases where development costs become substantial for businesses implementing initiatives that contribute to GX, the appropriate cost-sharing arrangements will also be examined.

C. Measures for financing and other issues related to the development of the power transmission and distribution network

The General Electricity Transmission and Distribution Utilities have made significant investments to date, including the development of inter-regional interconnection lines. Looking ahead, accelerated, and large-scale investments will be required to advance decarbonization, ensure a stable supply, and replace aging infrastructure. Under such circumstances, even if the General Electricity Transmission and Distribution Utilities have a high probability of recovering the necessary grid development and other costs under the revenue cap system, they may be concerned about cash flow deterioration due to the long construction periods and extended timeframes required for cost recovery in the case of large-scale investments exceeding a certain threshold. This could result in delays or stagnation in necessary investments. Additionally, in the case of project financing through the formation of a Special Purpose Company (SPC), financial institutions tend to hesitate to provide large-scale financing due to concerns over of cost recovery risks, such as potential cost overruns, which may also lead investment delays.

Given the potential increase in electricity demand, the expansion of renewable energy, and the rising risk of natural disasters, flexible and timely investments in projects such as the submarine high-voltage, direct current power transmission between Hokkaido and Honshu and large-scale local backbone grids will become increasingly important. Financing constraints must not hinder the implementation of these necessary investments. To this end, we will study improvements to the financing environment, including institutional measures such as cost recovery mechanisms within the wheeling charge system and frameworks to secure sufficient funding. In addition, we will consider measures to secure adequate construction capacity in the transmission and distribution sector, which is essential for large-scale grid development.

(iii) Upgrading of grids and supply/demand operations

A. Operational sophistication of the balancing power

Balancing power is crucial to ensure stable supply of electricity. While thermal power generation and pumped storage hydro power generation currently account for the majority of balancing power, the balancing market was established in FY2021 to reduce balancing costs through wide-area procurement and operation, as well as by promoting competition based on market principles. In FY2024, market trading of all balancing power products was launched. Further operational improvements will be promoted, including measures to increase market bid volumes.

In addition, as the amount of variable renewable energy continues to increase, the required volume of balancing power and the frequency of grid congestion are also expected to increase. Under these circumstances, we will conduct full-scale studies toward the introduction of a new electricity market which will optimize the procurement of balancing power and the operation of power sources by simultaneously contracting electricity and balancing power, while taking grid constraints into consideration.

B. Promoting the use of storage batteries and demand response (DR)

In providing flexibility to the power system, storage batteries play a vital role. They can store electricity generated from renewable energy and supply it during peak demand periods, such as in the evening. In addition, they serve as quick response balancing power sources. DR is also important as a demand-side approach to maintaining the supply-demand balance. Since FY2021, the introduction of grid-connected storage batteries has been supported through subsidies, and in FY2023, the Long-Term Decarbonized Capacity Auction was launched to promote their deployment by including them in the bidding process. Furthermore, the environment for trading in electricity markets is steadily improving, and the number of applications for grid connection of storage batteries is increasing. On the other hand, several challenging issues have emerged, including concerns that intensified price competition may compromise safety and sustainability, delays in grid connection, and sufficient profitability assessments in each electricity market. Therefore, it is necessary to promote the introduction of safe and sustainable storage batteries by examining requirements to ensure business discipline in support measures and by evaluating their profitability.

With the spread of Distributed Energy Resources (DERs[29]) such as storage batteries, heat pump water heaters, and cogeneration, DR utilizing these resources is also progressing. Going forward, a system will be introduced to require manufacturers to supply products equipped with DR-ready functions by the target fiscal year. It is necessary to further promote the spread of DR through demonstration projects using the IoT functionality of smart meters, and by encouraging aggregation business that utilize DERs such as electricity storage systems, cogeneration, load control equipment, and heat storage tanks. In utilizing DERs, local microgrids are also important, as they contribute to efficient energy use through local production for local consumption and to strengthening resilience in the event of disasters. In the future, we will pursue technical feasibility to alleviate grid congestion that is expected in certain regions.

C. Promoting the use of pumped storage hydropower generation

Pumped storage hydropower generation is becoming increasingly important as a power source that can store electricity generated from renewable energy, supply electricity during peak demand periods, and adjust to frequency fluctuations with short response times. We will continue to promote capital investment aimed at improving the profitability of existing facilities, and support feasibility studies for new developments, in order to further encourage new investments.

[29] A collective term for energy resources (power generation facilities, storage facilities, and load facilities) connected below the receiving point of a consumer, as well as power generation and storage facilities connected directly to the grid.

4. Securing next-generation energy and its supply system

(1) Basic concept

Hydrogen is a foundational material for ammonia, e-methane, and e-fuels, and is expected to be utilized across a wide range of sectors, including steel, chemicals, mobility, industrial heat, power generation, as a key energy source for achieving carbon neutrality by 2050.

Globally, bold support measures are beginning to emerge not only for technological development but also for the production of hydrogen and its derivatives infrastructure investment. In addition, several countries are developing industrial strategies that leverage their respective strengths, such as abundant and low-cost renewable energy, natural gas, CCS-suitable sites, and technological advantages in hydrogen-related fields, leading to growing competition for resources and suitable locations.

Japan has been a global leader in multiple hydrogen technologies, including hydrogen production, transportation, and combustion. In order to "excel in technology, and also succeed in business" Japan will continue to work with NEDO and other organizations, enhancing its competitiveness through world-leading technological development supported by initiatives such as the Green Innovation Fund projects, while also encouraging proactive capital investment by companies in anticipation of global market expansion.

For social implementation, we will strongly support the establishment of large-scale supply chains for low-carbon hydrogen and its derivatives under the Hydrogen Society Promotion Act. Taking into account global and corporate trends, Japan will continue to implement integrated regulatory and support policies to promote the large-scale supply and utilization of low-carbon hydrogen and its derivatives both domestically and internationally, aiming to reduce costs and expand usage in tandem. In addition, we will also promote the utilization of hydrogen and its derivatives based on local assets, contributing to regional revitalization.

(2) Hydrogen

In other countries, financial support measures such as subsidies and tax credits are in place. However, due to inflation-driven increases in development costs and other factors, it is particularly difficult to attract new customers for emerging technologies such as hydrogen, which face significant barriers to cost pass-through. In Europe, while the target for hydrogen production by 2030 is 10 million tons (equivalent to 100 GW of electrolyzer capacity), the installed capacity as of September 2023 is only 0.2 GW, indicating a substantial gap from the target. At the same time, strategic choices that do not undermine the competitiveness of key industries are considered essential for achieving these targets. While maintaining efforts toward decarbonization, the need to promote industrial policy is increasingly emphasized, and many companies are already advancing industrial-scale hydrogen projects to the final stage of investment preparation.

Currently, a commercialized supply chain has yet to be established, and challenges remain in terms of cost and the creation and expansion of new demand. Japan will also continue to aim to achieve its stated goals (30 yen/Nm^3 (CIF price) and maximum 3 million tons/year in 2030; 12 million tons/year in 2040; 20 yen/Nm^3 (CIF price) or less, 20 million tons/year in 2050). To support the development of supply chains for low-carbon hydrogen and its derivatives under the Hydrogen Society Promotion Act, Japan will provide approximately 3 trillion yen in support focused on bridging the price gap, aiming to strategically develop early stage use cases that will contribute to future industrial competitiveness. In doing so, from the perspective of energy security, Japan will provide maximum support for domestic projects that are expected to have sufficient price reductions and competitiveness, while also supporting the import of hydrogen and its derivatives that are produced using Japanese technologies and can be supplied in large quantities. In addition, Japan will promote investment to expand production capacity for electrolyzers, fuel cells, and related components and materials, and accelerate technological development of high-temperature gas-cooled reactors, which have the potential to produce hydrogen at competitive costs in the future, thereby enhancing industrial competitiveness.

In addition, in accordance with the Hydrogen Society Promotion Act, Japan will provide support for the development of strategic hubs and implement special measures for facilities that can benefit a wide range of businesses, contributing to the creation of large-scale demand for hydrogen use and the establishment of an efficient supply chain. Japan will also work to rationalize and optimize safety regulations.

To expand the use of hydrogen and its derivatives, in the transport sector, Japan will provide support for the deployment and expansion of fuel cell commercial vehicles and large-scale hydrogen stations, in conjunction with regulations and systems such as non-fossil energy transition targets under the Act on the Rational Use of Energy. Japan will also advance the development of a system to reduce greenhouse gas emissions from ships, promote the development and construction of zero-emission ships, support the social implementation of fuel cell railcars, and pursue initiatives for the development of ports and harbors necessary for large-scale hydrogen use.

In the power generation sector, where large-scale hydrogen demand is expected, hydrogen remains an important energy source for expansion. Japan will steadily promote technological development of combustion equipment and demonstration using actual generators. From the second round of bidding in the Long-Term Decarbonized Capacity Auction, the fixed payment portion of fuel costs for hydrogen and ammonia was added to the scope of support. Japan will promote steady social implementation while continuing to consider the need for additional institutional support, including raising the ceiling price.

In the industrial sector, hydrogen is expected to be used as both an industrial feedstock and a high-temperature heat for industrial processes. Japan will continue to promote technological development and demonstration for the large-scale transformation of production processes, such as hydrogen-reduced steelmaking, and for hydrogen burners and boilers. In the medium term, Japan will take appropriate and effective measures to support the shift to non-fossil energy,

including institutional reforms, while monitoring the status and outlook of technologies and market environments on both the supply and demand sides.

Japan will also promote the supply and transportation of hydrogen using locally available renewable energy and resources for area-wide utilization, which will lead to regional decarbonization, energy self-sufficiency, and local revitalization. In addition, Japan will support efforts to further reduce the cost of fuel cells, which will contribute to enhancing resilience.

(3) Ammonia

Ammonia is another energy source expected to be utilized in a wide range of sectors, such as chemicals, industrial heat, shipping, power generation. Although its current scale is limited, an existing supply chain is already in place for use as a feedstock in fertilizers and chemical products. It is attracting attention in Europe mainly as a hydrogen carrier, in Asia as a co-firing fuel for power generation, and in international shipping as a bunker fuel.

Ammonia is also facing a challenge due to inflation-driven increases in development costs and other factors, despite financial support measures such as subsidies and tax credits being implemented in other countries. Nevertheless, ammonia production projects are beginning to emerge overseas, and steady progress is being made toward fuel switching in the chemical and power generation sectors. While issues remain regarding costs and the creation and expansion of new demand, Japan will continue to pursue its projected domestic demand targets, 3 million tons/year in 2030, approximately 500,000 tons/year in hydrogen equivalent), and approximately 30 million tons/year in 2050 (approximately 5 million tons/year in hydrogen equivalent), as well as its cost target of the upper 10 yen range/Nm^3 in 2030 (converted to hydrogen calorific value equivalent). As with hydrogen, Japan will strategically proceed early-stage use case development that contributes to future industrial competitiveness, supported by measures under the Hydrogen Society Promotion Act.

In addition, from the viewpoint of early expansion into overseas markets, particularly in Asia, Japan will promote development and demonstration projects aimed at scaling up production, reducing costs, and lowering CO_2 emissions. On the utilization side, Japan will also support technological development for high co-firing ratios and mono-firing ammonia combustion. Furthermore, as with hydrogen, Japan will consider institutional frameworks to promote ammonia use in industrial, shipping, and power generation sectors.

(4) E-methane, other gases

(i) E-methane

E-methane that is synthesized from hydrogen and CO_2 ("methanation") can contribute to the smooth decarbonization of gas because it can use existing infrastructure. To create a market and expand the use of e-methane, it is important to promote technological development for practical application and cost reduction, while ensuring sustained investment.

Production costs of e-methane include CO_2 capture costs and methanation equipment costs, with hydrogen production costs account for a particularly large proportion. In order to reduce

these costs, continued efforts will be made to develop innovative methanation technologies that dramatically increase production efficiency compared to existing technologies. The goal is to establish basic technologies in 2030 and realize mass production technologies in the 2040s.

In order to inject e-methane or biogas equivalent to 1% of supply into pipelines in FY2030 and to make 5% of gas carbon neutral together with other measures, these introduction targets will be incorporated in the criteria for judgment under the Act on Sophisticated Methods of Energy Supply Structures[30]. A mechanism will be established whereby the portion of the introduction cost that exceeds general gas procurement cost can be included in the cost base for consignment charges, from the perspective of ensuring fair competition among gas retail operators. Furthermore, based on the above, we will develop necessary counting rules will be formulated. These include reflecting the introduction of e-methane in emission factors under the system for calculating, reporting, and disclosing greenhouse gas emissions based on the Act on Promotion of Global Warming Countermeasures, and considering specific requirements for third-party certification bodies regarding the emission reduction value of e-methane.

In order to achieve carbon neutrality in city gas by 2050 through various means such as the introduction of e-methane and biogas, we will consider the necessary systems and frameworks from the perspective of promoting carbon neutrality for city gas across Japan, not only by specific operators but by city gas operators nationwide.

(ii) Green LP gas

Green LP gas is a generic term for LP gas that is not derived from fossil fuels, such as bio-LP gas and synthetic LP gas. Currently, bio-LP gas, produced as a byproduct along with biodiesel, accounts for the majority of green LP gas. However, the production ratio of biodiesel to bio-LP gas is 10:1, making mass production a challenge. Moreover, no advanced technologies specialized in its production have been established globally. In the future, global demand for LP gas is expected to grow, driven by fuel switching in counties such as China and India, making the development of mass production technologies for green LP gas increasingly important.

To achieve mass production of green LP gas, we will promote technological development, such as innovative catalysts, and conduct demonstrations of production processes, aiming for social implementation in the 2030s. In doing so, we will utilize forums such as public-private study groups, and promote necessary initiatives, including the build business models that encompass production and distribution networks with a view toward overseas markets, through collaboration among domestic and international stakeholders. Additionally, to promote carbon neutrality in LP gas, we will support initiatives such as expanding the use of carbon credits and introducing low-carbon LP gas mixed with rDME (bio-derived dimethyl ether).

(5) Biofuels, e-fuels

[30] Act on the Promotion of Use of Non-Fossil Energy Sources and Effective Use of Fossil Energy Materials by Energy Suppliers (Act No. 72 of 2009).

Biofuels are produced from plants, waste cooking oil, and waste materials. Since the plants used as feedstocks absorb CO_2 from the atmosphere during their growth, biofuels are lower-carbon alternatives to fossil fuels. In the future, we will promote technological development for domestic production of next-generation bio-based feedstocks, while also strengthening collaboration with resource-rich countries and advancing the construction and reinforcement of supply chains.

In the automotive sector, while developing the necessary institutional environment, we aim to achieve carbon neutrality by 2050. By expanding the introduction of bioethanol, including direct blending with gasoline in certain regions, we aim to begin supplying low-carbon gasoline with a maximum concentration of 10% by FY2030. Moreover, by assessing the adoption of compatible vehicles and the status of supply chain readiness, we will seek to expand the regions and scale, aiming to supply low-carbon gasoline with a maximum concentration of 20% from FY2040.

In the aviation sector, to expand the introduction of SAF (Sustainable Aviation Fuel), we will support capital investment for the construction of large-scale SAF production facilities using GX Economy Transition Bonds, and provide tax credits for advance investments through the "Tax System for Promoting Domestic Production in Strategic Sectors." We will also set the 2030 SAF supply target as "at least 5% of the greenhouse gas emissions from jet fuel produced and supplied domestically in Japan in FY2019." Through these medium- to long-term regulatory and institutional measures, we aim to establish a system that enables stable SAF supply at internationally competitive prices. In addition, as competition for securing bio-derived SAF feedstocks is expected to intensify, it will be necessary to diversify feedstocks by exploring non-edible materials and to build and strengthen supply chains to ensure stable procurement.

For diesel fuel, which is widely used in sectors, such as automobiles, ships, railways, and construction machinery, we will promote the introduction of biodiesel, taking into account feedstock supply constraints.

E-fuels offer advantages such as compatibility with existing internal combustion engines and fuel infrastructure, and high energy density equivalent to fossil fuels. E-fuels are expected to be used as e-gasoline and e-diesel in the automobile sector, e-methanol in the marine sector, and e-SAF in the aviation sector. Aiming for commercialization of e-fuels by the first half of 2030s, we will advance necessary initiatives such as R&D and formation of domestic projects in collaboration with NEDO and other organizations, participation in overseas projects through investment, and creation of environmental value and business models through international dialogue.

5. Securing fossil resources/supply system

(1) Basic concept

Fossil fuels play a major role in our country's energy supply. While global demand is expected to decline, the extent of this decline remains uncertain. Once disrupted, the fossil fuel supply chains are extremely difficult to restore. Therefore, it is necessary to advance a realistic energy transition while ensuring a stable supply. In this context, Japan will pursue resource diplomacy, domestic and international resource development, diversification of supply sources, crisis management, and maintenance and strengthening of supply chains, taking into account geographical proximity and long-term cooperative relationships with resource-rich countries.

In particular, securing a stable supply of LNG is crucial for ensuring a stable electricity supply while reducing the output from inefficient coal-fired power plants. LNG-fired power generation serves as a practical transition measure and is also important from the perspective of maintaining a stable supply of city gas. To prepare for risks such as price hikes and supply disruptions, the public and private sectors must collaborate to secure the necessary long-term LNG contracts. In addition, given Japan’s vulnerability to natural disasters, it is also important to secure stable energy procurement and supply systems for portable and storable energy sources such as petroleum products and LP gas, from the perspective of energy resilience.

In order to win the future race for resources, including decarbonized fuels and technologies, we also aim to create internationally competitive "core companies" and transform them into "comprehensive energy industries," which will become the main players in the realization of a carbon neutral society by 2050.

(2) Natural gas

(i) General remarks

Natural gas is highly efficient as a heat source, has relatively low geopolitical risk, and currently accounts for approximately 30% of Japan’s power generation mix. It also emits the lowest greenhouse gases among fossil fuels and plays a central role as a balancing power for renewable energy. At the same time, the shift to natural gas through fuel switching contributes to reducing environmental impact. Furthermore, natural gas is expected to remain an important energy source even in a carbon neutral future, as technological progress is expected to lead to decarbonization of gas itself, and its use as a feedstock for hydrogen and its derivatives is also expected to expand.

On the other hand, the LNG market remains structurally tight due to the uncertainty of energy supply caused by Russia's aggression against Ukraine and other factors. Even under these circumstances, in promoting independent development, expanding the market, and diversifying supply sources, it is necessary to take into account factors such as geographical proximity and medium- to long-term cooperative relationships with resource-rich countries, and to enhance stability and resilience of supply. We will work to ensure stable procurement and supply systems

through resource diplomacy led by the Prime Minister, the provision of risk capital by JOGMEC, and continuation of the LNG Producer-Consumer Conference.

Japan's oil and natural gas development companies are expected to remain the major players in areas such as the supply of decarbonized fuels and technologies.

(ii) Further promotion of independent development

Japan faces structural problems, including limited bargaining power due to its high dependence on imports of oil and natural gas and vulnerability to political situations in the Middle East. Therefore, to ensure a stable supply of oil and natural gas even under changing global circumstances, it is extremely important to secure upstream interests in which Japanese companies are directly involved in development and production and to exploit domestic resource to promote independent development. Japan aims to increase its independent development ratio of oil and natural gas to 50% or more by 2030 and 60% or more by 2040.

(iii) Securing a stable supply of LNG

The 2024 LNG Producer-Consumer Conference confirmed that (a) LNG-fired power generation is needed to balance the intermittency of variable renewable energy, (b) LNG can meet energy demand and support the transition away from coal in growing economies in Asia and elsewhere, and (c) established LNG infrastructure can be repurposed to support the development of low-emission gases.

In addition, it is essential to secure a certain volume of LNG under long-term contracts to ensure supply and price stability for consumers, and we aim to establish indicators to measure and evaluate the degree of this stable LNG procurement and use these to inform and guide policy support.

Medium- to long-term LNG demand will be greatly affected by the growth of electricity demand from new industries and trends in decarbonized fuel prices. For example, the IEA has specified the possibility of a substantial increase in gas demand toward 2040, depending on the level of industrial gas demand, electricity consumption growth, and progress in fuel switching. In particular, it is important to address the risks associated with securing LNG in demand areas with high uncertainty. Based on private sector leadership, it is necessary to ensure coordination among companies and between public and private sectors. Therefore, based on the concept of the gas reserve mechanism, whose importance has been confirmed at the IEA Ministerial Meeting and other forums, we will strengthen security by implementing effective policy measures and securing flexible contracts, even in Japan, where gas storage is difficult due to geographical constraints. In particular, during emergencies, Japan, which relies on LNG imports due to the difficulty of gas storage, will secure the necessary volume with the Government taking the lead in collaboration with operators through initiatives such as SBL. However, since such measures are expected to incur significant costs, we will consider initiatives to promote inter-company cooperation for strengthening the LNG supply chain in normal times, such as enhancing storage capacity by increasing tank capacity and expanding reloading facilities. In addition, the Government will further promote the conclusion of an intergovernmental cooperation memorandum, which is the basis for cooperation such as mutual stock interchange

during emergencies and take all possible measures to establish an LNG procurement system through JOGMEC in case of emergencies that cannot be handled by the private sector alone. Furthermore, since the importance of public financial support as leverage for emergency procurement is increasing, a more robust support system is required to enhance energy security. From the perspective of securing procurement sources for this extremely important fuel for Japan's energy security, we will continue strategic dialogue with resource exporting countries.

In the global LNG market, international oil majors are taking risks by themselves and further expanding their presence. Recognizing this situation, we will maintain our target of 100 million tons of LNG handled by Japanese companies, including "offshore trading," and explore optimal procurement strategies, such as flexible destination clauses, shared use of tank facilities in Asia and other regions, joint procurement, and enhanced trading capabilities, in order to foster Japanese companies that can compete on the global market. We will also work on institutional development and human resource development related to LNG deployment in Asia and other regions with growing energy demand.

(iv) Initiatives for low carbonization of the LNG value chain

We will analyze the emission reduction effects and economic efficiency of key technologies that contribute to a low-carbon LNG value chain, and work with the IEA to create an environment in which producers and consumers can indicate pathways toward a low-carbon future. Regarding methane emission reduction measures, we will promote the CLEAN initiative, which encourages voluntary methane reduction efforts. We will advance collaboration and conduct technical demonstrations with international organizations such as the International Methane Emissions Observatory (IMEO) and energy companies. While reflecting Japan's perspectives and technologies in international standards for measurement, monitoring, reporting, and verification, we will promote cooperation among importing countries. We also consider establishing a certification system for low-carbon LNG.

(v) Promotion of domestic resource development, securing and fostering human resources in the oil and natural gas industry

Continuous promotion of domestic resource development in offshore and onshore areas is important as it enables a stable energy supply without being affected by geopolitical risks and exchange rates fluctuations. These resources are also expected to be used as feedstock for domestic production of hydrogen and its derivatives in the future. In particular, regarding methane hydrate (sandy sediment type, shallow type, and methane plume), we will promote technological development to establish the necessary technologies and systems for commercialization by private companies based on the Basic Plan on Ocean Policy[31]. In doing so, recognizing high uncertainty and difficulty of this globally unestablished technology, we will analyze and evaluate the progress and results of technological development, aiming to launch projects led by private sector for commercialization by FY2030. For oil and natural gas, we will conduct domestic exploration using the 3D seismic survey vessel "TANSA" (covering

[31] The Basic Act on Ocean Policy (A Cabinet decision was made in April 2023.)

approximately 50,000 square kilometers by FY2028) and carry out agile test drilling in promising sea areas. Additionally, we will enhance market competitiveness by utilizing the same vessel for effective exploration of suitable CCS sites both domestically and internationally.

In collaboration with the industry, we held the "Energy Career Academy" to promote the securing and development of diverse human resources who will lead the transformation of the oil and natural gas industry, while balancing the realization of GX and stable energy supply. We will continue to disseminate information aimed at students in this regard.

(3) Oil (including stockpiling/service stations (SSs))

(i) General remarks

Oil accounts for approximately 40% of primary energy and is used widely as fuel and as a material, including chemical products. Although geopolitical risks associated with crude oil procurement are significant and domestic demand for petroleum products is declining, oil remains an essential energy source for daily life and economic activities due to its high energy density, well-developed stockpile system, portability, and ease of storage, which make it the last resort for energy supply in times of disasters

(ii) Secure stockpiles

Although domestic demand for oil is declining, oil stockpiling remains important considering geopolitical risks and increasing oil demand in Asia. We will maintain oil stockpiling levels while securing necessary domestic oil refining capacity. To further enhance the flexibility reserve releases, we will strengthen collaboration with oil refining and wholesale companies, replace oil grades as necessary, and continue release drills and tabletop exercises. Additionally, we will continue to carry out necessary repairs and improvements to facilities at national oil reserve bases, tailored to the release capabilities of each base. Considering the possibility that some refineries may become inoperable during disasters, it is necessary to continue to work on the decentralization of stockpiling bases. As refinery consideration progresses, we will examine ways to secure distribution inventories in preparation for potential refinery shutdowns due to disasters. This includes the effective use of tanks for storing new fuels, considering the transition to alternative fuels.

In the event of an emergency, we will promptly release reserves from flexible private and national reserves prioritizing bases with greater release capacity. Furthermore, to ensure energy security in Asia, we will promote stockpiling cooperation with oil-producing countries and consuming countries in the region. We will also maintain and build relationships with the IEA and member countries to enable coordinated releases in the event that geopolitical issues in Asian waters, posing a risk of supply demand tightness in the region.

(iii) Maintenance and transition of the oil supply system

While domestic gasoline demand is declining due to improvements in automobile fuel efficiency and the shift toward electrification, aviation fuel demand is increasing, driven by rising inbound tourism. as Although overall domestic petroleum demand is declining, the extent

of the decline varies by product. In line with these changes in demand structure, the supply system must also evolve, with stable supply as a fundamental premise.

To ensure a stable supply amid declining demand, it is important to maintain refineries while advancing decarbonization efforts. It is also essential to ensure the flexibility of supply chain, such as by strengthening transportation system. During disasters, fuel may be needed in areas that typically have little or no demand, due to power outages and other disruptions. Therefore, it is necessary to ensure a robust supply system that can respond to emergencies. On the premise of the maintenance and management of aging facilities and compliance with relevant laws and regulations, efforts to improve productivity and strengthen competitiveness will be promoted. These include inter-company collaboration, further utilization of digital technologies, and effective use of crude oil through enhanced heavy oil cracking capabilities. These measures will help ensure the stable supply of petroleum products, particularly aviation fuel, which is expected to see increased demand. It is also important to upgrade water drainage facilities at refineries and oil depots to prepare for extreme weather events such as torrential rain and storm surges. Based on the experience of delivering kerosene and other oil products in drums to disaster-affected areas during the 2024 Noto Peninsula Earthquake, installing and upgrading drum filling facilities at refineries and oil depots is a key priority. Furthermore, it is necessary to maintain and strengthen emergency response capabilities by conducting drills for emergency request issuance and response based on requests from ministries and prefectures, as well as joint operation drills based on the oil supply coordination plan in case of a disaster.

The petroleum refining industry has been working toward becoming comprehensive energy companies. Moving forward, it is important to rebuild its business foundation through more proactive development of new business areas, and we will encourage businesses to take on the challenge of developing new capabilities for fuel supply leveraging existing infrastructure, networks, and human resources. Additionally, to achieve a cleaner oil refining process, further improvements in energy efficiency will be pursued, along with decarbonization initiatives such as the use of CO_2-free hydrogen.

(iv) Maintain and strengthen supply network through SSs

A. General remarks

Service stations (SSs) are important and indispensable social infrastructure that support daily life and economic activity through providing vehicle fueling services and delivering kerosene. During the 2024 Noto Peninsula Earthquake, despite sustaining damage themselves, SSs performed an essential role in supplying fuel to emergency vehicles, hospitals, and evacuation centers in areas that were isolated due to road disruptions, and their importance has been reaffirmed. On the other hand, most SSs are operated by small and medium-sized enterprises, and as demand for petroleum products continues to decline due to improved fuel efficiency of passenger vehicles, they face additional challenges such as labor shortages, succession difficulties, and aging facilities. As a result, the number of SSs continues to decrease. Given this ongoing decline, it is an urgent priority to maintain and strengthen the SS network that supports the community not only in normal times but also as a "last resort" in times of disasters.

B. Strengthening the management capabilities of SSs

Only when SSs are managed soundly in normal times can they fulfill their role as the "last resort" during disasters. To maintain and strengthen the SS network, it is essential to secure revenue from their core business of selling petroleum products, enabling them to attract and retain human resources through wage increases and to make necessary capital investments. In addition, efforts should be made to diversify revenue streams and improve operational efficiency beyond petroleum products sales, thereby enhancing the overall management capabilities of SSs. At the same time, while taking into consideration the fact that many SSs face financial and staffing challenges, the Government will mobilize a variety of support measures to encourage efforts to strengthen business operations. These include business diversification, addressing labor shortages through digital technologies, facilitating business succession, M&A, and encouraging the formation of business alliances among SSs. Furthermore, we will be provided to help SSs evolve into "integrated energy hubs" that can supply electricity for EVs, hydrogen for FCVs, and e-fuels and biofuels, while continuing to supply petroleum products.

C. Ensure stable supply through strengthened cooperation with local governments

From the perspective of strengthening the disaster response capabilities of SSs, we will continue to develop core SSs equipped with emergency generators (which provide priority refueling for emergency vehicles) and community-based SSs (which provide fueling for general vehicles). We will also promote regional disaster response drills and the "Full Tank & One Extra Can of Kerosene Campaign" encouraging residents to keep their gasoline tanks full in preparation for emergencies.

In light of the frequent natural disasters that have occurred in recent years, it is necessary for local governments, who play a central role in regional disaster preparedness, and prefectural petroleum associations, comprising many SSs and serving as coordination hubs during emergencies, which will serve as focal point for information on operating SSs during disasters, to work together to ensure a stable supply system that is tailored to regional needs. In addition to signing disaster response agreements, it is important to build communication systems and share information in advance, such as tank capacity, inlet size, and delivery routes, with hospitals, welfare facilities, and evacuation centers, and other important facilities through regular business relationships. In this regard, we will encourage the use of discretionary contracts based on the "Basic Policy on Governmental and Other Public Contracts with Small and Medium-size Enterprises." Moreover, considering risks such as fuel delivery disruptions due to heavy snow or landslides, and damage to equipment and other facilities due to flooding, local governments and petroleum associations will be encouraged to work together to develop plans for the strategic placement of SSs as regional fuel storage hubs and to establish fuel delivery methods during disasters.

To address the issue of depopulated areas with few SSs, it is also necessary to strengthen collaboration with local municipalities. Over the past decade, the number of such municipalities (three or fewer SSs in one municipality) has increased by approximately 100. In addition to the

above efforts, municipalities and SSs in the community, petroleum associations, and various support organizations should strengthen cooperation, including regular communication, so that proactive measures can be taken before SSs close down. When it becomes difficult for private businesses to maintain SSs on their own, the leadership of local municipalities becomes especially important. Local municipalities will continue to support initiatives such as the succession and establishment of SSs as "local community infrastructure" including through "publicly established and privately operated" models, while gaining the understanding and cooperation of local residents.

D. Establishment of a fair and transparent trading structure for petroleum products

Petroleum products are difficult to differentiate quality, and competition tends to be concentrated on price. When understanding the actual distribution of these products, it is important to continue efforts to establish a fair and transparent trading structure, considering the impact of market prices on the SS network and disaster response capabilities. Based on the "Measures against Unjustifiable Discounts and Discriminatory Pricing in the Distribution of Gasoline and Other Products" (Japan Fair Trade Commission) revised in 2022, strict actions will be taken against unfair practices. In addition, we will strive to ensure fair trading practices in line with the "Guidelines for Proper Trading Practices of Gasoline" (Agency for Natural Resources and Energy), which outlines desirable practices regarding wholesale price determination methods and related matters. We will take appropriate measures to deal with a case where a wholesaler, which typically has a superior bargaining position, takes advantage of that position to unilaterally determine trading conditions for SS operators, thereby causing unjust disadvantages contrary to standard business practices, such conduct may constitute a violation of the Antimonopoly Act.

(4) LP gas

LP gas is a decentralized energy source with relatively low greenhouse gas emissions among fossil fuels. It is supplied to approximately 40% of households and has a well-developed stockpiling system. LP gas is portable, easy to store, and does not degrade in quality over time. Over 90% of LP gas imports, accounting for 80% of domestic demand, come from the United States, Canada, and Australia, posing low geopolitical risks and contributing to energy security. It can be supplied anywhere in Japan via cylinders and is also an important energy source as a "last resort" during disasters that can be used as power source in hospitals and other facilities and to improve living conditions in evacuation centers.

Regarding LP gas reserves, in preparation for emergencies and increasing demand in Asia, it is necessary to maintain the current level of reserves, which includes both national and private stockpiles. In collaboration with the LP gas industry and JOGMEC, assuming emergency situations, drills will be conducted for the release of reserves from national storage bases, along with detailed transportation simulations to various regions, In preparation for disasters, we will promote the establishment and enhancement of core filling stations equipped with independent power generation facilities, as well as the buildup of stockpiles at hospitals, welfare facilities,

and evacuation centers such as elementary and junior high school gymnasiums, and the improvement of living conditions by installing generators and gas heat pumps. The "Emergency Petroleum and Gas Supply Collaboration Plan" will be continuously reviewed, and drills based on the plan will be conducted. Additionally, the introduction of smart meters will be encouraged to streamline delivery and strengthen the system to ensure a stable supply even under labor shortages.

In order to reform business practices in the LP gas industry and to ensure consumer trust, new regulations have been established, including restrictions on excessive sales promotion activities. To ensure their effectiveness, we will continue to enforce regulations through market monitoring and oversight in cooperation with related ministries and agencies.

(5) Coal

Based on current technology, coal has the highest greenhouse gas emissions among all fossil fuels. However, it currently poses relatively low geopolitical risks in terms of procurement and offers a relatively low cost per unit of energy. It is also easy to store, making it an important energy source due to its supply stability and cost-effectiveness. Domestic coal, in particular, is not affected by geopolitical risks or exchange rate fluctuations and can be reliably secured. Even as we continue to reduce electricity generation (kWh) mainly from inefficient coal-fired power plants, ensuring a stable supply of coal remains essential. The share of independent development ratio of coal will be maintained at 60% in 2040. Although the ratio is declining due to changes in the procurement environment for steam coal, relatively long-term contracts are considered to contribute to stable procurement. For steam coal, in addition to the independent development ratio, the share of multi-year contracts will be measured as a complementary indicator to ensure stable supply, and necessary policy actions will be taken.

6. CO_2 capture, utilization, and storage

(1) Basic concept

CCUS (Carbon dioxide Capture, Utilization and Storage) refers to the capture, effective utilization, and geological storage of CO_2 generated by hard-to-abate sectors such as steelmaking, cement, chemicals, and oil refining, and power generation. Since these sectors are difficult to decarbonize by conversion to non-fossil energy sources such as electrification, hydrogen, and its derivatives, CCUS is essential for simultaneously achieving a stable energy supply, economic growth, and decarbonization.

CDR[32] (Carbon Dioxide Removal) is considered necessary to achieve carbon neutrality by 2050 as a means of offsetting emissions (residual emissions) from sectors where CO_2 emissions are ultimately unavoidable, even after maximum emission reduction efforts.

(2) CCS

We aim to develop a business environment for launch of CCS projects by 2030 as part of the GX Promotion Strategy. In May 2024, the CCS Business Act was enacted, which stipulates a licensing system for storage business and related operations. Moving forward, specific initiatives will be advanced based on the "CCS Long-term Roadmap."

On the other hand, since the predictability of CCS projects is still low globally, Europe and the United States have implemented support measures focusing on the cost gap between CCS implementation and CO_2 emissions countermeasures, and offering subsidies at relatively high rates. Government support will enable early commercialization of CCS projects, facilitating their transition to self-sustaining operations and the establishment a cost-competitive CCS value chain.

Japan is also aiming to secure 6–12 million tons of annual storage capacity by 2030 through providing integrated support for "Advanced CCS Projects," including reservoir development activities such as exploratory drilling and support across the entire CCS value chain. Based on support measures in other countries and the knowledge gained through the "Advanced CCS Projects," we will consider a support system to encourage investment in the CCS business by operators. This will include perspectives to promote continuous cost reduction and competition among operators, aligned with Japan's geographical situation and energy policy direction. In doing so, we will consider investment promotion measures based on the “Sector-specific Investment Strategies” for CCS, coordination with other schemes such as GX-ETS, J-credits, and the Long-Term Decarbonized Capacity Auction, as well as coordination with discussions on energy and GX industrial location.

By establishing CCS projects early through these support systems and building a globally competitive CCS value chain in Japan, we aim to provide an enabling CCS environment for

[32] Carbon Dioxide Removal (CDR) is a method of removing CO_2 by collecting and absorbing CO_2 from the atmosphere and storing and solidifying it.

Japanese companies, maintain international competitiveness in hard-to-abate sectors such as steelmaking and chemicals, and decarbonization in the energy sector. Additionally, we aim to strengthen the competitiveness of Japanese CCS-related companies in securing contracts for international CCS projects.

To promote cost reduction for the self-sustainability of CCS projects, we will develop optimal separation and capture technologies based on the CO_2 concentration and pressure in exhaust gases. In the transportation sector, we will establish shipping technologies, such as optimal tank design for large-scale ships. In the storage sector, we will advance domestic and international demonstrations aimed at introducing low-cost monitoring technologies.

In addition, expanding CCS projects, it is important to gain local understanding of their significance in achieving carbon neutrality by 2050 and their safety based on scientific evidence, and related consideration. In addition to continuing to promote public understanding, we will advance reservoir development, including potential assessment, with a view to increasing the amount of storage toward 2040.

From the perspective of securing storage capacity, there are overseas areas, such as depleted oil and gas fields, which are already recognized as potential storage sites. If conditions are met, storing Japan's CO_2 overseas using domestic technologies could be a viable option. We will progressively engage in concrete dialogues with relevant countries and conduct joint surveys aimed at securing future storage interests. In some resource-rich countries, governments are beginning to require CCS implementation during upstream development of oil and natural gas. Therefore, from the perspective of securing a stable energy supply, JOGMEC will provide risk capital for overseas CCS projects. Moreover, to add value to overseas CCS projects, we will promote the development of an environment including engaging in discussions with partner countries on the use of the Joint Crediting Mechanism (JCM) and establishing methodologies to reduce greenhouse gas emissions through CCS projects.

(3) CCU/carbon recycling

Among CCU technologies, carbon recycling is a concept to consider CO_2 as a resource and reuse it as materials or fuels through methods such as mineralization and artificial photosynthesis, thereby contributing to CO_2 emission reductions. Based on the "Carbon Recycling Roadmap," Japan will promote technological development, social implementation, international expansion, and the establishment of CO_2 supply chains.

Since products made using carbon recycling technologies are more costly than conventional products, in addition to reducing the procurement cost of hydrogen and CO_2, we will promote technological development to optimize and improve the efficiency of the production. This will be done in cooperation with NEDO and other organizations, utilizing the R&D and Demonstration Base for Carbon Recycling established in Osakikamijima Town, Hiroshima Prefecture. To promote social implementation, it is important to foster inter-industry collaboration between CO_2 emitters and users, and to establish CO_2 supply chains. These initiatives can expand the scale of CO_2 distribution and contribute to future cost reductions,

maximize the CO_2 reduction effects, and support regional revitalization through the development of new industries. Therefore, while maximizing the use of existing infrastructure, we will support the construction of CO_2 supply chains led by local businesses in collaboration with new infrastructure developments such as hydrogen and its derivatives, and CCS. It is also important to clarify the value of CO_2 reductions through carbon recycling. Consideration will be given to incorporating carbon recycling into the Greenhouse Gas Calculation, Reporting and Publication System based on the Act on Promotion of Global Warming Countermeasures, and utilizing J-credits and other mechanisms.

(4) CDR

CDR refers to the removal of CO_2 from the atmosphere by capturing, absorbing, storing, and solidifying CO_2, and is broadly classified into engineering-based approaches and artificially accelerated natural processes. Representative CDR approaches include DACCS (Direct Air Capture and Carbon Storage), BECCS (Bio-Energy with Carbon Capture and Storage), afforestation, reforestation, forest management, biochar, enhanced weathering, and the conservation, restoration, and creation of coastal blue carbon ecosystems (e.g., mangroves, salt marshes, seagrasses, seaweeds).

According to the IEA's research report, "all sources of greenhouse gas emissions must be reduced to zero or offset by CDR in order to limit the rise in global temperatures." Some private sector reports also identify CDR as essential to achieving carbon neutrality by 2050. In hard-to-abate sectors, such as steelmaking, chemicals, cement, and oil refining, and in transportation sectors where electrification is difficult, such as heavy trucks, aviation and shipping, residual CO_2 emissions are expected to remain, making CDR a potentially valuable solution.

Based on the same recognition in Europe and the United States, R&D and large-scale demonstrations of CDR technologies are being supported with a view to creating new industries, and some projects have already begun to be implemented on a commercial basis.

In Japan, a "Study Group for Creating Markets of Negative Emissions Technologies" was established in March 2023. Through discussions with experts and others, the group identified trends in CDR technology and business development, in Japan and abroad, and clarified the elements necessary for industrialization of each technology.

Creating CDR markets requires, (1) create enabling environment for the values of carbon removals to be appraised, (2) creation of CDR markets, and (3) accelerated technological development to increase CDR efficiency.

To create enabling environment, it is necessary to establish methodologies for credit creation. Currently, J-Credits derived from forest management and biochar application, as well as voluntary J-Blue Credits for blue carbon removals are available in the market. For DACCS, a methodology for credit generation has recently been developed. This technology may benefit from the use of decarbonized power sources such as renewable energy and access to abundant CCS-suitable sites overseas. To contribute to Japan’s emission reductions, we will consider developing a system for international transfer of carbon removal values (through bilateral and

multilateral agreements). It is also important to recognize that Japan's advanced technology can be utilized by overseas companies, contributing to decarbonization while enhancing industrial competitiveness.

In order to create a CDR market, we will consider measures to stimulate and expand demand in the public and private sectors, including setting future targets for CDR introduction.

At the same time, to reduce costs and improve efficiency, we will support research and development through initiatives such as the Green Innovation Fund and the Moonshot Research and Development Program.

7. Securing critical minerals

(1) Basic concept

(i) General remarks

Mineral resources are essential materials that support people's lives and economic activities as raw materials for a wide range of industrial products. They are indispensable for the progress of DX and GX, as well as for responding to the anticipated increase in electricity demand associated with these transitions. In addition, securing a stable energy supply of minor metals such as copper and other critical minerals is essential for the production of storage batteries, motors, semiconductors, and other products that are key to the effective use of energy and will also determine the competitiveness of Japanese industries in the future. On the other hand, the situation surrounding critical minerals varies by mineral type, including differences in the geographical distribution of reserves and production areas, the degree of oligopoly in midstream processes, and price stability. Therefore, various supply risks exist from upstream mine development to downstream final product manufacturing.

In addition, domestic nonferrous smelters, as a key element in the supply chain of critical minerals, perform important functions such as supplying high-quality metal ingots, recovering minor metals as by-products of ores by utilizing the domestic smelting network, and recycling used products for resource circulation. However, the environment surrounding nonferrous smelters has become severe due to the declining grade of ores, and intensifying international competition driven by rising demand in emerging countries.

Under these circumstances, the Government has been supporting Japanese companies to secure a stable supply of critical minerals by providing risk capital provided via JOGMEC for acquiring overseas interests, subsidies for mineral resource development projects under the Economic Security Promotion Act, and resource exploration activities. Looking ahead, to ensure a stable supply of mineral resources that are at risk of supply disruption in the future, it is important to take comprehensive measures. These include securing sufficient stockpiles to prepare for supply disruptions, forming upstream development projects in collaboration with like-minded countries, diversifying supply sources through recycling, and ensuring supply at competitive prices based on long-term procurement commitments, including price pass-through mechanisms in midstream and downstream processes. It is also crucial to analyze supply chain risks for each mineral type, and to further advance future policies from both perspectives of economic security and industrial policy.

(ii) Securing stockpiles

Regarding the stockpiling system as a measure to address short-term supply disruptions of critical minerals, we will continuously enhance the stockpiling system to ensure that sufficient quantities while taking into account changes in consumer needs and supply trends specific to each mineral type. To enable agile and responsive management, we will implement flexible

replacement of stockpiled minerals and ensure the system allows for dynamic adjustments in line with evolving supply conditions.

(iii) Diversification of supply sources and other measures

To promote the diversification of supply sources, we will support investment in domestic smelters by using subsidies under the Economic Security Promotion Act. In addition, we will work to maintain and strengthen the domestic smelting network and consider measures to utilize recycled resources. Additionally, we will promote the participation of Japanese companies in upstream projects in frontier regions that are expected to have medium- to long-term potential for expansion. Specifically, we will consider measures to support Japanese companies in acquiring upstream interests in frontier regions, clarify the roles and participation frameworks of the public and private sectors to promote investment in "resource juniors" as a means of strategic seed investment. Additionally, we will explore approaches to utilizing recycled resources, including procurement from overseas sources that can ensure a long-term stable supply.

In parallel with these efforts, in terms of resource diplomacy, we will strengthen resource development in collaboration with like-minded countries such as the United States, Australia, and Canada. We will also enhance relationships with resource-rich countries such as Chile, and frontier regions with country and exploration risks, such Southern African countries. Furthermore, we will develop a comprehensive and integrated resource diplomacy policy, including high-level engagements at the head of state and ministerial levels. At the international level, as discussions progress on the establishment of sustainable supply chains and rule-making at organizations such as the International Organization for Standardization (ISO), we will consider human resource development and the strengthening of the system for this purpose. To implement these initiatives effectively, we will strengthen the function of JOGMEC, which has the capability to provide technical and financial support to Japanese companies. This includes enhancing its role in project coordination and policy intelligence gathering in overseas countries.

(iv) Development of domestic marine mineral resources

Japan's territorial waters and Exclusive Economic Zone (EEZ) contain a variety of domestic marine mineral resources, such as seafloor hydrothermal deposits rich in gold, silver, and copper, cobalt rich manganese crusts, manganese nodules, and rare earth muds. While continuing to monitor the international situation, we will promote efforts to establish technologies such as exploration, ore recovery, ore processing, and smelting, as well as to conduct surveys on reserves and environmental impacts.

(2) Minor metals

Although demand for minor metals is expected to increase, Japan remains heavily dependent on imports from specific countries.

Furthermore, resource development risks continue to rise due to the growing trend of resource nationalism and deterioration of development conditions. In the case of some minor

metals, oligopolistic control by certain countries is expanding, not only in upstream mining but also in midstream processes.

In particular, while Japan is dependent on certain countries for the mining and smelting processes of many minor metals, the number of items subject to government export controls is increasing. Export restrictions were introduced in 2023 for gallium and germanium-related items used in semiconductor materials and graphite-related items used in storage batteries, and in 2024 for antimony and related items. These developments have further increased supply chain uncertainty, including for rare earths and other critical minerals.

In this context, we will not set a uniform self-sufficiency target for minor metals as they are often by-products of base metal production and off-take rights are frequently allocated independently of equity ownership. Instead, we will pursue mineral-specific strategies to ensure a stable supply. On the other hand, for battery metals, rare earths, and uranium, which are indispensable for achieving carbon neutrality by 2050, we will take proactive measures to secure the amount of supply necessary to meet domestic demand by 2030, based on the "Policy for Measures to Ensure Stable Supply of Critical Minerals."

(3) Base metals

Regarding base metals, particularly copper, a representative nonferrous base metal, global demand is expected to increase due to the progress of DX and GX. However, with rising mine development costs, and declining ore grades in Chile, the world’s largest producer to date, supply may fall short of demand. Even when factoring new mine developments and advancements in recycling, there remains a possibility of further increases in copper prices. In fact, the price of copper ingot, which hovered around $2,000/t in the early 2000s, increased to approximately $10,000/t in 2024, about five fivefold increases. In addition, with 65% of global copper ore exports concentrated in China, which is rapidly investing in copper smelter facilities, many countries are intensifying efforts to secure equity interests, including through state-backed enterprises. As a result, the environment for securing equity interests to ensure stable and affordable long-term procurement is becoming increasingly challenging.

Under these circumstances, we will take action to achieve a base metal self-sufficiency ratio of at least 80% by 2030, up from 37.7% as of FY2022.

8. Energy system reform

(1) Basic concept

The Government has been implementing energy system reforms for electricity, gas, and heat, with the aim of ensuring a stable energy supply, curbing electricity rates to the maximum extent possible, and expanding the options for consumers and business opportunities for service providers. Even in the changing economic and social environment surrounding energy, it is necessary to take further steps toward building stable and sustainable energy systems, while reviewing the efforts made to date. In addition, energy companies are once again required to be well aware of their role in supporting people's daily lives and industrial activities, and to conduct appropriate and fair business operations so as not to arouse suspicion from the perspective of compliance with laws and regulations.

(2) Efforts to build a sustainable power system to achieve decarbonization and a stable supply

(i) Future Direction of the Power system

While some progress has been made toward the goals of the electricity system reforms in terms of establishing a mechanism for wide-area electricity interchange, curbing prices through liberalization of electricity retailing, and creating business opportunities, we are facing challenges such as securing supply capacity and surging electricity rates due to sharp increases in international fuel prices and other factors. In addition, there is a need to respond to the growing necessity for carbon neutrality and the possibility of increased electricity demand due to the development of DX and GX. In this context, from the perspective of strengthening industrial competitiveness, it is also becoming increasingly important to secure decarbonized power sources and to supply electricity at prices that are comparable to international prices by curbing fuel costs. Based on these points, the future direction of the power system should focus on addressing three major challenges: achieving a stable power supply that can respond to changes in international circumstances and potential increases in demand, promoting the decarbonization of the power system, and creating an environment where electricity can be supplied to consumers at a stable price level while mitigating the impact on electricity rates caused by ensuring a stable supply, measures for decarbonization, and commodity price increases.

(ii) Challenges the power system faces and response policies

A. Promoting the decarbonization of power sources with a fundamental premise of stable supply

Under the current business environment, the large uncertainty of future electricity revenues, combined with the risks associated with large-scale, long-term investments in decarbonized power sources, is a factor that is causing hesitation in power source investments. So, we will work to develop a market and business environment that can accommodate fluctuations in

revenues and costs associated with changes in market conditions during the project period, as well as a financing environment. Additionally, from the perspective of promoting investment in decarbonized power sources while responding to diverse needs, we will further promote the use of non-fossil certificates and examine how they should be used. In addition, we will steadily promote efforts toward the decarbonization of thermal power generation, and further promote the new construction and replacement of LNG-fired power generation on the premise of future decarbonization, while also monitoring future trends in the supply-demand balance.

In conducting these studies, consideration should be given to the actual conditions of remote islands and other regions that have constraints on power sources and grid sizes, such as being outside the scope of wide-area transmission.

B. Grid development and location guidance for efficient use of power sources and establishment of a flexible supply-demand operation mechanism

In order to promote the development of next-generation electricity networks to ensure stable electricity supply and maximize the use of renewable energy, we will develop inter-regional interconnection lines, and promote grid reinforcement with a view to locating large-scale local demand. To this end, we will create an environment for necessary financing and explore mechanism to encourage advance and strategic grid development.

At the same time, in order to upgrade supply-demand operations amid the massive introduction of renewable energy, we will further improve the operation of the supply-demand adjustment market, and in the mid- to long-term, we will deepen full-scale studies toward the introduction of a market that simultaneously trades electricity and balancing power, taking grid constraints into consideration.

C. Improvement of the retail business environment for the supply of electricity at stable prices through the market

Since the full liberalization of the electricity market, the share of new market participants has reached approximately 20%, and various rate menus and services have been created in response to changes in the environment surrounding the electricity business and the needs of customers. On the other hand, during challenging market conditions, there was a string of exits by retail electricity suppliers, unexpected contract cancellations for customers, and a shift to final guaranteed supply in the extra high-voltage and high-voltage sectors, causing confusion and a certain amount of burden on customers. In addition, it became clear that the rapid fluctuation in electricity prices due to the sharp rise in international fuel prices had an impact on the national economy, and that large fluctuations in prices were socially unacceptable.

In light of the above, retail electricity suppliers are expected to provide electricity to customers at stable price levels, respond to customer needs including decarbonization, and changes in the social environment, and serve as a bridge service provider between power utilities and customers. Therefore, we will develop market environments that enable retail electricity suppliers to demonstrate creativity and innovation. We will also establish systems to ensure necessary discipline.

Specifically, from the perspective of a stable power supply, consumer protection, and suppressing excessive fluctuations in price levels, rules requiring retail electricity suppliers to ensure stable operations. We will also consider mechanisms to encourage compliance with quantitative supply capacity requirements for retail electricity suppliers, taking into account the risks of short-term procurement of supply capacity in spot markets, the impact on fuel supply security, and power source investment, while referencing overseas examples. Additionally, while paying attention to fairness among operators, we will consider expanding and reorganizing trading systems, including bilateral transactions such as long-term physical trades, futures and forward markets, and the baseload market. We will also review the approach to indirect transmission rights in light of these changes in the market environment.

Furthermore, we will consider measures that take into account the fact that many electricity futures trades, a key means of hedging price fluctuation risks, are conducted on commodity exchanges governed by foreign laws. We will also advance the review of rules related to wholesale transactions, such as non-discriminatory access, considering the situation where consumers and regions seek access to decarbonized power sources.

(iii) Future vision of the electricity industry (direction of roles and responsibilities expected of business operators)

The power system is an important foundation for the sustainable development of Japan's industry and economic security, and its decarbonization is the key to achieving GX for Japan as a whole. The power industry, which plays a central role in supporting this, is expected to take on the following roles and responsibilities based on the challenges and response policies faced by the power system as mentioned above: (a) as the entity responsible for the installation of decarbonized power sources and power grid development to achieve a stable supply and decarbonization, (b) as the operator supplying electricity in stable quantities and prices from generation to consumers, and (c) as the energy service provider responding to the diverse needs of consumers.

In fulfilling the roles and responsibilities as the entity responsible for the installation of decarbonized power sources such as renewable energy and nuclear energy, and power grid development, "smooth and stable financing" is necessary. In order to promote decarbonization on the basic premise of a stable supply while meeting future increases in electricity demand, large-scale investments in decarbonized power sources and grids will need to be made continuously over the long term. Therefore, as mentioned above, we will consider measures to facilitate financing for decarbonization investments, such as utilizing public credit guarantees and government-backed loans to cover risks that private financial institutions cannot fully bear.

In addition to investing in decarbonized power sources, and utilizing non-fossil value, it is necessary for electric power companies themselves to enhance profitability and demonstrate growth by expanding internationally, and promoting DX. Among these, the "development of an integrated domestic and international electricity industry" is expected to enhance business stability and profitability through overseas expansion, where demand for electricity is expected to increase. This development will provide opportunities to learn technologies and know-how

in which other countries are outpacing Japan, such as renewable energy and storage batteries, and establish a globally expanding supply chain for fuel procurement. The Government will also promote the international expansion of the power industry by utilizing frameworks such as AZEC.

In fulfilling its role and responsibilities as an operator that supplies electricity stably, the power industry must ensure "responsible business operations for a stable supply." To deliver electricity to customers, numerous business operators are involved in the multiple stages including fuel, power generation, wholesale including transactions through exchanges and intermediary companies, transmission and distribution including supply and demand operations, and retail sales. In order to realize a stable supply, it is important for these businesses to operate and conduct transactions from a medium- to long-term perspective, without being overly influenced by short-term changes in the environment. For this reason, all business operators involved in the electric power business, such as power generation including renewable energy and storage batteries, transmission/distribution and retail are expected to fulfill their respective responsibilities to achieve a stable energy supply.

In particular, General Electricity Transmission and Distribution Utilities are also expected to regularly disseminate information on electricity supply and demand in their areas as neutral and ultimate providers of stable supply, in order to smoothly supply electricity in the face of expected large-scale local demand increases in a short period of time. Furthermore, in order to ensure stable business operations, it is necessary to secure and retain human resources who support the field of the electric power industry in our disaster-prone country, with high reliability, technological accumulation, and commitment to stable supply. It is also important to work on securing and maintaining the supply chain of power equipment that constitutes power plants and systems.

In order to fulfill their roles and responsibilities as energy service providers, it is necessary to "promote the use of distributed energy resources, and digitalization" to meet the diverse needs of the demand side. In the future, as more balancing power is needed, aggregators and other businesses that collectively manage distributed energy resources, such as photovoltaic power generation, storage batteries, and consumer equipment, are expected to contribute to supply and demand operations. To this end, a second-generation smart meter system capable of frequently acquiring multiple types of data such as electricity consumption, as well as gas and water meter data, will be installed for all consumers in principle by the early 2030s. In addition, it is necessary to promote the use of digital technologies such as AI and IoT in the power system, including distributed energy resource, and to take all possible measures to ensure cyber security of these technologies. To this end, the Government will strengthen supply chain resilience, and promote security measures for distributed energy resources, including small-scale photovoltaic power generation.

Based on the results of the review of the electricity system reforms to be compiled by the end of March 2025, the Government will strengthen the structure of organizations such as the OCCTO, which plays a public role in grid development, supply and demand operations, and power source investment from the perspective of ensuring public interest. At the same time, to

address the challenges faced by the power system, the Government will take necessary action for systems and budget measures to achieve both a stable supply and decarbonization, and to promote the activities of the power industry.

(3) The Progress of gas system reform and initiatives toward deepening the system

(i) General remarks

Regarding gas system reform, in order to build a gas system that ensures safe and reliable gas supply and offers consumers a variety of options, including new services, the Gas Business Act was revised to fully liberalization of gas retailing in April 2017. As a result, certain results have been achieved, including the expansion of new market entrants.

In April 2022, the legal separation of the pipeline divisions of major gas utilities (Tokyo Gas, Osaka Gas, and Toho Gas) was implemented to enhance the neutrality and fairness of the pipeline sector, completing a series of gas system reform processes. Under these circumstances, new challenges have emerged, such as achieving carbon neutrality by 2050 and responding to changes in the international LNG supply-demand structure. In addition to further pursuing the results of the system reforms, it is important to construct a gas system that responds to the new challenges, and by March 2027, we will review the gas system reforms to date and take the necessary actions.

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

In addition to further promoting competition to pursue the results of gas system reform, it is important to develop a sustainable and competitive market environment in order to respond promptly to changes in the economic and social environment and strengthen industrial competitiveness.

We will examine a well-functioning competitive market environment that contributes to further expansion of benefits and options for consumers. This will be done while taking into account the progress of measures implemented to date to stimulate competition in the gas business, such as a mechanism to make it easier for new entrants to obtain wholesale supply and the use of LNG terminals by third parties.

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

It is also important to build a gas system that contributes to decarbonization. To achieve carbon neutrality in city gas by 2050, various approaches will be combined, including the introduction of e-methane and biogas. In addition, given the emergence of diverse customer needs for non-price values, such as carbon-free menu options, we will promote the development of an environment that responds to new needs and further stimulates demand.

Regarding the gas calorific value system change, taking into account that e-methane is a promising option for decarbonization, it is necessary to consider various factors such as the cost and transition period, the potential for carbon reduction, and the progress and cost of decarbonization technologies. Based on the comprehensive consideration of those factors, at

this moment, shifting the standard calorific value to 40 MJ/m^3 between 2045–2050 is considered optimal. We aim to finalize the detail of the transition to the new calorific value system by 2030. This transition will be reviewed as part of the gas system reform, taking into account the progress of efforts to achieve carbon neutrality in city gas supply and the status of household fuel equipment adaptation.

(iv) The construction of a gas system that contributes to stable energy supply

It is necessary to comprehensively promote efforts at each stage of the value chain to build a gas system that contributes to a stable supply. In addition to diversification of procurement sources, some companies are engaged in stable and flexible LNG procurement by establishing cooperative relationships in procurement and transportation with other gas and electric utilities. From the perspective of securing a stable supply, as necessary, such inter-operator cooperation should be considered.

Efforts will also be made to contribute to a stable supply, including electricity through the expanded introduction of cogeneration systems. Furthermore, some gas utilities have recently been taken steps to improve security and resilience through the use of digital technology, such as smart meters that enable remote meter reading and remote control of gas valves. Including promotion of the use of such digital technologies, we will work to further enhance system resilience. Moreover, we will promote the development of infrastructures such as the construction of natural gas pipelines, while taking into account the economic feasibility and other factors considered by the operators.

As comprehensive energy companies, gas utilities will provide various energy supply services that meet consumer demands, while strengthening their management base through business diversification. They will also explore international expansion of new businesses and enhance competitiveness through collaboration with companies in various sectors, thereby capitalizing on the growing energy demand in global markets. Furthermore, as locally rooted businesses, gas utilities are expected not only to meet the needs of local consumers but also to ensure a stable energy supply in the regions. They should contribute to regional revitalization through collaboration with local governments and regional companies, and to decarbonization by utilizing local resources such as renewable energy, hydrogen, and biogas.

(4) Promotion of efficient heat supply

Heat system reforms have led to diversification in the forms of heat supply services, such as heating systems with area-wide heat pipe networks, and localized combined heat and power supply designed for individual buildings and essential urban functions in line with urban redevelopment projects. Based on these developments, by promoting the area-wide use of energy such as cogeneration and waste heat, we will contribute to achieving regional energy conservation and securing the flexibility needed for the expansion of renewable energy. Additionally, we will support enhance resilience during disasters and promoting local production and consumption of energy.

For high-temperature application including the industrial sector, it is important to promote the use of cogeneration and waste heat cascades, alongside the development of manufacturing processes technologies and the introduction of equipment to improve energy efficiency. In the low-temperature domain, such as the residential and commercial sectors, it is important to reduce heat demand itself by promoting the adoption of highly energy-efficient buildings, and to promote the spread of energy-efficient technologies such as fuel cells and heat pumps. In addition to these efforts, we will continue to promote the efficient use of heat through regulations under the Act on Rational Use of Energy.

9. International cooperation and coordination

(1) Basic concept

(i) Current resource and energy situation

While global energy demand is expected to increase, movement towards decarbonization is accelerating across the globe. For example, many countries have declared their commitment to achieving carbon neutrality, in response to the growing interest in measures against climate change. On the other hand, significant events affecting the global resource and energy situation are occurring around the world, such as Russia's aggression against Ukraine and the escalating tensions in the Middle East, leading to substantial changes in the current energy landscape.

As a country that lacks fossil resources, it is important for Japan to closely monitor the global energy situation and maintain a comprehensive view of international supply chains. Japan needs to continue to promote international cooperation through various bilateral and multilateral frameworks to ensure a stable supply of resources and energy, stabilize and improve the efficiency of the energy supply-demand structure, and secure energy security. At the same time, it is crucial to actively address climate change.

In this context, toward achieving carbon neutrality, it is necessary to take action in a way that is compatible with economic growth while ensuring energy security and preparing for various risks and scenarios. In light of the fundamental concept of simultaneously achieving energy security, economic growth, and decarbonization, Japan aims to achieve global decarbonization through various pathways, taking into account the different resource endowments, industrial structures, and energy mixes of each country. By leveraging Japan’s advanced technologies, we will also strive to contribute to global decarbonization. In addition, it is necessary to develop comprehensive resource diplomacy to secure stable supplies of oil, natural gas, metal, and mineral resources, as well as future decarbonized fuels and technologies, such as hydrogen and its derivatives, and CCUS/carbon recycling, in an integrated manner.

(ii) International deployment of decarbonization technologies and rule-making and technical cooperation for decarbonization

It is important to contribute to global decarbonization, especially in Asia, which accounts for more than half of global CO_2 emissions. Since Japan has technological advantages, it can implement more cost-effective measures abroad than domestically. Therefore, by promoting the dissemination of leading decarbonization technologies and implementing measures in developing countries, we will quantitatively evaluate our contributions to the achieved greenhouse gas emission reductions and absorptions. Additionally, we will work on the establishment and implementation of the Joint Crediting Mechanism (JCM) that contributes to achieving our greenhouse gas emission reduction targets.

Additionally, to ensure that the environmental value of Japan's products and services contributing to decarbonization is recognized internationally, we will actively participate in or cooperate on the elaboration and dissemination of international rules regarding CFP and

indicators focused on emission reductions (such as reduced emissions and avoided emissions) pursued under initiatives such as AZEC, the GHG Protocol, ISO, and industry-specific international initiatives.

Moreover, while keeping an eye on the future emergence of the hydrogen market, we will actively work on the elaboration of international standards and rules to establish a hydrogen trade based on carbon intensity, an issue highlighted in the Leaders' Communiqué of the G7 Hiroshima Summit. Ensuring the security of gas, which plays a role in an orderly energy transition, is important for decarbonization, and Japan will work on research including the gas reserve mechanism with the IEA. In addition, we will promote technical cooperation for innovation and social implementation in a wide range of clean energy fields—including next-generation technologies, hydrogen, ammonia, CCUS/carbon recycling, and nuclear energy — contributing to global decarbonization through the dissemination of Japan's advanced technologies.

(iii) External communication of information on Japan's initiatives

It is also important to promote the dissemination of information about Japan's advanced initiatives in the resources and energy fields to the international community. Japan will implement and exhibit its cutting-edge technologies that contribute to achieving carbon neutrality at the Osaka-Kansai Expo as a platform for external communication. Additionally, we will communicate information on Japan’s practices towards GX by actively utilizing international conferences such as the Asia Green Growth Partnership Ministerial Meeting, ICEF (Innovation for Cool Earth Forum), RD20 Conference, Hydrogen Energy Ministerial Meeting, International Conference on Carbon Recycling, LNG Producer-Consumer Conference, and GGX Finance Summit.

(2) Cooperation and coordination with other countries

(i) General remarks

Japan needs to develop not only its domestic market but also overseas markets, leveraging economies of scale to reduce costs and strengthen the competitiveness of domestic industries. Additionally, it is also essential for Japan to attract foreign capital, technology, sales channels, and management expertise. In addition, in order to further stabilize and streamline the energy supply-demand structure of each country under the changing global energy situation, it is important to expand international cooperation, not only through unilateral efforts but also through a strategic combination of bilateral and multilateral energy cooperation. Therefore, Japan will further strengthen and develop bilateral relations with developed countries such as those in Europe and the United States, emerging Asian countries, and resource-rich countries in the Middle East and others. We will also enhance cooperation with international organizations such as the IEA, IAEA, International Renewable Energy Agency (IRENA), Economic Research Institute for ASEAN and East Asia (ERIA), and contribute to international and regional frameworks such as the G7, G20, Asia-Pacific Economic Cooperation (APEC), and Indo-Pacific Economic Framework for Prosperity (IPEF), as well as initiatives under AZEC.

(ii) Contribution to GX in Asia

As many countries in Southeast Asia depend on thermal power generation for the majority of their electricity and the manufacturing sector plays a large role in their economies, they face common challenges in achieving decarbonization. Japan proposed the AZEC in 2022 to advance decarbonization in Asia in a pragmatic manner through a variety of pathways tailored to each country's circumstances.

Under the AZEC principles of "simultaneously achieving decarbonization, economic growth, and energy security" and "achieving net zero emissions through various pathways," we will promote individual projects and rule-making in accordance with the "Action Plan for Next Decade" adopted by the leaders of AZEC partner countries in October 2024. Efforts toward rule-making are important for continuously formulating decarbonization projects and enabling various decarbonization technologies to disseminate autonomously. For example, through AZEC Japan will promote the visualization of greenhouse gas emissions throughout the supply chain, and advance transition finance in collaboration with institutions like the Asian Development Bank (ADB), centered around initiatives such as the Asia Transition Finance Study Group (ATF SG) led by private financial institutions.

Japan will promote initiatives in high-emission sectors such as electricity, transportation, and industry, which are major emitters of greenhouse gases through AZEC. Specifically, in the electricity sector, we will promote zero-emission thermal power generation by utilizing various technologies, such as hydrogen and its derivatives, CCUS, and biomass, considering the circumstances of each country, and will also promote initiatives to maximize the use of renewable energy. In the transport sector, we will promote the use of sustainable fuels by securing raw materials and building Asia-centered supply chains. In the industrial sector, we aim to decarbonize industrial parks and build a next-generation automobile industry that utilizes EVs and sustainable fuels. These efforts will be promoted in cooperation with the Asia Zero Emission Center established at the ERIA.

In addition, we will strengthen energy cooperation and external communication centered on the AZEC in collaboration with the Asia Energy Transition Initiative (AETI) through supporting the formulation of decarbonization roadmaps and knowledge sharing on decarbonization technologies, and public-private partnerships such as the AZEC Advocacy Group and the Cleaner Energy Future Initiative for ASEAN (CEFIA). Moreover, in the clean economy sector of the IPEF, we will organically develop cooperative activities in areas such as hydrogen and clean power, taking into account the interests of each country.

(iii) Strengthening cooperation with developed countries—including the United States and Europe—in pursuit of carbon neutrality

Together with the United States and other advanced countries in Europe, we will promote innovation in the fields of energy and environmental technologies, and support efforts toward decarbonization in third countries, including emerging economies, in order to achieve global carbon neutrality.

Japan and the United States will work toward strengthening cooperation in a wide range of areas, including cooperation to ensure energy security. For example, we will pursue cooperative initiatives in a wide range of areas, including energy security and energy technology, while taking into account the progress of Japan's GX Promotion Strategy and trends in the U.S. energy policy.

Between Japan and the European Union, we will strengthen cooperation in renewable energy, hydrogen, CCUS/carbon recycling, nuclear energy, natural gas, and other areas under the Japan-EU Green Alliance.

(3) Comprehensive resource diplomacy

In promoting comprehensive resource diplomacy, Japan will actively engage not only through traditional bilateral frameworks but also through multilateral frameworks. These efforts will include shaping international public opinion on the necessity of energy transition and resilience enhancement, forming concrete cooperation projects on decarbonized fuels and technologies, fostering innovation with relevant countries for the decarbonization of fossil fuels, and actively participating in the formation of rules for methane measures, low carbon certification, and credit trading, through multilateral frameworks in addition to traditional bilateral frameworks. To facilitate the introduction and expansion of decarbonized fuels and technologies such as hydrogen and its derivatives and CCUS, which are the key to the realization of a carbon neutral society, we will also utilize the networks with resource-rich countries and consumer nations, including those in Asia that we have cultivated through our oil and natural gas resource diplomacy. Japan's oil and natural gas development companies are expected to continue to be the main players in the supply of decarbonized fuels and technologies.

VI. Innovations to achieve carbon neutrality

1. General remarks

Japan aims to achieve carbon neutrality by 2050 by simultaneously ensuring a stable energy supply, economic growth, and decarbonization, and it is necessary to promote decarbonization while maintaining the level of economic activity.

For this purpose, it is crucial to significantly reduce the costs of GX-related technologies, which include decarbonized power sources like renewable energy and nuclear power, energy-saving technologies such as energy-efficient semiconductors and photoelectric fusion technology, next-generation fuel technologies like hydrogen and its derivatives required for shifting to non-fossil fuels, and carbon capture and removal technologies like CCUS and DACCS.

In Japan, the Sunshine Plan led by NEDO has contributed to reducing the cost of solar cells to 1/250 over the past 30 years. Therefore, it is necessary to continue leveraging GX-related technologies owned by Japanese companies and pursue further innovation.

Japan has had a bitter experience of "excel in technology but fall behind in business. In order to "excel in technology and also succeed in business" it is also necessary to link innovation to business by sharing a clear international strategy among industry, academia, and government.

Through such efforts toward reducing global greenhouse gas emissions, it is critically important to reduce the costs of socially implementable technologies through discontinuous innovation as early as possible and establish them as economically viable businesses.

In Japan, toward creating such discontinuous innovation, it is necessary to utilize all cross-sectoral policy tools, including budget, tax, finance, regulatory reform, and standardization. Additionally, we support the innovations in GX-related technologies by utilizing the Green Innovation Fund and the GX Economy Transition Bonds. In doing so, it is essential to develop overseas markets and to promote strategic international standardization of technologies and systems from the R&D stage through public-private partnerships in order to increase certainty.

2. Detailed explanation

(1) Renewable energy

Promoting the expansion of domestically produced renewable energy and enhancing technological self-sufficiency will contribute to reducing greenhouse gas emissions toward achieving carbon neutrality by 2050 and strengthening Japan's industrial competitiveness. To this end, we will promote the development and deployment of next-generation renewable energy technologies. At the same time, we will advance, we will advance the development of inter-regional interconnection lines based on the Master Plan of Nation-wide Power Transmission Networks. We will also promote the development of next-generation storage batteries for balancing renewable energy supply and demand, and the social implementation of smart energy management systems.

Regarding next-generation solar cells, the goal is to introduce approximately 20 GW by 2040, promoting the early social implementation of perovskite solar cells. Looking ahead to 2050, we will accelerate the development of innovative technologies such as tandem cells through demonstration projects and other initiatives. Furthermore, we will steadily advance the R&D and demonstration of space solar power generation systems (SSPS).

Regarding floating offshore wind power, we will strengthen the domestic supply chain through technological development and promote its wider adoption, including in the exclusive economic zone. We aim to make it an economically viable power source by 2050, including the costs of grid and balancing power.

Regarding next-generation geothermal power generation, we will promote the development and deployment of supercritical geothermal power generation and closed-loop geothermal systems to maximize the use of Japan's geothermal power potential.

Regarding balancing power and smart energy management systems, we will promote the technological development to utilize decarbonized balancing power through storage batteries and hydrogen and its derivatives, and the development of next-generation inverters that support grid stability. In this way, by combining various distributed energy resources, we aim to enhance the flexibility and stability of the power system.

(2) Nuclear power

Regarding next-generation advanced reactors, they offer not only enhanced safety but also features such as decarbonized power supply, distributed energy supply, waste volume reduction and hazard mitigation, and carbon-free hydrogen and heat supply. Each reactor type has its own characteristics, and the Government will work towards their practical implementation. Taking into account differences in applications, development stages of each reactor type, and societal needs, the Government will promote research and development, facilitate technology deployment, and improve common understanding with regulatory authorities. This will be done

through collaboration among industry, academia, and government, utilizing international cooperation as well.

Small modular reactors are aimed at systems that enable core cooling without cooling pumps or external power sources through natural circulation by taking advantage of their small power output. In the United States, Canada, and other countries, there is a growing need for decarbonized and stable power sources for electricity-intensive facilities such as data centers, and a project involving Japanese companies is underway to implement this technology before 2030. Moreover, various new reactor types, including small reactors other than light water reactors, are being developed by start-ups. To secure options for Japan’s future energy needs, the Government will support the participation of Japanese companies in overseas projects and research and development that utilize Japanese technology. This will help maintain and strengthen Japan's industrial foundation.

Fast reactors are expected to enhance the effectiveness of the nuclear fuel cycle, which contributes to the reduction of high-level radioactive waste volume and hazardousness and to the effective use of resources. Additionally, they can be designed with high safety features such as stable air-cooling. Regarding the development of demonstration reactors, under the supervision of an integrated research and development organization that brings together engineers from JAEA, nuclear operators, and core companies, the Government will engage in intensive research and development of the entire reactor and fuel cycle, utilizing technical knowledge from international cooperation with like-minded countries such as the United States and France. In parallel, the Government will address medium- to long-term issues such as the establishment of a project management structure and safety design approach beyond the basic design stage, through collaboration among industry, academia, and government. Regarding the prototype fast breeder reactor Monju, the Government will prioritize safety and proceed with responsible and planned decommissioning. Furthermore, the Government, with the cooperation of the local community, will develop the Tsuruga area in Fukui Prefecture as a central research and development hub for nuclear and energy. The knowledge and technologies obtained from the Monju project and the operation of the experimental fast reactor Joyo, the Government will effectively utilize to the maximum extent in future fast reactor research and development including demonstration reactors.

As for the high-temperature gas-cooled reactors (HTGR), they are expected to contribute to the decarbonization of materials industries such as steelmaking and chemicals through the provision of quasi-domestic carbon-free hydrogen and heat supply by utilizing high-temperature heat. The High-Temperature Engineering Test Reactor (HTTR) has achieved the world's first generation of 950°C high-temperature heat, which can be used for carbon-free hydrogen production. In March 2024, it successfully conducted a demonstration test, which was also the first of its kind in the world, confirming that even if the reactor could not be cooled during 100% reactor output operation, the reactor output would naturally decrease and maintain a stable state. Based on the results of the HTGR research and development that have been accumulated so far, the Government will take on the further challenge of conducting hydrogen production tests using the HTTR. Utilizing international cooperation with like-minded

countries such as the United Kingdom, the Government will advance the development of demonstration reactors through broad collaboration with the industrial sector, involving industry, academia, and government.

Regarding fusion energy, based on the "Fusion Energy Innovation Strategy," the Government aims for early realization and industrialization. The Government will maximize the use of technologies and human resources developed through the International Thermonuclear Experimental Reactor (ITER), the JT-60SA superconducting tokamak, and other projects. To enhance technological maturity, the Government will strengthen the research and development capabilities of both the public and private sectors, including startups. Aiming for the world's first power generation demonstration, the Government will promote the development of prototype reactors and promote initiatives using various methods such as tokamak, helical, and laser types. At the same time, the Government will work on studies for ensuring safety through scientifically rational and internationally coordinated measures.

(3) Next-generation electricity network (grid and balancing power)

Based on the Master Plan of Nation-wide Power Transmission Networks, we will steadily advance the development of inter-regional interconnection lines and the reinforcement and renewal of domestic trunk systems, with a view toward the deployment of renewable energy by 2050. As the introduction of renewable energy expands, we will deepen the necessary considerations regarding the rules for grid connection and utilization. To secure decarbonized balancing power and improve the flexibility of the power system, we will promote the widespread adoption of products equipped with DR-ready functions, and further expand the use of DR through device control using smart meters. Furthermore, we will improve electricity storage technologies, such as storage batteries, and aim to introduce electricity storage systems (LDES [33]) featuring long-term energy storage and are expected to become increasingly necessary as renewable energy continues to expand.

(4) Next-generation energy

In order to expand the medium- to long-term utilization of hydrogen and its derivatives toward 2050, steady research and development of innovative technologies in the fields of "production," "transportation and storage," and "utilization" through collaboration among industry, academia, and government is essential. For "production," we will work on the development of high-efficiency, high-durability, and low-cost water electrolysis technology, hydrogen production technology utilizing high-temperature heat sources such as direct thermal decomposition of methane (turquoise hydrogen) and high-temperature gas-cooled reactors, natural hydrogen, hydrogen production ships, hydrogen production technologies using photocatalysts, innovative ammonia synthesis technologies, e-fuel production technologies, and advanced methanation technologies. For "transportation and storage," we will work on technologies such as high-efficiency hydrogen liquefiers, hydrogen storage alloys, cost

[33] Abbreviation for Long Duration Energy Storage.

reduction of hydrogen carriers, and ammonia cracking technologies. In the area of "utilization," we will promote the development of co-firing and mono-firing hydrogen power generation technologies for hydrogen and its derivatives, as well as manufacturing technologies for fuel cells which are highly efficient, highly durable, and low-cost.

(5) CO_2 separation, capture, and absorption

In order to introduce CO_2 separation and capture facilities, it is important to further reduce costs and space requirements. We will promote the practical deployment and social implementation of separation and capture technologies tailored to the conditions of each type of exhaust gas by utilizing new methods such as membrane technology. Through these efforts, we will further strengthen the competitiveness of Japanese companies which currently have a competitive edge in the field of CO_2 separation and capture plants. By supplying CO2 as a raw material at a low cost, we will also promote the social implementation of carbon recycling. Despite these emission reduction efforts, residual greenhouse gas emissions are expected to remain. Therefore, the introduction of CDR is required to achieve carbon neutrality by 2050. Further cost reductions and large-scale deployments are necessary in this field. By leveraging Japan's technological strengths, we will promote commercialization and the development of business models, thereby enhancing the competitiveness of Japanese companies. This includes utilizing overseas resources rich in renewable energy and suitable for CCS sites.

(6) High emitters

(i) Steelmaking

In the steelmaking industry, the current blast furnace method, which reduces iron ore using coke (coal), inevitably generates a large amount of CO_2 emissions. However, from the perspective of supply and demand, steel production through the reduction of iron ore will continue to be necessary. Therefore, we will promote both technological developments to reduce CO_2 emissions during the reduction process and promote investment in decarbonization. Specifically, we will advance the technological development such as hydrogen reduction using the blast furnace method and direct hydrogen reduction. In parallel, we will also promote investment in innovative electric furnaces which are capable of producing steel for multiple uses including automotive use. In addition, we will work to expand the use of green steel, produced by facilities where decarbonization investment has been made.

(ii) Chemicals

To achieve carbon neutrality by 2050, we will steadily promote "fuel switching" in heat sources of naphtha cracking furnaces and coal-fired power generation, and "feedstock switching" from naphtha-derived raw materials. At the same time, we will encourage the social implementation of new technologies that are being developed through the Green Innovation Fund, and increase the supply of market-oriented chemicals by transitioning to a robust supply chain that will facilitate the production GX products beyond the scope of existing supply chains.

Through these efforts, we will enhance the value of the entire value chain, including the automobile and semiconductor industries.

(iii) Cement

To achieve carbon neutrality by 2050, we will promote "fuel switching," which involves switching fuels in the calcination process and coal-fired power generation to waste materials and biomass, and secure the supply capacity of green cement by utilizing CO_2 capture technologies and carbonation technologies using diverse calcium sources developed through the Green Innovation Fund. At the same time, the cement industry will continue to play a key role in a circular economy by efficiently utilizing waste as fuel and raw materials, such as by accepting and processing disaster waste.

(iv) Paper and pulp

To achieve carbon neutrality by 2050, we will promote "fuel switching," such as replacing coal-fired power with black liquor (a byproduct of pulp production process), and expand business development into the pulp-based biorefinery industry. These efforts aim to simultaneously achieve decarbonization and enhanced industrial competitiveness. Especially, in the biorefinery business, we will promote collaboration between the paper and pulp industry and other industries, such as chemical manufacturers, to build a new supply chains and secure a supply system that can achieve economies of scale. By maximizing the strength of domestically procured pulp, we will ensure a stable supply of bioethanol and other products, thereby contributing not only to the decarbonization and industrial competitiveness of the paper and pulp industry, but also that partner industries.

(7) Semiconductor and digital industries

Semiconductors are essential strategic materials in DX, GX, and economic security. With the further advancement of digital technologies such as AI and autonomous driving, global demand for semiconductors is expected to increase.

Especially, with the advancement of AI utilization in both cloud and edge environments, semiconductors are anticipated to be integrated into products that currently do not contain them. Furthermore, even in existing products will likely require a greater number of semiconductors will increase, and their performance will be upgraded. Consequently, not only will higher performance be required, but demand is also expected to grow for high value-added semiconductors that can help reduce the extent of the anticipated increase in electricity consumption. To address the increase in electricity demand, in addition to utilizing most advanced semiconductors, we will pursue substantial improvements in energy efficiency at data centers by leveraging cutting-edge semiconductors, alongside the development and deployment of advanced information processing technologies such as photoelectric fusion, and state-of-the-art ancillary facilities, including liquid cooling technology.

Moreover, by utilizing AI and digital technologies, we will advance the development of technologies for energy efficiency improvement as discontinuous systems, enabling

optimization across multiple devices, entire factories, and inter-factory operations through automatic control.

From the perspective of economic security, it is essential to strengthen the resilience of the semiconductor supply chain. This will involve either building a domestic supply system or continuing collaboration among like-minded countries and regions.

(8) Storage battery industry

Storage batteries are indispensable for the realization of carbon neutrality by 2050, including the electrification of mobility and the expansion of renewable energy. It is important for Japan to become a key player in the global supply chain of storage battery. We will advance the establishment and strengthening of the domestic manufacturing base for batteries, components and materials, and production equipment, required from the perspective of economic security. Additionally, we will promote efforts to enhance the presence and competitiveness of Japan's battery-related production and technology in the global market. We will promote efforts to strengthen the global supply chain, including reducing dependence on specific countries, and to acquire markets through the development of next-generation battery technologies. We will also promote the development and retention of related human resources. In addition, through the establishment and full-scale operation of a reuse and recycling system for storage batteries, we will aim for resource circulation and the securing of resources such as minor metals.

(9) Resource recycling industry

We will promote mechanisms to encourage the use of recycled materials, establish certification systems for advanced environmentally friendly designs, and advance businesses related to reuse. Additionally, we will foster high-value-added resource recycling industries and establish information sharing platforms. To ensure the quality and quantity of recycled materials, we will continue to innovate in sorting and recycling technologies, and technologies to improve the quality of recycled materials. We will also promote the creation of resource circulation networks and major recycling facilities to realize an advanced resource recycling system. Through these efforts, we will further promote a virtuous cycle between the environment and the economy. In addition, we will expand the resource recycling technologies and systems established domestically into overseas markets, particularly in Asia, and realize the construction of an international resource recycling system with Japan as a hub. By all these efforts, we will establish ourselves as a frontrunner in the global circular economy (CE) business market and create a world-leading recycling business model by contributing to carbon neutrality.

(10) Bio-manufacturing

Bio-manufacturing is expected to contribute to achieving carbon neutrality and addressing various social issues by producing valuable materials through biological processes at ambient temperature and pressure, using biomass that contributes to the recycling of CO_2 emitted from daily life and economic activities, as well as CO_2 captured directly from the atmosphere. Taking

into account the specific social challenges of each industrial sector and the optimal applications of bio-manufacturing, we will facilitate its integration across a wide range of industries.

Specifically, we will promote rulemakings to facilitate the expansion of domestic and international market share for products developed via bioprocesses that utilize CO_2 and unused biomass through initiatives such as the Green Innovation Fund and the Bio-manufacturing Revolution Promotion Project. By advancing these products－which have low environmental impact based on LCA[34] and are developed at costs no more than 1.2 times those of conventional alternatives－as substitutes for petroleum-derived products, we will accelerate the shift away from excessive dependence on petroleum. In addition, we will promote the development of contract manufacturing services in Japan and overseas for bio-foundries design platforms for microorganisms and cells, including hydrogen-oxidizing bacteria, currently under development.

(11) Agriculture, forestry and fisheries and the industry

Based on the "MIDORI Strategy for Sustainable Food Systems" (May 2021), we will promote the development and the social implementation of innovative technologies and production systems throughout the supply chains, from inputs, production, processing and distribution to consumption, with the aim of achieving zero CO_2 emission in the agriculture, forestry and fisheries sector by 2050.

Specifically, we will strongly promote the electrification and fuel cell use for agricultural and forestry machinery and fishing vessels, the introduction of fossil fuel-free horticultural facilities, the reduction of greenhouse gas emissions from agriculture and livestock sectors, greenhouse gas sequestration measures, such as sequestrating carbon into farmlands and oceans, the establishment of energy systems based on local production and consumption, tailored to rural areas, etc. In addition, with regard to forests and timber, we will ensure carbon sequestration of forest through appropriate forest management such as reforestation, the development and expanded use of construction materials for wooden high-rise buildings and new wood-based chemical materials, and other timber-based decarbonization efforts.

(12) Transportation and infrastructure

(i) Automobile

In the automobile sector, we aim to achieve zero CO_2 emissions throughout the life cycle of automobiles by 2050 through the pursuit of a variety of options. To this end, we will promote the decarbonization of manufacturing processes for automobiles and related components, the development of technologies to enhance the performance of batteries and motors, the expansion of biofuel adoption, and the stable supply and cost reduction of e-fuels and low-carbon hydrogen, and the secondary use and recycling of batteries, as well as the supply and utilization of recycled materials. We will also accelerate the widespread deployment of electrified vehicles, charging and hydrogen refueling facilities, and power supply facilities from vehicles. At the

[34] Abbreviation for Life Cycle Assessment.

same time, we will build a decarbonized supply chain that includes the participation of medium-sized and small suppliers.

(ii) Aircraft

Focusing on the expanding single aisle aircraft market in the Asia-Pacific region, we will work to increase the participation rate of Japan's aircraft industry and expand its market presence. In the airframe business, we will participate in single aisle aircraft technological development employing new environmental technologies, including subsystems and business integration. In the engine business, leveraging new technologies such as ultra-high efficiency propulsion systems and hybrid electric propulsion systems, as well as a Japan's robust domestic supply chain, we will collaborate with overseas aircraft manufacturers from the upstream stages of development, including conceptual design. Furthermore, based on our comprehensive business capabilities, including the MRO [35] business, which is becoming increasingly important as the aircraft market grows, we will engage in the airframer business of next-generation aircraft that utilize innovative technologies such as lightweighting, high efficiency, electrification, and hydrogen utilization to contribute carbon neutrality, in collaboration with international partners.

(iii) Maritime

Based on the greenhouse gas emission reduction targets from international shipping agreed upon at the International Maritime Organization (IMO), we aim to reduce greenhouse gas emissions by 70–80% from 2008 levels by 2040, and to achieve zero emissions around 2050. Therefore, we will further promote the switching from fossil fuels to decarbonized fuels, and the expanded use of battery-powered vessels, which are expected to make significant progress. Additionally, we will strategically lead the formulation of international rules at the IMO to respond to the emergence of new energy sources and technologies. In addition, we will promote the technological development for improving energy efficiency in ships, which will become increasingly important after the fuel transition, we will further strengthen the industrial base of Japan's shipbuilding and marine industries to ensure global leadership in the supply of next-generation vessels. Through these efforts, we will ensure the high competitiveness and stable position of Japan's maritime industry in a global market where fuel and decarbonization have become mainstream.

(iv) Logistics, passenger service, and railroad

To promote green logistics, we will advance efforts to optimize transportation efficiency throughout the supply chain by utilizing new technologies such as AI and IoT. We will promote measures to improve road traffic flow, encourage the widespread adoption of double articulated trucks, and support the development of automated logistics roads to enhance logistics efficiency. In the passenger transport sector, we will promote the use of regional public transportation by ensuring its availability and improving its convenience. In the railway sector, we will work to

[35] Abbreviation for maintenance, repair and operations, a generic term for materials purchased and procured by companies.

expand the deployment of hydrogen fuel cell-powered railcars and other next-generation rolling stock.

(v) Infrastructure (ports, roads, dams, water supply, and sewage systems, and other facilities)

We will promote the development of "compact plus network" urban structures, and the decarbonization of urban areas on a district-by-district basis. We will also advance the development of evaluation methods for green infrastructure and promote the use of green finance. In the water supply sector, we will install energy-saving equipment, introduce renewable energy generation facilities, and optimize facility location. In the sewage sector, we will develop new water treatment technologies and further advance energy conservation. In the public works, we will promote the introduction and dissemination of construction machinery using new power sources and decarbonized construction materials. Each road manager will collaborate to promote the decarbonization of road infrastructure. In the port sector, we will promote Carbon Neutral Port initiatives by developing environments for receiving hydrogen and its derivatives, taking into account supply and demand trends and technological advancements expected beyond 2040.

(13) Region and lifestyle (including housing and buildings)

We will promote innovation by aiming to implement advanced decarbonized products and technologies led by local governments to contribute to regional decarbonization. We will also promote innovation to stimulate domestic demand for GX-related products. These efforts aim to achieve community-based and locally-beneficial decarbonization across many regions, thereby contributing to regional revitalization.

Housing and buildings are key sectors for achieving carbon neutrality in the residential and commercial sectors. From the perspective of advancing zero-energy buildings that do not rely on external energy as much as possible, it is necessary to achieve self-consumption housing and buildings with higher energy efficiency standards and advanced energy management including DR systems. To this end, we will promote innovation towards next-generation solar power generation systems, high-efficiency water heaters, advanced building materials, storage batteries, charging and discharging equipment for electrified vehicles, cost reduction, and the development of compact systems suitable for installation in limited spaces.

VII. Communication with various sectors of the public

1. General remarks

Energy is closely related to our daily lives, and the choices we make about energy today shape our future. For this reason, it is of utmost importance for each citizen to have a sense of ownership regarding energy policy. The Government to promote understanding among various sectors of the public through transparent information disclosure and foster interactive communication.

2. Promote an understanding of energy among various sectors of the public

(1) General remarks

Japan aims to reduce its greenhouse gas emissions by 46% in FY2030, and will strive towards a 50% reduction. Furthermore, we have set ambitious targets of a 60% reduction in FY2035, a 73% reduction in FY2040, and carbon neutrality by 2050. In order to achieve carbon neutrality, it is necessary to transform our entire economic and social structures centering around fossil energy sources into ones based on clean energy. This transition will inevitably entail a thorough overhaul of industrial structure and social systems.

Toward 2040, further decarbonization will require the introduction of measures with relatively high marginal abatement costs for greenhouse gases, which is expected to increase the cost burden on the public.

In this period of energy transition, it is essential for all companies and citizens to recognize the energy situation as a "personal matter," understand its specifics, and take action accordingly.

For all segments of society to deepen their understanding of energy and make appropriate choices, transparent information disclosure by the Government is important. In this context, a major obstacle in the past was the existence of the "myth of safety" held by the Government and industry. The myth created the impression that meeting the standards and conditions set by the Government and industry would eliminate all risks, discouraging further management. Public communication on energy issues prior to the accident at TEPCO's Fukushima Daiichi Nuclear Power Station failed to correct this perception, and after the accident, the Government and nuclear operators faced significant criticism for inadequate information sharing and lack of awareness regarding communication with host communities. The Government deeply regrets this and is making efforts to establish a system for providing objective and diverse information based on scientific knowledge and data. This will enable the public to access and utilize appropriately organized information aligned with their interests. The Government must also continue to provide information related to energy policy, such as basic terminology, current trends, and relevant topics, in a clear and accessible manner. It will also be important to provide the rest of the world with accurate information on Japan's energy situation and progress toward decarbonization.

(2) Public relations regarding energy

Since the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, public interest in energy policy has increased. Public relation about energy is important for all levels of the public to deepen their understanding and to make appropriate choices.

To this end, we will proactively and clearly disseminate information both domestically and internationally using various media, including pamphlets and the website of the Agency for Natural Resources and Energy. We will also actively provide information to the media, private

research institutes, and non-profit corporations, allowing third parties to share information in various forms based on their unique perspectives. This will help creating an environment where energy-related discussions are widely conducted across the country.

(3) Energy education

In order to foster interest in energy and deepen public understanding, it is also important to provide opportunities for children to learn basic knowledge about energy in school education. Through such efforts, understanding the energy situation from a young age will be beneficial for making appropriate decisions when they become adults and take an active role in making energy choices.

The discussions about energy, as represented by the principle of S+3E, involve trade-offs between multiple values and do not have a single "correct" answer. This makes it a valuable theme for children to deepen their own thinking. Therefore, providing educational opportunities focused on energy and encouraging children to engage in discussions with teachers and community members can help them deepen their thinking and exploration, while also connecting it to their career development. These activities could eventually lead to an increase in the number of students who study energy as a specialized field in higher education level and contribute to the development of human resources who will support the future energy supply-demand structure.

Based on these points, we will create and improve lesson plans and various content related to energy education, including topics such as energy efficiency. These will be provided through websites and printed materials. We will also support the creativity and voluntary efforts of teachers and others involved in energy education across the country.

3. Transparency in policy-making process and enhancement of interactive communication

In order to enhance interactive communication about energy policy, it is important to increase transparency in the policy-making process and gain public trust in the Government. We will maximize openness and transparency in the policy-making process through councils and other bodies.

Especially, energy policies can be technical and complex, which can hinder public understanding. Therefore, it is important not only to convey information unilaterally but also to deepen careful dialogue across the country. This includes the utilization of local energy resources with diverse stakeholders and leveraging collaboration between industry, academia, and government, and we will continue to promote such initiatives. There are also various perspectives among young people, for example, differing opinions on decarbonized power sources such as nuclear energy, views that prioritize climate change, and others that emphasize future economic growth. Therefore, it is necessary to enhance communication with a wide range of people, including young people.