

Japanese Chemical Industry's Stance on Carbon Neutrality and the Creation of a Sound Material-Cycle Society: A Solution Provider That Leads Social Transformation

Introduction

Chemical industry supports the foundation and innovation of all industries through the provision of materials. Products created by using these materials help improve people's lives across a range of areas, for example, by contributing to the purification of the environment and water; spreading the use of renewable energy; energy and resource conservation; development of an information society; progress of medical treatment; stable supply of food; and recycling of waste. These products also make great contributions to sustainable development. The chemical industry thus makes diverse contributions as its unique feature, which other industries cannot match, and this diversity implies the infinite possibilities of chemistry. The value of shipments by the "chemical industry in a broad sense" reached about 51 trillion yen in 2022, including shipments of both plastic and rubber products, and the value-added amount totaled about 18 trillion yen. The industry is thus a major contributor to the Japanese economy. Moreover, about 960,000 people work in the industry, which therefore also supports people's lives in terms of employment.

Toward carbon neutrality and the creation of a sound material-cycle society in 2050, the Japanese chemical industry plays an extremely important role based on its base technology and the ability to supply various materials. The chemical industry regards carbon neutrality and the creation of a sound material-cycle society not simply as a requirement to be met for compliance with environmental regulations but as **a strategic opportunity for the industry to achieve sustainable growth and enhance its international competitiveness** as a "solution provider" that leads social transformation.

The Plan for Global Warming Countermeasures, the GX2040 Vision, and the Seventh Strategic Energy Plan, which were approved by the Cabinet in 2025, regard decarbonization as a growth strategy and strongly call for innovation and proactive investment in decarbonization. The industry, academia and

government need to make a concerted effort with persistence and speed to achieve specific goals under these plans.

The chemical industry uses oil and other fossil resources as materials and consumes a lot of energy. The industry therefore emits a lot of carbon dioxide (CO₂). Toward carbon neutrality and the creation of a sound material-cycle society, the chemical industry is faced with the great challenges of moving away from fossil resources and reforming its manufacturing processes. For such fundamental transition of the industrial structure, the Japanese chemical industry needs to solve numerous technological and economic issues. In order to meet this requirement, the industry recognizes that it needs to receive strong support from the government, a stable supply of decarbonized energy at reasonable prices and political considerations that support the maintenance of its international competitiveness.

Against this backdrop, we have identified the targets to be achieved by the chemical industry for carbon neutrality, the challenges to be met for the achievement, and the methods to meet the challenges by envisioning a carbon-neutral world in 2050 and in consideration of present and future technological, economic and social changes.

Targets to Be Achieved by the Chemical Industry

1. Establish a net zero-emission resource recycling-based production system as an autonomous innovator.

The chemical industry will minimize the emissions of greenhouse gases (GHGs) from its manufacturing processes and build a system to maximize the recyclability of resources.

- **Accelerate energy transition and take on the challenge of building innovative processes:**
 - Replace electricity and heat sources derived from fossil fuels on a large scale with **those derived from decarbonized energy sources such as solar power, wind power and nuclear power, CO₂-free hydrogen, CO₂-free ammonia** and other substitutes.

Specifically, we will promote the practical use of innovative process technologies, as represented by ammonia-fired naphtha crackers.

- We will continue to make capital investments and introduce new technologies to make the manufacturing processes more efficient and energy-saving, thereby reducing CO₂ emissions.
- **Optimize and increase the efficiency of the production processes:**
 - We will make effective use of AI, IoT, digital twin and other digital technologies to maximize the energy efficiency of the entire production process to reduce our emissions on a continual basis.
- **Promote innovative materials transition:**
 - Aiming to end dependence on oil and other fossil resources, we will expand the use of **biomass-derived materials and carbon capture and utilization (CCU) technology to use CO₂ directly** for the manufacture of chemicals.
 - With a focus on **chemical recycling**, which transforms used plastic materials into raw materials for chemicals, we will foster the establishment of a carbon-circular supply chain.

2. Support the decarbonization of the entire society and the recycling of resources as a solution provider.

The chemical industry will enhance its role as an “unsung hero” to strongly support the decarbonization of the entire society, including other industries, and the recycling of resources through the supply and provision of its highly functional materials and technologies.

- **Supply highly functional materials that are indispensable for the creation of a decarbonized society:**
 - We will develop and supply innovative materials to help **create, store and make efficient use of decarbonized energy**, such as materials used in solar cells, storage batteries, fuel cells, wind turbine blades and materials required for the manufacture, storage and transportation of hydrogen.
 - We will provide materials that contribute to the reduction of energy consumption in all industries, such as those contributing to reducing the weight of automobiles, prolonging the life of buildings and making them more effectively insulated, and to increasing the efficiency of electronic devices.

- **Offer products and technologies that help speed up the creation of a sound material-cycle society:**
 - We will work to expand the market for recycled materials and foster the use of such materials, including high-quality chemical-recycled plastic materials.
 - We will help speed up the creation of a sound material-cycle society by contributing to recyclable product design as well as by developing and spreading the use of environment-friendly materials including biodegradable plastics.

3. Foster collaboration and innovation in and outside Japan as a “co-creator.”

It is impossible for the chemical industry to achieve carbon neutrality and create a sound material-cycle society on its own. In order to achieve these targets, we need to collaborate with partners in and outside the industry and in and outside Japan.

- **Enhance industry-academia-government collaboration:**
 - We will collaborate with the government, universities and research institutes to promote the whole process from basic research to the practical use of developed technologies on a full scale in society in an integrated manner. In particular, we will make maximum use of public support, including the Green Innovation Fund and Japan Climate Transition Bonds.
- **Collaborate with partners across the supply chain:**
 - We will enhance collaboration to reduce CO₂ emissions and recycle resources across the supply chain, from the supply of materials through to the manufacture of final products and the recovery and recycling of end-of-life products.
- **Establish international rules and promote the global use of technologies:**
 - We will proactively participate in the standardization and establishment of rules for carbon neutrality and resource recycling and will promote the global use of technologies and know-how developed in Japan to contribute to the solution of global issues.
- **Gain more understanding from people through dialogue:**

- We will proactively disseminate information and engage in dialogue to gain more understanding from people about the chemical industry's contribution to carbon neutrality and a sound material-cycle society as well as about the resulting increase in costs and the need of social transformation, thereby building and expanding a new market.
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Challenges to Overcome for the Achievement

In order to achieve the vision as described above, the Japanese chemical industry needs to meet a range of complex challenges.

1. Technological challenges: Difficulties concerning the development of innovative technologies and the practical use of developed technologies

- **Availability of CO₂-free electricity and heat sources in a large amount and at reasonable cost:**
 - Decarbonizing the energy (electricity and heat sources necessary for high-temperature processes) consumed in a vast amount at chemical plants is a major challenge to be met by the chemical industry. Specifically, we need to increase the amount of decarbonized energy produced in Japan to expand the supply of such energy while reducing the related cost. Also, we need to conduct R&D and demonstration tests on a large scale in order to make practical use of unestablished technologies such as for ammonia-fired naphtha crackers.
- **Practical and extensive use of innovative technologies for materials transition**
 - We need to develop a technology to further expand the use of biomass-derived materials with different qualities, although biomass-derived materials have been gradually adopted for practical use. In addition, we are urgently required to increase the energy efficiency of CCU technologies and reduce their costs for

more use of CO₂. Many CCU technologies have not yet reached the level required for practical use.

- Chemical recycling technologies have been progressing, but we still need to establish a processing technology to deal with a range of waste plastic materials (mixed, composite, polluted and other plastics). We also need to increase the processing volume and develop an efficient chemical recycling process.
- **Supply highly functional materials that are indispensable for the creation of a decarbonized society:**
 - Materials that help improve the performance of solar cells, storage batteries and fuel cells need to be highly functional and should also be provided at lower cost for the faster spread of their use. To this end, we need to develop innovative technologies while establishing mass production technology.
 - In these fields, Japanese companies are facing fierce competition with overseas counterparts and need to maintain their competitive advantages by increasing their speed of technological development and cost competitiveness.
- **Handling of existing processes for which it is difficult to reduce CO₂ emissions:**
 - For some existing chemical processes, it is technologically and economically difficult to reduce CO₂ emissions. In order to offset emissions from such processes, the introduction of CCS technologies is being considered. For the use of such technologies, it is essential to reduce the introduction and operation costs and secure sites for CO₂ storage.

2. Economic challenges: Vast amount of investment and maintenance of international competitiveness

- **High capital investment in R&D and facilities:**
 - The chemical industry as a whole needs to invest a vast amount of money in the development of innovative technologies for carbon neutrality and the creation of a sound material-cycle society, as well as for the replacement of existing facilities and the establishment of a new supply chain for materials that help increase product

functionality. This puts pressure on the financial situation of each company, making them take a more prudent attitude to investments.

- **Rise in product costs, which might lead to lower international competitiveness:**
 - Measures for decarbonization and the recycling of resources might result in an increase in production costs. Due to the implementation of these measures, products made in Japan might lose their international competitiveness relative to products made in countries with less stringent regulations on GHG emissions and countries that can use clean energy at lower cost. In order to maintain their international competitiveness, Japanese chemical companies need to pass through the rise in the costs to their products as “green premium” and have this premium accepted by the market.
- **Design of a carbon pricing system and fair burden sharing:**
 - The introduction of a carbon pricing system can give an incentive to reducing CO₂ emissions but can also cause a rise in costs. It is desirable to design a fair system that takes into account international competitive conditions and ensure that costs are appropriately borne by the entire supply chain.
 - By supplying highly functional materials for use in solar cells, storage batteries and fuel cells, the chemical industry can contribute to a substantial reduction of CO₂ emissions in society, but its own emissions will increase. The chemical industry’s contribution to the decarbonization of the entire society should therefore be evaluated in an appropriate manner.

3. Social and institutional challenges: Political support and social acceptability

- **Need to be consistently supported by governmental policies:**
 - Consistent support by governmental policies, which is given based on the government’s long-term vision (in the form of subsidies, preferential tax treatment, deregulation, clarification of the guidelines on the antimonopoly law, and the promotion of standardization) is indispensable for the chemical industry to implement a range of measures for carbon neutrality and a sound material-cycle society, including measures for technological

development, capital investment and infrastructure improvement. In particular, the industry needs to receive continued support for large-scale technological innovations.

- **Establishment of an entire resource recycling system:**
 - The chemical industry needs to build a supply chain-wide cooperation system for the efficient recovery, sorting and recycling of waste plastic and other materials. The industry also needs to gain understanding and support from consumers and other industries, raise people's awareness about resource recycling, and encourage them to change their behaviors to foster recycling.
- **Sharing of value and costs of carbon neutrality by entire society:**
 - It is important for the chemical industry to create and expand the markets for products that contribute to decarbonization and the creation of a sound material-cycle society. It is also essential for the entire society to acknowledge and share the rising costs and recognize the new value created by such products. The importance of the roles played by procurement systems and standards should also be recognized. In addition, for the creation of a sound material-cycle society, consumers need to change their behaviors, for which we need to help them deepen their understanding of the importance of recycling and encourage them to value the products made by using recycled materials.
- **Spread of life-cycle evaluation:**
 - Chemical recycling temporarily increases the emissions of CO₂ in the manufacturing stage, but can contribute to substantially reducing life-cycle CO₂ emissions from the products. We need to meet the challenge of spreading life-cycle evaluation across society and establish appropriate evaluation criteria to this end.
- **Supporting SMEs in implementing response measures:**
 - We need to help small and medium chemical companies, whose resources are limited relative to large companies, to respond to the need for carbon neutrality and recycling in society through technological support, information provision and financing.

4. Challenges concerning human resources and intergenerational transfer of technologies

- **Development and retention of specialists in decarbonization and recycling technologies:**

- It is urgently necessary to develop and retain researchers and engineers who have expertise in the field for the development of new technologies and the upgrading of existing processes. Specifically, young talent to lead the development of new technologies needs to be developed to work with experienced personnel who have expertise in operating existing facilities. Moreover, the industry and academia need to collaborate to enhance their educational programs and invite people from other fields to participate in their initiatives.

The challenges faced by the Japanese chemical industry are entangled in a complex manner and for the industry to achieve its vision, individual companies in the industry need to foster co-creation with governments, academic organizations, other industries, and the entire society including consumers in addition to making their respective efforts.

Direction of measures for achieving of the goals

The production of ethylene has been decreasing on a long-term basis in Japan, and to deal with the intensification of international competition and changes in domestic demand, the chemical industry has been promoting the transition of the industrial structure, with optimization of production capacity and suspension of operation being considered for some aging or unprofitable ethylene plants. On a global basis, the production of ethylene has been increasing, with ethylene manufacturing facilities being newly constructed or expanded in particular in Asia, the Middle East and North America.

New solutions are required for carbon neutrality and the creation of a sound material-cycle society, which the Japanese chemical industry regards as a great growth opportunity. Accordingly, we are working for a shift to and enhancement of decarbonization technologies and value-added functional chemicals, including electronics materials, mobility-related materials (such as battery materials), and materials for healthcare, medical and welfare equipment.

The Japanese Ministry of Economy, Trade and Industry disclosed a technology roadmap for transition finance in the chemical sector in December 2021. In this document titled *Technology Roadmap for “Transition Finance” in Chemical Sector*, the Ministry shows “Summary of Major Emission Sources and Methods for Decarbonization” and the “Technology Roadmap.” (The followings are extracts from this document.)

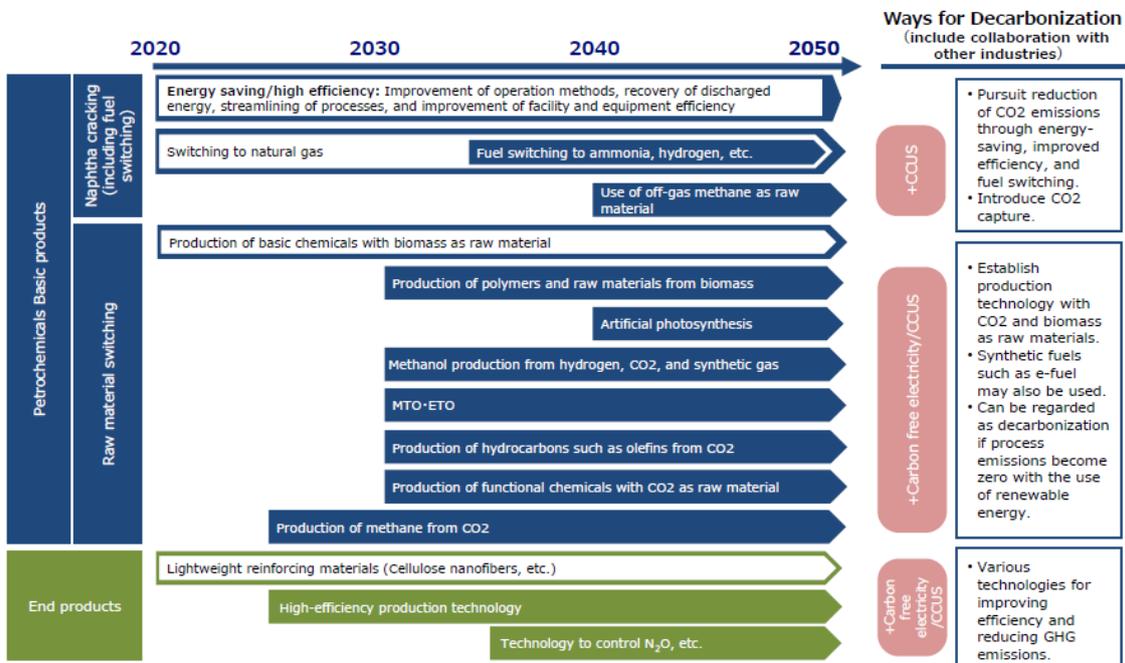
2. Overview of Chemical Industry | (5) Summary of Major Emission Sources and Methods for Decarbonization

Sector		Main emission sources	Methods for decarbonization
Petrochemicals	Basic products	<ul style="list-style-type: none"> Heat and energy utilization during naphtha pyrolysis 	<ul style="list-style-type: none"> Utilization of energy-saving technologies, etc. Heat source decarbonization of naphtha cracking furnaces Switching of raw materials using artificial photosynthesis, etc.
	Derivative products	<ul style="list-style-type: none"> Use of heat and energy from polymerization of basic chemical products, etc. 	<ul style="list-style-type: none"> Fuel switching and electrification during heat and energy use
	End products	<ul style="list-style-type: none"> Use of heat and energy during product molding 	<ul style="list-style-type: none"> Utilization of energy-saving technologies, etc. Fuel switching and electrification during heat and energy use
	Recycling	<ul style="list-style-type: none"> Emissions from combustion of waste plastics, etc. Energy consumption during recycling 	<ul style="list-style-type: none"> Expansion of chemical and material recycling Improvement in efficiency of chemical material recycling, development of low-carbon processes
Inorganic chemicals (Caustic soda, industrial gases)		<ul style="list-style-type: none"> Use of heat and energy by electrolysis, etc. in the production of caustic soda and industrial gases 	<ul style="list-style-type: none"> Utilization of energy-saving technologies, etc. Fuel switching and electrification during heat and energy use

Technology Roadmap for Transition Finance in Chemical Sector: p. 24

3. Technology Pathways to Decarbonization |

②-1 Technology Roadmap (Naphtha Cracking, Raw Material Switching, End Products)



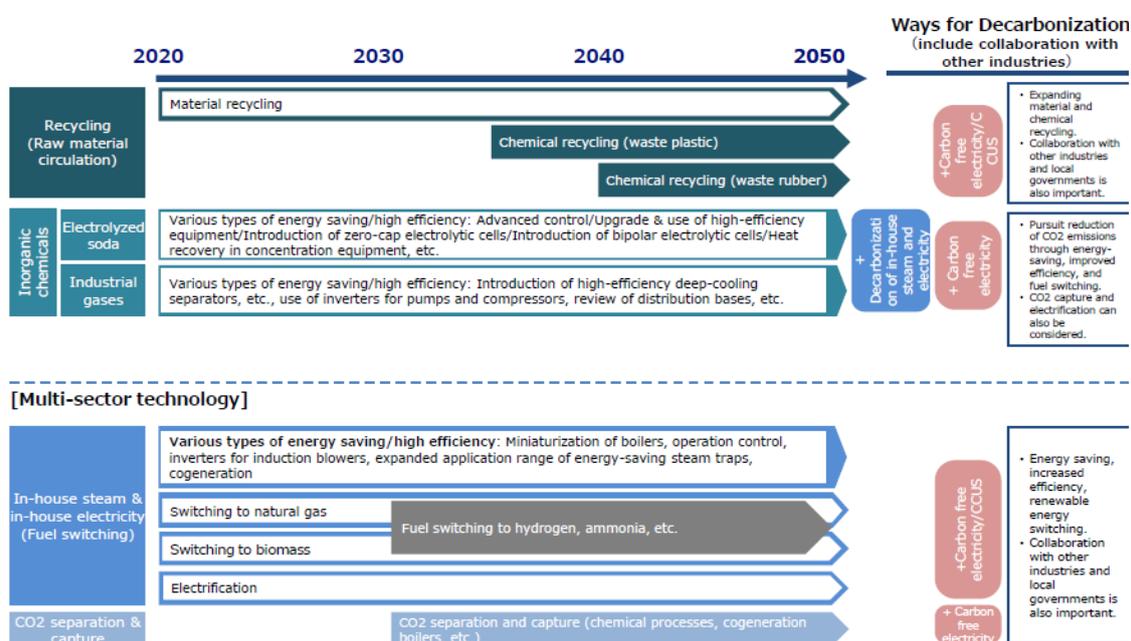
*Products contributes to decarbonization (Eco-products, noted in P7) are not listed in the Technology Roadmap, though can still be the use of proceeds for transition finance.

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Technology Roadmap for Transition Finance in Chemical Sector: p. 31

3. Technology Pathways to Decarbonization |

②-2 Technology Roadmap (Recycling, Inorganic Chemicals, In-House Use)



Technology Roadmap for Transition Finance in Chemical Sector: p. 33

For the practical use of technologies shown in the roadmap, R&D and demonstration projects are underway through industry-academia-government collaboration. In particular, focus is being placed on the reduction of CO₂ emissions across supply chains and on the development of innovative technologies (for artificial photosynthesis, CCUS/CCU, etc.). The development and practical use in society of new technologies have been steadily progressing in line with the roadmap. However, concerning various innovative measures, more development and demonstration activities need to be conducted to meet a range of technological challenges for commercialization, as indicated in the roadmap. Accordingly, the practical use of new innovative technologies will start on a full scale only in or after 2030. Toward this year, we will work for energy conservation, higher energy efficiency and the transition of raw materials and fuels through the optimization of production capacity and the proactive introduction of the best available technology (BAT).

JCIA will proactively participate in the review of this roadmap for the acceleration of a range of related measures.

Also, for the practical adoption of chemical recycling, which is indispensable for the creation of a sound material-cycle society, individual companies are making progress with necessary examinations and have announced their respective plans for chemical recycling. Based on these plans, the chemical

industry as a whole will implement a project to chemically recycle a total of several hundred thousand tons of materials per year in FY2030 (Table 1).

(Table 1) Trends in commercialization of chemical recycling

< based on publicly available information >

Company Name	Target raw materials	recycling technology	Capacity forecast for 2030(kT/Y)	remarks
Resonac	waste plastic	gasification	70	https://www.resonac.com/jp/kpr/method.html
Mitsubishi Chemical/ENEOS	waste plastic	Plastic-to-Oil Conversion	20	https://www.mcgc.com/news_release/pdf/02376/02642.pdf
Mitsubishi Chemical	Polycarbonate	monomerization	10	https://prtimes.jp/main/html/rd/p/000000021.000104418.html
Sumitomo Chemical/Maruzen Petrochemical	waste plastic	Direct olefinization	Thousands to tens of thousands T/Y	GI Fund Project 450~645kt PE/PP replacement target https://www.meti.go.jp/shingikai/sankoshin/green_innovation/energy_structure/pdf/013_05_00.pdf reference (P.33)
PS Japan Corporation	PS	monomerization	1	https://www.psjp.com/sustainable/circular/monomer-recycle-ps/
Toyo Styrene	PS	monomerization	3	http://www.toyo-st.co.jp/cgi-bin/toyo-st.cgi?name=ts_240319&type=pdf
Chemical Recycle Japan	waste plastic	Plastic-to-Oil Conversion	20	Idemitsu Kosan aims to process hundreds of thousands of tons of waste plastic by 2030 https://www.idemitsu.com/jp/news/2023/230420.html
Bridgestone Corporation/ENEOS	waste tires	Plastic-to-Oil Conversion \ monomerization		GI Fund Project: Commercialization on a scale of 100,000 T/Y https://www.meti.go.jp/shingikai/sankoshin/green_innovation/energy_structure/pdf/013_05_00.pdf reference 2 (P.28)
CFP	waste plastic	Plastic-to-Oil Conversion	12	https://www.mitsuiipr.com/news/2024/0328-4/
TOYOBO	PET	monomerization		Commercialization on a scale of 200,000 T/Y in the 2030s https://rplusjapan.co.jp/midtermgoal/ https://www.toyobo.co.jp/sustainability/environment/circulation/
PET REFINE TECHNOLOGY	PET	monomerization	20	https://www.meti.go.jp/policy/recycle/main/3r_policy/policy/html/pdfjirei/03_refine.pdf
Microwave Chemical	PP/PS	monomerization	10	https://www.gomutimes.co.jp/?p=175806
TEIJIN FRONTIER	polyester	monomerization	tens of thousands T/Y	https://www.nonwovens-review.net/2022/05/18/

※ Compiled by JCIA based on publicly available information

Conclusion

As its vision, JCIA aims to establish a sustainable production system through **the transformation of the chemical industry** and to powerfully support the decarbonization of the entire society through **the unique technologies and products** delivered by the industry. Also, the chemical industry will strive to transform itself from “a consumer of resources” to “**a creator and circulator of resources**”.

This is **the mission** to be fulfilled by the chemical industry for Japan to lead the world in the creation of a decarbonized, sound material-cycle society, and it also provides the industry with new **growth opportunities**. Based on this recognition, we will work for the implementation of specific initiatives and practical use in society.