



Japan Credit Rating Agency, Ltd. (JCR) announces the reviewed Climate Transition Bond Evaluation Results as follows.

## The Government of Japan

### Japan Climate Transition Bond (FY2023)

#### Affirmation



Issuer	The Government of Japan
Subject	10-year Japan Climate Transition Bonds (1 <sup>st</sup> ) 5-year Japan Climate Transition Bonds (1 <sup>st</sup> )
Type	Interest-bearing government bonds
Issue Amount	10-year bonds: JPY 799.5 billion 5-year bonds: JPY 799.8 billion
Interest Rate	10-year bonds: Nominal Coupon 0.7% (per annum) 5-year bonds: Nominal Coupon 0.3% (per annum)
Auction Date	10-year bond: February 14, 2024 5-year bond: February 27, 2024
Redemption Date	10-year bond: December 20, 2033 5-year bond: December 20, 2028
Method of Redemption	Lump-sum redemption at maturity
Use of Proceeds	Projects that meet the eligibility criteria identified in the Japan Climate Transition Bond Framework based on the GX Promotion Strategy

## Summary

The purpose of this evaluation report is to review the status of funding allocation and impact related to the 10-year Japan Climate Transition Bonds (1st) and the 5-year Japan Climate Transition Bonds (1st) issued by the Government of Japan in FY2023 (collectively, or individually referred to as the "Japan Climate Transition Bonds (FY2023)", or the "Bonds").

JCR assigned Green 1(T)(F) to the Japan Climate Transition Bond Framework (the "Framework") developed by the Government of Japan on November 7, 2023 and an overall rating of Green 1(T) to the Bonds issued under the Framework on February 27, 2024. In addition, the Bonds have obtained CBI certification. The main outline is as follows:

The proceeds of the Bonds have been used to subsidize research and development and capital investment that the Government of Japan secured in the FY2022-FY2023. All of these proceeds are intended for projects that significantly contribute to reducing GHG emissions in Japan, and are included in the Sector-Specific Investment Strategies formulated based on the GX Promotion Strategy (revised in February 2025 as the GX 2040 Vision).

The Government of Japan revised the Plan for Global Warming Countermeasures, the 7th Strategic Energy Plan, and the GX 2040 Vision in February 2025. In conjunction with the formulation and revision of these plans and visions, the Government revised the Framework in June 2025, and JCR conducted a review of the Framework in the same month. Furthermore, in January 2026, JCR conducted an additional review to confirm alignment with the new Climate Transition Bond Guidelines (CTBG)<sup>1</sup> published by ICMA in November 2025, and maintained the evaluation of Green 1(T)(F). In this review, JCR reconfirmed that the revised Framework's transition strategy continues to satisfy the four elements required by the "Climate Transition Finance Handbook."<sup>2</sup> Since then, JCR has confirmed that there have been no major changes in the Government of Japan's transition strategy and that it remains valid.

Regarding the criteria for selecting projects, JCR has confirmed that there have been no changes from the assumptions at the time of the initial evaluation and that the selection procedures were carried out in accordance with the processes defined in the Framework. JCR has also confirmed, through verification of the allocation status, that the entire amount of 1.5947 trillion yen raised by the Bonds<sup>3</sup> has been allocated to projects evaluated as eligible at the time of the initial evaluation.

In the impact report, actual or estimated CO<sub>2</sub> emission reduction values are reported for most projects. For research and development-related projects, progress reports are also provided. Although the impact calculations contain certain assumptions and estimated parameters, JCR has confirmed that the Government of Japan calculates GHG emission reduction effects appropriately based on its assumed scenarios. Furthermore, the estimated results demonstrate large GHG reduction effects from each project, and JCR evaluates that the projects financed by the Bonds contribute to the achievement of Japan's GHG emissions reduction targets. At the

<sup>1</sup> International Capital Market Association (ICMA) "Climate Transition Bond Guidelines 2025"  
<https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/climate-transition-finance-handbook/>

<sup>2</sup> International Capital Market Association (ICMA) "Climate Transition Finance Handbook 2023"  
<https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/climate-transition-finance-handbook/>

<sup>3</sup> The total amount of funds that the Government obtained from the market through the issuance of this Bond (the cash proceeds). The total subscription amount of this Bond is JPY 1,599.3 billion, and the difference from the cash proceeds reflects the difference between the face value and the issue price.

same time, it is expected that the projects will also strengthen Japan's industrial competitiveness by creating new demand and markets in the decarbonization sector.

After the review, JCR evaluated the Bonds at "gt1" for "Green/Transition Evaluation (Use of Proceeds)" and "m1" for "Management, Operation and Transparency Evaluation," and "Green 1(T)" for the overall "JCR Climate Transition Bonds Evaluation" based on JCR's Green Finance Evaluation Methodology. As a result, JCR concluded that the Bonds met the standards for the items required in the Green Bond Principles<sup>4</sup>, the Green Bond Guidelines<sup>5</sup>, the Climate Transition Finance Handbook and the Basic Guidelines for Climate Transition Finance<sup>6</sup>.

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<sup>4</sup> International Capital Market Association (ICMA), Green Bond Principles (2021)  
<https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/>

<sup>5</sup> Ministry of the Environment Green Bond Guidelines (2022)  
<https://www.env.go.jp/content/000062495.pdf>

<sup>6</sup> Financial Services Agency, Ministry of Economy, Trade and Industry, Ministry of the Environment, Basic Guidelines for Climate Transition Finance (2021)  
<https://www.meti.go.jp/press/2021/05/20210507001/20210507001-1.pdf>

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## Review Items

This evaluation report aims to review the post-issuance allocation of proceeds and the impact report for the 10-year Japan Climate Transition bond (1st) and the 5-year Japan Climate Transition bond (1st) issued by the Government of Japan in FY 2023. These two are collectively, or individually, referred to as the “Japan Climate Transition bonds (FY2023)” or “the Bonds.”

JCR assigned Green 1(T)(F) to the Climate Transition Bond Framework formulated by the Government of Japan on November 7, 2023. In addition, for the Bonds issued under this framework, JCR assigned the overall rating “Green 1(T)” on February 27, 2024. The Bonds have also obtained CBI certification.

In this evaluation report, the following items will be verified, with particular emphasis on those whose content has changed compared to the previous assessment.

### **1. Alignment with the items required in the Climate Transition Finance Handbook, etc.;**

Japan's medium- to long-term economic policy and transition strategy, which the Government of Japan referred to when implementing Transition Finance, remain unchanged from the time of Evaluation of the Climate Transition Finance. If there are any changes, JCR will examine whether they are important environmental issues in Japan and are appropriate.

### **2. Use of Proceeds;**

The classification of the eligibility criteria for the Transition Finance and the use of proceeds remain unchanged from what the issuer specified at the time of evaluation of the Climate Transition Finance. If there are any changes, JCR will examine whether they retain the eligibility of transition after the changes.

### **3. Selection Criteria and Processes for Use of Proceeds;**

The objectives of the Transition Finance, the selection criteria and processes and other relevant processes remain appropriate.

### **4. Management of Proceeds;**

The Government of Japan continues to have a system and internal functions in place to ensure to allocate the proceeds raised through the Transition Finance to eligible projects and to easily track and manage the allocation status.

### **5. Reporting;**

The status of funding allocation is or will be properly disclosed. The impact of projects that the proceeds of the existing bonds is used for are or will be properly calculated and disclosed in the way specified by the issuer at evaluation of the Climate Transition Finance.

## Review Contents

### 1. Alignment with the items required in the Climate Transition Finance Handbook, etc.

#### 1-1. Japan's Economic Policy and Transition Strategy

The Government of Japan revised the Plan for Global Warming Countermeasures in February 2025 and formulated the 7th Strategic Energy Plan and the GX2040 Vision. An overview of these revisions is as follows.

##### <The Plan for Global Warming Countermeasures>

The Government of Japan established goals set forth in the Paris Agreement (keep the global temperature rise well below 2 °C and to pursue efforts to limit the temperature increase even further to 1.5 °C) and set out the basic principles for promoting global warming countermeasures, such as realizing decarbonized society for net-zero by 2050, the integrated improvement of the environment, economy and society and the close cooperation with citizens and other parties concerned in the Act on Promotion of Global Warming Countermeasures revised in March 2021. The goal of reducing GHG by 46 % in FY2030 from its FY2013 levels, as an interim target was announced, adding to continue strenuous efforts on its challenge to meet the lofty goal of cutting its emission by 50% in the Plan for Global Warming Countermeasures revised in October 2021, based on the revised the Act on Promotion of Global Warming Countermeasures.

In February 2025, a revision of the Plan for Global Warming Countermeasures was carried out, setting targets for FY2035 and FY2040. According to it, the targets are set to reduce GHG emissions by 60% in FY2035 and by 73% in FY2040, respectively, from its FY2013 levels. As for the current trend in Japan's GHG emissions, the total GHG emissions for the FY 2023 amounted to 1.071 billion tons-CO<sub>2e</sub>, which is approximately a 23.3% reduction (324.40 million tons-CO<sub>2e</sub>) compared to the total emissions of the FY2013 (1.395 billion tons-CO<sub>2e</sub>).

##### <The 7th Strategic Energy Plan and the GX2040 Vision >

In the 6th Strategic Energy Plan decided by the Government of Japan in a cabinet meeting in October 2021, the government introduced the concept of "Green Transformation (GX)" which aims to shift the industrial and social structures centered on fossil energy since the Industrial Revolution to those centered on clean energy.

Starting in 2022, the GX Implementation Council chaired by the Prime Minister and composed of experts from government, private sector, and academia was held, and in 2023, the "Basic Policy for Realizing GX" was compiled. Furthermore, the GX Promotion Act and the GX Decarbonized Power Act were enacted in the same year, establishing a framework for promoting initiatives toward the "Pro-Growth Carbon Pricing Concept." Also, as a concrete strategy for the implementation of a series of policies, the "GX Promotion Strategy" was approved by the Cabinet in July 2023 based on the GX Promotion Act.

The 7th Strategic Energy Plan approved by the Cabinet in February 2025 highlights changes since the 6th Strategic Energy Plan, such as the Russian invasion of Ukraine, increased economic security demands due to tensions in the Middle East, and increased power consumption due to green transformation (GX) and digital transformation (DX). It emphasizes that securing decarbonized power sources at internationally competitive prices is directly linked to Japan's industrial competitiveness. The plan discusses aiming for a balanced power supply composition that avoids excessive dependence on specific sources or fuels, from the perspective of simultaneously ensuring a stable energy supply and decarbonization. It aims to maximize the

use of renewable energy, nuclear power, and other power sources that contribute to energy security and have high decarbonization effects.

In addition, regarding the GX Promotion Act, a revised law that includes the legalization of the emissions trading system, the implementation of concrete measures for collecting fossil fuel surcharges, and the establishment of financial support for the GX field was enacted in May 2025. Furthermore, the GX Promotion Strategy has been revised in February 2025 as the "GX2040 Vision," taking into account the increased possibility of power demand in line with the intensification of international affairs and the progress of GX and DX.

### **1-2. Alignment with the items required in the Climate Transition Finance Handbook, etc.**

The Government of Japan revised this Framework in June 2025 in line with the formulation and revision of the above plans and vision. In the same month, JCR conducted a review assessment of the revised Framework. In addition, to further confirm alignment with the new guidelines on climate transition finance -ICMA's Climate Transition Bond Guidelines (CTBG) published in November 2025- a review assessment was conducted in January 2026, and a maintained rating of Green 1(T)(F) was provided. In that assessment, JCR confirmed that the transition strategy set out in the revised Framework conforms to the four elements required by the CTFH. Thereafter, JCR has confirmed that Japan's transition strategy has not undergone any major changes and remains valid.

Below, JCR reprints the assessment it conducted at the time of review assessment in January 2026.

## **Element 1. Issuer's climate transition strategy and governance**

### **(1) Does the issuer who is financing proceeds have a transition strategy for climate change mitigation?**

The Government of Japan has made clear in the Act on Promotion of Global Warming Countermeasures its aim to achieve carbon neutrality by 2050, and to implement the necessary measures to achieve this. Additionally, in the Plan for Global Warming Countermeasure revised in 2021, it has set a 2030 target, aligned with the goals agreed upon in the Paris Agreement, to reduce GHG emissions by 46% in FY2030 from its FY2013 levels, and has established reduction targets for each source of emissions for FY2030 compared to FY2013. Also, in February 2025, a revision of the Plan for Global Warming Countermeasures was conducted, setting reduction targets that Japan aims to reduce its GHG by 60% in FY2035 and by 73% in FY2040, respectively, from its FY2013 levels. For FY2040, reduction targets by emission source are being established in the same manner as for the FY2030.

Concrete measures to achieve the realization of GX towards these aforementioned targets are outlined as the GX2040 Vision (see Table 3 above). In the GX2040 Vision, the Government of Japan is focusing on providing a longer-term direction than the existing GX promotion strategy, to enhance the foreseeability of investment towards GX amidst increasing uncertainties about future prospects. This includes policies on the GX industrial structure and GX industrial location. In addition to initiatives in individual sectors towards GX, which were already indicated in the traditional GX promotion strategy, they are formulating policies with an emphasis on industrial policy. In addition, in efforts toward GX in specific sectors, it is indicated that investment promotion measures should be advanced based on not only the "Sector-specific Investment

Strategies" but also the Plan for Global Warming Countermeasures and the 7th Strategic Energy Plan.

Therefore, it can be said that the Government of Japan has a strategy for the transition for climate change mitigation.

**(2) Is the use of the "transition" label in financing intended to contribute to realizing a corporate strategy to transition to a business model that allows issuers to effectively address climate change-related risks and to contribute to achieving the goals of the Paris Agreement?**

Japan's government-led GX aims to transform the economy, society, and industrial structure, which have centered on fossil fuels since the Industrial Revolution, to one focused on clean energy. It seeks to achieve a simultaneous stable energy supply, economic growth, and reduced emissions in order to reform the entire socioeconomic system.

The Japanese government intends to utilize funding raised through "transition"-labeled bonds and use these as a source for concrete support programs, thereby demonstrating to domestic businesses and citizens the significance and direction of GX.

In December 2020, immediately after the first edition of the CTFH was published by ICMA in May 2021, the Government of Japan released the "Basic Guidelines on Climate Transition Finance." This basic guideline is intended to promote efforts toward steady low-carbon energy saving in sectors where emission reductions are difficult, and to accelerate innovation contributing to transitions such as long-term research and development for decarbonization. Additionally, it was formulated with the purpose of popularizing climate transition finance, which is in its nascent stage, and ensuring the credibility when raising funds under the name of transition finance. This will establish the position of transition finance as a means of funding transition, particularly in sectors where emission reductions are difficult, and contribute to realizing Japan's 2050 net zero and the goals of the Paris Agreement through the introduction of more funds.

The basic guidelines are revised in a timely manner, taking into account international movements related to transition finance, and the most recent revision was made in March 2025.

This Framework is formulated in accordance with the CTFH and the same basic guidelines, and aims to contribute to the realization of a strategy to transition to a business model that allows Japan as a whole to contribute to achieving the goals of the Paris Agreement.

**(3) Is a governance system established to ensure the effectiveness of the transition strategy?**

As previously mentioned, the Government of Japan recruits relevant ministries and agencies, external experts, and specialists required for GX, and after necessary discussions, the transition strategy is ultimately formulated at the GX Implementation Council chaired by the Prime Minister. Progress is then reported to this conference, where revisions are made as necessary.

Therefore, JCR evaluates that the Government of Japan is establishing a system to steadily implement its transition strategy.

## Element 2. Business model environmental materiality

Japan ranks seventh in the world in terms of GHG emissions, and in order to keep the global temperature rise at the level set by the Paris Agreement, it is expected to take the lead in reducing them while leading the international community. Considering that the introduction of carbon pricing will begin domestically and internationally in the future, for many manufacturing industries with international competitiveness to maintain good performance while achieving a carbon-neutral society, it is urgent to implement various decarbonization measures and structural transformations for each industry type as stipulated in the GX Promotion Act. In this context, in June 2023, the Government of Japan presented the "Grand Design and Action Plan for a New Form of Capitalism," and the revised version of the above plan was issued in June 2024 and June 2025. Within this, it is anticipated that in Japan, GX (Green Transformation) will contribute to enhancing the industrial competitiveness of the country by maximizing the utilization of expertise in fields where Japanese companies have technical strengths in decarbonization-related technology research, thus accelerating the nation's transition to decarbonization.

Based on the above, JCR evaluates that the Government of Japan's efforts toward achieving carbon neutrality, known as GX initiatives, are one of the most crucial challenges for Japan.

### Element 3. Climate transition strategy and targets to be science-based

#### Does the transition roadmap meet the followings?

#### (1) It is quantitatively measurable and the target covers Scope 1 and 2 (It is recommended that the target of Scope 3 be established to the extent feasible)

As indicated in the Plan for Global Warming Countermeasures, Japan's GHG emissions reduction target is aligned with the goal set by the scientifically based objectives agreed upon by the international community in the Paris Agreement (keep the global temperature rise well below 2 °C and to pursue efforts to limit the temperature increase even further to 1.5 °C). In Japan, since the government does not adopt the concept of Scope 1, Scope 2, and Scope 3 emissions, this section has been considered by JCR in accordance with the definitions established by the PCAF<sup>7</sup>. If the direct business activities of the country are defined as Scope 1 and Scope 2, the target setting and specific measures are planned in the National Government Action Plan. As for the emissions for the whole of Japan, which fall under Scope 3, the total emissions by source or sector are disclosed in the Plan for Global Warming Countermeasures as mentioned above. Moreover, the targets and measures for FY2030, FY2035, and FY2040 have been meticulously set based on specific technical examinations.

Therefore, JCR evaluates the Government of Japan's plan as having an appropriately covered scope, and high transparency in both disclosed achievements and targets.

#### (2) Alignment with generally recognized science-based target setting

Japan's GHG emissions reduction target was set assuming alignment with the Paris Agreement in 2021. Furthermore, the sectoral technology roadmaps, particularly for high-emission industries, are formulated to align as much as possible with the IEA<sup>8</sup>'s NZE scenario<sup>9</sup> and SDS scenario<sup>10</sup>, provided there is a current or future technical basis for such alignment, with the achievement of the respective targets as a premise.

Moreover, the Government of Japan has set a target (-2.7% reduction per year \*JCR conversion) that aligns with the goal of limiting global warming to 1.5°C as indicated in the IPCC<sup>11</sup> Special Report<sup>12</sup> on Global Warming of 1.5°C (approximately 45% reduction from the 2010 level by 2030; -2.25% reduction per year), which JCR evaluates as aligned with the scientifically-based goal setting under the Paris Agreement aiming for 1.5°C<sup>13</sup>.

For reference, the relative ambition levels of targets compared to other countries are shown in the following figure.

<sup>7</sup> MOE "Practical Decarbonization Guidance for Financial Institutions Based on Portfolio Carbon Analysis"  
<https://www.env.go.jp/content/000125696.pdf>

<sup>8</sup> International Energy Agency (IEA)

<sup>9</sup> Net Zero Emissions by 2050 Scenario by IEA

<sup>10</sup> Sustainable Development Scenario, which is the path to fully achieve the sustainable development goals by the IEA

<sup>11</sup> Intergovernmental Panel on Climate Change (IPCC)

<sup>12</sup> IPCC "Global Warming of 1.5°C An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty  
[https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15\\_Full\\_Report\\_HR.pdf](https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Full_Report_HR.pdf)

<sup>13</sup> The IPCC Special Report on Impacts of Global Warming of 1.5°C was updated in the IPCC's 6th Assessment Report (AR6). The target of 1.5 °C therein will reduce the CO2 emissions by roughly 36% to 69% from the FY2019 level by FY2030 (Reduction Rate: 3.3% to 3.6% per year)

Country	Emission Reduction Target by 2030 (Base Year 2013)
United Kingdom	-54.6%
Switzerland	-49.4%
Brazil	-48.7%
Japan	<b>-46.0%</b>
United States	-45.6%
Saudi Arabia	-43.3%
EU27	-41.6%
Canada	-40.4%
South Africa	-33.3%
South Korea	-23.7%
Ukraine	-23.0%
Australia	-18.4%
Mexico	-0.4%
Thailand	7.0%
Kazakhstan	8.6%
China	14.1%
Malaysia	23.1%
Russia	51.8%
India	99.2%
Indonesia	131.0%
Pakistan	234.6%

**Figure 1: GHG emission reduction rate target for FY2030 (comparison when each country's target is replaced with figures based on the 2013 standard)<sup>14</sup>**

### (3) It shall be Publicly disclosed (including Interim Targets)

The Government of Japan's goal of achieving carbon neutrality by 2050 is clearly stated in the Act on Promotion of Global Warming Countermeasures. Additionally, interim targets have been declared in the Plan for Global Warming Countermeasures, aiming to reduce its GHG emissions by 46% in FY2030, by 60% in FY2035, and by 73% in FY2040, respectively, from its FY2013 levels. Moreover, specific targets for FY2030 and FY2040, categorized by emission sources, are disclosed in the same plan, ensuring high transparency.

### (4) It shall be Supported by Independent Assurance or Verification

Regarding GHG emissions, due to their unique nature, they have not received third-party certification or verification that general companies would undergo. However, given the fact that the Global Warming Prevention Headquarters, where the Prime Minister serves as chairperson and all the cabinet members participate, approves the status of the progress after the deliberation of relevant councils on an annual basis, the process is well-managed by internal and external experts. Accordingly, JCR considers that the status of the progress of the plan is virtually monitored by a third party.

From the above, JCR evaluates that the Government of Japan's efforts toward achieving net zero by 2050 are based on scientific evidence and meet the necessary requirements in Element 3.

<sup>14</sup> Source: Materials of a joint meeting for a clean energy strategy "Materialize political initiatives for realizing GX"

## Element 4. Implementation transparency

The Government of Japan, in its GX Promotion Strategy and GX2040 Vision, has decided on a total investment of 150 trillion yen by both the public and private sectors over the decade. Furthermore, the specific breakdown has been announced as follows according to the energy supply sector and the demand sector.

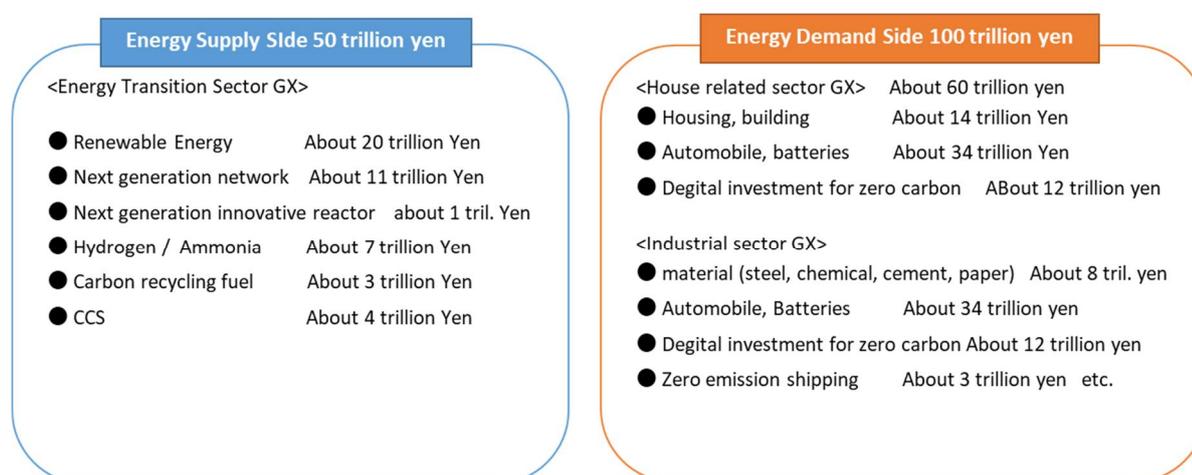


Figure 2: Breakdown of public/private investments for 10 years<sup>15</sup>

Out of the total investment of 150 trillion yen, 20 trillion yen is expected to be executed as an investment promotion measure through GX Economy Transition Bonds. Regarding this investment promotion measure, to enhance predictability for companies and strongly stimulate GX investment, the Government of Japan is compiling a "Sector-Specific Investment Strategies<sup>16</sup>" as a means to present concrete investment promotion measures and a "Five-Year Action Plan" for the next ten years in the FY2023. Incidentally, approximately 1.6 trillion yen of Climate Transition Bonds (referred to as GX Economy Transition Bonds, or "CT Bonds" hereafter) have already been issued in FY2023, and about 1.4 trillion yen is issued in FY2024. Furthermore, at the GX Implementation Council held in May 2024, the breakdown of the government's investment plans for the next 3-10 years as part of the main implementation status of the GX Investment Support Measures was presented as follows, and at the GX Implementation Council held in December 2024, the budget amount for each item was indicated.

<sup>15</sup> Sources: Materials for the GX Implementation Council: Toward the achievement of GX in Japan

<sup>16</sup> December 22, 2023 "Sector-specific Investment Strategies" [https://www.meti.go.jp/english/press/2023/1222\\_002.html](https://www.meti.go.jp/english/press/2023/1222_002.html)

Innovative technology development	<u>Already allocated</u> <u>1 trillion yen</u>	<ul style="list-style-type: none"> <li>Representative examples from the Green Innovation Fund, which supports innovative technology development with high decarbonization effects:               <ol style="list-style-type: none"> <li>Promoting development of next-generation solar cells (perovskite), to be launched on the market in 2025</li> <li>Demonstration equipment for hydrogen reduction steelmaking to be introduced in 2026</li> <li>Successfully developed ammonia combustion, to be commercialized in Malaysia in 2026 (MOU signed), etc.</li> </ol> </li> <li>*Support for R&amp;D of ammonia ships (plus support for production equipment for zero-emission ships, etc.)               <ul style="list-style-type: none"> <li>Support for basic research and human resource development at universities, etc. through the Green Technologies for Excellence (GteX) Program</li> <li>Support for development of semiconductor technology (photonics-electronics fusion) to drastically reduce electricity consumption, etc.</li> </ul> </li> </ul>
Structural transformation of high-emission industries	<u>1.3 trillion yen or more</u> <u>(for 10 years)</u>	<ul style="list-style-type: none"> <li>"Innovative electric furnaces" that cut emissions by more than half, chemical recycling, biorefineries, CCUS, etc.</li> </ul>
Household GX	<u>2 trillion yen or more</u> <u>(for 3 years)</u>	<ul style="list-style-type: none"> <li>Renovating homes to insulated windows (strengthening the insulation of windows, which account for 70% of heat entering and leaving homes)</li> <li>Introduction of high-efficiency water heaters (heat pumps, etc.)</li> <li>Support for the introduction of electric vehicles/storage batteries, etc.</li> </ul>
Hydrogen, etc.	<u>3 trillion yen or more</u> <u>(for 15 years)</u>	<ul style="list-style-type: none"> <li>Support measures focusing on the price difference of hydrogen, etc.</li> </ul>
Next-generation renewable energy	<u>1 trillion yen or more</u> <u>(for 10 years)</u>	<p>In addition to renewable energy introduction support measures (FIT system) on the scale of several trillion yen per year,</p> <ul style="list-style-type: none"> <li>Support for building supply chains for perovskite, floating offshore wind, water electrolysis equipment, etc., and consideration of support for the introduction of perovskite (in addition to the GI fund, 1 trillion yen will be provided over 10 years)</li> </ul>
Small and medium-sized enterprises, startups, etc.	<u>1 trillion yen or more</u> <u>(for 3-5 years)</u>	<ul style="list-style-type: none"> <li>Support for energy conservation for small and medium-sized enterprises, etc. (700 billion yen will be provided over 3 years)</li> <li>Support for GX startups (200 billion yen will be provided over 5 years) etc.</li> </ul>
Tax measures		- Establish new tax credits based on the production and sales volume of green steel, green chemicals, SAF, EVs, etc.

**Figure 3: Implementation status of GX investment support measures<sup>17</sup>**

Regarding the investment details for each fiscal year, as the government's budget is executed on an annual basis, they plan to announce it after the annual budget is passed.

Based on the above, JCR evaluates the Government of Japan's investment plan as having high transparency, as the government discloses information such as planned government expenditures, the scale of public-private investment expected to be promoted by these expenditures, and the 10-year roadmap.

The Ministry of Economy, Trade and Industry in Japan has pointed out in its sectoral technology roadmaps that there are multiple areas requiring business transformation and employment shifts that accompany the execution of transition strategies. Since most of the expenditures from GX

<sup>17</sup> Source: "Toward Accelerating Japan's GX," a material for GX Implementation Council  
[https://www.cas.go.jp/jp/seisaku/gx\\_jikkou\\_kaigi/dai11/siryou1.pdf](https://www.cas.go.jp/jp/seisaku/gx_jikkou_kaigi/dai11/siryou1.pdf)

Economy Transition Bonds are directed towards research and development or subsidy programs for multiple companies, they do not inherently require the direct consideration of a just transition as business transition strategies do. On the other hand, the Government of Japan recognizes that achieving a fair transition is an important issue, considering Japan's characteristics of having a high proportion of manufacturing industries and low labor mobility. Based on the above, the GX2040 Vision includes additions regarding a "just transition," detailing support for the facilitation of labor mobility to growth sectors, transfer support, and reskilling assistance for career upgrades of current employees. It also describes efforts to support the acquisition of new skills necessary to respond to the advancement of supply chains through the use of DX such as robotics and AI, taking into account ensuring that workers can continue to thrive in an advanced supply chain as the transition to a GX industrial structure occurs.

Regarding the possibility of being locked into fossil fuels, both the sectoral technology roadmaps and the GX2040 Vision formulated by the Government of Japan are designed to achieve net zero by 2050. They are aimed at achieving carbon neutrality through next-generation technological innovation rather than relying heavily on carbon credits, thus assessing the risk as low. In addition, it is a prerequisite that the target projects for the support measures funded by these bonds are aligned with Japan's transition strategy, such as sectoral technology roadmaps, and it is evaluated that the risk of locking in fossil fuels is low.

Regarding the perspective of DNSH (Do No Significant Harm), it is considered that the significant use of this Framework's funds allocated towards research and development, and the establishment of clear criteria in the grant program for benchmarking subsidies, work to avoid serious negative impacts on the environment.

**Accordingly, JCR has evaluated that this Framework satisfies the four elements required in the Climate Transition Finance Handbook, etc.**

## 2. Use of Proceeds

JCR confirmed that the proceeds from the Bonds were allocated to projects that JCR had evaluated as appropriate at the time of the initial evaluation, as described below (Table 1).

In addition, with regard to the “Grant for decarbonization transition acceleration for specific regions (construction of local government- and private-owned microgrids etc.)”, JCR had initially assessed its green category as “Renewable Energy” at the time of the original evaluation. However, after confirming the details of the subsidy that were subsequently finalized as well as the actual facilities<sup>18</sup> to which the funds were allocated, JCR added “Energy Efficiency” as an additional category.

**Table 1: Allocated Projects of the Bonds<sup>19</sup>**

	Budget Year	Type of project	Allocated Projects	Green Category
(1) GI Fund	FY2022 Suppl. FY2023 Initial	R&D	See Table 2	-
(2) R&D other than GI Funds	FY2022 Suppl.	R&D	Innovative GX technology creation project (GteX)	<ul style="list-style-type: none"> <li>● Clean transportation</li> <li>● Energy efficiency</li> <li>● Renewable energy</li> <li>● Circular economy adapted products, production technologies and processes</li> </ul>
	FY2022 Suppl.	R&D	Research and development project for enhancing the post-5G information and communication system infrastructure	<ul style="list-style-type: none"> <li>● Energy efficiency</li> </ul>
	FY2023 Initial	R&D	Demonstration reactor development project for high-temperature gas reactor	<ul style="list-style-type: none"> <li>● Low-carbon and decarbonized energy</li> </ul>
	FY2023 Initial	R&D	Demonstration reactor development project for fast reactor	<ul style="list-style-type: none"> <li>● Low-carbon and decarbonized energy</li> </ul>
(3) Subsidy programs	FY2022 Suppl.	Subsidy	Support project for strengthening the manufacturing supply chain of batteries	<ul style="list-style-type: none"> <li>● Energy efficiency</li> <li>● Renewable energy</li> <li>● Clean transportation</li> </ul>
	FY2022 Suppl.	Subsidy	Support project for strengthening the semiconductor manufacturing supply chain for achieving GX	<ul style="list-style-type: none"> <li>● Clean transportation</li> <li>● Renewable energy</li> </ul>
	FY2022 Suppl.	Subsidy	Support project costs for promoting energy efficiency investment and demand structure transformation	<ul style="list-style-type: none"> <li>● Energy efficiency</li> </ul>
	FY2023 Initial	Subsidy	Grant for decarbonization transition acceleration for specific regions (microgrid-related projects utilizing privately-owned distribution lines and other related initiatives)	<ul style="list-style-type: none"> <li>● Renewable energy</li> <li>● Energy efficiency</li> </ul>
	FY2022 Suppl. FY2023 Initial FY2023 Suppl.	Subsidy	Subsidy for promoting the introduction of clean energy vehicles	<ul style="list-style-type: none"> <li>● Clean transportation</li> </ul>
	FY2023 Initial	Subsidy	Promotion project for the electrification of commercial vehicles	<ul style="list-style-type: none"> <li>● Clean transportation</li> </ul>

<sup>18</sup> JCR has confirmed that high-efficiency air-conditioning equipment and lighting equipment were included among the facilities financed by the Bonds.

<sup>19</sup> Prepared by JCR from materials provided by the Ministry of Economy, Trade and Industry. Regarding the budget year, “FY2022 Suppl.” indicates the supplementary budget projects for FY2022, “FY2023 Initial” indicates the initial budget projects for FY2023, and “FY2023 Suppl.” indicates the supplementary budget projects for FY2023 (the same applied to the following).

	FY2022 Suppl.	Subsidy	Promotion project for the installation of advanced equipment to improve the insulation performance of detached houses Support project for accelerating energy conservation and CO <sub>2</sub> reduction in the household sector through insulating windows	<ul style="list-style-type: none"> <li>● Energy efficiency</li> </ul>
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**Table 2: GI Fund projects that are candidates for the use of proceeds of the Bonds<sup>20</sup>**

Type of project	Allocated Projects (Including candidate projects for Allocation)	Green Category
R&D	Development of next-generation solar cells	● Renewable energy
R&D	Cost reductions for offshore wind power generation	● Renewable energy
R&D	Large-scale hydrogen supply chain establishment	● Circular economy adapted products, production technologies and processes
R&D	Development of Next-Generation Aircraft	● Clean transportation
R&D	Development of Next-Generation Ships	● Clean transportation
R&D	Development of Technology for producing fuel using CO <sub>2</sub> , etc.	● Clean transportation
R&D	Hydrogen utilization in Iron and steelmaking processes	<ul style="list-style-type: none"> <li>● Energy efficiency</li> <li>● Circular economy adapted products, production technologies and processes</li> </ul>
R&D	Decarbonization of thermal processes in manufacturing	<ul style="list-style-type: none"> <li>● Energy efficiency</li> <li>● Circular economy adapted products, production technologies and processes</li> </ul>
R&D	Hydrogen production through water electrolysis using power from renewables	● Circular economy adapted products, production technologies and processes
R&D	Achieving carbon neutrality in waste and resource circulation systems	● Pollution prevention and control
R&D	Development of technology for producing raw materials for plastic using CO <sub>2</sub> and other sources	<ul style="list-style-type: none"> <li>● Energy efficiency</li> <li>● Circular economy adapted products, production technologies and processes</li> </ul>
R&D	Promotion of carbon recycling using CO <sub>2</sub> from biomanufacturing technology as a direct raw material	● Circular economy adapted products, production technologies and processes

### 3. Selection Criteria and Process for the Use of Proceeds

At the time of the initial evaluation, JCR concluded that the selection criteria for the use of proceeds and the process were appropriate. As a result of conducting interviews with the Government of Japan for this review, JCR confirmed that the selection criteria has not been changed from the assumption at the time of the initial evaluation, and that the selection procedure was carried out according to the assumed process.

### 4. Management of Proceeds

<sup>20</sup> Compiled by JCR based on materials provided by the Ministry of Economy, Trade and Industry.

JCR assessed the fund management as appropriate at the time of the initial evaluation. It has confirmed that the entire amount of proceeds raised through the Bonds has been allocated in accordance with the prescribed procedures set forth in the Framework.

## 5. Reporting

### 5-1. Reporting on the Status of Allocation of Proceeds

JCR confirmed that the total amount of proceeds raised through the Bonds was JPY 1,594.7 billion, and that the entire amount was allocated to each eligible project. The Government of Japan discloses this information on its website. JCR has evaluated this disclosure as appropriate, noting that it satisfies the items stipulated in the Framework.

**Table 3: Proceeds Allocated to Eligible Projects<sup>21</sup>**

	Budget Year	Allocated Projects	Allocated Amount (Billion Yen)
(1) GI Fund	FY2022 Suppl. FY2023 Initial	Green Innovation Fund	<b>756.4</b> *1
(2) R&D other than GI Funds	FY2022 Suppl.	Innovative GX technology creation project (GteX)	49.6
	FY2022 Suppl.	Research and development project for enhancing the post-5G information and communication system infrastructure	75.0
	FY2023 Initial	Demonstration reactor development project for high-temperature gas reactor	4.7
	FY2023 Initial	Demonstration reactor development project for fast reactor	7.4
Subtotal of R&D other than GI Funds			<b>136.7</b>
(3) Subsidy programs	FY2022 Suppl.	Support project for strengthening the manufacturing supply chain of batteries	331.6
	FY2022 Suppl.	Support project for strengthening the semiconductor manufacturing supply chain for achieving GX	152.3
	FY2022 Suppl.	Support project costs for promoting energy efficiency investment and demand structure transformation*2	2.4
	FY2022 Suppl. FY2023 Initial FY2023 Suppl.	Subsidy for promoting the introduction of clean energy vehicles	114.1
	FY2023 Initial	Grant for decarbonization transition acceleration for specific regions (microgrid-related projects utilizing privately-owned distribution lines and other related initiatives)	0.2
	FY2023 Initial	Promotion project for the electrification of commercial vehicles	10.8
	FY2022 Suppl.	Promotion project for the installation of advanced equipment to improve the insulation performance of detached houses Support project for accelerating energy conservation and CO <sub>2</sub> reduction in the household sector through insulating windows	90.3
Subtotal of R&D other than GI Funds			<b>701.6</b>
<b>Total</b>			<b>1,594.7</b> *3
<b>Total issuance amount of the JCTBs issued in FY2023 (cash proceeds)</b>			<b>1,594.7</b>

<sup>21</sup> Prepared by JCR from materials provided by the Ministry of Economy, Trade and Industry

<b>Amount of unallocated proceeds (cash proceeds - amount of proceeds allocated)</b>	<b>0</b>
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\*1 With respect to the GI Fund, allocation to the Fund is deemed complete at the point when disbursements are made from the Special Account for Energy Policy to NEDO, the implementing body of the fund. Funds allocated to the Fund are executed, in line with the progress of research and development under each GI Fund project.

\*2 At the time of the initial assessment, it was understood that the eligible allocations from the Bonds under the subsidy program were limited to (A) Advanced Projects and (B) Custom-designed Projects among the following business categories: (A) Advanced Projects, (B) Custom-designed Projects, (C) Designated Equipment Installation Projects, and (D) Energy Demand Optimization Projects. However, after confirming the actual allocation status, JCR has verified that allocations have also been made to (D)<sup>22</sup>.

\*3 The allocated amounts to the projects are inconsistent with the total amount as the values are rounded off to one decimal place.

Before the issuance of the Bonds, proceeds from government bonds instead of JCTBs<sup>23</sup> were allocated to a portion of the supplementary budget projects for FY2022 (allocation of JPY 908.7 billion), but such projects were refinanced by the Bonds. As this was done with the initial intention of refinancing through JCTBs issued in FY2023, JCR considers that all projects will generate new environmental improvement effects after the issuance of the Bonds and provide the market with additionality.

## 5-2. Impact Reporting

As the Bonds' impact report, the Government of Japan reports—except for certain projects—either actual or estimated amounts of CO<sub>2</sub> emissions reductions. For R&D-related projects, progress updates are also provided.

**Table 4 : List of progress or reported impacts of allocated projects<sup>24</sup>**

	Budget Year	Project Type	Allocated Project	R&D Progress / Reported Impact
(1) GI Fund	FY2022 Suppl. FY2023 Initial	R&D	Development of next-generation solar cells	Progressing largely as planned
		R&D	Cost reductions for offshore wind power generation	Progressing largely as planned
		R&D	Large-scale hydrogen supply chain establishment	Progress checked continuously through monitoring and stage-gate reviews; feasibility studies and plan revisions conducted as appropriate according to R&D progress
		R&D	Development of next-generation aircraft	Progressing as planned
		R&D	Development of next-generation ships	Progressing steadily. Some themes have delays of over one year due to development delays at overseas manufacturers not covered by the

<sup>22</sup> For (C) Designated Equipment Installation Projects, the subsidies are provided under a separate budget program from the Bonds.

<sup>23</sup> JCTBs or Japan Climate Transition Bonds are labelled bonds of Decarbonized Pro-Growth Economic Structure Transition Bonds (GX Economy Transition Bonds) issued under the GX Promotion Act.

<sup>24</sup> Compiled by JCR based on materials provided by the Ministry of Economy, Trade and Industry and publicly available information on subsidized projects.

				subsidy, but no overall project impact is anticipated.
		R&D	Hydrogen utilization in iron and steelmaking processes	Progressing largely as planned (some items ahead of schedule)
		R&D	Decarbonization of thermal processes in manufacturing	Progressing largely as planned
		R&D	Hydrogen production through water electrolysis using power from renewables	Element-technology development is progressing; in response to equipment delivery delays, plans are being revised; careful preparation toward demonstration is underway.
		R&D	Achieving carbon neutrality in waste and resource circulation systems	Effectively started in FY2024; progressing largely as planned.
		R&D	Development of technology for producing raw materials for plastic using CO2 and other sources	Stage-gate review conducted in Dec 2023; all themes continued with some conditions; preparations for pilot tests have started. Foundational technology development is progressing as initially planned. For later demonstration tests, plan revisions are underway for some themes due to rising equipment costs and longer construction timelines.
(2) R&D other than GI Funds	FY2022 Suppl.	R&D	Innovative GX technology creation project (GteX)	Team-based research: 15 teams adopted in FY2023 and 1 in FY2024. Single-year innovative element-technology research: 16 themes adopted in FY2023; after completion, end-of-project reports and ex-post evaluations are published.
	FY2022 Suppl.	R&D	Research and development project for enhancing the post-5G information and communication system infrastructure	In FY2023, three themes were adopted: (1) Optical chiplet packaging technology, (2) Opto-electronic convergence interface memory module technology, (3) Deterministic-latency computing platform technology.
	FY2023 Initial	R&D	Demonstration reactor development project for high-temperature gas reactor	For the demonstration reactor project, Mitsubishi Heavy Industries was selected as the core company in July 2023; design and R&D for demonstration reactors being implemented. For the hydrogen production test using HTTR, an application for a reactor installation change permit was submitted to the Nuclear Regulation Authority.
	FY2023 Initial	R&D	Demonstration reactor development project for fast reactor	Mitsubishi Heavy Industries was selected as the core company in July 2023; an integrated R&D organization was established in July 2024. Work is progressing on establishing a large sodium test facility; demonstration plans for reactor equipment/systems have been organized, and necessary facility development plans have been

				compiled. Dialogue with the Nuclear Regulation Authority has begun to build common understanding on severe-accident evaluation methods and seismic-isolation technology. Studies on fuel-cycle technology are advancing toward concrete fuel-technology considerations around FY2026.
(3) Subsidy Programs	FY2022 Suppl.	Subsidy	Support project for strengthening the manufacturing supply chain of batteries	<b>Supported:</b> 14 cases <b>Environmental impact:</b> approx. 13.5 million t-CO <sub>2</sub> /year
	FY2022 Suppl.	Subsidy	Support project for strengthening the semiconductor manufacturing supply chain for achieving GX	<b>Supported:</b> 3 companies <b>Environmental impact:</b> approx. 1.74 million t-CO <sub>2</sub> /year
	FY2022 Suppl.	Subsidy	Support project costs for promoting energy efficiency investment and demand structure transformation*2	<b>Supported:</b> 16 cases <b>Environmental impact:</b> approx. 3,300 t-CO <sub>2</sub> /year
	FY2023 Initial	Subsidy	Grant for decarbonization transition acceleration for specific regions (microgrid-related projects utilizing privately-owned distribution lines and other related initiatives)	<b>Supported:</b> 4 local governments <b>Environmental impact:</b> approx. 342,000 t-CO <sub>2</sub> /year
	FY2022 Suppl. FY2023 Initial FY2023 Suppl.	Subsidy	Subsidy for promoting the introduction of clean energy vehicles	<b>Supported:</b> 153,882 vehicles *1 <b>Environmental impact:</b> approx. 95,000 t-CO <sub>2</sub> /year *1
	FY2023 Initial	Subsidy	Promotion project for the electrification of commercial vehicles	<b>Supported:</b> 3,698 vehicles <b>Environmental impact:</b> approx. 14,000 t-CO <sub>2</sub> /year
	FY2022 Suppl.	Subsidy	Promotion projects for the installation of advanced equipment to improve the insulation performance	<b>Supported:</b> Detached houses 203,365 Apartment units 40,301 <b>Environmental impact:</b> Detached houses approx. 63,000 t-CO <sub>2</sub> /year Apartment units approx. 8,000 t-CO <sub>2</sub> /year

\*1 Although the allocation target of the “Subsidy for promoting the introduction of clean energy vehicles” includes a portion of the project under the FY2023 supplementary budget, the support results and environmental improvement effects reported are based on the actual results of the FY2022 supplementary budget and the FY2023 initial budgets. The actual results for the FY2023 supplementary budget are scheduled to be reported in subsequent fiscal years.

JCR confirmed that, although the impact calculations include certain assumptions and estimated parameters, the GHG emissions reduction effects have been calculated using reasonable methods based on the scenarios assumed by the Government of Japan. JCR’s confirmation status for each project is shown below.

### 5-2-1. GI Fund Project: “Development of next-generation solar cells” Project

The Government of Japan, aiming to achieve carbon neutrality by 2050, is promoting the maximum possible introduction of renewable energy including solar power as a main power source. While the installed capacity of solar power in Japan has expanded significantly, reaching one of the highest levels among major countries in terms of installed capacity per unit of flat land area, challenges have emerged such as site constraints and issues related to coexistence with local communities. One promising approach to overcoming these challenges is to accelerate deployment in locations where installation of existing silicon solar cells was difficult—such as factory roofs with limited load-bearing capacity and curved building surfaces. To enable such deployment, it is essential to develop next-generation solar cells that are lightweight, flexible enough to be installed on curved surfaces such as walls, and comparable to silicon solar cells in terms of performance including conversion efficiency and durability.

In this project<sup>25</sup>, recognizing that the social implementation of solar cells requires three development stages—efficiency improvement at laboratory scale, scaling-up and improvement of durability, and implementation and practical application—and also taking into account the need to address derivative tandem technologies, the work is divided into four phases: (1) efficiency improvement at laboratory scale, (2) scaling-up and improvement of durability, (3) implementation and practical application, and (4) tandem technology development<sup>26</sup>. For single-junction solar cells, the goal is “to achieve a generation cost of 14 yen/kWh or lower under certain defined conditions (such as solar irradiation) by FY2030,” and for tandem-type solar cells, “to achieve a generation cost of 12 yen/kWh or lower under certain defined conditions (such as solar irradiation) and a conversion efficiency of 30% or higher by FY2030.”

The project as a whole is progressing largely as planned, and as reported in the Working Group on the Promotion of Green Power, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, the progress status is as shown in Table 5. For R&D Item 3 (Next-Generation Solar Cell Demonstration Project), projects have been selected sequentially since September 2024.

**Table 5: Progress of the GI Fund Project “Development of next-generation solar cells” and Status of New Project Selections<sup>27</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Development of foundational technologies for next-generation solar cells	TRL4	See below	-

<sup>25</sup> A tandem-type perovskite solar cell is a technology in which materials with different absorption wavelength ranges are stacked to achieve high-efficiency photoelectric conversion.

<sup>26</sup> Tandemization was added as a research and development item in September 2025 and is currently in the public solicitation process.

<sup>27</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on the Promotion of Green Power, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.).

<p>Development of Common Fundamental Technologies Contributing to the Commercialization of Next-Generation Perovskite Solar Cells</p>	<ul style="list-style-type: none"> <li>• Through optimization using Materials Informatics (MI) and Process Informatics (PI), fabrication conditions exceeding the previously established optimal values were identified.</li> <li>• An initial power conversion efficiency of 19.6% was achieved using a highly durable hole-transport material.</li> <li>• Developed degradation evaluation techniques, including transient photoluminescence spectroscopy, impedance measurement, and transient current response measurement were developed.</li> <li>• Established high-precision performance evaluation techniques, achieving output measurement reproducibility within <math>\pm 1\%</math>.</li> <li>• Completed the specification design of an indoor performance evaluation and measurement system for practical-size modules (<math>&gt;900 \text{ cm}^2</math>).</li> <li>• Launched the Committee for the Study of International Standardization, etc.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
2. Next-Generation Solar Cell Commercialization Project	-	See below	FY2025 TRL5
<p>(1) Development of roll-to-roll manufacturing technology for ultra-lightweight solar cells</p>	<ul style="list-style-type: none"> <li>• Reduction of in-plane variation in conversion efficiency and introduction of a 1 m-wide pilot line.</li> <li>• Achieved a conversion efficiency of 25.6% using a process compatible with film substrate at temperature of <math>140^\circ \text{ C}</math> or below. Improvement of laser scribing conditions.</li> <li>• Estimated an equivalent outdoor operational lifetime of 28.4 years based on temperature extrapolation from accelerated high-temperature testing. High-temperature/high-humidity and high-temperature plus light-soaking test are currently underway.</li> <li>• Initiation of practical implementation verification at the Water Reclamation Center in collaboration with the Tokyo Metropolitan Government.</li> </ul>		
<p>(2) Technology development for the commercialization of film-type perovskite solar cells</p>	<ul style="list-style-type: none"> <li>• Achievement of an intermediate milestone in power generation efficiency through defect reduction effects realized by improving perovskite composition and film-deposition conditions.</li> <li>• Conversion efficiency of 23% in small-area cells through the study of hole transport materials and low-temperature deposition process (application to film substrates)</li> <li>• Formulation of design guidelines for high-efficiency device development based on simulations using SAM</li> </ul>		
<p>(3) Development of high-performance perovskite solar cell technology leveraging size-free and ultra-thin characteristics</p>	<ul style="list-style-type: none"> <li>• By applying highly reliable device fabrication technologies cultivated in the silicon-based PV market, a conversion efficiency of approximately 20% (in-house measurement) has been confirmed for <math>780 \text{ cm}^2</math> glass-substrate samples. Efforts are also underway to develop technologies aimed at practical applications, including building-integrated photovoltaics (BIPV) and window applications.</li> <li>• Prototype modules in the assumed product size (e.g., 1-meter width) have been produced, and currently engaging with multiple prospective user companies to explore specific deployment opportunities that leverage the strengths of perovskite solar cells.</li> <li>• In designing the production line, preliminary estimation of the required capital investment has begun, taking into account progress in materials and process technology development.</li> </ul>		

<p>(4) Social implementation of perovskite solar cells with a high degree of installation flexibility</p>	<ul style="list-style-type: none"> <li>Achieved a conversion efficiency of 20.6% on a film substrate through device structure optimization using world-class photoelectric conversion materials (JET-certified, compared to 14% at the start of the GI Fund project).</li> <li>Currently developing manufacturing technology for 30-cm-square modules of a size suitable not only for indoor applications but also for expanded application to building-material.</li> <li>Preparation is underway for investment in continuous production equipment with the aim of expanding demonstration tests and minimizing production costs.</li> </ul>		
<p>(5) Technology development for the commercialization of high-efficiency, high-durability modules</p>	<ul style="list-style-type: none"> <li>Achieved a conversion efficiency of 23.1% in small-area cells through improvements to the perovskite layer, a low-cost hole transport layer was developed, and the spray-coating process was enhanced.</li> <li>Obtained certified conversion efficiency of 25.7% for small-area cells fabricated on thin glass substrates and 22.8% for six series-connected cells with an area of 11 cm<sup>2</sup>.</li> <li>Initiated interviews with construction companies to clarify commercialization targets and product requirements. Investigation of legal and regulatory frameworks is also underway.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
<p>3. Next-Generation Solar Cell Demonstration Project</p>	-	-	FY2030 TRL6-7
<p>(1) Establishment of mass-production technologies and field demonstration for lightweight, flexible perovskite solar cells</p>	<ul style="list-style-type: none"> <li>Selected in September 2024</li> </ul>		
<p>(2) Development of production technologies for inkjet-printed perovskite solar cells and development of installation/construction and electrical system technologies for social implementation</p>	<ul style="list-style-type: none"> <li>Selected in September 2025</li> </ul>		
<p>(3) Development of mass-production technologies and field demonstration for glass-based perovskite solar cells</p>	<ul style="list-style-type: none"> <li>Selected in September 2025</li> </ul>		
<p>(4) Development and demonstration of mass-production technologies for highly versatile perovskite solar cells toward social implementation</p>	<ul style="list-style-type: none"> <li>Selected in September 2025</li> </ul>		

The Government of Japan estimates the global CO<sub>2</sub> emission reduction effect expected from the deployment of next-generation solar cells to be approximately 1.5 million tons in 2030 and approximately 100 million tons in 2050. The estimate for 2030 assumes that the global annual installation pace of solar power continues at the current level (112 GW installed in 2019), and that next-generation single-junction solar cells account for 1% of this amount, leading to an estimated installation volume of 3.5 GW in 2030

<sup>28</sup>. For Japan's share, the Government adopts 25%, based on Japan's share of global solar cell production after 2010. These parameters were used to calculate the impact of this GI Fund project. For tandem-type solar cells, the estimate is based on an assumed domestic production scale leading to the introduction of 1.3 GW. For 2050, the Government assumes that next-generation solar cells will represent 50% of the global solar power market, with cumulative installations reaching approximately 0.6 TW after 2030. Japan's share is again estimated at 25% as in the 2030 case.

Japan's Next-Generation Solar Cell Strategy sets out projections for the deployment of next-generation solar cells, targeting 20 GW of domestic installations and 500 GW of overseas installations by 2040. The assumed cumulative installed capacity of 0.6 TW used in the impact calculation appears to be conservative relative to the outlook presented in the strategy. Moreover, the assumed conversion efficiency of 15% is conservative for tandem-type solar cells, which generally are expected to achieve higher conversion efficiencies of around 30% relative to single-junction solar cells. JCR thus evaluates that although some parameters include conservative assumptions, the selected parameters and calculation formulas are generally appropriate.

Based on the above, JCR concludes that the technological development under this GI Fund project is steadily progressing toward the 2030 targets, and that the project is expected to contribute to the realization of a carbon-neutral world in the future.

#### 5-2-2. GI Fund Project: "Cost reductions for offshore wind power generation"

The Government of Japan, aiming to achieve carbon neutrality by 2050, has adopted a policy of maximizing the introduction of renewable energy as a main power source, with offshore wind power positioned as a key technology due to the potential for large-scale deployment, cost reduction, and economic ripple effects. While offshore wind power has expanded mainly in Europe to date, rapid growth of the Asian market is expected toward 2050, and capturing Asian demand will require Japan to advance the formation of supply chains and strategically promote next-generation technology development with a view to future market acquisition.

This GI Fund project targets areas where technological development is expected to have substantial policy impact (fields with relatively low technology maturity requiring long-term support). Based on the "Roadmap for Strengthening Industrial Competitiveness in Offshore Wind Power,"<sup>29</sup> among the eight supply-chain fields identified, the project focuses on five: (2) wind turbines, (5) floating foundation manufacturing, (6) floating installation, (7) electrical systems, and (8) operation and maintenance. The R&D goals are:

"For bottom-fixed offshore wind power, to establish technologies by 2030 that enable a generation cost of 8–9 yen/kWh under certain defined conditions (such as wind conditions)," and

"For floating offshore wind power, to establish technologies enabling commercialization at internationally competitive cost levels by 2030 under certain defined conditions."

As of the September 2025 meeting of the Working Group on the Promotion of Green Power,

<sup>28</sup>The research, development, and social implementation plan assumes that, from around 2028 onward, progress will be made in establishing mass production systems for next-generation solar power.

<sup>29</sup>[https://www.meti.go.jp/shingikai/energy\\_environment/yojo\\_furyoku/sagyo\\_bukai/pdf/003\\_s01\\_00.pdf](https://www.meti.go.jp/shingikai/energy_environment/yojo_furyoku/sagyo_bukai/pdf/003_s01_00.pdf)

Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, it was confirmed that the project as a whole is progressing largely as planned. The progress status of each project is shown in Table 6.

**Table 6: Progress of the GI Fund Project "Cost reductions for offshore wind power generation" and Status of New Project Selections<sup>30</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
Phase 1-(1) Next-Generation Wind Turbine Technology Development Project	TRL4 or higher	-	-
Development of sliding bearings for wind turbine shafts	<ul style="list-style-type: none"> <li>With respect to the wear resistance of the sliding material* applied to the bearings, fatigue testing has confirmed 90% of the target number of cycles, with no abnormalities observed.</li> <li>Testing of reduced-size bearings has been completed, and it has been confirmed that the trends in the test results are consistent with those in the analytical results.</li> <li>Design of the 3–6 MW class test rig, test bearings, and building has been completed; construction of the experimental building has been finished, and installation of the test rig is scheduled.</li> </ul> <p>* Materials characterized by a low coefficient of friction and high durability (such as wear resistance).</p>		
Development of Low-Cost Specifications for Extra-Large Main Bearings for Offshore Wind Turbines	<ul style="list-style-type: none"> <li>Tests were conducted to establish the internal design specifications of the bearing, and, based on the results, the specifications were reviewed and revised as necessary.</li> <li>Among the items to be implemented, development related to production engineering has been discontinued. With respect to product engineering development, progress continues toward completion of development.</li> </ul>		
Development and Demonstration Project for High-Efficiency Production Technologies for Offshore Wind Turbine Towers	<ul style="list-style-type: none"> <li>To develop streamlined welding technology, installation of welding equipment has been completed, and phased trial operations are currently being conducted on site. Bending of test specimens and subsequent beveling operations were carried out, followed by seam welding. Going forward, grow-up operations to connect cans and perform external beveling and related processes will be conducted.</li> <li>For the development of a blast and painting robot application system, the study and delivery of the painting building/booth as well as the blast and painting robots have been completed. Trial operation of the blast robot has been completed up to the stages of assembly and dummy work. Going forward, demonstration tests of the blasting robot and assembly of the painting robot will be carried out.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
Phase 1-(2) Project for the development of cost-reduction technologies for the manufacturing and installation of floating foundations	TRL4 or higher	Completed and transitioned to Phase 2	-
Mass production and cost reduction of	<ul style="list-style-type: none"> <li>Completed in FY2023 as planned</li> </ul>		

<sup>30</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on the Promotion of Green Power, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

<p>semi-submersible hybrid floaters</p>	<ul style="list-style-type: none"> <li>• To establish design methodologies for composite structures, the appropriateness of design methods for floating foundations employing such composite structures is currently being validated.</li> <li>• For the mass production of floaters, studies have been conducted on methods for joining large blocks and on concrete casting methods.</li> <li>• A preliminary design of the mooring system has been carried out, and comparative examinations of multiple mooring configurations have been conducted.</li> </ul>
<p>Development of a floating offshore power generation facility using a TLP system that achieves low cost and superior social acceptability</p>	<ul style="list-style-type: none"> <li>• Completion as scheduled in FY2023</li> <li>• Aiming to establish integrated design technology, a coupled response and strength analysis process for the 15-MW-class wind turbine and the TLP-type floater—covering the turbine, floater, and mooring system—has been developed.</li> <li>• With a view to mass production of the floater, the floater configuration has been determined and construction methods have been examined.</li> <li>• Aiming to optimize the mooring system and establish low-cost construction techniques, durability tests of connector bearings and on-site pull-out tests were conducted.</li> </ul>
<p>Technology development and construction method development related to semi-submersible floating structures and hybrid mooring systems</p>	<ul style="list-style-type: none"> <li>• Completed in FY2023 as planned.</li> <li>• Construction of the floating body optimization system was completed, and the optimal configuration was determined. Coupled analysis of the wind turbine and floating structure has been almost completed.</li> <li>• As a mass-production technology for floating structures that does not depend on dock size, offshore joining experiments were conducted.</li> <li>• To optimize the hybrid mooring system, sea trials were conducted using the newly developed synthetic fiber for floating structure mooring.</li> <li>• As low-cost construction technologies, studies were carried out on wind turbine installation using modified SEP vessels and on the standardization of work procedures for installing floaters with high-performance vessels.</li> </ul>
<p>Development of cost-reduction technologies for the fabrication and installation of large spar-type floating foundations aimed at large-scale deployment of floating structures.</p>	<ul style="list-style-type: none"> <li>• Completed in FY2023 as planned.</li> <li>• To optimize the floating foundation, coupled analysis of the wind turbine and the floater will be performed, and a detailed plan for tank model testing of the floater will be formulated.</li> <li>• Aiming at mass production, the size of floater blocks and block transportation methods for port-based floater construction will be studied. Open-sea tests will be conducted with the goal of developing efficient installation technologies for mooring lines, including hybrid mooring systems.</li> </ul>
<p>Development of a low-cost, mass-production system for hybrid spar-type floaters compatible with large 15 MW-class wind turbines</p>	<ul style="list-style-type: none"> <li>• Completed in FY 2023 as planned</li> <li>• To verify the effectiveness of the development approach for weight reduction of the floating PC section and optimization of the steel components, a full-scale element test is planned.</li> <li>• For the development of an anchor installation method, a review of the specifications was conducted based on the results of tank tests on a small onshore vibro hammer modified for deep-sea specifications.</li> </ul>
<p>Mass production and cost reduction of semi-submersible floating foundations for early social implementation of</p>	<ul style="list-style-type: none"> <li>• Completed in FY2023 as scheduled.</li> <li>• To optimize the floating foundation, the steel weight was calculated based on the modeling of the wind turbine and the floating foundation, as well as the results of the coupled analysis.</li> <li>• With respect to the mass production of floating foundations, the conceptual design of the launch barge has been completed.</li> </ul>

manufacturing and installation.	Aiming to obtain basic design approval, preparations such as model fabrication for tank testing are underway.		
R&D Activities	At Project Commencement	Progress Status	Targets
Phase 1-(3) Offshore Wind Power-Related Electrical System Technology Development Project	TRL4 or higher	Completed and transitioned to Phase 2	-
Dynamic cables, offshore substations, and offshore converter stations	<ul style="list-style-type: none"> <li>Completed in FY 2024 as planned</li> <li>Within the working group led primarily by electric power companies, the study of specifications for floaters and other components required for the development of common elemental technologies—such as high-voltage dynamic cables and floating offshore substations/converter stations—necessary to realize a low-cost floating offshore wind power generation system assuming Japanese sea areas has been completed, and tank tests and other evaluations have been conducted. In addition, assessments related to system integration were carried out.</li> <li>In the research items led by the development manufacturers, the development of high-voltage, fatigue-resistant, long-life dynamic cables and electric equipment for floating offshore substations/converter stations will be promoted.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
Phase 1-(4) Advanced Offshore Wind Operation and Maintenance Project	TRL4 or higher	Completed and transitioned to Phase 2	-
Development of innovative inspection technology for floating wind turbine blades	<ul style="list-style-type: none"> <li>Completed in FY2024 as planned</li> <li>Developed a UAV capable of long-distance flights assuming floating offshore wind power generation 20 km off the coast, achieving a 20 km long-distance flight.</li> <li>Developed a UAV for continuity testing that can autonomously contact designated points on the blade.</li> <li>Conducted continuity testing on an actual floating offshore wind power facility (“Hibiki”).</li> <li>A simulated verification was conducted, confirming that impact sound data from the blades can be acquired by a UAV equipped with a tapping device.</li> </ul>		
Submarine Cable Laying Vessel (CLV) Development Project	<ul style="list-style-type: none"> <li>Completed in FY 2023 as planned</li> <li>The CLV concept design was completed, and a clear outlook was obtained for achieving the operational limits.</li> <li>By examining operation systems and monitoring systems that contribute to shortening construction periods, the certainty and feasibility of carrying out submarine cable laying and burial work on domestic sites according to schedules comparable to those in Europe have increased.</li> </ul>		
Advanced operation and maintenance through remote and automated control, and preventive maintenance enabled by digital technologies	<ul style="list-style-type: none"> <li>Completed in FY2023 as planned.</li> <li>To enhance preventive maintenance and regular servicing through digital technologies, platforms considered applicable to floating offshore wind power generation were identified based on a survey related to digital twins.</li> <li>Various functions for wind turbine visual inspection were implemented on a prototype research drone, its operation was verified using a motion simulation device and coastal wind turbines, and detailed design and prototyping of a drone compatible with offshore wind turbines were subsequently undertaken.</li> </ul>		

Project for the development of service operation vessels (SOVs) dedicated to wind turbine construction and maintenance.	<ul style="list-style-type: none"> <li>Completed in FY2023 as planned.</li> <li>Completed consolidation of the concept design for the hull form and main outfitting equipment and conducted analyses of hull motions.</li> <li>Conducted studies on an operational plan assuming specific projects.</li> </ul>		
Development of an operation and maintenance digital platform for floating offshore wind power generation.	<ul style="list-style-type: none"> <li>Completed in FY2023 as planned.</li> <li>Implemented the development plan, detailed design of sensing, and selection of data acquisition sites.</li> <li>Conducted information sharing and related activities with stakeholders toward the development of an API for the integrated O&amp;M information system.</li> <li>Preparing for demonstration tests using the Hibiki Wind Power Plant.</li> </ul>		
Advanced development of a CMS for offshore wind turbines to realize bearing life-cycle management.	<ul style="list-style-type: none"> <li>Completed in FY2023 as planned.</li> <li>Completed prototype evaluation for enhancing and expanding the functions of the data acquisition device and currently promoting evaluation of the improved design.</li> <li>Currently conducting demonstration operation with measurement equipment for blade sensors installed on an actual wind turbine.</li> <li>In parallel with establishing a collaboration scheme with maintenance companies, initiatives were implemented to formulate a concept for the repair business.</li> </ul>		
Development of production preventive maintenance technologies using Digital Twin and AI technologies	<ul style="list-style-type: none"> <li>Completed in FY2024 as planned.</li> <li>Input of 3D models of wind turbines and floating facilities into the PLM software has been completed.</li> <li>Operational data from existing floating offshore wind turbines were provided, and the AI model was validated.</li> <li>A performance measurement system using 3D measuring devices was constructed.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
Phase 1-(5) Common Platform	TRL4 or higher	-	-
Common Platform Development Project for Floating Offshore Wind Power	<ul style="list-style-type: none"> <li>Adopted in February 2025</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
Phase 2-(1) Floating Offshore Wind Demonstration Project	Demonstration at a Stage Close to Social Implementation	See below	FY2030 TRL6-7
Floating Offshore Wind Power Demonstration Project off the Southern Coast of Akita Prefecture Aimed at Overseas Deployment through Cost Reduction	<ul style="list-style-type: none"> <li>Currently organizing the assumptions for cost and takt time evaluation.</li> <li>Currently commissioning wind and ocean condition surveys, formulating specifications and defining requirements for seabed geological surveys and design work.</li> <li>Conducting numerical analysis and developing policies to understand the motion characteristics of the two floaters.</li> <li>Conducting additional studies on candidate floater configurations assuming large-scale wind turbines, as well as studies aimed at reducing floater weight.</li> <li>Conducted an overview survey of 5G-related equipment for use in remote operations.</li> </ul>		
Aichi Prefecture Offshore Floating Offshore Wind Power Demonstration Project	<ul style="list-style-type: none"> <li>Preparing for wind condition observations.</li> <li>Preparing for surveys related to the cable route survey and subsea ground survey.</li> </ul>		

	<ul style="list-style-type: none"> <li>Discussed the details of the environmental assessment and began preparations for drafting the scoping document.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
Phase 2-(2). Floating Offshore Wind Power Demonstration Project in Harsh Marine Environments	Demonstration at a stage close to social implementation	To be additionally undertaken in FY2025. Before public solicitation.	FY2032 TRL6-7

The Government of Japan estimates the CO<sub>2</sub> emission reduction effect of this GI Fund project to be approximately 3–7 million tons of CO<sub>2</sub> per year in 2030 and approximately 0.09 billion tons per year in 2050. These estimates are based on the assumption that offshore wind power generation replaces thermal power generation, and the emission factor used for calculating the reduction effect is the assumed average emission coefficient of thermal power in FY2030 (0.66 kg-CO<sub>2</sub>/kWh)<sup>31</sup>. For expected installed capacity of offshore wind power generation, the Government assumes a total of 1.68–3.68 million kW in 2030 (comprising 1–3 million kW under the Marine Renewable Energy Act and 0.68 million kW in port areas and general sea areas under the Act on Special Measures Concerning Renewable Energy)<sup>32</sup> and 45 million kW in 2050 (the upper value of the capacity of 30–45 million kW targeted for project formation by 2040 under the Green Growth Strategy and also used as the reference value for the renewable energy ratio estimate of 50–60% in 2050). For the capacity factor, 33.2% is used, assuming bottom-fixed offshore wind systems.

Using the assumed capacity factor of 33.2%, which is applied for impact calculation, annual power generation is estimated at approximately 5–10 TWh in 2030 and 118 TWh in 2050. According to the 6th Strategic Energy Plan, the total power generation in 2030 is estimated at 934 TWh; thus, the share of offshore wind generation in 2030 corresponds to approximately 1.6% of Japan’s annual generation. For 2050, according to the RITE “Below 1.5° C Scenario,”<sup>33</sup> total generation is approximately 1200–1400 TWh, meaning that offshore wind power generation would account for about 8–10% of national electricity output. The same scenario assumes offshore wind generation of approximately 160–270 TWh in 2050, suggesting that the Government’s assumed potential impact is conservative. For CO<sub>2</sub> emissions, comparing the reduction effect with FY2023 emissions in the energy transformation sector (before allocation of electricity and heat: 397 million tons CO<sub>2</sub>), the estimated reduction of approximately 9.8 million tons CO<sub>2</sub> per year in 2030 corresponds to about 2.5%, and the estimated reduction of approximately 0.09 billion tons CO<sub>2</sub> per year in 2050 corresponds to 22.7%. Based on the above, JCR considers that the parameters and calculation formula used are appropriate.

The technological development under this GI Fund project is steadily progressing toward the 2030 targets and is expected to generate environmental improvement effects that will contribute to Japan’s future achievement of carbon neutrality.

<sup>31</sup>JCR has confirmed that, based on assumptions regarding Japan’s 2030 energy mix and the global power generation and CO<sub>2</sub> emissions from thermal power generation shown in the IEA’s World Energy Outlook, the CO<sub>2</sub> emission intensity of thermal power generation in 2030 is approximately 0.6–0.7 kg-CO<sub>2</sub>/kWh.

<sup>32</sup>At the time of the formulation of the 6th Strategic Energy Plan, the introduction target for offshore wind power was 5.7 GW; however, considering the current situation in which the first round (1.7 million kW) under the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities has been reopened for bidding, this target can be regarded as a realistic setting.

<sup>33</sup> [https://www.rite.or.jp/system/latestanalysis/2024/12/energymix\\_addinfo.html](https://www.rite.or.jp/system/latestanalysis/2024/12/energymix_addinfo.html)

### 5-2-3. GI Fund Project: “Large-scale hydrogen supply chain establishment”

Hydrogen is an important secondary energy enabling the expanded introduction of zero-emission power sources by not only directly contributing to decarbonization in the power generation sector but also by storing and using surplus electricity derived from renewable energy. In addition, in industrial sectors where electrification is difficult, hydrogen is expected to contribute to decarbonization through its use as a feedstock or through heat utilization.

On the other hand, for social implementation of hydrogen, it is necessary to simultaneously pursue both the reduction of supply costs and the creation of large-scale demand. However, private-sector companies are facing difficulties making large-scale infrastructure investments due to uncertain future demand. To reduce this uncertainty, it is necessary to build a social implementation model that maximizes the use of existing infrastructure and enables both supply expansion and demand creation.

This project aims to establish technologies that achieve both the creation of large-scale demand and the reduction of supply costs through large-scale hydrogen transportation equipment—including hydrogen carriers—and demonstration of hydrogen power generation (co-firing and dedicated firing). The goals are to achieve a hydrogen supply cost of 30 yen/Nm<sup>3</sup> in 2030 and 20 yen/Nm<sup>3</sup> or less in 2050. Although some project components experienced changes in the plan according to progress, continuous monitoring and stage-gate reviews have been conducted, and efforts are underway to complete demonstration and social implementation within the project period. Specific progress is shown in Table 7.

**Table 7: Progress of the GI Fund Project “Large-scale hydrogen supply chain establishment”<sup>34</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Establishment of international hydrogen supply chain technologies and development of an evaluation platform for liquefied hydrogen-related equipment	TRL4	See below	-
(1) Commercialization demonstration of the liquefied hydrogen supply chain	<ul style="list-style-type: none"> <li>Studies were conducted on demonstration sites, facility configurations, and other aspects for a large-scale maritime transportation demonstration of liquefied hydrogen.</li> <li>In light of the materialization of schedule delays due to obtaining permits and approvals overseas, the liquefied hydrogen shipping location was changed from Australia to Japan. The plan was revised to prioritize the earliest possible establishment of the technology by completing the demonstration within FY2030.</li> <li>Based on the supply–demand balance expected in the early 2030s, the initial phase of social implementation, the tank capacity of the hydrogen carrier has been scaled down from 160,000 m<sup>3</sup> to 40,000 m<sup>3</sup>. A capacity of 40,000 m<sup>3</sup> corresponds to 32 times the size of the world’s first and only liquefied hydrogen carrier, Suiso Frontier, currently in operation.</li> </ul>		

<sup>34</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on Energy Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

	<ul style="list-style-type: none"> <li>• Construction of shipping and receiving terminals and the building of hydrogen carriers is currently underway.</li> <li>• Construction of the demonstration facilities is scheduled to be completed in 2029, with demonstration tests to commence thereafter.</li> </ul>
(2) MCH Supply Chain Demonstration Project	<ul style="list-style-type: none"> <li>• Potential demonstration sites and facility configurations for the commercialization demonstration of MCH—which has properties similar to gasoline and can utilize existing refinery infrastructure—were examined.</li> <li>• Regarding the shipping site, we are currently evaluating and selecting from 7 candidate sites.</li> <li>• Regarding the receiving site, the selection is underway, taking into account the hydrogen supply to consumers within the industrial complex.</li> <li>• Facilities to be installed at the shipping and receiving locations are currently being examined.</li> <li>• Construction at the shipping and receiving locations is scheduled to begin in 2026, with completion of the demonstration facilities in 2029 and the commencement of demonstration tests thereafter.</li> </ul>
(3) Development of a Materials Evaluation Infrastructure to Support R&D on Liquefied Hydrogen-Related Equipment	<ul style="list-style-type: none"> <li>• The project is scheduled for completion in March 2026.</li> <li>• <b>(1) Development of evaluation test facilities:</b> Examine the detailed development specifications for the evaluation test facilities and place the order in January 2023; construction to be completed by the end of July 2024. Identifying technical issues and starting round-robin testing.</li> <li>• <b>(2) Development of specialized experimental facilities:</b> Examine the detailed development specifications for the special experimental facilities and place the order in January 2023; construction to be completed by the end of February 2024. Verified whether the tests could be conducted without any problems.</li> <li>• <b>(3) Construction of a Materials Database Platform:</b> An order was placed in March 2023 to build a database with a common structure, making maximum use of the databases provided by the National Institute for Materials Science (NIMS), a National Research and Development Agency. Programming was completed in November 2024.</li> </ul>
(4) Development of large-scale, high-efficiency equipment for hydrogen liquefaction machinery.	<ul style="list-style-type: none"> <li>• For the compressor, the design and fabrication of a compact test unit incorporating the elemental technologies required to achieve a high pressure ratio and high efficiency have been completed, and performance testing has confirmed that the target performance has been achieved. In addition, detailed design of the demonstration test facility using hydrogen has been carried out, and construction has commenced.</li> <li>• For the power-recovery type expansion turbine, the wet turbine, and the magnetic refrigerator, various elemental tests necessary for establishing the key elemental technologies have been conducted, and feasibility has been confirmed for all of them. Verification of technical feasibility.</li> </ul>
(5) Development of direct MCH electrolytic synthesis (Direct MCH) technology	<ul style="list-style-type: none"> <li>• Unlike conventional methods, this technology directly produces MCH without going through intermediate processes, thereby simplifying the facilities and enabling a potential reduction of capital expenditures by up to 50%; a technology demonstration has been conducted.</li> <li>• In Brisbane, a production demonstration using a medium-sized electrolyzer with an electrode capacity of 150 kW, which can also be used as a commercial unit, was completed in March</li> </ul>

	<p>2024.</p> <ul style="list-style-type: none"> <li>Currently, preparations are underway in Australia for the construction of a demonstration plant using a large-scale electrolyzer (1.2 MW (1,200 kW)).</li> <li>From FY2026 to FY2027, demonstration tests will be conducted at a large-scale electrolyzer plant.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
2. Establishment of technologies to realize hydrogen power generation (co-firing and dedicated firing).	TRL4	See below	FY2030 TRL8 or higher
(1) Technical verification of hydrogen co-firing power generation related to the construction of a large-scale hydrogen supply chain (completed in FY2024)	<ul style="list-style-type: none"> <li>At the stage-gate review in February 2025, a decision was made to terminate the project.</li> <li>The reason for the decision to terminate is that, due to technological progress in the development of hydrogen gas turbines (combustors), the significance of conducting a demonstration test in FY2028 was lost.</li> <li>On the other hand, the results obtained from this project can be leveraged at the time of full-scale introduction of hydrogen power generation, such as in studies on the scope of necessary modifications to gas turbines.</li> </ul>		
(2) Demonstration project of hydrogen co-firing / dedicated hydrogen firing power generation utilizing existing thermal power plants	<ul style="list-style-type: none"> <li>A demonstration of hydrogen co-firing power generation will be conducted using the gas turbine power generation facilities installed at existing thermal power plants, with the aim of verifying safety, reliability, and other factors, thereby establishing comprehensive operational management technologies—such as operation, maintenance, and safety measures for hydrogen power generation facilities—required for commercialization.</li> <li>Detailed design, construction, and installation of related facilities were completed as planned by the end of FY2024.</li> <li>In FY2025, the project will transition to the demonstration phase, and verification tests were conducted to coincide with the Osaka-Kansai Expo period.</li> </ul>		
(3) Demonstration of CO <sub>2</sub> -free hydrogen-fired power generation	<ul style="list-style-type: none"> <li>The goal is to establish hydrogen-exclusive combustion power generation technology using large-scale power generation facilities by 2030.</li> <li>A candidate site for large-scale hydrogen power generation was selected, and studies were carried out on modifications for hydrogen-exclusive combustion and on hydrogen/natural gas supply facilities.</li> <li>On the other hand, as a result of the commercial viability assessment of the proposed demonstration site, it was confirmed that it would be difficult to secure the conditions required for large-scale hydrogen-fired power generation (such as hydrogen volume, pressure, and the probability of success of new technologies).</li> <li>Since it will be difficult to secure sufficient hydrogen volume by 2030, the plans for FY2025 onward will be reviewed.</li> </ul>		

The Government of Japan estimates the CO<sub>2</sub> emission reduction effect of this GI Fund project to be approximately 7 million tons of CO<sub>2</sub> per year in 2030 and approximately 0.4 billion tons of CO<sub>2</sub> per year in 2050. For the 2030 estimate, the Government of Japan calculates the CO<sub>2</sub> reduction effect based on the estimated hydrogen volume supplied by international hydrogen supply chains, assuming that the

supplied hydrogen replaces natural gas for power generation on a calorific equivalent basis. In calculating the 2030 reduction effect, the hydrogen supply volume is assumed to be 1 million tons per year from overseas, which corresponds to the difference between the Government's hydrogen introduction target of 3 million tons in 2030 and the domestic supply volume (2 million tons), assuming the domestic supply remains at the same level as at present. For the estimate for 2050, the Government uses the assumed reduction resulting from hydrogen replacing natural gas, based on the projected international hydrogen trade volume. In 2050, the hydrogen supply volume is assumed to be 55 million tons per year, which is based on the assumption that 10% of hydrogen demand of 550 million tons per year in 2050 projected by the Hydrogen Council's "Hydrogen Scaling Up" (November 2017)<sup>35</sup> will be internationally traded. It should be noted that both the 2030 and 2050 calculations consider only the avoided emissions from natural gas combustion at the point of hydrogen use but not lifecycle emissions. JCR evaluates that the parameters and calculation formula used are appropriate.

Regarding the estimated CO<sub>2</sub> emission reduction effect of this GI Fund project of approximately 7 million tons in 2030, JCR compares this with Japan's FY2024 actual electricity generation. According to the FY2024 electricity generation statistics published by the Agency for Natural Resources and Energy of the METI<sup>36</sup>, total power generation was 853.75 billion kWh and thermal power generation was 626.64 billion kWh (73.4%) including LNG-fired generation of 284.17 billion kWh (33.3%). If the CO<sub>2</sub> emission factor for LNG-fired power generation is assumed to be 0.415 kg-CO<sub>2</sub>/kWh<sup>37</sup>, CO<sub>2</sub> emissions from LNG-fired power generation are estimated at approximately 118 million tons per year. Therefore, the estimated CO<sub>2</sub> emission reduction effect of approximately 7 million tons in 2030 corresponds to approximately 6% of the FY2024 LNG-fired power generation CO<sub>2</sub> emissions. On the other hand, not all hydrogen supplied from overseas will necessarily be used for power generation; therefore, this figure should be understood as representing the potential impact.

The research results of this project are expected to be utilized not only domestically but also internationally, contributing to further reductions in CO<sub>2</sub> emissions.

#### 5-2-4. GI Fund Project: "Development of Next-generation Aircraft"

Aviation has higher CO<sub>2</sub> emissions intensity of transport compared to other public transportation modes such as buses and railways, and efforts toward decarbonization in the aviation sector are considered indispensable for achieving carbon neutrality. Although aviation demand temporarily decreased due to the impacts of COVID-19, according to forecasts by IEA, ICAO, etc., demand is expected to steadily recover, and both revenue ton kilometers (RTK) and revenue passenger kilometers (RPK) are expected to continue increasing. The increase in aviation demand leads directly to an increase in CO<sub>2</sub> emissions, and therefore further efforts toward decarbonization in the aviation industry are expected to be required. At the 41st ICAO Assembly held in October 2022, the long-term global aspirational goal (LTAG), which

<sup>35</sup> <https://hydrogencouncil.com/en/study-hydrogen-scaling-up/>

<sup>36</sup> Source: Agency for Natural Resources and Energy "Electricity Statistics Survey (FY2024)"  
[https://www.enecho.meti.go.jp/statistics/electric\\_power/ep002/pdf/2024/0-2024.pdf](https://www.enecho.meti.go.jp/statistics/electric_power/ep002/pdf/2024/0-2024.pdf)

<sup>37</sup> Source: Ministry of the Environment "Evaluation Results on the Progress of Global Warming Countermeasures in the Electric Power Sector (Reference Materials Collection)"  
<https://www.env.go.jp/press/files/jp/114277.pdf>

aims to achieve net-zero CO<sub>2</sub> emissions in international aviation by 2050, was adopted, and efforts toward decarbonization in the aviation sector are accelerating worldwide.

In the Action Plan for Promoting Decarbonization of Aviation formulated by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the major CO<sub>2</sub> reduction measures in the aviation sector include (1) the introduction of new technologies into aircraft and their equipment, (2) improvements in flight operations through advanced air traffic control, (3) promotion of SAF introduction, and (4) the use of carbon credits. Regarding the shift to green technologies based on the decarbonization requirements of the aviation sector as an opportunity to dramatically strengthen the competitiveness of Japan's aviation industry, this GI Fund project aims to develop core technologies for hydrogen aircraft and major structural components for next-generation aircraft that require complex shapes and significant weight reduction. Furthermore, the project conducts R&D on “fuel cell propulsion systems” and “power control and thermal/air management systems,” which are expected to be used in next-generation aircraft. As overall goals of this GI Fund project, TRL 6 or higher is targeted for core technologies essential for hydrogen aircraft, TRL 6 or higher is targeted for research on weight reduction and structural strength of major structural components such as main wings for small- and medium-sized aircraft, TRL 6 or higher is targeted for a 4 MW-class fuel cell electric propulsion system using liquid hydrogen, and TRL 6 or higher is targeted for core technologies in power control and thermal and air management systems.

In the Action Plan for Promoting Decarbonization of Aviation, regarding (1) the introduction of new technologies into aircraft and their equipment,, it is stated that weight reduction and production efficiency improvements of aircraft will be advanced in the near term, while R&D toward the realization of hydrogen aircraft and electric aircraft will be promoted in parallel. Generally, new aircraft models are developed and introduced in intervals of approximately 15–20 years, and energy savings of approximately 15–20% compared to previous-generation aircraft are expected through the use of advanced composite materials for weight reduction, optimal wing design, and improvements in engine performance. Hydrogen aircraft and electric aircraft do not use fossil fuels as an energy source and therefore do not emit CO<sub>2</sub> during operation, and the IEA's “Net Zero Roadmap: A Global Pathway to Keep the 1.5° C Goal in Reach” cites them as important innovative technologies for achieving decarbonization.

**Table 8: Progress of the GI Fund Project “Development of Next-Generation Aircraft” and Status of New Project Selections<sup>38</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Development of core technologies for hydrogen-powered aircraft	TRL 1–2	TRL 2–3	FY2030 TRL3 to 6
Hydrogen aircraft engine combustor and system technology development	<ul style="list-style-type: none"> <li>Improved designs of hydrogen burners are underway to further reduce NO<sub>x</sub> emissions.</li> <li>Conducting studies on combustor structures (liner, burner, fuel piping, and flow-straightening structures) in preparation for partial combustor testing.</li> <li>Preparing for hydrogen operation tests using an engine for ground-based demonstration.*</li> </ul>		

<sup>38</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on Industrial Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

	<ul style="list-style-type: none"> <li>• Currently conducting performance verification tests using prototype hydrogen pumps, valves, and heat exchangers.</li> <li>• Plans to establish domestic combustor test facilities have been abandoned, and the tests will instead be conducted overseas. (Small-scale preliminary verification tests will be carried out domestically.)</li> </ul>		
Liquefied hydrogen fuel storage tank development	<ul style="list-style-type: none"> <li>• Based on an assessment of the vibrational characteristics of the tank support structure, a weight-reduction design is currently being implemented. Welding methods and assembly methods are under review. The first prototype of the mock-up tank has been completed, and the second prototype is currently in production.</li> <li>• Measures against hydrogen permeation and outgassing in composite material tanks are under consideration. The first prototype of the mock-up tank has been completed, and the second prototype is currently in progress.</li> <li>• Specification setting and design of the components for the temperature and pressure control system inside the tank have been completed. Evaluation tests of the prototype pressure relief valve have been completed.</li> </ul>		
Hydrogen-aircraft architecture concept research	<ul style="list-style-type: none"> <li>• By participating in meetings hosted by overseas certification authorities and the SAE, the latest trends in standards formulation are being studied, and the anticipated standards for hydrogen-powered aircraft are being updated.</li> <li>• In coordination with each system representative, formulate conceptual safety measures against hydrogen leakage and hydrogen fires around the fuel supply piping.</li> <li>• Conduct wind tunnel tests using a model based on the aircraft specification concept and verify that the range performance requirements are satisfied.</li> </ul> <p>* Successful hydrogen operation test of the ground demonstration engine at JAXA Noshiro (October 2024)</p>		
R&D Activities	At Project Commencement	Progress Status	Targets
2. Development of primary aircraft structures with complex shapes and dramatically reduced weight	TRL1-3	TRL2-5	FY2025-FY2030 TRL 6
Research on weight reduction, high production rate, and complex shapes for primary aircraft structures using composites	<ul style="list-style-type: none"> <li>• In order to improve design strain in fastenerless structures, the fabrication of test specimens for various strength tests and the execution of those tests are continuing.</li> <li>• Significant progress has been made in building relationships with CMH-17 (active participation in task groups) toward establishing certification methods and promoting international standardization for fastener-less designs.</li> <li>• Small-scale main wing spar element tests (1.2 m and 2.6 m) are scaled up, and defect-free technology is currently being demonstrated.</li> <li>• Automatic lay-up tests for main wing skin panels are being conducted, and knowledge of automatic lay-up technologies tailored to specific part characteristics is currently being validated.</li> <li>• The development of technologies for the automation of visual inspection and for high-speed, high-efficiency NDI is being promoted to improve inspection efficiency.</li> </ul>		
Development of lightweight structures using thermoplastic composites.	<ul style="list-style-type: none"> <li>• Completion of fabrication of a small-scale partial test specimen with a complex three-dimensional curved surface element (in the span and chord directions) equivalent to a full-scale aileron.</li> </ul>		

	<ul style="list-style-type: none"> <li>In the study of the welding jig for the full-scale test specimen, the approach to core removal has been established by segmenting the cores and relaxing the part geometries.</li> <li>For the small-scale partial test specimens (single-curved surface and double-curved surface), locations prone to the occurrence of voids and wrinkles have been identified. It has been confirmed that void-free and wrinkle-free quality has been achieved, with defect levels suppressed to an internal quality standard applicable to aircraft structural components.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
3. Development of Fuel Cell Electric Propulsion Systems Using Liquid Hydrogen Fuel and Core Technologies	TRL1-4	TRL2-6	FY2029-FY2030 TRL 2-6
Development of technology for hydrogen fuel cell electric propulsion systems	<p>In order to use this as an input for the basic design (Phase 1) of the fuel cell electric propulsion system, a system that satisfies safety requirements, functional/performance requirements, and environmental durability requirements will be conceptualized, and the following will be carried out.</p> <ol style="list-style-type: none"> <li>1) Verification of System Feasibility <ul style="list-style-type: none"> <li>Based on new technology guidelines such as those of the SAE and existing standards, the assumptions regarding safety requirements associated with the use of hydrogen have been finalized.</li> <li>Developed multiple system concepts that achieve the target performance of at least 40 seats and range performance of three hours or more, while satisfying the assumed safety and environmental resistance requirements, and the associated technical challenges to realize these systems were identified.</li> </ul> </li> <li>2) Through simulations, the feasibility of the above systems was verified, and tentative KPI target values for each component were established.</li> <li>3) Based on a study of overseas trends, it was confirmed that aircraft OEMs are currently progressing with development plans for hydrogen-powered aircraft.</li> <li>4) Based on the results of the review conducted in Phase 0, the criteria for SG1 (Phase 1) have been specifically defined.</li> </ol>		
Development of hydrogen fuel cell core technologies	<ul style="list-style-type: none"> <li>For the development of materials for the core section of large fuel cell stacks, the study of specifications for nanofiber reinforcements and the development of a compounding process with Toray's electrolyte polymers were commenced in collaboration with the subcontractor Japan Vilene, and prototype samples of nanofiber-reinforced membranes with excellent surface quality were successfully produced.</li> <li>In the development and demonstration of fuel cell stacks for aircraft, it was confirmed that the newly developed reinforced membrane using nanofiber nonwoven fabric exhibited favorable power generation performance in small cell X under medium-temperature conditions.</li> <li>In the development and demonstration of implementation technology for core materials in standard large fuel cell stacks, it was confirmed that the newly developed reinforced membrane using nanofiber nonwoven fabric exhibited favorable power generation performance in small cell Y under medium-temperature conditions.</li> <li>Initiated consideration of the specifications and installation locations for full-stack evaluation and demonstration facilities, as</li> </ul>		

	well as onshore demonstration facilities, in preparation for ground testing.		
R&D Activities	At Project Commencement	Progress Status	Targets
4. Development of Technology for Power Control, Thermal and Air Management Systems	TRL2-3	TRL2-3	FY2030 TRL6
Technology development for power control and thermal/air management systems	<ul style="list-style-type: none"> <li>To promote system feasibility studies and research on optimization solutions, requirement definition and comprehensive simulation analysis studies for an integrated power control and thermal/air management system were conducted.</li> <li>Toward ground-based system demonstration, evaluation metrics, facility plans, and infrastructure development concepts required for full-scale demonstration were formulated, and benchmarking studies were conducted for that purpose.</li> <li>The basic design of the core MW-class generator was conducted, taking into account its environmental resistance, and requirement definition was implemented with the deployment of electric turbo machinery equipped with gas-bearing motors into the IA GI business in mind.</li> <li>As part of international standardization activities, collaboration was undertaken with domestic consultation bodies, and participation occurred in the SAE E-40 Nagoya meeting. In the technical presentation, the need to clarify business aspects, predict deterioration related to partial discharge, and standardize measurement methods was proposed.</li> </ul>		

The Government of Japan estimates the CO<sub>2</sub> emission reduction effect of this GI Fund project to be 640 million tons in 2050. This represents the total CO<sub>2</sub> emission reduction effect expected worldwide from the introduction of next-generation aircraft. CO<sub>2</sub> emissions from aircraft in 2019, (Supplement : before COVID-19, were equivalent to 620 million tons.)

The basis of this calculation assumes that CO<sub>2</sub> emissions from aircraft using jet fuel in FY2050 will be more than three times the 2019 level, reaching over 2 billion tons. Of this amount, assuming that hydrogen aircraft and fuel cell electric aircraft will each replace one-third (two-third in total) of domestic flights (which account for 40% of emissions), approximately 530 million tons of CO<sub>2</sub> emissions will be reduced.

In addition, the weight reduction and electrification targeted in this GI Fund project contribute to reducing fuel consumption of conventional jet-fuel aircraft. The plan aims for a 2% reduction through weight reduction and a 5% reduction through electrification, and if these goals are met, total CO<sub>2</sub> emissions of aircraft flying on jet fuel are expected to be reduced by approximately 100 million tons.

Combining these two CO<sub>2</sub> reduction effects, an estimated annual reduction of approximately 640 million tons is expected.

Waypoint 2050, which was released by the Air Transport Action Group composed of aviation industry experts including IATA, forecasts that most jet fuel will be replaced with SAF and that carbon neutrality by 2050 will be achieved by combining SAF with other carbon credits.

Based on the above, JCR evaluates that the parameters and calculation formulas used are appropriate.

The technological development in this GI Fund project is steadily progressing toward the targets set for FY2025–FY2030 and is expected to generate environmental improvement effects that will contribute to Japan’s realization of carbon neutrality in the future.

#### 5-2-5. GI Fund Project: “Development of Next-Generation Ships”

CO<sub>2</sub> emissions from international maritime transport account for approximately 2.1% of global emissions as of 2018, and since maritime transport demand is expected to continue increasing due to global economic growth, CO<sub>2</sub> emissions from maritime transport would further increase if no measures were taken. To achieve carbon neutrality in maritime transport, it is essential to shift from existing heavy fuel oil to gaseous fuels such as hydrogen, ammonia, and carbon-recycled methane, and it is necessary to develop marine products for ships that use hydrogen or ammonia as fuel, as well as to reduce methane slip from LNG-fueled vessels (including carbon-recycled methane).

In this GI Fund project, in order to enable full-scale dissemination of zero-emission vessels by 2050, development of hydrogen-fueled vessels and ammonia-fueled vessels (development of engines, fuel tanks, and fuel supply systems), as well as demonstrations using actual vessels, will be carried out. In addition, measures to address methane slip, which is one of the issues of LNG-fueled vessels, will be implemented. Through this, the Government of Japan aims to strengthen the international competitiveness of Japan’s shipbuilding and marine equipment industries, and, together with the maritime transport sector, to advance social implementation.

Maritime vessels are categorized into two types: domestic coastal shipping, which operates within Japan, and international maritime shipping, which operates between two or more countries. For coastal shipping, since operations are limited to within Japan, GHG reduction targets follow national GHG targets based on the Paris Agreement, while for international maritime shipping, targets follow those agreed upon by the International Maritime Organization (IMO). The IMO’s GHG reduction targets for international maritime transport are as follows:

##### **【Outline of the IMO GHG Emission Reduction Strategy】**

At the 80th session of the IMO Marine Environment Protection Committee (MEPC80) held in London, United Kingdom in July 2023, the GHG reduction targets were revised in a more ambitious manner.

Three targets were established with the aim of achieving them through measures (rules) formulated by IMO:

1. Achieve net-zero GHG emissions by around 2050.
2. Achieve a 5–10% share of zero-emission fuels by 2030.
3. Reduce CO<sub>2</sub> emissions (per ton-mile) throughout international maritime transport by 40% by 2030.

In addition, for achieving net-zero GHG emissions by around 2050, the following reduction guidelines were presented for each year:

1. Reduce GHG emissions by 20–30% by 2030 (compared to 2008).

2. Reduce GHG emissions by 70–80% by 2040 (compared to 2008).

### **【Outline of the GHG Emission Reduction Strategy for Domestic Coastal Shipping】**

For domestic coastal shipping, the MLIT established the “Study Group for Carbon-Neutral Coastal Shipping” in 2021 and compiled a report. In this report, the CO<sub>2</sub> reduction target for FY2030 was set at approximately 1.81 million tons of CO<sub>2</sub> compared to FY2013, including measures such as improving ship types, installing energy-saving equipment, operational improvements, and fuel switching. Additionally, in March 2025, new GHG reduction targets for FY2040 in domestic coastal shipping were set: a reduction of 3.87 million tons of CO<sub>2</sub> (considering modal shift), or 4.25 million tons of CO<sub>2</sub> (not considering modal shift), compared to FY2013.

### **【Roadmap for the Vessel Sector in the Green Growth Strategy Toward Carbon Neutrality】**

To achieve Japan’s national goal of “Carbon Neutrality by 2050,” the METI formulated the “Green Growth Strategy Associated with Carbon Neutrality by 2050 (the 'Green Growth Strategy')” in cooperation with relevant ministries. This strategy is an industrial policy that aims to link the challenge toward “Carbon Neutrality by 2050” with a “virtuous cycle of the economy and the environment.” In the vessel sector, the strategy aims to acquire technological capabilities necessary for achieving zero-emission vessels using LNG, hydrogen, and ammonia; to lead the development of international standards; to strengthen the international competitiveness of Japan’s shipbuilding and maritime industries; and to promote carbon neutrality in maritime transport. The roadmap presented in the strategy toward 2050 consists mainly of three measures:

1. Transition to carbon-free alternative fuels.
2. Higher efficiency in LNG-fueled vessels.
3. Development of international frameworks.

Additionally, in the “Sector-Specific Investment Strategy for Vessels (ver.2)” presented in 2024, it is stated that toward achieving Carbon Neutrality by 2050, penetration of zero-emission vessels in both domestic and international shipping will be promoted, along with vessels that support the stable supply of clean energy such as fuel carriers and offshore wind farm service vessels. Specific measures include the introduction of zero-emission vessels, establishment of domestic production bases, and improvement of training environments for seafarers. Up-front investments toward GX (Green Transformation) include “investment in building production bases for zero-emission vessels” and “investment in the introduction of zero-emission vessels.”

In this GI Fund project, development of next-generation vessels will be carried out. As overall research and development goals, the project aims to: develop hydrogen-fueled engines, fuel tanks, and fuel supply systems, and complete demonstration operations by 2030 (TRL 8 or higher) for hydrogen-fueled vessels; achieve commercial operation as early as possible by 2028 (TRL 9 or higher) through the development of ammonia-fueled engines, fuel tanks, fuel supply systems, and the establishment of ammonia fuel supply infrastructure for vessels; and achieve a methane slip reduction rate of 60% or higher by 2026 (TRL 8 or higher) for LNG-fueled vessels. For each of these goals, target research items and TRLs are set within each R&D category.

**Table 9: Progress of the GI Fund Project “Development of Next-Generation Ships” and Status of New Project Selections<sup>39</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Development of hydrogen-fueled vessels	TRL1–3	TRL1–4	FY2026–FY2030 TRL5–8
Development of marine hydrogen engines and MHFS	<ul style="list-style-type: none"> <li>Hydrogen-fueled engine onshore demonstration test: Construction of hydrogen supply facilities shared by the three companies has been completed, and a live-fuel trial run will be conducted in February 2025.</li> <li>Kawasaki Heavy Industries: Hydrogen combustion testing of the first KHI-manufactured engine (8L30KG-HDF) will commence in June 2025. A co-firing ratio of 95% or higher will be achieved at a 50% load factor. The specifications of the second unit (12V30KG-HDF) have been modified for use in an actual vessel demonstration. The output and EGR system, among other elements, are being modified, with development underway targeting shipment in March 2027. Onboard demonstration: Due to the impact of the hull form modification, the demonstration has been postponed to FY2030.</li> <li>Yanmar Power Technology: Completed verification of 95% hydrogen co-firing (BMEP 1.5 MPa) in a medium-speed single-cylinder engine and hydrogen-only operation in a high-speed single-cylinder engine. Hydrogen combustion testing of an 800 kW medium-speed dual-fuel engine (6EY22ALDF-H) will commence in mid-July.</li> <li>Japan Engine Corporation: Completed the manufacturing and durability testing of a standalone hydrogen-fuel injection system (from 1 million to 10 million cycles). No impact from hydrogen embrittlement was observed. Reliability has been verified. Commencement of manufacturing of the actual engine. Installation of hydrogen operation facilities within the plant has been completed. In April 2025, a construction contract for a vessel equipped with a hydrogen-fuel engine (6UEC35LSGH) was concluded with Mitsui O.S.K. Lines and Onomichi Dockyard. The target is to commence sea trials by the end of FY2027. The demonstration period is approximately 2.5 to 3 years. Verification tests combining hydrogen-fueled operation with heavy fuel oil operation are planned.</li> <li>Small MHFS: The detailed and production designs of the unit, which fits within a 40 ft container, is almost complete, and manufacturing is underway with a target completion date around the summer of 2026. The onshore demonstration is scheduled for FY2026, and the demonstration on an actual vessel is planned for FY2028 and beyond.</li> <li>Large MHFS: Detailed and production designs are in progress. Manufacturing is scheduled to begin in September 2025, with completion expected in February 2027. To simplify installation work at shipyards, modular design of the equipment units is being promoted.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets

<sup>39</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on Industrial Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

2. Development of ammonia-fueled vessels	TRL1-3	TRL1-6	FY2028-FY2030 TRL3-10
Development of vessels equipped with domestically produced ammonia-fueled engines	<ul style="list-style-type: none"> <li>• Nippon Yusen Kabushiki Kaisha (NYK Line): The world's first commercial ammonia-fueled vessel (an ammonia-fueled tugboat) was completed in August 2024, with demonstration voyages completed in November of the same year. Achieved a reduction of over 90% in GHG emissions. The AFMGC (Ammonia-Fueled Ammonia Carrier) is scheduled for completion in November 2026. A time charter contract with YARA was concluded in February 2025.</li> <li>• IHI Power Systems: Development has been completed for the 28ADF main engine for installation on an ammonia-fueled tugboat. Received the President Award at CIMAC 2025, the International Council on Combustion Engines. The 25ADF auxiliary engine for installation on the AFMGC began generator performance evaluation tests in March 2025 and has achieved its target performance in standalone operation. Evaluation with two units operating in parallel is currently in progress.</li> <li>• Japan Engine Corporation: Land-based operation of the main engine equipped for AFMGC installation is underway. A 95% ammonia co-firing ratio has already been achieved. N<sub>2</sub>O and unburned ammonia remain at low levels. Various parameters are being optimized toward shipment in October 2025. Manufacturing of the ammonia supply system for the actual vessel is in progress.</li> <li>• Japan Shipyard: Construction of the AFMGC commenced in April 2025. After completion in 2026, demonstration tests will be conducted on an actual vessel. Initiated consultations with relevant authorities and local governments in preparation for full-scale sea trials.</li> </ul>		
Integrated project for the development and social implementation of ammonia-fueled vessels	<ul style="list-style-type: none"> <li>• Japan Clean Ammonia Shipping: Due to a delay of more than one year in the development of the Evellence (formerly MAN) engine, which is not covered by the subsidy, the stage-gate originally scheduled for the end of FY2024 was postponed to the end of FY 2025. Due to delays in concluding the shipbuilding contract, it will be difficult to complete the full-scale ship demonstration by the end of FY2028. However, the development of the maritime fuel ammonia supply chain, including the construction of an ammonia bunkering vessel (not eligible for subsidies), is progressing as scheduled.</li> <li>• Mitsui E&amp;S: Ongoing detailed design of the fuel tank (including cooling nozzles, water spray systems, support structures, etc.). Coupling tests between the main engine and the fuel supply system (onshore coupling tests) are currently being conducted. A re-evaluation is being carried out by the manufacturer of the high-pressure pump unit as a countermeasure to component damage (bearings and impellers). In the performance test of the abatement equipment, the ammonia concentration was maintained at 25 ppm or less, well below the IMO standard of 110 ppm. The integrity of the catalysts after main engine operation was confirmed (both the ASC and the DeNO<sub>x</sub> catalysts were in good condition). Ammonia slip in the exhaust gas is expected to remain within the IMO limits.</li> <li>• NSY: As the IMO guidelines (CCC 10, September 2024) have clarified the storage requirements for ammonia fuel tanks, a redesign review is required. Detailed studies are underway in terms of hull structure, safety, and process control, with enhanced integration among design, testing, and simulation.</li> </ul>		

Development of an N2O reactor for installation on ammonia-fueled vessels	<ul style="list-style-type: none"> <li>• Kanadevia: Delivery, catalyst loading, and installation work for the test reactor have been completed. Creation of the logic for onshore testing has also been completed, and the marine-use logic is currently under development. The HAZID (Hazard Identification) safety assessment has also been completed. Onshore testing was conducted from July 2025 at the head office factory of Japan Engine Corporation.</li> <li>• NYK Line: Determination of control methods based on risk assessment</li> </ul>		
Development of peripheral equipment in building an ammonia-fueled vessel supply chain	<ul style="list-style-type: none"> <li>• Itochu Corporation: In preparation for construction in the pilot project, the company is examining methods for supplying the ammonia (500 tons per vessel) to be used in sea trials. It is jointly developing a 5,000 m<sup>3</sup>-class refrigerated ammonia bunkering vessel with Sasaki Shipbuilding. Utilizing the METI's "Subsidy for the Future-Oriented Co-Creation Project with the Global South." Starting from Singapore, horizontal rollout to countries in the Global South and other key maritime transport hubs is planned.</li> <li>• Fuji Electric: The high-sensitivity ammonia gas measurement sensor has achieved a measurement range of 0–5 ppm and a detection time of within 4 seconds. In experiments, it achieved a detection accuracy of 36 ppb, enabling detection at the ppb level. The trace leak detection sensor combines an infrared camera with an acoustic sensor, enabling rapid detection of leaks of 25 ppm or higher. Compared with competing technologies, it has advantages in detection range, accuracy, and response time. The ammonia recovery and reliquefaction unit has demonstrated higher absorption performance (lower HOG value) than conventional packed columns through the use of a spray column system.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
3. Measures against methane slip from LNG-fueled vessels	TRL3	TRL3	FY2026 TRL 7~8
Development of technologies to reduce methane slip from LNG-fueled vessels through catalyst and engine improvements	<ul style="list-style-type: none"> <li>• Kanadevia: Production of catalysts and adsorbents identical to those used in FY2023 onshore tests has been completed, as has the installation work on the actual vessel. Demonstration tests on the vessel will commence in January 2025. Achieved a methane oxidation rate of 92% or higher on the actual vessel. A reduction rate equivalent to that in the onshore tests has been confirmed.</li> <li>• Yanmar Power Technology: Achieved a 94–99% reduction in methane slip through engine improvements combined with catalysts. GHG emissions will be reduced by up to 65%.</li> <li>• Mitsui O.S.K. Lines: Commencement of demonstration tests on the actual vessel "REIMEI." The demonstration tests are planned to last for approximately 1.5 years through 2027. Samples of catalysts and adsorbents will be collected every six months to assess any performance degradation. After completion of the demonstration, all blocks will be retrieved and analyzed to estimate service life.</li> </ul>		

The Government of Japan estimates that the CO<sub>2</sub> emission reduction effect of this GI Fund project will be 330,000 tons of CO<sub>2</sub> in 2030 and 560 million tons of CO<sub>2</sub> in 2050. The 2050 figure is based on the reduction amount indicated for next-generation fuels in the scenario for achieving the 2050 GHG reduction target for international maritime transport agreed upon at IMO.

For the 2030 figure, it is assumed that ten zero-emission vessels will be in operation that year, and the CO<sub>2</sub> emissions per vessel are estimated at 33,000 tons per year. This CO<sub>2</sub> emission amount is calculated

based on aggregated 2019 data under the IMO fuel oil consumption reporting scheme (for ocean-going vessels of 5,000 gross tons or more), and JCR considers this estimation procedure appropriate.

For the 2050 figure, the reduction amount through next-generation fuels indicated in the scenario for achieving the IMO GHG reduction target for international maritime transport in 2050 is used.

If this reduction amount is simply allocated according to the national shares of shipbuilding volume in 2022, Japan's contribution through zero-emission vessels is estimated at approximately 100 million tons of CO<sub>2</sub>.

Based on the above, JCR evaluates that the parameters and calculation formulas used are appropriate.

The technological development under this GI Fund project is steadily progressing toward the targets for FY2026 to FY2030, and the project is expected to generate environmental improvement effects that will contribute to Japan's realization of carbon neutrality in the future.

#### 5-2-6. GI Fund Project: "Hydrogen utilization in Iron and steelmaking processes" Project

Japan's domestic CO<sub>2</sub> emissions from the steel industry were 131 million tons (FY2023), accounting for about 38.7% of the industrial sector and about 13% of Japan's total emissions<sup>40</sup>. Globally, CO<sub>2</sub> emissions from the steel industry were 2,761 million tons in FY2023<sup>41</sup>, making it an industry in which further reductions in total emissions are necessary. This GI Fund project supports the development of hydrogen reduction technology using blast furnaces (blast furnace hydrogen reduction technology), and the development of technology to directly reduce low-grade iron ore with hydrogen (direct hydrogen reduction technology). The project as a whole is progressing roughly as planned (some items ahead of schedule), and progress has been reported to the Working Group on Energy Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, as shown in Table 10.

**Table 10: Progress of the GI Fund Project " Hydrogen utilization in Iron and steelmaking processes"<sup>42</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Development of Hydrogen Reduction Technology Using Blast Furnaces	TRL4	TRL4	FY2030 TRL6-7
(1) Development of hydrogen reduction technology utilizing in-plant hydrogen	<ul style="list-style-type: none"> <li>Installation work is underway for facilities to conduct demonstration tests of hydrogen-based gas injection technology using the No. 2 blast furnace at the Kimitsu area of Nippon Steel Corporation's East Nippon Works, based on coke oven gas (COG) generated within the steelworks. Test operations are scheduled to commence within FY2026.</li> </ul>		
(2) Development of low-carbon technologies utilizing external	<ul style="list-style-type: none"> <li>Through high-temperature hydrogen injection tests into the SC50 experimental blast furnace conducted in November 2023</li> </ul>		

<sup>40</sup> Source: Based on the Ministry of the Environment's Japan GHG Emissions Data (FY2023) <https://www.env.go.jp/content/000310279.pdf>

<sup>41</sup> IEA "World Energy Outlook 2025" <https://www.iea.org/reports/world-energy-outlook-2025>

<sup>42</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on Energy Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

hydrogen and CO <sub>2</sub> contained in blast furnace off-gas, among others.	<p>and November 2024, CO<sub>2</sub> reduction levels of 33% and 43%, respectively, were confirmed for the first time in the world.</p> <ul style="list-style-type: none"> <li>Using a blast furnace mathematical model, the design of operating parameters that would enable achievement of a 40% reduction in CO<sub>2</sub> emissions in the demonstration test blast furnace has already been brought forward and completed.</li> <li>Construction of a 150 m<sup>3</sup>-class CR experimental blast furnace is currently underway in preparation for the commencement of trial operations in April 2025.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
2. Technology for the direct reduction of low-grade iron ore using hydrogen (direct hydrogen reduction technology)	TRL3-4	TRL4	FY2030 TRL6-7
(1) Development of direct hydrogen reduction technology	<ul style="list-style-type: none"> <li>Construction of a small test shaft furnace (1 t/h) installed at Nippon Steel's Hasaki R&amp;D Center has been completed, and trial operation is underway.</li> <li>Construction of a continuous bench-scale experimental furnace (15 kg/h) installed at JFE Steel's East Japan Works (Soga District) has been completed, and direct reduction testing is in progress.</li> </ul>		
(2) Development of impurity removal technology for electric arc furnaces utilizing directly reduced iron	<ul style="list-style-type: none"> <li>Nippon Steel: A 10-ton small-scale test electric furnace facility, designed for the evaluation and study of heat and flow behavior, refractory cooling, dephosphorization and nitrogen reduction, commenced operation in December 2024.</li> <li>JFE Steel: A 10-ton small-scale test electric furnace facility, designed for the development of technologies for preheating reduced iron and supplying heat inside the furnace, commenced operation in December 2024.</li> <li>Using a 20t electric furnace, Kobe Steel conducted a comparative analysis of the heat input efficiency between conventional scrap and direct reduced iron and confirmed that the solubility of direct reduced iron improves when it is continuously charged in the high-temperature region near the electrodes.</li> </ul>		
(3) Technological development for high-efficiency melting using an electric melting furnace that utilizes direct reduced iron	<ul style="list-style-type: none"> <li>Based on the results of the efforts to date, the implementation plan has been revised from focusing on medium-scale tests under the conventional plan to primarily conducting small-scale tests.</li> </ul>		

The Government of Japan has indicated that the expected environmental improvement effect in FY2030 is a CO<sub>2</sub> emission reduction of approximately 2 million tons per year through the development of hydrogen reduction technology using on-site hydrogen (COURSE50) under R&D Activities 1-(1)<sup>43</sup>. This figure is calculated based on the typical crude steel production volume of domestic blast furnaces (4 million tons), the conventional blast furnace CO<sub>2</sub> emission factor per ton of crude steel, the R&D targets, and the number of COURSE50 blast furnaces planned to be introduced by FY2030 (one unit). JCR considers the parameters and calculation method appropriate. After FY2030, if this technology is introduced to all blast furnaces in Japan (20 units<sup>44</sup>), further GHG emission reductions are expected. R&D Activities 1-(2) and

<sup>43</sup>Note: This figure compares one year of operation with a conventional blast furnace to one year of operation after conversion to a COURSE50 blast furnace, and it does not mean that emissions will decrease by 2 million t-CO<sub>2</sub> every year after the COURSE50 blast furnace is introduced.

<sup>44</sup>As of November 2024. Based on disclosure materials of Nippon Steel, JFE Holdings, and Kobe Steel.

2 are expected to be commercialized in and after FY2030. The technology roadmap for the steel sector formulated by the METI also indicates a path toward achieving carbon neutrality by FY2050 through the commercialization of these technologies in the 2030s to 2040s.

Citing the IEA Steel Roadmap, the Government of Japan indicates that the impact of the Bonds by FY2050 would be a global CO<sub>2</sub> reduction effect of 1.3 billion tons per year if these technologies are globally adopted. The parameters used are those reduction rates for the steel sector required in the IEA Sustainable Development Scenario, and it should be noted that not all of this is attributable to the results of this project. On the other hand, if Japan's steel industry achieves carbon neutrality by FY2050 (from about 150 million tons in FY2019), this would correspond to about 5.8% of the world's steel industry emissions (2.6 billion tons) in that year. The research outcomes of this project are expected to be utilized not only domestically but also internationally, contributing further to emissions reductions.

#### 5-2-7. GI Fund Project: “Decarbonization of thermal processes in manufacturing”

CO<sub>2</sub> emissions from 37,000 industrial furnaces in Japan<sup>45</sup> amount to 150 million tons, accounting for more than 40% of emissions in the industrial sector, and decarbonization of industrial furnaces is urgently required. However, many companies in the casting and forging materials industry are small and medium-sized enterprises, and it is difficult for them to advance efforts toward decarbonization on their own. This GI Fund project supports the development of technologies for ammonia- and hydrogen-combustion industrial furnaces used for metal products, as well as technologies related to reducing power receiving capacity and improving efficiency in electric furnaces. Since industrial furnaces are custom-designed to optimize combustion methods and control technologies depending on the product, it is necessary to establish decarbonization technologies that can accommodate a wide variety of furnace shapes and usage methods, and the significance of this GI Fund project, which is comprehensively supported by the Government of Japan, is considerable.

As of the October 2024 meeting of the Working Group on Industrial Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, the project is progressing generally as planned, and the anticipated impacts have not changed from those assumed in the initial R&D and social implementation plans. There are multiple types of industrial furnaces for which technological establishment is being targeted—ammonia industrial furnaces, hydrogen industrial furnaces, and electric furnaces—but issues common to all, such as impacts on the quality of metal products and the mechanisms behind these impacts, as well as simulation and digital-twin technologies, should be addressed collaboratively. Therefore, until FY2026, common foundational technologies applicable to all types of industrial furnaces will be developed, and thereafter, toward the technological establishment of each industrial furnace type by FY2031, the plan is to advance furnace-specific initiatives in parallel with further refinement of the foundational technologies.

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<sup>45</sup>A collective term for “furnace” equipment used in heating processes—such as melting, smelting/refining, heat treatment, drying, and deodorization—in industrial fields including steel, automotive, electrical, and electronics. Blast furnaces, basic oxygen converters, and electric arc furnaces used in steelmaking processes are excluded. The same applies hereinafter.

**Table 11: Progress of the GI Fund Project “Decarbonization of thermal processes in manufacturing”<sup>46</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Development of common fundamental technologies for carbon-neutral industrial furnaces	TRL2–3 (Some at TRL1, 4, and 5)	TRL3–4	FY2026 TRL3–4 (some at TRL5–6)*
1-A Development of common foundational technologies	<p>The bench-scale furnace will be modified, and systematic experiments will be initiated to elucidate mechanisms for low NO<sub>x</sub>, low unburned NH<sub>3</sub>, and low N<sub>2</sub>O.</p> <p>Testing and analytical equipment necessary to clarify the influence of the heated material will be installed, and it will be verified, through observation of metal specimens subjected to heating tests, that flame testing can be linked with materials analysis.</p> <p>Regarding the investigation of detailed chemical reaction mechanisms, potential candidate mechanisms will be identified and selected.</p> <p>Combustion models will be examined going forward.</p>		
1-B Establishment of combustion technology for industrial furnaces using ammonia fuel	<p>For steel reheating furnaces, ammonia combustion tests using one pair of regenerative burners are being planned. In steel forging furnaces, heated materials and refractory samples are being investigated under ammonia co-firing and mono-firing conditions in order to achieve both rapid temperature ramp-up and temperature uniformity. For aluminum melting furnaces, test facilities are currently under construction.</p>		
1-C Establishment of combustion technology for industrial furnaces using hydrogen fuel	<p>Testing of steel process furnaces is being planned using laboratory test burners, with combustion tests to be conducted going forward. Various simulations are currently being carried out for the heat treatment furnaces.</p>		
1-D Establishment of technologies for reducing and improving the efficiency of power receiving facility capacity, etc. for 1-D electric furnaces.	<p>For the hybrid furnace, preliminary preheating experiments using induction heating (rapid heating) in the upstream stage are being conducted. For steel process furnaces, a preliminary experimental model has been introduced to examine coil configurations. A compact test unit of an induction-heated Acheson furnace was manufactured for use in high-temperature process furnaces.</p>		
1-E Empirical survey and study on the decarbonization of industrial furnace users	<p>To improve the questionnaire response rate and enable expert scrutiny of the results, the cooperation of major related industrial associations (including the Industrial Furnace Association, the Japan Metal Heat Treatment Association, etc.) was secured. The questionnaire will be distributed going forward, with the aim of compiling an interim summary of the survey results within 2024.</p>		

\*After the development of common fundamental technologies, the project will move to Phase 2 (Target: TRL 6 or higher by FY2031).

The Government of Japan estimates the CO<sub>2</sub> emission reductions from this GI Fund project to be approximately 2.6 million tons of CO<sub>2</sub> per year from FY2032 to FY2040 (equivalent to approximately 20 million tons of CO<sub>2</sub> per year as of 2040), and approximately 5.2 million tons of CO<sub>2</sub> per year from FY2041 to FY2050 (equivalent to approximately 80 million tons of CO<sub>2</sub> per year as of FY2050). These figures are based on the assumption that ammonia- and hydrogen-combustion furnaces and electric furnaces will become widespread in and after FY2032, and are calculated using the CO<sub>2</sub> emissions per unit of conventional industrial furnaces, the R&D targets (CO<sub>2</sub> emissions reduction rate: 50% compared to

<sup>46</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on Industrial Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

conventional industrial furnaces until FY2040, and 100% thereafter), and the planned number of low- and zero-carbon industrial furnaces to be introduced (approximately 1,300 units annually). JCR evaluates that the parameters and calculation formula are appropriate. These CO<sub>2</sub> emission reduction amounts correspond to 8% of CO<sub>2</sub> emissions in Japan's industrial sector (289 million tons in FY2030, before the introduction of low- and zero-carbon industrial furnaces) as of FY2040, and 26% as of FY2050.

Based on the above, technological development under this GI Fund project is steadily progressing toward the FY2031 targets, and the project is expected to generate environmental improvement effects that will contribute to Japan's achievement of carbon neutrality in the future.

#### 5-2-8. GI Fund Project: "Hydrogen production through water electrolysis using power from renewables"

Hydrogen not only directly contributes to decarbonization in the power sector, but also enables the maximum use of the potential of zero-emission power sources such as renewable energy by converting surplus electricity into hydrogen for storage and utilization. For this reason, hydrogen is expected to serve as an indispensable secondary energy source for achieving carbon neutrality and also contribute to decarbonization in industrial sectors where decarbonization through electrification is difficult (such as feedstock use and heat demand).

To promote the social implementation of hydrogen, it is necessary to simultaneously pursue both the reduction of supply costs through scaling up supply equipment and the creation of large-scale hydrogen demand. However, during the early stage of hydrogen development, long-term hydrogen demand is uncertain, which creates the challenge that private-sector operators find it difficult to proceed with large-scale infrastructure investment. To reduce this uncertainty, it is necessary to build a social implementation model that maximizes the use of existing infrastructure and enables both the expansion of supply volume and the creation of hydrogen demand.

To realize this social implementation model, this GI Fund project aims to establish a hydrogen production base in Japan and to secure overseas markets, by achieving technologies that will allow equipment costs of 52,000 yen/kW for alkaline water electrolysis systems with technology levels close to commercialization, 65,000 yen/kW for polymer electrolyte membrane (PEM) water electrolysis systems, and below 68,000 yen/kW for solid oxide electrolysis cell (SOEC) systems. The project as a whole is progressing roughly as planned (with some additions forthcoming), and the progress has been reported to the Working Group on Energy Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry as shown in Table 12.

**Table 12: Progress of the GI Fund Project " Hydrogen production through water electrolysis using power from renewables"<sup>47</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Development of technologies for scaling up water electrolysis	TRL5	See below	FY2030 TRL 8 or higher

<sup>47</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on Energy Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

systems and large-scale Power-to-X demonstration			
(1) Development of large-scale alkaline water electrolysis systems and demonstration of green chemicals	<ul style="list-style-type: none"> <li>Green chemical demonstration: In Phase 1 (Namie ammonia plant), delivery of certain equipment was delayed, and in Phase 2, the overseas demonstration site plan was reviewed and revised. Although these reviews and revisions of the overseas demonstration site plan have occurred, through close examination of the operating plan and other aspects, the required demonstrations are expected to be completed within the project period.</li> <li>Since the completion of the pilot test facility in March 2024, operations have proceeded smoothly, and the development of elemental technologies (multi-module control and component development) has progressed.</li> </ul>		
(2) Development of large-scale PEM water electrolysis systems and demonstration of decarbonization of heat demand.	<ul style="list-style-type: none"> <li>Due to the impact of long lead-time equipment, the project completion date has been extended from March to December 2026. The development of elemental technologies has generally progressed smoothly, and the project passed the stage-gate review in April 2025.</li> <li>In October 2025, a demonstration was launched to utilize the equipment developed under this project (a water electrolysis system and a hydrogen boiler) in the natural mineral water sterilization process at Suntory's natural mineral water plant.</li> </ul>		
(3) Development of a large-scale SOEC-type water electrolysis system	<ul style="list-style-type: none"> <li>An additional public call for proposals will be conducted until December 2025 to achieve technologies that will make it possible to foresee a reduction in SOEC capital costs to below 68,000 yen/kW by 2032. The selected recipients are scheduled to be decided in February 2026.</li> </ul>		
R&D Activities	At Project Commencement	Progress Status	Targets
2. Establishment of performance evaluation technologies for water electrolysis systems	-	-	-
	<ul style="list-style-type: none"> <li>The installation of the three categories of equipment required for performance evaluation of water electrolysis systems was completed by FY2024. With respect to evaluation methodologies, discussions and examinations are under way in an expert committee. In parallel, a domestic framework has been established to participate in international standardization meetings, such as ISO/TC 197 (hydrogen sector), in order to collect information and ensure a strong presence.</li> </ul>		

The Government of Japan estimates the potential global CO<sub>2</sub> reduction effect expected from the widespread deployment of water electrolysis systems to be approximately 400 million tons per year in 2030 and approximately 1.52 billion tons per year in 2050. This estimate is based on the assumption that hydrogen produced by water electrolysis is used as a substitute for the heat demand currently met by imported natural gas. For installed capacity of water electrolysis systems, the figure for 2030 is set using the combined installation targets of major countries and regions (the EU, Chile, and the United Kingdom), while the figure for 2050 is set based on the water electrolysis capacity (approximately 2,600 GW) in 2050 under the Faster Innovation Case of the IEA's "Energy Technology Perspectives 2020."<sup>48</sup>

<sup>48</sup> IEA Energy Technology Perspectives 2020  
[https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy\\_Technology\\_Perspectives\\_2020\\_PDF.pdf](https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf)

The operating rate of the equipment is set at 30%, with reference to Germany’s National Hydrogen Strategy. Since this is a potential estimate, it should be noted that not all of the effects are attributable to this project; however, JCR evaluates that the parameters and calculation formula are appropriate, including the use of imported natural gas—which emits less CO<sub>2</sub> than other fossil fuels such as oil and coal—as the basis for calculating the most conservative estimate.

The research results of this project have the potential to be utilized not only domestically but also internationally and to further contribute to emission reductions are expected.

#### 5-2-9. GI Fund Project: “Achieving carbon neutrality in waste and resource circulation systems”

GHG emissions from the waste sector in Japan amount to approximately 40 million tons (3.4%) of the country’s total emissions, making it the third-largest sector following the energy sector and the industrial processes and product use sector. Of the GHG emissions in Japan’s waste sector, those associated with waste incineration (simple incineration as well as heat recovery and use as raw fuel) account for about 80%. Japan has limited land area, and in order to secure remaining capacity in final disposal sites (landfills), waste volume reduction is necessary. Moreover, it is said that if organic waste is landfilled as is, methane—with a global warming potential 25 times that of carbon dioxide (CO<sub>2</sub>)—will be generated through biological decomposition. In addition, there are wastes with infectious or other hazardous properties that require thermal treatment, and with current technologies it is not possible to reduce emissions from this sector to zero.

In this GI Fund project, development and demonstration aimed at realizing a “carbon-neutral (CN) carbon circulation system,” which minimizes atmospheric emissions of CO<sub>2</sub> and methane, stably and efficiently recovers carbon contained in waste, and seeks to achieve net-zero GHG emissions while circulating and supplying biomass-derived carbon as a resource for industry, are included as eligible activities. The project as a whole is progressing roughly as planned, and progress has been reported as shown in Table 13 at the Working Group on the Promotion of Green Power, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry.

**Table 13: Progress of the GI Fund Project “Achieving carbon neutrality in waste and resource circulation systems”<sup>49</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Development of waste incineration treatment technology premised on CO <sub>2</sub> separation and capture	TRL4	TRL4–6	FY2027–FY2030 TRL6–7
1-1 Development of waste incineration treatment technologies premised on CO <sub>2</sub> separation and recovery / CN-type waste incineration facility	(1) Development of processes applicable to waste-treatment flue gas <ul style="list-style-type: none"> <li>• Conduct flue gas analysis at waste treatment plants to identify trace components in the flue gas.</li> <li>• Laboratory accelerated tests of CO<sub>2</sub> absorption liquids using simulated waste incineration flue gas are being conducted at our in-house research institute to evaluate the impact on absorbent performance.</li> </ul>		

<sup>49</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on the Promotion of Green Power, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

<p>based on chemical absorption methods (Project completed in September 2025; addition of the successor project approved in November)</p>	<ul style="list-style-type: none"> <li>Laboratory exposure tests of CO<sub>2</sub> absorption liquids using actual waste incineration flue gas are being conducted at a waste treatment plant to evaluate the impact on absorbent performance.</li> <li>A portable bench-scale test unit has been installed at a waste treatment plant, and CO<sub>2</sub> recovery tests are being conducted. Under conditions where the flue gas flow rate and CO<sub>2</sub> concentration are artificially varied, testing was conducted. The effectiveness of the developed flue-gas fluctuation-following control has been verified, and it is expected that a 90% CO<sub>2</sub> capture rate can be achieved without changing the heat consumption per unit output.</li> </ul> <p>(2) Development of an optimal heat utilization system</p> <ul style="list-style-type: none"> <li>Through a desk study of an absorbent regeneration system utilizing waste-heat recovered from waste treatment, the effect of reducing specific heat consumption has been confirmed.</li> <li>A portable laboratory test unit has been fabricated in-house, and CO<sub>2</sub> capture tests are being conducted at an in-house research facility and at a waste treatment plant, with energy efficiency currently under evaluation.</li> </ul>		
<p>1-2 Development of waste incineration technologies premised on CO<sub>2</sub> separation and capture / CN-type waste incineration facility based on oxygen-enriched (combustion)</p>	<p><u>Improvement of CO<sub>2</sub> capture rate</u></p> <ul style="list-style-type: none"> <li>In preparation for the construction of a small-scale demonstration unit, process studies (flowsheet, mass balance, equipment specifications) will be conducted, major equipment will be selected and ordered, applications in accordance with relevant laws and regulations will be prepared, and civil and construction works will be examined.</li> <li>Laboratory tests of CO<sub>2</sub> separation and capture were conducted, confirming performance achieving a CO<sub>2</sub> capture rate of 90% or higher and a CO<sub>2</sub> concentration of 95% or higher.</li> <li>Under high-CO<sub>2</sub> conditions, simulations of combustion reaction characteristics and CO<sub>2</sub> recovery volumes, combustion tests in the laboratory, and corrosion tests using ash and flue gas will be conducted.</li> </ul> <p><u>LCC Evaluation</u></p> <ul style="list-style-type: none"> <li>For the collection of basic data for LCC evaluation, analytical instruments have been selected and ordered.</li> </ul>		
<p>R&amp;D Activities</p>	<p>At Project Commencement</p>	<p>Progress Status</p>	<p>Targets</p>
<p>2. Large-Scale Demonstration of a High-Efficiency Thermal Decomposition Treatment Facility</p>	<p>TRL4</p>	<p>TRL4</p>	<p>FY2027–FY2030 TRL 6–7</p>
<p>Development of waste chemical recycling technologies for ethanol production using gasification reforming and microorganisms</p>	<ul style="list-style-type: none"> <li>For the elemental technologies of the pyrolysis treatment facility, carry out detailed design of a small-scale demonstration unit while also conducting simulations and preliminary tests, and proceed with the ordering of equipment.</li> <li>For the small-scale demonstration unit, conduct foundation work starting in November 2024 and commence plant construction in April 2025.</li> <li>Procedures for applications and other filings based on laws and regulations, coordination with local governments to secure waste for testing, and formulation of test plans using small-scale demonstration equipment were carried out.</li> </ul>		
<p>R&amp;D Activities</p>	<p>At Project Commencement</p>	<p>Progress Status</p>	<p>Targets</p>
<p>3. Development of High-Efficiency Biomethane</p>	<p>TRL4</p>	<p>TRL4–6</p>	<p>FY2027–FY2030 TRL6–7</p>

Conversion and Related Technologies			
Development of biomethanation technology	<ul style="list-style-type: none"> <li>▪ Study of methods to accelerate the biomethanation reaction. Completion of continuous testing under high-load conditions at low temperature (55° C) and low pressure (0.55 MPaG). Completion of simulations of the biomethanation reaction for continuous testing. Completion of the acquisition of microbial reaction parameters to be used in bubble column reactor simulations.</li> <li>▪ Optimization of reactor type and configuration. Establishment of measurement methods for gas holdup and kLa in bubble columns. As methods to promote hydrogen dissolution: Completion of testing of the sparger plate, followed by completion of fabrication of the stirred bubble column</li> <li>▪ Study of bubble column reaction simulation. Completion of the development of a bubble column simulation program. Ongoing verification of the simulation program using literature values and test data.</li> <li>▪ Characterization of biogas properties: First biogas composition analysis conducted at the methane fermentation facility (where a pilot test is planned).</li> </ul>		

The Government of Japan indicates the impact of this GI Fund project as the global CO<sub>2</sub> reduction effect expected from the introduction of CN-type carbon circulation plants, estimating approximately 10.5 million tons of CO<sub>2</sub> per year as of 2030 and approximately 1.24 billion tons of CO<sub>2</sub> per year as of 2050. In both cases, the impact consists of the reduction in methane emissions resulting from the decrease in landfill volume due to the introduction of CN-type carbon circulation plants, the reduction resulting from the substitution of fossil fuels by biomethane produced by CN-type carbon circulation plants, and the reduction resulting from CO<sub>2</sub> capture by the CCUS installed in the plants. The portion of waste diverted from landfilling is assumed to be incinerated or sent to methane fermentation, and for the incinerated portion, CO<sub>2</sub> emissions arising from plastic materials derived from fossil fuels are excluded from the methane reduction effect.

The technological development under this GI Fund project is steadily progressing toward the 2030 targets, and it is expected to generate environmental improvement effects that will contribute to Japan's future carbon neutrality. In addition, the impact indicated by the Government of Japan represents approximate values of the methane and CO<sub>2</sub> emissions avoided through the technologies to be put into practical use by this R&D, as well as the reduction contribution from the utilization of the produced biomethane, and JCR evaluates that the parameters and calculation formulas are appropriate.

#### 5-2-10. GI Fund Project: "Development of technology for producing raw materials for plastic using CO<sub>2</sub> and other sources"

The Government of Japan considers carbon recycling to be a technology that effectively utilizes CO<sub>2</sub> as a resource and a key technology for realizing a carbon-neutral society. Of Japan's CO<sub>2</sub> emissions by sector, the industrial sector and industrial processes account for 34.3% of total emissions (2023), and the chemical industry emits 52.3 million tons of CO<sub>2</sub> annually, representing 15.4% of emissions within

the industrial sector and industrial processes<sup>50</sup>. Most plastic raw materials are derived from naphtha (crude gasoline) obtained through petroleum refining, and approximately half of the CO<sub>2</sub> emissions from the chemical industry originate from processes such as breaking down naphtha to manufacture basic chemicals such as ethylene and propylene. In addition, although approximately 84% of waste plastic is recycled in Japan, approximately 57% of this portion is used as a heat source (thermal recycling) in waste-to-energy and similar processes and is ultimately emitted as CO<sub>2</sub>.

This GI Fund project provides support for the development of four carbon-recycling technologies related to the production of plastic raw materials: (1) advanced technology for naphtha cracking furnaces through carbon-free heat sources, (2) technology for manufacturing chemicals from waste plastics and waste rubber, (3) technology for producing functional chemicals from CO<sub>2</sub>, and (4) technology for manufacturing chemicals from alcohols. The goal of this project is to establish, by 2030, technologies capable of producing basic chemicals such as ethylene, propylene, and butadiene from waste plastics and waste rubber at yields of 60%–80%, while reducing CO<sub>2</sub> emissions generated during production to 0.8 kg-CO<sub>2</sub>/kg-olefin or 1.2 kg-CO<sub>2</sub>/kg-olefin or less<sup>51</sup>, respectively. In addition, through demonstrations at scales of several thousand to tens of thousands of tons per year, the aim is to reduce production costs by 20% compared to current chemical recycled plastics. Furthermore, by 2032, the project aims to establish technology that enables the production of recycled carbon black (CB) from waste tires at a quality equivalent to virgin material, while reducing CO<sub>2</sub> emissions generated during the production of recycled products to 1 kg-CO<sub>2</sub>/kg-CB or less<sup>52</sup>, and through demonstrations at scales of several thousand to 10,000 tons per year, aims to utilize it in tire production at a level comparable to virgin material.

As of the June 2024 meeting of the Working Group on Energy Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, it has been reported that although foundational technology development is progressing according to the initial plan, for the demonstration tests scheduled for the latter half of the project, some themes are undergoing review due to factors such as rising equipment costs and lengthened construction periods. The progress status of each project is shown in Table 14.

**Table 14: Status of Progress and Adoption of New Projects under the GI Fund Project "Development of technology for producing raw materials for plastic using CO<sub>2</sub> and other sources"<sup>53</sup>**

R&D Activities	At Project Commencement	Progress Status	Targets
1. Development of Advanced Technology for Naphtha Cracking Furnaces	TRL 4	See Below	Mid-2030s TRL 7

<sup>50</sup> Source: National Institute for Environmental Studies, Japan, "The GHG Emissions Data of Japan (FY2023 final figures)"

<sup>51</sup> Ethylene and propylene each emit 1.6 kg-CO<sub>2</sub>/kg-olefin, and butadiene 2.1 kg-CO<sub>2</sub>/kg-olefin, during production by the naphtha cracking method; however, the goal is to reduce CO<sub>2</sub> emissions during production from waste plastics and waste rubber, etc., to about half of the conventional level.

<sup>52</sup> When fossil-derived feedstock oil is used, 2.06 kg-CO<sub>2</sub>/kg-CB13 of CO<sub>2</sub> is emitted during CB production; however, the aim is to reduce CO<sub>2</sub> emissions during the production of CB equivalent to virgin material from waste tires to about half of the conventional level.

<sup>53</sup> Prepared by JCR based on hearings with the Ministry of Economy, Trade and Industry and disclosed materials (including NEDO reports presented to the Working Group on Energy Structural Transformation, Subcommittee on Green Innovation Project, Industrial Structure Council, Ministry of Economy, Trade and Industry, and R&D and Social Implementation Plan, etc.)

<p>Commercialization of ammonia-fueled naphtha cracking furnaces</p>	<p><b>Theme 1: Development of ammonia burners applicable to naphtha cracking furnaces</b></p> <ul style="list-style-type: none"> <li>Using wall burners, 100% ammonia co-firing ratio has been verified, and the target NO<sub>x</sub> level has been achieved.</li> <li>For floor burners, measures to stabilize the flame under high ammonia co-firing ratios are under continued examination. A clear prospect has been established for achieving the target NO<sub>x</sub> level.</li> </ul> <p><b>Theme 2: Basic design of a test-scale naphtha cracking furnace compatible with ammonia burners</b></p> <ul style="list-style-type: none"> <li>Based on performance information for the wall burner under development, as well as the prepared material balance and process flow diagram, the basic design and outline drawings of the test furnace were carried out and completed. Examination of the size and related specifications of the denitrification equipment is currently in progress.</li> </ul> <p><b>Theme 3: Development of a naphtha cracking furnace (test scale) compatible with an ammonia burner.</b></p> <ul style="list-style-type: none"> <li>Based on the basic design information of the test furnace using an ammonia burner implemented under R&amp;D Theme (2), the detailed design of the test furnace (including various strength calculations and creation of detailed drawings) was initiated. In parallel, procurement activities were also commenced based on the prepared drawings.</li> </ul> <p><b>Others</b></p> <ul style="list-style-type: none"> <li>As the procurement of green/blue ammonia is essential, studies and examinations of the necessary infrastructure for such procurement are continuing.</li> </ul>		
<p>R&amp;D Activities</p>	<p>At Project Commencement</p>	<p>Progress Status</p>	<p>Targets</p>
<p>2-(1) Development of technologies for producing chemicals from waste plastics and waste rubber</p>	<p>TRL4</p>	<p>See below</p>	<p>Mid-2030s to 2040 TRL 6</p>
<p>Development of technologies for producing chemicals from end-of-life tire rubber waste</p>	<p><b>Theme 1: Chemical recycling through precision pyrolysis of end-of-life tires</b></p> <ul style="list-style-type: none"> <li>KPI achieved in terms of the oil-to-gas ratio in bench-scale pyrolysis-to-oil studies and catalyst lifetime in studies on using the pyrolysis oil as a petrochemical feedstock. KPI for chemical product yield achieved through simulations based on compositional analysis results.</li> <li>The CO<sub>2</sub> reduction effect was estimated using the LCCO<sub>2</sub> evaluation and calculation model, confirming the superiority of this technology over conventional incineration treatment.</li> <li>Design of the pilot unit was initiated.</li> </ul> <p><b>Theme 2: High-yield chemical recycling of end-of-life tires through low-temperature decomposition and depolymerization.</b></p> <ul style="list-style-type: none"> <li>In laboratory evaluations, the KPI for FY2023 and the target for FY2024 were achieved in terms of both the isoprene backbone retention rate during low-temperature decomposition of multiple types of end-of-life tire model rubber and the monomer yield after depolymerization.</li> <li>The characteristics and issues of each reaction system for bench-scale equipment design and LCA evaluation are currently being identified.</li> </ul> <p><b>Others</b></p> <ul style="list-style-type: none"> <li>Discussions among the four companies (Bridgestone, ENEOS, ZEON Corporation, and Yokohama Rubber) on the LCCO<sub>2</sub> calculation methodology are continuing.</li> </ul>		
<p>Development of manufacturing technology</p>	<p><b>Theme 1: Highly efficient butadiene synthesis from ethanol</b></p>		

<p>for basic chemical products for synthetic rubber based on carbon resource circulation</p>	<ul style="list-style-type: none"> <li>Efforts to achieve both higher catalytic activity and longer catalyst life are ongoing, with examinations of catalyst metal composition, supports, and preparation conditions currently underway. World-class catalytic activity has been achieved, and progress remains on track to attain the butadiene yield targeted for FY2024.</li> <li>The data required for scale-up studies have been collected, and the design of the bench-scale unit has commenced as planned.</li> </ul> <p><b>Theme 2: Development of production technologies for bio-butadiene and isoprene derived from plant-based raw materials</b></p> <ul style="list-style-type: none"> <li>By introducing four types of mutant strains into E. coli, enzyme efficiency has improved significantly, and evaluations focusing on cofactors are proceeding toward achieving the FY2024 KPIs.</li> <li>It has been identified that aeration conditions significantly influence the cultivation process, and optimization of these conditions is currently underway.</li> </ul>		
<p>Development of chemical recycling technology that uses waste plastics</p>	<p><b>Theme 1: Production of olefins through direct decomposition of waste plastics</b></p> <ul style="list-style-type: none"> <li>A target yield of 60% or higher has been confirmed in mini-bench tests. Due to delays in the schedule, yield verification using the bench-scale unit has not yet been achieved.</li> <li>In light of soaring equipment and related costs, it has become necessary to review the process. Concrete proposals are scheduled to be deliberated at the committee meeting in July 2024.</li> </ul> <p><b>Theme 2: Ethanol production using synthetic gas derived from waste plastics</b></p> <ul style="list-style-type: none"> <li>A catalyst capable of achieving the target cost and ethanol selectivity has been identified through high-throughput testing and machine learning. In response to surging capital expenditures and related costs, revision of the pilot and demonstration plans is proposed.</li> </ul> <p><b>Others</b></p> <ul style="list-style-type: none"> <li>CFP-TOMO®, a proprietary system that enables simple and efficient calculation of product carbon footprints, has been developed and is being offered widely free of charge.</li> </ul>		
<p>Development of chemical recycling technologies to produce basic chemicals from mixed plastics</p>	<ul style="list-style-type: none"> <li>Selected in January 2025</li> </ul>		
<p>R&amp;D Activities</p>	<p>At Project Commencement</p>	<p>Progress Status</p>	<p>Targets</p>
<p>2-(2) Development of technology for recovering carbon black from end-of-life tires</p>	<p>TRL4</p>	<p>Added in August 2024</p>	<p>Mid-2030s TRL6-7</p>
<p>Development of carbon recycling technologies from polymer products, including end-of-life tires</p>	<ul style="list-style-type: none"> <li>Selected in January 2025</li> </ul>		
<p>R&amp;D Activities</p>	<p>At Project Commencement</p>	<p>Progress Status</p>	<p>Targets</p>
<p>3. Development of manufacturing technology for functional chemicals from CO<sub>2</sub></p>	<p>TRL5</p>	<p>See below</p>	<p>2030 TRL7</p>
<p>Development of manufacturing technology for functional plastic materials using CO<sub>2</sub></p>	<p><b>Development of manufacturing technology for polyurethane raw materials</b></p> <ul style="list-style-type: none"> <li>Under consideration: improving the yield of elementary reactions (MDI and HDI synthesis). For MDI, the FY2023 targets</li> </ul>		

	<p>(concentration and yield) were achieved through process optimization. Process data for bench-scale facility design were obtained using a batch reactor. Initiated the design of the bench-scale facility.</p> <ul style="list-style-type: none"> <li>Examined catalyst optimization for dialkyl carbonate synthesis and improvement of the yields of the elementary reactions. Identified conditions achieving yields exceeding 60% and promising types of supports.</li> </ul> <p><b>Development of novel synthesis technologies for intermediates used in polycarbonate (PC) production and process development for enhancing functionality of melt-process PC.</b></p> <ul style="list-style-type: none"> <li>Concerning the production process for diphenyl carbonate (monomer), the GHG emissions reduction target for FY2030 has been largely achieved at the laboratory experiment stage. Construction of the bench plant building was completed in March 2023. Installation of the bench plant equipment was completed in November 2023, and start-up operations are currently underway. Work on the basic design of the pilot plant commenced ahead of schedule.</li> <li>Regarding the polycarbonate melt polymerization process, bench plant experiments have confirmed that the introduction of high-speed high-molecular-weight formation through the addition of a special monomer enables improvement of the properties of melt-process PC. Each process must subsequently be scaled up to a demonstration plant, followed by commercial feasibility assessment and LCA verification.</li> </ul>		
<p>Establishment of a mass production process for multifunctional cyclic carbonate compounds and development of their applications.</p>	<ul style="list-style-type: none"> <li>Catalyst performance was evaluated under supercritical CO<sub>2</sub> conditions. The target values (activity, selectivity, robustness, etc.) were achieved with the developed catalyst.</li> <li>Preliminary experiments were conducted on a flow synthesis unit under supercritical CO<sub>2</sub> conditions, based on which the specifications were finalized, and the equipment was ordered.</li> <li>As polyurethane-based products, the development of gas-barrier coating agents and waterborne products was carried out, and oxygen barrier properties on par with existing barrier materials have been confirmed. Active promotion of these CO<sub>2</sub>-utilizing products in catalogs and at trade shows will be undertaken.</li> </ul>		
<p>R&amp;D Activities</p>	<p>At Project Commencement</p>	<p>Progress Status</p>	<p>Targets</p>
<p>4. Development of chemical production technologies from alcohols / (1) Development and demonstration of technologies for producing chemical raw material from green hydrogen (artificial photosynthesis) and related processes</p>	<p>TRL4</p>	<p>See below</p>	<p>2040 TRL 6</p>
<p>Development and demonstration of technologies for producing chemical raw material from green hydrogen, artificial photosynthesis, and related methods</p>	<ul style="list-style-type: none"> <li>Photocatalyst candidates with high quantum efficiency and visible-light responsiveness capable of achieving an STH of 4% or higher—the 2024 target—have additionally been identified, and development is currently underway.</li> <li>Candidate separation membranes—zeolite membranes with controlled pore size and corrugated-structure polyamide thin films—capable of achieving the target hydrogen/oxygen separation performance have been identified, and methods to improve their fundamental performance are being examined.</li> <li>Demonstration experiments on the safety of hydrogen–oxygen mixed gases have commenced.</li> </ul>		

R&D Activities	At Project Commencement	Progress Status	Targets
4. Development of chemical production technologies from alcohols / (2) Development and demonstration of basic chemical production technologies from methanol, ethanol, and related substances	TRL5	See below	2030 to mid-2030s TRL 7
Development and Demonstration of Technologies for Producing Basic Chemical Products from CO <sub>2</sub>	<p><b>Theme 1: Development of a Methanol Reactive Separation Process</b></p> <ul style="list-style-type: none"> <li>As a result of high-pressure, high-linear-velocity experiments, the need to reassess the membrane development strategy was indicated, and outsourced membrane evaluation was initiated to accelerate the study.</li> <li>Acquisition of fundamental data for the catalyst alone under the assumed conditions of the membrane-type methanol reactive separation process.</li> <li>A simulation model for the membrane-type methanol reactive separation process was constructed, enabling case studies (manufacturing cost, CO<sub>2</sub> emissions, etc.).</li> </ul> <p><b>Theme 2: Development of an innovative MTO catalytic process</b></p> <ul style="list-style-type: none"> <li>Achieved cost reduction and performance improvement of zeolite catalysts for MTP.</li> <li>Commissioned a service life evaluation unit and, taking economic viability into account, launched catalyst life testing under conditions more severe than previously assumed.</li> </ul> <p><b>Others</b></p> <ul style="list-style-type: none"> <li>In response to the addition of CO<sub>2</sub> raw-material certification to ISCC PLUS, obtaining certification for CO<sub>2</sub>-based plastics will be considered.</li> </ul>		
Development of chemical recycling technologies that convert CO <sub>2</sub> and other substances used as raw material into alcohols and olefins.	<p><b>Theme 1: Highly efficient production of alcohols from CO<sub>2</sub></b></p> <ul style="list-style-type: none"> <li>Regarding methanol, the target yield has been achieved and an outlook for catalyst life has been established on a bench-scale unit.</li> <li>A new pilot facility aimed at demonstrating the highly efficient production of methanol from CO<sub>2</sub> has been constructed at the Ehime Plant, and trial operation has commenced.</li> <li>The study on ethanol production from CO<sub>2</sub> under this project theme has been discontinued.</li> </ul> <p><b>Theme 2: Production of olefins from alcohols</b></p> <ul style="list-style-type: none"> <li>In the ETP (Ethanol to Propylene) process, an improvement in propylene yield has been confirmed. A pilot facility is currently under construction in the Sodegaura area of the Chiba Plant.</li> </ul> <p><b>Others</b></p> <ul style="list-style-type: none"> <li>CFP-TOMO®, a system independently developed to enable simple and efficient calculation of product carbon footprints, has been developed and is being offered widely free of charge.</li> </ul>		

The Government of Japan indicates the global CO<sub>2</sub> emission reduction resulting from this GI Fund project as 40 million tons of CO<sub>2</sub> per year in 2030 and 1.5 billion tons of CO<sub>2</sub> per year in 2050. In the R&D and social implementation plan of this GI Fund project, the domestic CO<sub>2</sub> emission reductions are also shown with reference to Japan's market share of ethylene plant production capacity and carbon black production capacity (ethylene: 2.8%, carbon black: 5%), and these are estimated at 1.13 million tons of CO<sub>2</sub> per year in 2030 and 36.3 million tons of CO<sub>2</sub> per year in 2050. For the market sizes (production volumes) of basic chemicals and carbon black in 2030 and 2050, the values are based on the assumed market sizes at the time of formulation of the R&D and social implementation plan and are set based on information

through interviews with companies. JCR evaluates that the parameters and calculation formulas are appropriate.

In the chemical industry sector, the Japan Chemical Industry Association has formulated the “Carbon Neutral Action Plan,” which aims to reduce emissions by 32% (20 million tons of CO<sub>2</sub>) from the 2013 level of 63.651 million tons of CO<sub>2</sub> by FY2030. The reduction potential of this GI Fund project contributes approximately 5.7% of the Japan Chemical Industry Association’s 2030 target. The CO<sub>2</sub> reduction in 2050 contributes to a reduction exceeding half of the chemical industry sector’s CO<sub>2</sub> emissions in 2013, representing a very large impact.

Based on the above, although some plan revisions are expected going forward, foundational technology development under this GI Fund project is progressing according to the initial plan, and the project is expected to generate environmental improvement effects contributing to Japan’s realization of carbon neutrality in the future.

#### 5-2-11. Innovative GX technology creation project (GteX)

The “Green technologies of eXcellence (GteX)” project is intended to make the most of Japan’s academic sector’s high potential and accumulated strengths in basic research and is aimed at contributing to the realization of GX through the creation of innovative technological seeds and the development of human resources, by supporting research and development and human resource development at universities and national research and development agencies,.

In order to achieve ambitious goals such as carbon neutrality in 2050, it is recognized that merely deploying and implementing existing technologies will not be sufficient and that the creation of “innovative GX technologies” capable of bringing about discontinuous innovation is indispensable. With this awareness of the issue, efforts have begun, following instructions from Prime Minister Kishida (at the time) in January 2022 to accelerate unified government consideration and implementation through the formulation of the “Clean Energy Strategy,” which indicates concrete pathways toward realizing a carbon-neutral economic society. In particular, it has been declared that priority investment will be made in research and development in areas such as hydrogen, renewable energy, and bio-manufacturing.

In the GteX project, foundation research related to innovative GX technologies in three fields—batteries, hydrogen, and bio-manufacturing—will be promoted at universities and national research and development agencies, using the FY2022 budget. Furthermore, the implementation policy provides support for “all-Japan, team-based” research and development to promote integrated efforts from materials development, engineering, and evaluation/analysis and also plans to promote collaboration with NEDO in projects to seamlessly connect basic and foundational research in academia to technology development, demonstration, and social implementation in companies.

As mentioned earlier, in order to realize GX, it is indispensable not only to introduce existing technologies but also to create new technologies and to promote research and development and human resource development through collaboration between industry and academia. The GteX project provides support for research and development and human resource development at universities and other institutions with the goal of raising a currently low-TRL of innovative technologies to a level based on which

companies and others can make full-scale investment decisions. The project aims not only to achieve academically excellent results but also to strengthen networks and research environments among researchers in academia in Japan and overseas and to improve TRLs toward social implementation.

In addition, "Advanced Low Carbon Technology Research and Development Program (ALCA-Next) under the JST Strategic Basic Research Programs," which is a complementary project to GteX, targets a wider range of areas, aims to create game-changing technologies through small teams of researchers, and maximizes outcomes under the same program director with the two projects working in an integrated manner.

The GI Fund project included in use of the proceeds from the Bonds provides continuous support based on industrial needs from research and development and demonstration by companies to social implementation. The project complements GteX, which approaches bottleneck issues expected to be resolved through academia-driven ideas, holds joint workshops and bridges research themes as part of this collaboration.

The progress status of this project is as follows.

In FY2023, the Japan Science and Technology Agency ("JST") adopted 15 team-based research and development projects (7 in batteries, 3 in hydrogen, and 5 in bio-manufacturing). In FY2024, one additional team-based research and development project in the battery field was adopted, and as of FY2025, a total of 16 research and development projects are underway.

In addition, in FY2023, 16 research and development projects (6 in batteries, 5 in hydrogen, and 5 in bio-manufacturing) related to innovative elemental technologies implemented within a single year were adopted in each field. After their completion, research and development completion reports and post-project evaluations (4 rated S, 8 rated A, and 4 rated B) were published. Some of the research and development projects that achieved excellent results have joined team-based research after completion and continue to conduct research and development.

Furthermore, since this project is intended for research and development, at this point no quantitative impacts contributing to the reduction of GHG emissions or the achievement of carbon neutrality have yet materialized.

The impacts on the three GteX fields are as follows:

**【Batteries】** Establishment of foundational technologies for next-generation batteries

**【Hydrogen】** Establishment of advanced technologies related to hydrogen production, storage, and utilization

**【Bio-manufacturing】** Establishment of technologies enabling improved CO<sub>2</sub> fixation capacity and the development of innovative microorganisms

The use of the proceeds promotes technological innovation in battery, hydrogen, and bio-manufacturing projects aimed at achieving carbon neutrality by 2050. JCR evaluates that advancement of efforts in batteries and energy conservation, use of proceeds through the Bonds, will contribute to the realization of carbon neutrality in Japan.

## 5-2-12. Research and development project for enhancing the post-5G information and communication system infrastructure

This project aims to strengthen Japan's development and manufacturing base for 5G information and communication systems and to achieve both a digital society and decarbonization, by developing core technologies for information and communication systems that support the fifth-generation mobile communication system with advanced functions of ultra-low latency and massive simultaneous connections (post-5G) among 5G more advanced than the fourth-generation mobile communication system (4G).

The research and development activities of this project are classified into the following four categories.

[1] Development of post-5G information and communication systems (commissioned and subsidized)  
Develop systems and related technologies, including semiconductors and edge devices used in such systems that are particularly important for achieving the performance required in post-5G.

[2] Development of advanced semiconductor manufacturing technologies (subsidized and commissioned)

Develop front-end and back-end manufacturing technologies for logic semiconductors with advanced features not currently available domestically, through activities such as constructing pilot lines. (subsidized)

Develop foundational technologies in which Japan has strengths, such as system design technologies for advanced semiconductors and packaging technologies and miniaturization-related technologies necessary for manufacturing. (commissioned and subsidized)

[3] Exploratory research (commissioned and subsidized)

Conduct exploratory research and development on technical issues related to R&D categories [1] and [2] that may not be commercialized in post-5G but are considered promising for the latter half of post-5G and the communication generation beyond 5G.

[4] Human resource development (commissioned)

Pursue programs to develop human resources with practical skills in this field, problem-solving capabilities, and the ability to create markets as well as R&D efforts, for continued growth of the entire industry where the developed results are deployed.

Of the above, the Bonds cover allocation to three themes: "optical chiplet packaging technology," "optoelectronic fusion interface memory module technology," and "deterministic latency computing platform technology," all of which fall under the development related to [2] of "packaging technology related to optoelectronic fusion and deterministic latency computing platform technology," which contributes to GX.

Optoelectronic fusion technology is a technology that utilizes optical signals—whose energy consumption and processing delay are significantly lower than those of conventional electrical signals—for data processing and communication. This research and development aims to establish a platform that enables deterministic control of delays required for communication and computation by implementing

this technology and leveraging the high speed and low latency of the post-5G communication infrastructure, with the expectation of its application in data centers where power demand is increasing.

In the Government of Japan's impact reporting, when the technologies of the respective research and development themes are introduced into data center infrastructure, the emission reduction effects resulting from reductions in power consumption by each technology on the power use of data centers are reported. Specifically, using global data center infrastructure power consumption (cumulative total for 2032–2041), the share of the elements targeted by respective technologies within that power consumption, and the percentage reduction in power consumption, the cumulative reduction amount over ten years was converted into an annual average, resulting in an estimate of approximately 3.54 million tons of CO<sub>2</sub> per year. Regarding the percentage of power consumption reduction by each technology, the planned target values set in the research and development plan are adopted: more than 40% reduction compared to conventional products for the optical chiplet packaging technology, and more than 30% reduction for the optoelectronic fusion interface memory module technology<sup>54</sup>. Meanwhile, although no reduction target is indicated for the deterministic latency computing platform technology, the reduction percentage is set at 40% based on information from the companies engaged in the R&D. JCR evaluates that the calculation formula for environmental improvement effects is appropriate.

### 5-2-13. Demonstration reactor development project for high-temperature gas reactor

The the energy mix for FY2040 published in February 2025 is presented, indicating that renewable energy will account for 40–50% and nuclear power will account for around 20%, with the position that both will be utilized to the maximum extent possible.

In the 6th Strategic Energy Plan published in 2021, nuclear power was positioned as energy on which “dependence should be reduced as much as possible,” but in the 7th Strategic Energy Plan, this was changed to “expand and maximize the use of decarbonized power sources.” JCR evaluates that this clearly indicates the maximum utilization of nuclear power from the perspectives of energy security and decarbonization.

The projected electricity generation for FY2040 Plan is approximately 1.1 to 1.2 trillion kWh, exceeding the 934 billion kWh presented for FY2030 in the 6th Strategic Energy Plan. This is based on the assumption that electricity demand will increase due to the future progress of DX and GX, and high expectations are placed on renewable energy and nuclear power as carbon-free and decarbonized power sources.

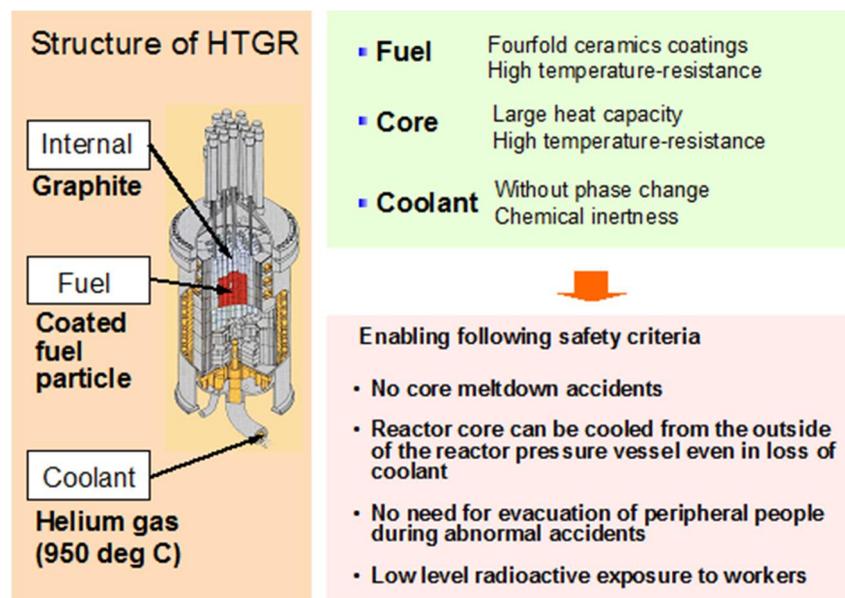
As electricity demand is expected to increase in the future, as described above, maximizing the use of nuclear power as a decarbonized power source is essential. Among such power sources, the high-temperature gas-cooled reactor (HTGR), one of the next-generation advanced reactors, is a reactor that uses ceramic materials centered on graphite as the main structural material of the reactor core and helium gas as the coolant to extract heat generated by nuclear fission. HTGRs can extract heat of around

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<sup>54</sup>Innovation and Environment Bureau / Manufacturing Industries Bureau / Commerce and Information Policy Bureau  
Research and Development Plan for the Post-5G Information and Communications Systems Infrastructure Enhancement R&D  
Project  
[https://www.meti.go.jp/policy/mono\\_info\\_service/joho/post5g/pdf/20251204\\_kenkyukaihatsukeikaku.pdf](https://www.meti.go.jp/policy/mono_info_service/joho/post5g/pdf/20251204_kenkyukaihatsukeikaku.pdf)

1,000° C, using ceramic materials with excellent heat resistance, which is extremely high compared to the approximately 300° C in light-water reactors that use water as the coolant. In addition, the fuel of an HTGR is coated in multiple layers with heat-resistant ceramic materials, and therefore does not break even at 1,600° C. Furthermore, since the reactor core uses graphite with high heat resistance and the reactor's internal structures have high thermal conductivity and high heat capacity, even in the event of an accident, the temperature change in the reactor core is slow, and the heat generated in the core is naturally dissipated through the outer surface of the reactor vessel, preventing damage to the fuel. Thus, the HTGR has inherent safety features.

The approximately 1,000° C heat characteristic of HTGRs improves the efficiency of carbon-free hydrogen production, making it important both for contributing to the decarbonization of energy supply as a decarbonized power source and for the production and supply of carbon-free hydrogen.



**Figure 4: Structure of a High-Temperature Gas-Cooled Reactor<sup>55</sup>**

Under Japan's Basic Hydrogen Strategy, Japan has introduction targets of producing up to 3 million tons/year of hydrogen/ammonia in 2030, 12 million tons/year in 2040, and 20 million tons/year in 2050. Moreover, in order to achieve a carbon-neutral society by 2050, decarbonization of the industrial sector, which accounts for approximately 25% of Japan's total domestic emissions, is indispensable, and the establishment of a large-scale and low-cost hydrogen supply infrastructure is essential for that purpose. HTGRs have the potential for cost-competitive hydrogen production in the future and are one of the options for large-scale production of clean hydrogen for a carbon-neutral society. As described above, they have excellent safety features and can supply high-temperature heat suitable for hydrogen production, enabling stable and large-scale carbon-free hydrogen production and other industrial uses, as well as wide-ranging heat uses such as district heating using low-temperature heat. In Japan, the High-Temperature Engineering Test Reactor (HTTR), an experimental reactor of the Japan Atomic Energy Agency (JAEA), has already been restarted in 2021, and Japan is now at the stage where it can carry out

<sup>55</sup>Website of Japan Atomic Energy Agency <https://www.jaea.go.jp/04/o-arai/nhc/en/faq/index.html>

development of a demonstration reactor aimed at commercialization as a means of decarbonizing heat demand and hydrogen production. In this project, with the aim of developing a demonstration reactor, (1) through hydrogen production tests using the HTTR, development of technologies to connect HTGRs and hydrogen production facilities and evaluation methods will be advanced, and (2) design and construction of an HTGR demonstration reactor, development of elemental technologies, and examination of the entire supply chain including fuel fabrication will be carried out in parallel.

(1) The following two points can be mentioned as efforts to date. Regarding the hydrogen production test using the HTTR, JAEA has been selected as the implementing organization, and in March 2025, for modifications of nuclear reactor facilities related to the connection of the HTTR and the hydrogen production facility, an application for reactor installation change approval was submitted to the Nuclear Regulation Authority under the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors.

(2) Regarding the domestic demonstration reactor plan, Mitsubishi Heavy Industries was selected in July 2023 as the core company for developing the HTGR demonstration reactor. The company has established a plant concept of the demonstration reactor, compiled basic specifications, begun core, system, and equipment design, and started development with the goal of commencing the operation of the demonstration reactor.

Going forward, toward achieving the start of operation of the HTGR demonstration reactor in the 2030s, the project aims to complete the HTTR–heat utilization test by 2030 and to establish safe connection technologies between HTGRs and hydrogen production facilities. Specific progress and future prospects of each research and development activity will be regularly reviewed and published in the Innovative Reactor Working Group.

If hydrogen production using HTGRs becomes possible, then not only carbon-free hydrogen production but also hydrogen production from natural gas and other sources would generate less CO<sub>2</sub> and other GHG than using other heat sources. JCR evaluates that this would contribute to CO<sub>2</sub> emission reductions of 7.22 tons of CO<sub>2</sub> per ton of hydrogen produced.

#### 5-2-14. Demonstration reactor development project for fast reactor

The energy mix for FY2040 is presented, indicating that renewable energy will account for 40–50% and nuclear power will account for around 20%, and both are positioned to be utilized to the maximum extent possible.

In the 6th Strategic Energy Plan published in 2021, nuclear power was positioned as energy on which “dependence should be reduced as much as possible,” but in the 7th Strategic Energy Plan, this has been changed to “expand and maximize the use of decarbonized power sources.” JCR evaluates that this clearly indicates the maximum utilization of nuclear power from the perspectives of energy security and decarbonization.

It should be noted that the projected electricity generation for FY2040 is approximately 1.1 to 1.2 trillion kWh, which exceeds the 934 billion kWh projected for FY2030 in the 6th Strategic Energy Plan. This is because it is assumed that electricity demand will increase due to the future progress of DX and GX, and high expectations are placed on renewable energy and nuclear power as carbon-free decarbonized power sources.

As electricity demand is expected to increase in the future as described above, maximizing the use of nuclear power as a decarbonized power source is indispensable. Among next-generation innovative reactors, fast reactors are nuclear reactors that extract heat from nuclear fission reactions caused by fast neutrons, and they have multiple significances, such as contributing to the decarbonization of energy supply as decarbonized power sources, the effective use of resources, and the reduction of high-level radioactive waste volume and hazardousness and to the effective use of resources. Research and development is progressing in various foreign countries, and in Japan, steady promotion of fast reactor development is positioned in the Strategic Energy Plan.

This project conducts research and development toward the realization of a fast reactor demonstration reactor, in accordance with the strategic roadmap for fast reactor development revised in December 2022, and among several fast reactor technologies, the development of a sodium-cooled fast reactor demonstration reactor—considered the most promising from the perspectives of technological maturity, marketability, and international collaboration—began in July 2023.

In addition to conceptual design of the demonstration reactor, research and development of elements necessary for achieving high safety and reliability is being carried out in stages. Specifically, prototype testing of large-scale equipment, development of test and research facilities, acquisition of data contributing to design evaluation technology development and standards and regulatory code formulation are underway. Going forward, toward realizing the start of operation of the fast reactor demonstration reactor in the 2040s, conceptual design and research and development necessary for making a decision to transition to the basic design and licensing phase by around FY2028 will continue. Furthermore, after examining the overall system including fuel fabrication facilities and reprocessing facilities, concrete examinations of fuel technology will be conducted around FY2026.

Fast reactors to be developed in this project offer emission reduction effect as a decarbonized power source and exhibit characteristics of contributing to reduction in volume and toxicity of radioactive waste, and effective use of resources. In the utilization of nuclear power, the management of radioactive waste

is extremely important, and therefore this project discloses the amount and half-life of high-level radioactive waste as an impact indicator.

#### **【Reduction of High-Level Radioactive Waste Volume】**

Since fast reactors recover and use uranium, plutonium, and other materials that make up the majority of spent fuel, the effect of volume reduction is significant compared with direct disposal, and the volume can be reduced to one-seventh.

#### **【Half-Life of High-Level Radioactive Waste】**

If high-level radioactive waste is disposed of directly, it takes 100,000 years for its radioactivity to fall to the same level as natural uranium; however, if it is burned in a fast reactor, this period is shortened to 300 years.

Based on the above, this project can be evaluated as an indispensable initiative for the decarbonization of electricity and for the reduction of high-level radioactive waste volume and hazardousness and to the effective use of resources.

### **5-2-15. Support for strengthening supply chain resilience of critical materials in response to economic and environmental changes: Project for strengthening the manufacturing supply chain of batteries essential for a green society**

Batteries are indispensable for maintaining the foundation of an electrified and digitalized society in the future, including the electrification of mobility such as automobiles, use for balancing electricity supply and demand toward making renewable energy a main power source, and use as backup power sources for 5G communication base stations. Batteries are regarded as one of the important materials for realization of Japan's carbon neutrality by 2050. A disruption in the battery supply would lead to the suspension of many manufacturing industries such as the automotive industry and services and businesses related to electricity supply. Therefore, the Government of Japan has designated batteries as "specified critical materials" under the Economic Security Promotion Act and is providing support for strengthening the battery manufacturing supply chain in Japan. In the Battery Industry Strategy formulated in August 2022, the goal of establishing domestic manufacturing capacity of 150 GWh per year and global manufacturing capacity of 600 GWh per year by 2030 is set for the purpose of strengthening the competitiveness of the battery industry.

This project provides support by granting approval for supply-security plans prepared by business operators working to ensure the stable supply of batteries under the Economic Security Promotion Act. The support covers capital investment and technology development related to batteries and their components and materials. As an outcome of this project, 15 supply-security plans were approved in FY 2023, of which two include plans to produce batteries themselves, with an expected increase in production capacity of 45 GWh per year. Under these plans, battery production and supply are scheduled to begin sequentially between FY 2026 and FY2027. In addition, this project is funded through the Government of Japan's FY2023 supplementary budget, FY2024 initial budget, and FY2024

supplementary budget, and more than 100 GWh per year of domestic battery production capacity is already expected to be secured.<sup>56</sup>

The environmental improvement effect is calculated using the two plans among the 15 supply-security plans approved in FY2023 that involve the production of batteries themselves<sup>57</sup>. These two plans are related to the establishment of production bases for automotive batteries. As a result of the estimation, it is shown that approximately 13.5 million tons of CO<sub>2</sub> reduction can be expected over the life cycle of the vehicles in which the batteries are installed. This reduction effect results from replacement of internal combustion engine vehicles by BEV based on the assumption that 100% of the planned production capacity of batteries is manufactured and that all the manufactured batteries are installed in BEVs. The parameters used in the calculation (installed capacity per BEV, life-cycle GHG emissions of BEVs and internal combustion engine vehicles) adopt the 2035 values cited from the IEA<sup>58</sup>, and the life-cycle GHG emissions adopt the STEPS scenario. While the IEA assumes that life-cycle GHG emissions for BEVs (well-to-tank for the electricity used to charge BEVs) will be reduced by 55% between 2023 and 2035, assuming decarbonization of power sources, the value used for BEV life-cycle GHG emissions in this case study adopts a conservative estimate that assumes only about half of the reduction effect (well-to-tank emissions reduction). JCR evaluates that the above parameters and the calculation formula using them are appropriate.

The IEA assumes the service life of vehicles to be 15 years, and converting the GHG emission reduction of this project into an annual reduction yields approximately 0.9 million tons of CO<sub>2</sub> per year<sup>59</sup>. In the Plan for Global Warming Countermeasures, the reduction target for the transport sector is set at 78 million tons of CO<sub>2</sub> over the 17 years from FY2013 to FY2030, which corresponds to approximately 4.6 million tons of CO<sub>2</sub> per year. The annual GHG emission reduction of 0.9 million tons of CO<sub>2</sub> from this project is equivalent to approximately 20% of that amount.

In addition, converting the expanded annual battery production capacity of 45 GWh under this project into the number of BEVs comes to approximately 750,000 vehicles per year<sup>60</sup>, which is about 8.5 times larger than the number of electric vehicles sold in Japan as of FY2023, which was approximately 88,000 vehicles<sup>61</sup>. In IEA scenarios as well, sales of EVs, including PHEVs and FCEVs, are expected to triple between 2023 and 2030 and increase more than fourfold by 2035. Thus, this project is expected to respond to the growing global demand for EVs.

Based on the above, JCR evaluates that this project contributes to carbon neutrality not only in Japan but also worldwide.

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<sup>56</sup>Note: The funds procured through the Bonds covered by this review are allocated to the certified portion for FY2023, while the FY2023 supplementary budget and the FY2024 initial budget will be funded from CT government bonds to be issued in FY2024 and thereafter.

<sup>57</sup>The other 13 projects are plans related to the production of components and materials, and the environmental improvement effect is consolidated in battery production. To avoid double-counting the environmental improvement effect, the effect is calculated only for the plans related to the production of batteries.

<sup>58</sup> IEA, 2024, Global EV Outlook 2024

<https://iea.blob.core.windows.net/assets/a9e3544b-0b12-4e15-b407-65f5c8ce1b5f/GlobalEVOutlook2024.pdf>

<sup>59</sup>Note: Because the life-cycle GHG emission reduction is converted to an annual rate using the service life, the difference in GHG emissions associated with manufacturing and disposal is apportioned over the 15-year service life.

<sup>60</sup>Calculated using a battery capacity per BEV of 60kWh per vehicle.

<sup>61</sup> IEA, Global EV Data Explorer <https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer>

## 5-2-16. Support for strengthening supply chain resilience of critical materials in response to economic and environmental changes: Project for strengthening the semiconductor manufacturing supply chain for achieving GX through improved power performance

Semiconductors, particularly power semiconductors, which control current and voltage, are used as power control devices in all types of equipment, including EVs and wind power generation, and are regarded as one of important materials for achieving Japan's carbon neutrality by 2050. The Government of Japan has designated semiconductors as "specified critical materials" under the Economic Security Promotion Act and is providing support for strengthening the semiconductor supply chain.

Silicon (Si) has been used as the wafer material for power semiconductors until now, but next-generation power semiconductors with better energy-saving performance, such as silicon carbide (SiC), are currently drawing attention and are expected to reduce energy losses by approximately 55% compared with conventional Si power semiconductors. Toward the achievement of global carbon neutrality, demand is expected to expand particularly for SiC power semiconductors, which have excellent energy-saving performance, and the METI estimates that the market will increase approximately 24-fold over the next 10 years (from about 140 billion yen to about 3.4 trillion yen).

This project supports companies that seek to ensure a stable supply of semiconductors by granting approval to supply-security plans prepared by business operators under the Economic Security Promotion Act. As a condition for support, the performance of the equipment and devices to be introduced must be advanced, and eligible items are limited to custom-designed products or those listed in the latest catalogs of manufacturing equipment companies or their equivalent. As an outcome of this project, proceeds from the Bonds have been allocated to two semiconductor supply-security plans approved in FY2023, and at the three companies that implement each project plan, supply capacities equivalent to 1.008 million SiC wafers (6-inch diameter) per year and 1.68 million Si wafers (6-inch diameter) per year are expected. Under these plans, semiconductor production and supply are scheduled to begin sequentially from FY 2025 to FY2027.

Regarding environmental improvement effects, assuming that this entire supply capacity is installed in BEVs, estimates were made for the case in which old-generation Si power semiconductors are replaced by SiC power semiconductors or next-generation Si power semiconductors with higher energy efficiency. The results show an expected reduction potential of approximately 1.74 million tons of CO<sub>2</sub> per year in total for the three companies. Among the parameters used in the calculation, reductions in power loss relative to old-generation Si power semiconductors are assumed to be 50% for SiC power semiconductors and 25% for next-generation Si power semiconductors. These figures were established by the METI based on information provided by each company. The 50% reduction effect in power loss for SiC power semiconductors is considered an appropriate figure for the advanced performance targeted by this project, given that there are examples of approximately 55% reduction in the case of railway rolling stock inverters and examples of SiC inverters for BEVs that can reduce power loss to half or less under certain driving conditions. The 25% reduction in power loss for next-generation Si power semiconductors is also considered generally appropriate, given that development is progressing for Si power semiconductors with performance approaching that of SiC.

The proportion of power loss attributable to power semiconductors in BEVs is said to be about 20%, and applying the above power-loss reduction rates, BEVs equipped with SiC power semiconductors or next-generation Si power semiconductors can achieve energy-saving effects of 10% and 5%, respectively, compared with those equipped with old-generation Si power semiconductors. The reduction potential shown in this case study is calculated by considering the energy-saving effect of BEVs and the supply capacity of each business operator and is equivalent to approximately 40% of the annual reduction amount of 4.6 million tons of CO<sub>2</sub> required to achieve the transportation sector's target set by the Government of Japan.

Although not all of the power semiconductors produced by the businesses eligible for this project will be used in BEVs, converting the above supply capacity (a combined annual total of 2.68 million SiC and Si wafers) into the number of BEVs comes to approximately 38.3 million BEVs per year. The number of new EVs (BEVs, PHEVs, and FCEVs) sales worldwide was approximately 15 million vehicles as of 2023, and this figure corresponds to approximately 2.6 times that amount.

Based on the above, this project can be evaluated as an initiative that contributes to carbon neutrality not only in Japan but also worldwide.

#### **5-2-17. Support project costs for promoting energy efficiency investment and demand structure transformation**

The Government of Japan expressed its intention to reduce GHG emissions by 46% from FY2013 levels by FY2030 and further to continue striving toward a 50% reduction. Based on this, the 6th Strategic Energy Plan formulated in 2021 set a target of reducing final energy consumption by approximately 62 million kiloliters (crude oil equivalent) from FY2013 levels by FY2030 through energy conservation. This energy conservation target was set by estimating the anticipated demand before implementing additional energy-saving measures, taking into account factors such as the economic growth rate under the "Economic Revitalization Case" in the Cabinet Office's "Medium- to Long-Term Economic and Fiscal Projections" (July 2021), the latest medium-variant population projections by the National Institute of Population and Social Security Research, and activity level projections for major industries. On that basis, the maximum feasible energy-saving measures considered technically possible and realistic were accumulated for the industrial, commercial, residential, and transport sectors.

This project aims to achieve 21.55 million kiloliters of energy savings out of the approximately 27 million kiloliters of energy savings targeted in the industrial and commercial sectors in the FY2030 energy supply and demand outlook, by supporting the replacement of factory and business-site equipment and machinery with high energy-saving performance, collaboration across multiple businesses, and the introduction of advanced energy-saving equipment and machinery that also contribute to the shift to non-fossil energy. Although this project consists of the four business categories listed below, in FY2023 CT bonds allocate proceeds to categories (A), (B), and (D) <sup>62</sup>:

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<sup>62</sup>(C) As for the Designated Equipment Installation Project, subsidies are provided under a budget program separate from the Bonds.

(A) **Advanced Projects:** Support for the introduction of advanced equipment that can achieve substantial energy savings at factories/business sites.

(B) **Custom-Designed Projects:** Support for energy-saving initiatives involving equipment replacement or process modifications that require individually custom-designed equipment.

(C) **Designated Equipment Installation Projects:** Support for the replacement of utility equipment, production equipment, etc. with high energy-saving performance.

(D) **Energy Demand Optimization Projects:** Support for more efficient and effective energy-saving initiatives such as EMS control, introduction of high-efficiency equipment, and operational improvements based on plans jointly prepared with energy management service providers.

Regarding subsidy rates: for category (A), up to two-thirds for small and medium-sized enterprises (SMEs) and up to one-half for large enterprises; for categories (B) and (D), up to one-half for SMEs and up to one-third for large enterprises. The annual subsidy upper limit per project is 1.5 billion yen for energy-saving projects and 2 billion yen for non-fossil energy projects under categories (A) and (B), with a minimum of 1 million yen for both. For category (D), the annual subsidy upper limit is 100 million yen, with a minimum amount of 1 million yen for the entire project.

In FY2023, 149 projects were selected across business categories (A), (B), and (D), but among these, only 16 single-year projects with a total project scale of 2.7 billion yen are designated to receive proceeds from FY2023 CT bonds. The CO<sub>2</sub> emission reduction effect expected from equipment and machinery upgrades under this project is approximately 3,300 tons of CO<sub>2</sub>. These CO<sub>2</sub> reduction effects are based on actual results reported by subsidized businesses. Multi-year projects selected in FY2023 are scheduled to receive proceeds from FY2024 CT bonds.

#### 5-2-18. Grant for decarbonization transition acceleration for specific regions (subsidy for private line microgrid project)

The Regional Decarbonization Promotion Grant is a scheme that, based on the “Regional Decarbonization Roadmap” (decided at the 3rd National-Local Council for the Realization of Regional Decarbonization on June 9, 2021), the Plan for Global Warming Countermeasures (approved by the Cabinet on February 18, 2025), and the Basic Policy for the Realization of GX (approved by the Cabinet on February 10, 2023), provides local governments, etc., that have been designated as leading decarbonization regions and are ambitiously working on decarbonization in collaboration with the private sector with the Specific Regional Decarbonization Transition Acceleration Grant as an investment to support regional decarbonization transitions and continuous and comprehensive multiyear support. The Regional Decarbonization Promotion Grant consists of (1) the Regional Decarbonization Transition and Renewable Energy Promotion Grant (Leading Decarbonization Area Creation Project and Priority Measure Acceleration Project) and (2) the Specific Regional Decarbonization Transition Acceleration Grant (projects such as private-benefit-type privately owned microgrids), and only (2) is eligible for proceeds from the Bonds.

The projects funded by the Bonds are private line microgrid-related projects implemented by four entities designated as leading decarbonization regions—Tsukuba City in Ibaraki Prefecture, Hidaka Village in Kochi Prefecture, Ikusaka Village in Nagano Prefecture, and Nagoya City in Aichi Prefecture.

In each region, installation of privately owned transmission lines, batteries, renewable energy power generation facilities, high-efficiency air-conditioning equipment, high-efficiency lighting equipment, etc., is being systematically advanced based on each region's five-year plan as a leading decarbonization area.

In the Government of Japan's impact report, the planned CO<sub>2</sub> reduction amounts based on the five-year plans of these four leading decarbonization regions are reported, with the cumulative CO<sub>2</sub> reduction effect estimated at approximately 342,000 tons of CO<sub>2</sub>. It should be noted that this reduction effect includes the effects of item (1) above—the Regional Decarbonization Transition and Renewable Energy Promotion Grant—which is not funded by the Bonds.

Meanwhile, the expected CO<sub>2</sub> emission reduction effect from equipment that has been installed and put into operation in these four regions by FY2024 is approximately 1,082 tons of CO<sub>2</sub> per year<sup>63</sup>. These CO<sub>2</sub> reduction effects from installed equipment are based on equipment performance and actual results, and JCR has verified that the parameters and calculation formulas used are appropriate. Going forward, as equipment installation progresses in accordance with the implementation schedules of each region, it is expected that the Government of Japan will continue to disclose impact results based on actual performance.

#### 5-2-19. Subsidy for promoting the introduction of clean energy vehicles

In FY2023, CO<sub>2</sub> emissions in Japan amounted to approximately 990 million tons, of which emissions from the transport sector (approximately 190 million tons) accounted for 19.2%. Within the transport sector, the automobile segment accounts for 85.7% (16.5% of Japan's total), and in order to achieve carbon neutrality by 2050, the spread of clean-energy vehicles with excellent environmental performance is important. As an intermediate goal, Japan aims for "100% electrified vehicles in new passenger car sales in 2035."

This subsidy program provides partial financial support to individuals, corporations, and local governments, etc., that purchase eligible EVs, PHEVs, and FCVs. Through this, it creates initial demand for electrified vehicles and promotes vehicle price reductions through mass-production effects. In addition, with a view toward future demand expansion, the program aims to encourage companies to invest in production facilities and research and development. Furthermore, by leveraging the spread of electrified vehicles in the domestic market, the program aims to strengthen the competitiveness of the automobile industry and capture overseas markets, thereby improving industrial competitiveness and reducing CO<sub>2</sub> emissions.

In the Government of Japan's impact reporting, environmental improvement effects have been reported, assuming that the number of vehicles introduced under the FY2022 supplementary budget project and the FY2023 initial budget project reflects EVs and PHEVs introduced in place of gasoline passenger cars at the time of new vehicle purchase and CO<sub>2</sub> emissions equivalent to the number of vehicles introduced being effectively reduced in the fiscal year of the introduction. The report bases its calculations on

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<sup>63</sup>Note: The outlook for the CO<sub>2</sub> emission reduction effect from equipment that has come into operation also includes the effect of item (1), the Regional Decarbonization Transition and Renewable Energy Promotion Grant, which is not funded by this bond.

statistical data from the Ministry of the Environment<sup>64</sup>. The statistical data is based on the calculation of multiplying annual driving distance by vehicle type using automobile ownership per capita, vehicle operation rates, the number of trips, and average trip length per trip based on the nationwide Road Traffic Census Origin-Destination (OD) Survey conducted by the MLIT<sup>65</sup> by CO<sub>2</sub> emission factors by powertrain, to calculate annual CO<sub>2</sub> emissions. Specifically, for gasoline vehicles and PHEVs, average CO<sub>2</sub> emission factors based on fuel consumption are used<sup>66</sup>, while for EVs, CO<sub>2</sub> emission factors of electricity are applied to electricity consumption during driving. However, for PHEVs, because it is difficult to set an average CO<sub>2</sub> emission factor that takes electricity consumption into account, the same CO<sub>2</sub> emission factor as hybrid vehicles is applied. For FCVs, since the current number of subsidized vehicles is small and emission factors and calculation methods are yet to be established, they are excluded from the present calculation of environmental improvement effects. JCR confirms the validity of the calculation parameters because national statistical surveys are referenced for the reported CO<sub>2</sub> emission reduction effects. On the other hand, although PHEVs (electricity-consumption portion) and FCVs are currently excluded because they are difficult to calculate, it is expected that calculations including these will be conducted in the future.

As noted above, Japan aims for “100% electrified vehicles in new passenger vehicle sales in 2035.” In the Government of Japan’s impact reporting, it is reported that a total of 153,882 vehicles were supported through the Bonds under the FY2022 supplementary budget project and the FY2023 initial budget project. Of these, 90,346 were EVs, 50,725 were PHEVs, and the remainder was FCVs, electric motorcycles, etc. Comparing this with the table below showing the share of electrified vehicles in new passenger car sales in 2023, it can be seen that many of the EVs and PHEVs sold were purchased using this subsidy. (The number of EVs subject to subsidy payments exceeds the number of new EV sales due to a difference between fiscal-year and calendar-year bases.) On the other hand, relative to the above-mentioned goal, the current share of electrified vehicles in new car sales remains around 49.7%, and further progress in initiatives is expected. JCR has confirmed that a portion of the FY2023 supplementary project’s introduction support is also funded by the Bonds.

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<sup>64</sup>Ministry of the Environment, Estimated CO<sub>2</sub> Emissions Data for the Transport Sector, Next-Generation Vehicle–Adjusted Version.  
[https://www.env.go.jp/policy/local\\_keikaku/tools/car.html](https://www.env.go.jp/policy/local_keikaku/tools/car.html)

<sup>65</sup>A national statistical survey conducted to grasp the actual state of road traffic throughout Japan and utilize it for road policy, which examines automobile operating conditions (origin and destination, trip length, trip purpose, etc.).  
[https://www.mlit.go.jp/road/road\\_fr4\\_000071.html](https://www.mlit.go.jp/road/road_fr4_000071.html)

<sup>66</sup> Aggregated data from the Ministry of Land, Infrastructure, Transport and Tourism’s Automobile Fuel Consumption Survey.  
<https://www.mlit.go.jp/k-toukei/nenryousyohiryou.html>

**Table 15: Share of electric vehicles in total new four-wheel vehicle sales in 2023<sup>67</sup>**

Category	Number of new vehicles sold	
	Number of vehicles sold (units)	Four-wheel vehicles Share of total
Four-wheeled vehicles total	3,992,727	100.00%
Electrified vehicles total	1,984,720	49.7%
HV	1,843,662	46.2%
PHEV	52,126	1.3%
EV	88,512	2.2%
FCV	420	0.0%

### 5-2-20. Promotion project for the electrification of commercial vehicles

In the transport sector, CO<sub>2</sub> emissions account for 19.2% of Japan's total emissions (FY2023 results), and among these, emissions from commercial vehicles such as trucks account for 40.9%. To achieve carbon neutrality by 2050 and the FY2030 GHG reduction target (46% reduction compared with FY2013), the electrification of commercial vehicles (BEVs, PHEVs, FCVs, etc.) is indispensable. Therefore, this project provides subsidies for the electrification of commercial vehicles (trucks and taxis), and by supporting the acceleration of early-stage deployment, aims to achieve both the strengthening of industrial competitiveness and economic growth through cost reductions as well as reductions in GHG emissions.

Under this project, subsidies are provided to business operators with plans to introduce non-fossil-fuel vehicles for the introduction of vehicles and charging equipment for the electrification (BEVs, PHEVs, and FCVs) of commercial vehicles (trucks and taxis). Through this project, domestic investment will be encouraged, helping achieve the 2030 targets for commercial vehicles: “for vehicles of 8 tons or less: 20–30% electrified vehicles in new vehicle sales; for vehicles over 8 tons: cumulative introduction of 5,000 electrified vehicles.” Combined with separate support measures for the introduction of passenger cars, this will promote decarbonization across the entire transport sector. In addition, by reducing vehicle prices and accelerating innovation, price competitiveness will be enhanced.

In the Government of Japan's impact reporting, the total environmental improvement effects from the commercial vehicles introduced under this project is estimated by calculating the reduction effects by vehicle type, assuming the replacement to BEVs of gasoline vehicles for mini-trucks, diesel vehicles for small and standard trucks, and average gasoline vehicles for taxis. For taxis, of the 430 subsidized vehicles, five are PHEVs, and 19 are FCVs, and since many of them are BEVs, it is assumed that all are replaced with BEVs. Similarly, for trucks, of the 3,268 subsidized vehicles, six are FCVs, and therefore it is assumed that all are replaced with BEVs. Although the source of calculation parameters differs from

<sup>67</sup> Prepared by JCR based on the *four-wheel vehicle new car sales* figures in “Automobile Industry of Japan 2025” published by the Japan Automobile Manufacturers Association (JAMA; a general incorporated association). [https://www.jama.or.jp/library/publish/mioj/ebook/2025/MIoJ2025\\_j.pdf](https://www.jama.or.jp/library/publish/mioj/ebook/2025/MIoJ2025_j.pdf)

the Clean Energy Vehicle Introduction Promotion Subsidy, both subsidies apply the same calculation method, which considers the electricity consumption of BEVs and includes CO<sub>2</sub> emissions attributable to electricity use. JCR evaluates the calculation method for the environmental improvement effects of this subsidy as appropriate. On the other hand, although PHEVs and FCVs are assumed to be entirely replaced by BEVs because they are small in the subsidized number in the present calculation, JCR expects that calculations will be conducted individually for each type of electrified vehicle in the future.

Although approximately 50% of new passenger car sales in Japan are electrified vehicles, the share of electrified vehicles among new commercial vehicle sales remains only a few percent<sup>68</sup>, and further progress is expected toward achieving the 2030 targets.

#### 5-2-21. Promotion projects for the installation of advanced equipment to improve the insulation performance

CO<sub>2</sub> emissions from the household sector amount to 158 million tons of CO<sub>2</sub>, accounting for approximately 15% of Japan's total emissions<sup>69</sup>. To reduce these emissions, in August 2021, the Government of Japan compiled the "Approach to Energy-Saving Measures in Housing and Buildings Toward a Decarbonized Society," which presents a future vision in which, by 2050, the average housing stock has achieved energy-saving performance equivalent to ZEH/ZEB standards<sup>70</sup>. Meanwhile, as approximately 90% of existing houses do not meet the current energy-saving standards<sup>71</sup>, energy-saving renovations for existing houses are an indispensable measure for achieving decarbonization in the household sector.

Among such measures, insulation retrofitting to reduce heat transfer inside and outside the home is directly linked to improving the efficiency of heating and cooling operations and greatly contributes to reducing energy consumption. Windows are with particularly high heat loss among the household components, thus improving their insulation performance directly enhances heating and cooling efficiency and reduces energy consumption.

This project has been implemented based on this background and supports renovation projects that improve the insulation performance of windows in detached houses and apartment units. As an outcome of this project, subsidies were provided for insulation retrofits of windows in 203,365 detached houses and 40,301 apartments. As the 7,062,950 houses were remodeled/renewed in FY2023<sup>72</sup>, the number of renovation cases under this project corresponds to approximately 3% of them.

Regarding environmental improvement effects, annual CO<sub>2</sub> emission reductions for FY2023 were approximately 71,000 tons of CO<sub>2</sub> (approximately 63,000 tons for detached houses and approximately

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<sup>68</sup> Ministry of Economy, Trade and Industry, Trends toward Building a Smart Mobility Society (March 13, 2025). [https://www.meti.go.jp/shingikai/sankoshin/green\\_innovation/industrial\\_restructuring/pdf/030\\_03\\_00.pdf](https://www.meti.go.jp/shingikai/sankoshin/green_innovation/industrial_restructuring/pdf/030_03_00.pdf)

<sup>69</sup> Ministry of the Environment, "Japan's National Greenhouse Gas Emissions and Removals in FY 2022" <https://www.env.go.jp/content/000216816.pdf>

<sup>70</sup> 'Securing energy-saving performance at the level of ZEH/ZEB standards on a stock-average basis' means a state in which, on a stock-average basis, for housing, primary energy consumption is reduced by around 20% from the energy-saving standard, and for buildings, it is reduced by around 30% or 40% depending on use.

<sup>71</sup> Ministry of Land, Infrastructure, Transport and Tourism, 1st Meeting of the Study Group on Approaches to Energy-Saving Measures for Housing and Buildings toward a Decarbonized Society (April 19, 2021).

<sup>72</sup> Ministry of Land, Infrastructure, Transport and Tourism, "Survey Report on Building Renovation and Renewal (Summary)" (published June 11, 2024).

8,000 tons for apartment units). This value was calculated by classifying renovation projects based on housing attributes (detached/apartment (end unit/middle unit)), insulation performance of windows after renovation, the scale of the insulation retrofit (living-dining-kitchen windows only / all windows), and climate characteristics of the region in which the house is located, and using the “WEB Program (a program compliant with energy-saving standards for housing) <sup>73</sup>” to calculate environmental improvement effects for each renovation pattern. For basic information unrelated to the renovation work (such as floor area and layout), general housing characteristics were assumed, and JCR has confirmed that reasonable parameters were used. Comparing this value to the average annual reduction target of 130,000 tons of CO<sub>2</sub> indicated in the Plan for Global Warming Countermeasures for achieving the FY2030 target<sup>74</sup>, the contribution of this project amounts to approximately 54%, exceeding half of the required reduction. As this project is ongoing, continued environmental improvement effects are expected<sup>75</sup>.

In addition to this project, the Government of Japan is implementing other measures to reduce emissions from the household sector, such as support for new construction and renovations and support for improving the energy efficiency of water heaters. Through such comprehensive support, the Government of Japan aims to achieve the household sector’s FY2030 GHG reduction target (a reduction of approximately 138 million tons of CO<sub>2</sub> from FY2013 levels).

Based on the above, JCR evaluates that this project is steadily generating environmental improvement effects as one of the emission reduction measures in the household sector and that these effects contribute to achieving reduction plans in the sector. Furthermore, the project is considered important as one of the measures that promote understanding of energy-saving initiatives among consumers and encourage changes in consumer behavior.

As described above, JCR has confirmed that although assumptions and parameters include estimates, the Government of Japan has calculated environmental improvement effects using reasonable methods based on the assumed scenarios. In addition, as each project is expected to generate significant GHG emission reduction effects, JCR evaluates this as an initiative that contributes to Japan’s GHG emission reduction targets. At the same time, by creating new demand and markets in the decarbonization sector, it is also expected to contribute to strengthening Japan’s industrial competitiveness.

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<sup>73</sup> <https://house.app.lowenergy.jp/#/select>

<sup>74</sup> Calculated by JCR based on the expected emission reductions (2.23 million t-CO<sub>2</sub>) for energy-efficiency improvements (retrofits) of housing in the *Plan for Global Warming Countermeasures* (<https://www.env.go.jp/content/000290553.pdf>). Note that, since electricity-related GHG emissions account for about two-thirds of emissions in the household sector, the measures for the housing sector described in the Plan assume that reductions in the GHG emission factor of electricity will be carried out in parallel.

<sup>75</sup> For FY2024, the Sector-specific Investment Strategies (Life-related Industry) indicates that more than 400,000 homes, roughly twice the current level, are scheduled to be supported.

## Review Results (Conclusion)

## Green 1(T)

After the review, JCR evaluated the Bonds at "gt1" for "Green/Transition Evaluation (Use of Proceeds)" and "m1" for "Management, Operation and Transparency Evaluation," and "Green 1(T)" for the overall "JCR Climate Transition Bonds Evaluation" based on JCR's Green Finance Evaluation Methodology. As a result, JCR concluded that the Bonds met the standards for the items required in the Green Bond Principles, the Green Bond Guidelines, the Climate Transition Finance Handbook and the Basic Guidelines for Climate Transition Finance.

		Management, Operation, and Transparency Evaluation				
		m1	m2	m3	m4	m5
Green and Transition Evaluation	gt1	Green 1(T)	Green 2(T)	Green 3(T)	Green 4(T)	Green 5(T)
	gt2	Green 2(T)	Green 2(T)	Green 3(T)	Green 4(T)	Green 5(T)
	gt3	Green 3(T)	Green 3(T)	Green 4(T)	Green 5(T)	Not qualified
	gt4	Green 4(T)	Green 4(T)	Green 5(T)	Not qualified	Not qualified
	gt5	Green 5(T)	Green 5(T)	Not qualified	Not qualified	Not qualified

(Responsible analysts for this evaluation) Kosuke Kajiwara, Tomohiko Inamura, Takuto Toda

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## Important explanations of this Evaluation

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### 1. Assumptions, Significance and Limitations of JCR Climate Transition Bond Evaluation

JCR Climate Transition Bond Evaluation, which is determined and provided by Japan Credit Rating Agency, Ltd. (JCR), covers the policies set out in the Climate Transition Finance Framework, and expresses JCR's comprehensive opinion at this time regarding the appropriateness of the Green/Transition Project as defined by JCR and the extent of management, operation and transparency initiatives related to the use of funds and other matters. Therefore, JCR Climate Transition Finance Framework Evaluation is not intended to evaluate the effects of specific environmental improvements and the management, operation and transparency of individual bonds and borrowings, etc. to be implemented based on these policies. In the event an individual bond or individual borrowing based on this Framework is subject to a green/transition finance evaluation, a separate evaluation is needed. JCR Climate Transition Finance Framework Evaluation does not prove the environmental improvement effects of individual bonds or borrowings implemented under this Framework, and does not assume responsibility for their environmental improvement effects. JCR confirms the environmental improvement effects of funds procured under the Climate Transition Finance Framework measured quantitatively and qualitatively by the issuer/borrower or by a third party nominated by the issuer/borrower, but in principle it does not directly measure such effects.

### 2. Method used to conduct this evaluation

The methodologies used in this assessment are described in "JCR Green Finance Evaluation" on the "Sustainable Finance ESG" section of the JCR website (<https://www.jcr.co.jp/en>).

### 3. Relationship with Acts Concerning Credit Rating Business

JCR Climate Transition Finance Framework Evaluation is determined and provided by JCR as a related business, which is different from its activities related to the credit rating business.

### 4. Relationship with Credit Ratings

The Evaluation is different from the Credit Rating and does not assure to provide or browse a predetermined credit rating.

### 5. Third-Party Evaluation of JCR Climate Transition Finance Framework Evaluation

There are no capital and/or personnel relationships that may result in a conflict of interests between the subject of this evaluation and JCR.

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#### ■ Glossary

JCR Climate Transition Finance Framework Evaluation: This evaluates the extent to which the funds procured through Green/Transition Finance are appropriated for green/transition projects as defined by JCR and the degree to which the management, operation and transparency of the Green/Transition Finance are ensured. Evaluations based on a 5-point scale are given from top to bottom using the Green 1(T), Green 2(T), Green 3(T), Green 4(T), and Green 5(T) symbols.

#### ■ Status of Registration as an External Evaluator of Sustainability Finance

- Registered as an External Reviewer of Green Bonds by the Ministry of the Environment
- ICMA (registered as an observer with the Institute of International Capital Markets)

#### ■ Status of registration as a credit rating agency, etc.

- Credit Rating Agency: the Commissioner of the Financial Services Agency (Rating) No.1
- EU Certified Credit Rating Agency
- NRSRO: JCR has registered with the following four of the five credit rating classes of the U.S. Securities and Exchange Commission's Nationally Recognized Statistical Rating Organization (NRSRO): (1) financial institutions, broker-dealers, (2) insurance companies, (3) general business corporations and (4) governments and municipalities. If the disclosure is subject to Section 17g-7 (a) of the Securities and Exchange Commission Rule, such disclosures are attached to the news releases appearing on the JCR website (<https://www.jcr.co.jp/en/>).

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