Roadmap for Bioplastics Introduction

- For the sustainable use of plastics -

January 2021

Government of Japan

Ministry of the Environment

METI Ministry of Economy, Trade and Industry

MAFF Ministry of Agriculture, Forestry and Fisheries

MEXT Ministry of Education, Culture, Sports, Science and Technology-Japan

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Summary

1. Purpose of this Roadmap

Plastics have brought tremendous convenience and benefits to our lives because of their high functionality. However, they are related to resource and waste problems, marine plastic litter issues, and climate change, and have become an urgent international issue. In response to this situation, Japan has formulated the Resource Circulation Strategy for Plastics (May 2019).

The Resource Circulation Strategy for Plastics (hereafter referred to as “the Strategy”) sets forth the “3Rs + Renewable” as a basic principle. Based on the premise that sustainability will be assured throughout their lifecycle, the Strategy aims to introduce the maximum amount of **bio-based plastics** (approximately 2 million tons) by 2030.

This Roadmap summarizes the current status and challenges of **bioplastics** for a wide range of related entities (especially **bioplastic** manufacturers, users, such as product manufacturers and brand owners, and retail and service providers). The Roadmap also presents directions for the sustainable introduction of **bioplastics** and policies for promoting their introduction. This is intended to stimulate innovation in manufacturing of **bioplastics**, recycling technologies and systems, and consumer lifestyles, and to serve as a basis for the sustainable increase of demand and supply of **bioplastics**.

2. Current status and issues related to the introduction of bioplastics

Bioplastics are expected to be one solution to the various problems of plastics because of their value, such as reducing the environmental impact as follows.

Values of using each bioplastics

- **Bio-based plastics:** mainly reduces greenhouse gas emissions and the use of exhaustible resources if sustainable raw materials are used and the greenhouse gas emission reduction effects throughout their life cycles have been verified
- **Biodegradable plastics:** mainly rationalize the waste disposal process and reduce marine plastic litter if appropriate **biodegradable plastics** according to the degradation environment are used

However, internationally, questions are often raised as to whether greenhouse gases are truly reduced throughout the life cycle, whether biomass feedstock is sustainable, or whether biodegradability is adequately exercised. In addition, by using biomass as a raw material, the major bottleneck for the introduction of **bioplastics** is that the cost of resin production has not been optimized due to the low efficiency of raw material procurement and manufacturing characteristics based on biological processes, compared to conventional fossil-based plastics. Therefore, the ratio of **bioplastic** input (in 2018, approximately 41,000 tons are **bio-based plastics** (nonbiodegradable) and approximately 4,000 tons are **biodegradable plastics**[1]) to the total domestic input of plastics in Japan (approximately 9.9 million tons (2018)[2]) is only approximately 0.5%.

For future sustainable introduction of **bioplastics**, the following points should be considered well.

- [1] raw materials, [2] supply, [3] cost, [4] functions during use,
- [5] impacts on post-use flow, including the current plastic recycling system
- [6] environmental and social aspects.

3. Principles and measures related to the introduction of sustainable bioplastics

(1) Basic principles for introduction

In view of the fact that **bioplastics** use valuable resources, the following two points should be considered as general rules when introducing them.

- Rationalize the avoidable use of plastics, including single-use containers, packaging, and products, to completely reduce wasted resources.
- Maximize the value of **bio-based plastics** and **biodegradable plastics**, including their ability to reduce environmental impacts.

Based on these points, basic principles for the introduction of **bioplastics** are provided below.

[1] Raw materials

Diversification efforts are needed to expand raw materials in anticipation of increased demand for **bio-based plastic** applications in the future. Therefore, we need to expand the scope of the raw material uses of domestic biomass (domestically grown resource crops, waste cooking oil, cellulosic sugars, such as wood pulp, rice straw, and rice husk) in a manner so that it will not interfere with securing a stable supply of food and feed.

[2] Supply

Although it is necessary to increase the supply of **bioplastics** produced both domestically and in abroad, in particular, to increase the amount of domestically

1 The estimates calculated by the Japan BioPlastics Association were used as the reference.

2 2018 materials flow chart describing plastic product production, disposal, recycling, and treatment and disposal as prepared by the Plastic Waste Management Institute was used as the reference (http://www.pwmi.or.jp/pdf/panf2.pdf). (accessed October 16, 2020)

produced **bioplastics** in the future, we need to increase the production by Japanese companies that produce **bioplastics** to expand the range of supply sources in Japan.

[3] Cost

We aim to optimize the cost of **bioplastic** production via collaboration and cooperation among related entities in raw material procurement and production and provide support for development and installation of equipment. In addition, we aim to promote the use of **bioplastics** in a way that takes their environmental value into account, e.g., by appealing to users by using their environmental value (reduction of the use of exhaustible resources and greenhouse gas emissions, rationalization of the waste disposal process by the degradation of **biodegradable plastics**).

[4] Functions during use

We aim to develop and introduce **bioplastics** with general-purpose functions (strength, heat resistance, and processability) equivalent to those of conventional fossil-based general-purpose plastics to apply them in a wide range of product groups. Additionally, we aim to further expand applications through the development and introduction of **bioplastics** with higher functionality, including durability and toughness. In products for which applications are intended, we need to expand the use of **bioplastics** by flexibly considering the product performance required based on the characteristics of **bioplastics**, such as strength and heat resistance.

[5] Impacts on post-use flow including the current plastic recycling system

In product areas where recycling of multiple plastic types has been already implemented, we need to actively promote the use of bio-based general-purpose plastics with physical properties that are equivalent to those of general-purpose plastics for which recycling has already been established. Because sorting technologies, processes have not yet been established for other types of **bioplastics**, we should be aware of the risk of adverse effects when they are mixed into the recycling process. Moreover, we need to continue to improve technologies and processes to make recycling possible. However, this does not apply where single plastic type recycling is implemented. In either case, to promote recycling, cooperation between stakeholders is required.

When organic waste is processed by composting or anaerobic digestion, using plastics that have biodegradable functions suitable for degradation in organic waste collection bags may contribute to lower the processing cost by omitting the process of separating and processing garbage bags in a separate process.

Among the mulch films for agricultural use, when mulch films that use **biodegradable plastics** that have biodegradable functions in the soil are used, they are plowed into the farmland under proper management as part of agricultural processing after harvesting. Thus, we need to expand the use of **biodegradable plastics** for this application.

Additionally, even though leakage into the natural environment after use must be avoided, for some products, there are possibilities of unintentional leakage into the natural environment, such as the ocean, due to their usage characteristics. Therefore, to promote the use of plastics with marine biodegradability for these applications, we should implement dissemination measures that focus on the development of technologies and the establishment of evaluation methods using Japan's advanced technologies, knowledge, and expertise.

[6] Environmental and social aspects

It is of utmost importance to use sustainable **bioplastics** during their entire life cycle. Thus, we need to create an environment in which consumers can purchase and use them with conviction and confidence, and we need to promote using **bioplastics** that have been confirmed to be more sustainable over their entire life cycle at least in terms of greenhouse gas emissions, land use change, biodiversity, labor, governance, competition with food.

Regarding **biodegradable plastics**, to prevent consumers from misunderstanding that it is acceptable to litter them because they degrade, we need to conduct educational activities to improve consumer understanding and create an environment that does not lead to moral hazards, such as littering.

In addition, because the greenhouse gases emitted when **bio-based plastics** are incinerated are expected to be carbon neutral, **bio-based plastics** will be actively introduced for applications, such as sanitary goods that require sterilization by a certain type of treatment, such as incineration, and for other applications in which there is no other choice but to be incinerated after use.

(2) Principles for the introduction of bioplastics for different plastic product areas

Based on basic principles [1] to [6] above, **bioplastics** suitable for introduction in each plastic product area have been categorized, and an overview is shown in the following table.

Table **Bioplastics suitable for each plastic product area**

Category : 1 Bio-based plastics (nonbiodegradable) that have no adverse effects on recycling and belong to either [1] or [2] below:
[1] Bio-based general-purpose plastics (At present, bio-PE, bio-PP, and bio-PET)
[2] The same types of bio-based plastics that substitute for fossil-based high-performance plastics (e.g., PA → bio-PA, PC → bio-PC)

Category : 2 Bio-based plastics (nonbiodegradable)

Category : 3 Biodegradable plastics (Plastics with suitable biodegradability in each environment)

Product area	Suitable bioplastics for introduction
Containers and packaging Plastic shopping bags	**Category : 1** From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the higher effect for environmental impact reduction is to be selected.
Electrical and electronic equipment, wires and cables, and machinery	**Category : 1** From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the higher effect for environmental impact reduction is to be selected.

Product area	Suitable bioplastics for introduction
Daily goods, clothing and footwear, furniture, toys used in households and offices	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the higher effect for environmental impact reduction is to be selected.
Combustible waste collection bags	Category : 2 Category 2, which contributes to reducing greenhouse gas emissions, is introduced.
Organic waste collection bags for composting and anaerobic digestion	Category : 3 From the viewpoint of post-use functions, those with biodegradable functions such as composting or anaerobic digestion are introduced from Category 3.
Construction materials	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the stronger effect for environmental impact reduction is to be selected.
Transportation	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the stronger effect for environmental impact reduction is to be selected.
Agriculture, forestry, and fisheries	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the stronger effect for environmental impact reduction is to be selected.
Agricultural mulch films	**[For collection and recycling]** Category : 1 From the viewpoint of post-use impacts, Category 1 with a low impact on the current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; thus, the one with the stronger effect on environmental impact reduction is to be selected. **[For plowing into the soil of farmland]** Category : 3 From the viewpoint of post-use functions, those with biodegradable functions in the soil are introduced from Category 3. This is limited to cases where the plastic is plowed into the soil of farmland under proper management as a part of the farming process.
Coating materials for controlled-release fertilizer	Category : 3 From the viewpoint of post-use impacts, plastics with biodegradability in both soil and ocean are introduced from Category 3.
Production materials for fisheries, such as fishing gears	**[For collection and recycling]** Category : 1 From the viewpoint of post-use impacts, Category 1 with a low impact on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; thus, the one with the higher effect on environmental impact reduction is to be selected. **[For cases where high strength or durability is not necessarily required]** Category : 3 From the viewpoint of post-use impacts, plastics with biodegradable functions in the ocean are introduced from Category 3.

Note : Because changes in the status and characteristics of use, composition of products, recycling technologies and systems, and development of new bioplastics may alter the categorization, this table will be updated as required.

(3) Measures for introduction by the government

Based on the principles described in (1) above, the government will implement the measures for [1]Promotion of use, [2]Appeal and awareness-raising activities to target consumers, [3]Development of R&D and production systems, [4]Measures related to Research and follow up, and [5]Measures for the specific product areas in coordination to actions of relevant entities.

Table **Measures for the introduction of bioplastics**

Promotion of the use

Measures	2020 – 2025 – 2030 – 2050
Compilation of examples and commitments of bioplastics introduction by companies, Business matching	Compilation of examples and commitments of bioplastics introduction Promotion of business matching (CLOMA, Plastics Smart)
Proactive procurement using the Green Procurement System, and measures to stimulate demand for bio-based products	Examination of evaluation criteria for designated procurement items under the Act on Promoting Green Procurement, consideration of measures to increase demand for bio-derived products, promotion of proactive procurement by local governments
Fair and equitable recycling system that promotes the use of bioplastics.	Examination of recycling systems
Improvement of reliability related to marine biodegradability	Examination toward the international standards for evaluation methods

Appeal to consumers, Awareness-raising

Measures	2020 – 2025 – 2030 – 2050
Certification that takes sustainability through an entire life cycle into account	Start of operation Examination of certification and labeling systems
Increasing awareness among consumers	Promotion of the proactive use of bioplastic products and correct understanding

Development of R&D and production system

Measures	2020 – 2025 – 2030 – 2050
R&D and demonstration projects to improve functions, reduce manufacturing costs, and diversify raw materials	Support for research and development, demonstration projects
Expansion of manufacturing facilities in Japan	Support for the installation of manufacturing facilities
Facilitation of fundraising for R&D and the installation of manufacturing facilities	Support for smooth fundraising

Research and follow up

Measures	2020 – 2025 – 2030 – 2050
Survey on the introduction status of bioplastics and follow up	Research and follow up on introduction status of bioplastics by applications and materials, international trends and technological trends related to bioplastics

Measures for the introduction in individual product areas

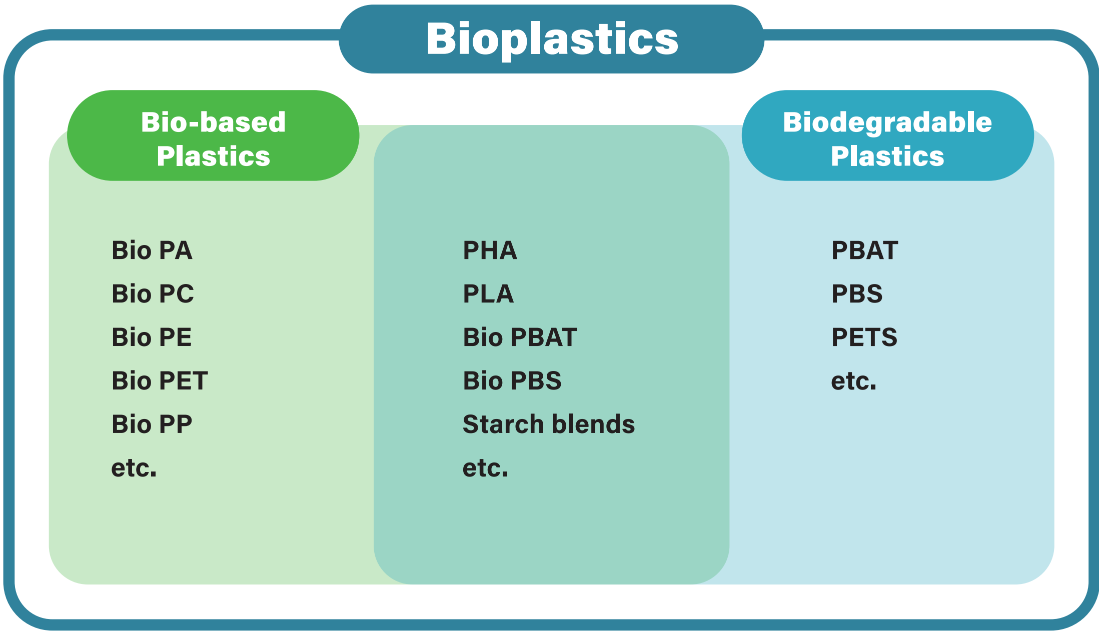
Measures	2020 – 2025 – 2030 – 2050
Plastic shopping bags	Increase of bio-based synthetic polymer content, examination of evaluation criteria for designated procurement items under the Act on Promoting Green Procurement, promotion of proactive procurement by local governments
Combustible waste bags, organic waste collection bags used for composting and anaerobic digestion	- "Revision of Guide to the Introduction of Fee-based Household Waste Treatment" for local governments - Development of the Bioplastics Introduction Guideline Examination of decision criteria for designated procurement items under the Act on Promoting Green Purchasing, and promotion of proactive procurement by local governments
Coating materials for controlled-release fertilizer and production materials for fisheries (fishing gear etc.)	Research and development of innovative technologies and materials

Terms

No.	Term	Description
1	**ABS**	Acrylonitrile butadiene styrene resin
2	**Anaerobic digestion**	Anaerobic digestion is a technology to obtain biogas through the anaerobic fermentation (digestion) of organic matter by methanogenic bacteria.
3	**Bio-based plastics**	A type of plastic that uses renewable organic resources, such as plants, as the raw materials
4	**Bio-based synthetic polymer content**	Percentage of bio-based plastic content in plastic products
5	**Biodegradability**	Biodegradability is the ability of decomposition by microorganisms that exist abundantly in nature under certain conditions and that are eventually converted to carbon dioxide and water. Depending on the degradation environment, biodegradability can be subdivided into industrial compostable, home compostable, soil biodegradable, and marine biodegradable.
6	**Biodegradable plastics**	Biodegradable plastics are plastics that, in addition to their functions and physical properties as plastics, degrade under certain conditions via the action of microorganisms that exist in abundance in nature and are eventually degraded into carbon dioxide and water.
7	**Biomass**	Biomass is a term originally used in ecology to describe the amount (mass) of living organisms (bio). In this Roadmap, it refers to resources that are organic matter-derived from plants and animals, excluding fossil fuels.
8	**Bio-PA**	Abbreviation for polyamides that use renewable organic resources, such as plants, as raw materials
9	**Bio-PBAT**	Abbreviation for polybutylene adipate terephthalate that uses renewable organic resources, such as plants, as raw materials
10	**Bio-PBS**	Abbreviation for polybutylene succinate that uses renewable organic resources, such as plants, as raw materials
11	**Bio-PC**	Abbreviation for polycarbonate that uses renewable organic resources, such as plants, as raw materials
12	**Bio-PE**	Abbreviation for polyethylene that uses renewable organic resources, such as plants, as raw materials
13	**Bio-PET**	Abbreviation for polyethylene terephthalate that uses renewable organic resources, such as plants, as raw materials
14	**Bioplastics**	A collective term for bio-based plastics and/or biodegradable plastics
15	**Bio-PP**	Abbreviation for polypropylene that uses renewable organic resources, such as plants, as raw materials

No.	Term	Description
16	**Carbon neutral**	When burning a biomass does not increase the net amount of carbon dioxide in the atmosphere as long as the carbon in the biomass is the result of fixation of carbon dioxide from the atmosphere during its growth and reproduction
17	**CNF**	Cellulose nanofibers
18	**Composting**	Technology that uses microorganisms to break down organic waste to produce fertilizer
19	**General-purpose plastics**	PE, PET, PP, PS, and PVC, which are the most commonly used types of plastics
20	**Home composting**	A composting facility at home that has lower fermentation temperatures and a smaller processing capacity than industrial composting facilities
21	**Industrial composting**	A dedicated facility for composting that is characterized by the high temperatures maintained for fermentation
22	**Mass balance approach**	A method in which, during the process of turning raw materials into final products and the distribution process (chain of custody), raw materials with certain properties (e.g., bio-based raw materials) are mixed with raw materials that do not have the properties (e.g., fossil-based raw materials); thus, the properties are assigned to a portion of the product according to the amount of input of the raw materials with those properties.
23	**Microplastics**	Microplastics refer to fine plastics of 5 mm or less
24	**PA**	Polyamide (also known as nylon)
25	**PBAT**	Polybutylene adipate terephthalate
26	**PBS**	Polybutylene succinate
27	**PC**	Polycarbonate
28	**PE**	Polyethylene
29	**PET**	Polyethylene terephthalate
30	**PETS**	Polyethylene terephthalate succinate
31	**PHA**	Polyhydroxyalkanoic acid
32	**PHBH**	Poly (3-hydroxybutyrate-co-3-hydroxyhexanoate)
33	**PLA**	Polylactic acid
34	**PP**	Polypropylene
35	**PS**	Polystyrene
36	**PU**	Polyurethane
37	**PVA**	Polyvinyl alcohol
38	**PVC**	Polyvinyl chloride

Definition of bioplastics



Bio-based plastics	A type of plastic that uses renewable organic resources, such as plants, as raw materials
Biodegradable plastics	A plastic that, in addition to its functions and physical properties as a plastic, degrades under certain conditions through the action of microorganisms that exist in abundance in nature and is eventually degraded into carbon dioxide and water. Renewable organic resources, such as plants, or fossil resources are used as raw materials
Bioplastics	A collective term for bio-based plastics and/or biodegradable plastics

1 Preface

Plastics have brought tremendous convenience and benefits to our lives because of their high functionality. However, they are related to resource and waste problems, marine plastic litter issues, and climate change, and have become an urgent international issue. In response to this situation, Japan has formulated the Resource Circulation Strategy for Plastics (May 2019) and has been taking initiatives, such as sharing the Osaka Blue Ocean Vision[1] with the leaders of each country at the G20 Osaka Summit in 2019. In addition, Japan is planning to take actions for establishing a carbon-neutral society, which involves reducing greenhouse gas emissions to zero by 2050.

Among these, the use of **bioplastics** (a general term for **bio-based plastics** and/or **biodegradable plastics** and used hereafter) has been attracting attention as a necessary measure to reduce the use of fossil and other exhaustible resources, to reduce greenhouse gas emissions, and to reduce the pollution caused by newly produced plastic waste in the oceans to zero.

The Resource Circulation Strategy for Plastics (hereafter referred to as “the Strategy”) sets forth the “3Rs + Renewable” as a basic principle. Based on the premise that sustainability will be enhanced, policies, such as appropriately switching to raw materials from plastic containers and packaging, and products made of materials derived from renewable resources, including **bio-based plastics**, have been presented as priority strategies. Additionally, to increase the use of **bioplastics**, the Strategy requests to develop the Roadmap for Bioplastics Introduction, which carefully indicates appropriate applications and materials for **bioplastics**. In addition, the Strategy states that, as a milestone, it aims to introduce the maximum amount of **bio-based plastics** (approximately 2 million tons) by 2030 by increasing the introduction of **bio-based plastics** by promoting understanding of **bio-based plastics** with the cooperation of the public.

This Roadmap summarizes the current status and challenges of **bioplastics** for a wide range of related entities (especially **bioplastic** manufacturers, users, such as product manufacturers and brand owners, and retail and service providers). The Roadmap also presents detailed directions for the introduction of **bioplastics**, taking into account the sustainability of the environmental and social aspects in its total life cycle, and harmonization with the plastic resource circulation system, including plastic recycling, to expand the use of **bioplastics** in the future. This is intended to stimulate innovation in manufacturing, recycling technologies and systems, and consumer lifestyles, and to serve as a basis for the sustainable increase of demand and supply of **bioplastics**.

1 Osaka Blue Ocean Vision was established at the G20 Osaka Summit in 2019. The Vision aims to reduce additional pollution by marine plastic litter to zero by 2050 through a comprehensive life-cycle approach that includes reducing the discharge of mismanaged plastic litter by improved waste management and innovative solutions while recognizing the important role of plastics in society.

1 Preface

[Resource Circulation Strategy for Plastics (Extract)]

2. Basic principles

Based on the basic principles in the Basic Act on Establishing a Sound Material-Cycle Society,

1. rationalize avoidable plastics, including single-use containers, packaging, and products, to thoroughly reduce unnecessary use of resources,
2. appropriately switch raw materials for plastic containers, packaging, and products to recycled materials and renewable resources (e.g., paper and bio-based plastics) to enhance sustainability,
3. use plastic products for as long as possible, and
4. after using plastic products, promote their circular use by thoroughly sorting and collecting them in a sustainable manner via an effective and efficient recycling system (including recycling and, if this is difficult from a technical and economic standpoint, energy recovery).

In particular, for plastics, of which the primary result is incineration, such as plastic bags for combustible waste, maximize the use of carbon-neutral bio-based plastics and ensure energy recovery.
In all cases, we need to consider the economic efficiency, technological feasibility, and the functions(e.g., safety and convenience) of products, containers, and packaging.

3. Key strategies

1. Ensuring reduction
   - ▶ For single-use containers, packaging, and products for which alternatives may be available, promote the use of appropriate alternatives made from renewable resources, such as paper and bio-based plastics.
   - ▶ For single-use containers, packaging and products for which alternatives may be available, an appropriate substitution using renewable resources, such as paper and bio-based plastics, should be promoted.
2. Effective, efficient, and sustainable recycling
   - ▶ Propose fair and optimal recycling systems that promote innovations, such as environmentally friendly designs, for easy recycling and the use of recycled materials and bio-based plastics
3. Promotion of recycled materials and bioplastics
   - ▶ In addition to enhancing the utilization potential of recycled materials and bioplastics through technological innovation in recycling and support for infrastructure development, lower the barriers for the use of recycled materials and bioplastics by making them more cost effective, increasing biodegradability, and providing appropriate support for their introduction, especially in situations where incineration or degradation are required.
   - ▶ Additionally, while determining the actual market situation regarding recycled materials and bioplastics, implement comprehensive measures to stimulate demand, such as proactive public procurement by the national or local governments based on the Act on Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities and other laws and regulations, incentivize measures for use based on the recycling system, matching support, certification, and labeling of low-carbon products, and the promotion of disseminations to consumers.
   - ▶ For plastics, of which the primary purpose results in incineration, such as plastic bags for combustible waste, make efforts to ensure that bio-based plastics are used.
   - ▶ Regarding bioplastics and their environmental and social aspects, appropriate situations for the use of biodegradable plastics (e.g., composting and biogas) through the evaluation of their degradability and the impacts on current plastic recycling systems will be analyzed and "Roadmap for Bioplastics Introduction," which indicates the purpose and materials of bioplastics, will be developed in detail. Introduction of bioplastics will be promoted along with the Roadmap in cooperation with proper management of the collection and recycling system.

(2) Measures against marine plastics

4. Promote the development and use of materials (e.g., paper and marine biodegradable plastics) that can be degraded in the ocean

(4) Institutional development

3. To encourage innovation in technology and consumer lifestyles

- Provide comprehensive support for the development and conversion of plastic alternatives, such as paper and bio-based plastics, which are renewable resources

4. Conclusion

- ▶ The goal is to introduce bio-based plastics to the maximum extent possible (approximately 2 million tons) by 2030 by promoting understanding and collaboration among all members of the public.

2 Current status and issues related to the introduction of bioplastics

1. General remarks

In 2018, the annual production of all plastics worldwide was approximately 360 million tons[2] with a production capacity of approximately 1.2 million tons for **bio-based plastics** (nonbiodegradable) and approximately 0.9 million tons for **biodegradable plastics**[3]. In recent years, the production capacity of **bioplastics** has been increasing year over year[2].

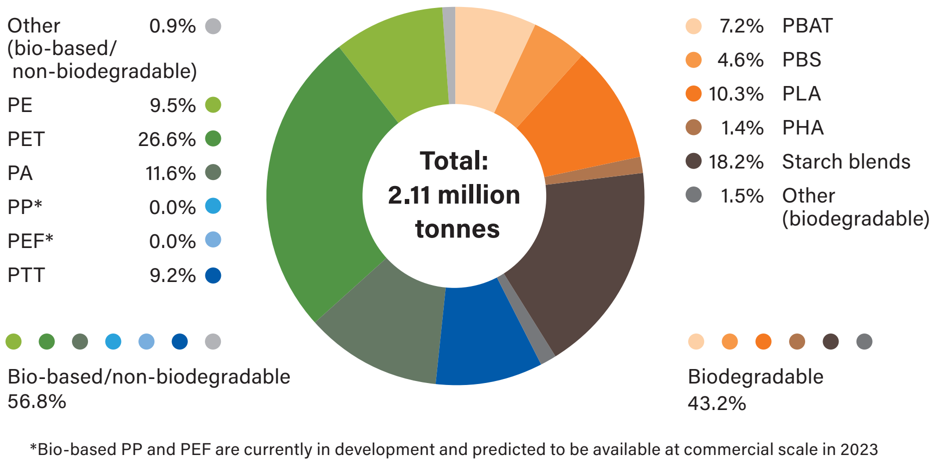


Figure 2-1 **Global production capacities of bioplastics 2018 (by material type)**

Source : European Bioplastics, Bioplastics market data 2018

More information : www.european-bioplastics.org/market and www.bio-based.eu/markets

In Japan, the annual domestic input of plastics is approximately 9.9 million tons (2018)[4], of which approximately 41,000 tons (2018) are **bio-based plastics** (nonbiodegradable) and approximately 4,000 tons (2018) are **biodegradable plastics**[5]. In addition, in terms of the milestone of domestic introduction of **bio-based plastics** in 2030 (2 million tons of products), the domestic shipment of **bio-based plastic** products is approximately 72,000 tons (FY 2018)[6]. **Bio-based plastics** (nonbiodegradable) are used for applications such as containers and packaging, clothing and textiles, electrical and information equipment, and automobiles. **Biodegradable plastics** are used for applications such as agricultural and civil engineering materials, food residue (organic waste) collection bags, and containers and packaging.

2 PlasticsEurope, The Facts 2019, (https://www.plasticseurope.org/en/resources/publications/1804-plastics-facts-2019) (accessed October 16, 2020)
3 European Bioplastics, Bioplastics market data, (https://www.european-bioplastics.org/market/) (accessed October 16, 2020)
4 2018 materials flow chart describing plastic product production, disposal, recycling, and treatment and disposal as prepared by the Plastic Waste Management Institute was used as the reference (http://www.pwmi.or.jp/pdf/panf2.pdf). (accessed October 16, 2020)
5 The estimates calculated by the Japan BioPlastics Association were used as the reference.
6 Based on a survey of domestic shipments of bio-based plastic products with certification marks (FY2018) conducted in cooperation with the Japan Organics Recycling Association and the Japan BioPlastics Association

2 Current status and issues related to the introduction of bioplastics

JBPA estimates

Biodegradable plastics 3,700 tons

- PBAT
- PBS <Including partially bio-based ones>
- Starch blends
- PHA <100% bio-based>
- PETS
- Others

Bio-based plastics (non-biodegradable) 41,057 tons

- Bio-PET 19,000 tons
  <Partially bio-based>
- Bio-PA 6,500 tons
  <Including partially bio-based>
- Bio-PE 9,248 tons
- PLA 4,474 tons
  <Mainly used as bio-based plastic (non-biodegradable), although it also has biodegradable functions>
- Others 1,835 tons
  - Bio-PC <Partially bio-based>
  - Bio-PU <Partially bio-based>
  - Bio-PTT* <Partially bio-based>
  - Others

*Polytrimethylene terephthalate

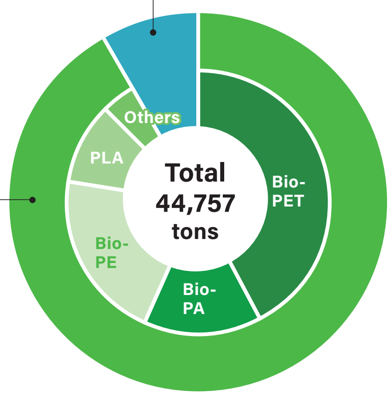


Figure 2-2 **Shipment of bioplastics in Japan (FY 2018)**
Source : Data prepared by the Japan BioPlastics Association

Bioplastics are expected to be one solution to the various problems of plastics because of their value, such as reducing the environmental impact as follows.

Values of using each bioplastics

- **Bio-based plastics:** mainly reduces greenhouse gas emissions and the use of exhaustible resources if sustainable raw materials are used and the greenhouse gas emission reduction effects throughout their life cycles have been verified
- **Biodegradable plastics:** mainly rationalize the waste disposal process and reduce marine plastic litter if appropriate **biodegradable plastics** according to the degradation environment are used

However, internationally, questions are often raised as to whether greenhouse gases are truly reduced throughout the life cycle, whether biomass feedstock is sustainable, or whether biodegradability is adequately exercised. In addition, by using biomass as a raw material, the major bottleneck for the introduction of **bioplastics** is that the cost of resin production has not been optimized due to the low efficiency of raw material procurement and manufacturing characteristics based on biological processes, compared to conventional fossil-based plastics. Therefore, the ratio of **bioplastic** input to the total domestic input of plastics in Japan is only approximately 0.5% as of 2018, and the current status and issues need to be organized to promote its introduction.

In the following chapters, **bioplastics** are categorized into two categories, **bio-based plastics** (nonbiodegradable) and **biodegradable plastics**, which have significantly different properties. Then, for both categories, the following points that need to be considered during different life stages are reviewed.

- [1] raw materials, [2] supply, [3] cost, and [4] functions during use (in the supply chain until they are used by plastic users)
- [5] impacts on post-use flow, including the current plastic recycling system (whether they impose a burden on the processing system or on the natural environment in the post-use stage, such as disposal and recycling)
- [6] environmental and social aspects (whether sustainability is increasing throughout the life cycle)

2. Current status and issues related to the introduction of bio-based plastics (nonbiodegradable)

[1] Raw materials

As shown in Table 2-1, **bio-based plastics** (nonbiodegradable) are mainly manufactured from sugars and bio-oils. Typical raw materials include sugarcane, corn, and cassava. In many cases, edible parts are used, but there are also cases where inedible parts are used.

The typical **bio-based plastics** (nonbiodegradable) manufactured in Japan include bio-PA and bio-PC. Imported bio-oils are used as raw materials for bio-PA, and imported sugar-based materials are used for bio-PC in whole or in part.

There is no information regarding shortages of raw materials for the current production of **bio-based plastics** (nonbiodegradable). For example, in Brazil, the area of sugarcane cultivated to produce 200,000 tons of bio-PE is 0.02% of the country's cultivable land, which is a small percentage of the total[7]. However, as the demand for raw materials expands in the future, there will be a risk of competition with food and other raw materials, such as bio-ethanol used for fuel, and the risk of insufficient quantities from the perspective of procuring sustainable raw materials.

Table 2-1 **Raw material-producing and resin-manufacturing countries and regions of major bio-based plastics (nonbiodegradable)[8]**

Resin	Raw material	Main raw material-producing countries	Main resin-manufacturing countries and regions
Bio-PE	Sugars (process in which sugars are converted to ethanol as a precursor of PE by fermentation)	Brazil	Brazil
	Bio-oils (process in which modified bio-oils are mixed with fossil-based naphtha for cracking)	Various countries	Europe

7 Source: Website of Braskem (http://plasticoverde.braskem.com.br/site.aspx/Sugarcane) (accessed September 15, 2020)
8 Reference: Bio-based Building Blocks and Polymers: Global Capacities, Production and Trends 2019–2024, nova Institute GmbH, 2020

Resin	Raw material	Main raw material-producing countries	Main resin-manufacturing countries and regions
Bio-PET	Sugars (mono-ethylene glycol part of the monomers)	India	Various countries
	Petroleum (terephthalic acid part of the monomers)	Various countries	
Bio-PP	Bio-oils (process in which modified bio-oils are mixed with fossil-based naphtha for cracking)	Various countries	Europe
Bio-PA*	Bio-oils (some monomers [e.g., sebacic acid])	China, India	China, United States, Japan, France
	Petroleum (some monomers [such as hexamethylenediamine])	Various countries	
Bio-PC	Sugars (isosorbide part of the monomers)	France	Japan
	Petroleum (monomers that copolymerize with isosorbide)	Various countries	

*There are various types of bio-PA, each with a different bio-based content.

[2] Supply

From the viewpoint of transportation efficiency, **bio-based plastics** (nonbiodegradable) are mostly manufactured in the country where the raw materials are produced. Because of the rapid increase in demand for **bio-based plastics** (nonbiodegradable) in recent years, there are plans to increase production capacity by resin manufacturers in various countries, but it will take several years to construct manufacturing facilities, and there is a risk that the supply will not be able to keep up with the demand during this time.

Additionally, in Japan, although some **bio-based plastics** (bio-PA and bio-PC) are manufactured domestically[9], there has been little progress in the construction of manufacturing facilities for bio-based general-purpose plastics (bio-PE, bio-PET, and bio-PP) to increase their production volume and manufacturing technologies, the suitability for commercialization have not been demonstrated, and the future demand outlook is uncertain.

[3] Cost

Bioplastics are more expensive for users and consumers than conventional fossil-

9 The main applications of bio-PA are electrical and electronic parts, automotive parts and fuel piping, and optical equipment, and the main applications of bio-PC are automotive interior and exterior parts, sound insulation walls, cell phone casings, display polarizers, sunglasses, cosmetic containers, LED lighting, and automotive door handle films.

based plastics. The low efficiency of raw material procurement compared to fossil resources and the characteristics of manufacturing (often via biological processes) are the main reasons. According to interviews with stakeholders in Japan, the unit price of each **bio-based plastic** (nonbiodegradable) is approximately three times higher for bio-PE and approximately 1.5 times higher for bio-PET than for conventional fossil-based counterparts[10], which is a major reason why demand for **bio-based plastics** (nonbiodegradable) is not increasing.

[4] Functions during use

When the same type of **bio-based plastics** (nonbiodegradable) is used as a substitute for conventional fossil-based plastics (bio-PE, bio-PET, and bio-PA fall into this category and account for approximately 80% of the use of **bio-based plastics** [nonbiodegradable] in Japan), the functions are almost the same, although the physical properties may be slightly different due to differences in grade, thus, there are a few issues related to manufacturing and use of the products.

[5] Impacts on post-use flow including the current plastic recycling system

The main post-use flows are assumed to include recycling (mechanical/chemical) and degradation associated with fertilizer production, such as composting, anaerobic digestion, and waste incineration (including those with energy recovery). The impacts of **bio-based plastics** (nonbiodegradable) that are mixed into these post-use flows are summarized below.

Because the impact on recycling differs depending on the type of **bio-based plastics** (nonbiodegradable), different cases are assumed in which (a) bio-based general-purpose plastics (bio-PE, bio-PET, and bio-PP, of which a shift to bio-based materials has started or is expected to start soon on a commercial basis) are mixed and (b) other **bio-based plastics** (nonbiodegradable) are mixed.

Recycling is categorized as recycling in which multiple types of resins are still mixed even after separate collection and sorting (hereafter referred to as "multiple plastic type recycling") and as recycling in which a single type of resin is recycled through separate collection and sorting (hereafter referred to as "single plastic type recycling").

In the case of multiple plastic type recycling, the impact on the recycling differs depending on the type of **bio-based plastic** (nonbiodegradable). (a) Bio-based general-purpose plastics are recyclable because they have the same physical properties as those for which recycling technologies and processes have already been established.

However, when (b) **bio-based plastics** (nonbiodegradable) other than general-purpose plastics are mixed with the recycling of general-purpose plastics, they become foreign substances and may hinder recycling because recycling technologies and processes, such as sorting, have not been established. However, if single plastic type recycling is implemented, recycling may become possible.

10 Based on information obtained from interviews with trading companies that sell bioplastics

In addition, **bio-based plastics** (nonbiodegradable) do not degrade but remain during the process of fertilizer production, including composting and anaerobic digestion, and they have a negative impact on the process.

Bio-based plastics (nonbiodegradable) have no adverse effects on the waste incineration (including those with energy recovery).

Table 2-2 shows the impacts of **bioplastics** (nonbiodegradable) on the post-use flow, which summarizes the above points.

Table 2-2 Impacts of bio-based plastics (nonbiodegradable) on post-use flow

	Recycling (mechanical/chemical)		Degradation associated with fertilizer production, including composting	Anaerobic digestion	Waste incineration (including those with energy recovery)
	Multiple plastic type recycling	Single plastic type recycling			
(a) Bio-based general-purpose plastics	Recyclable by established technologies and processes	Recyclable by established technologies and processes	Cannot be degraded		No adverse impact
(b) Bio-based plastics (nonbiodegradable) other than (a)	Possibly inhibit recycling because technologies and processes have not yet been established *1	Recyclable by established technologies and processes *2			

Note : The organization of this table may be updated by future development of recycling technologies.
*1 May be recyclable using certain recycling methods. In addition, the same type of bio-based plastic (e.g., PA → bio-PA, PC → bio-PC), which replaces fossil-based high-performance plastics used from the viewpoint of quality and performance required for products, does not have an adverse impact on recycling compared to the current situation.
*2 In some cases, recycling technologies and processes have not been established for some thermosetting resins.

[6] Environmental and social aspects

The environmental value of **bio-based plastics** (nonbiodegradable) is that they can be expected to reduce greenhouse gas emissions and reduce the use of exhaustible resources. Biomass, which is a raw material for **bio-based plastics**, is carbon neutral as long as it fixes atmospheric carbon dioxide during its growth and reproduction. Thus, for sanitary goods that require sterilization by certain treatment, such as incineration, and for other applications where they have no other choice but to be incinerated after use due to the usage characteristics, **bio-based plastics** (nonbiodegradable) can contribute to reducing greenhouse gases emitted during heat treatment. Based on these environmental values, there are many examples of life cycle assessments that focus mainly on the effect of reducing greenhouse gas emissions. However, the problem is that in many cases, the evaluation is done only from the perspective of greenhouse gas emissions; additionally, there are cases where the impacts of land use change and other factors are not included even in the evaluation of greenhouse gas emissions.

When biomass feedstock is used for **bio-based plastics**, it may cause competition with food demand. There are also various perspectives on the sustainability of raw materials other than whether they are edible or inedible, and there are examples of the use of certification systems. In some cases, manufacturers and users use their own methods to confirm sustainability, and the difficulty of ensuring the objectivity of these methods has been an issue.

3. Current status and issues related to the introduction of biodegradable plastics

[1] Raw materials

Approximately 70% of the **biodegradable plastics** currently in widespread use in Japan are bio-based[11] , and the current status and issues for bio-based **biodegradable plastics** are the same as for **bio-based plastics** (nonbiodegradable). Other **biodegradable plastics** are manufactured mainly from fossil-based naphtha.

As a raw material for **biodegradable plastics** (bio-based) manufactured in Japan, bio-oil is used for PHBH, a kind of PHA.

Table 2-3 **Raw material-producing and resin-manufacturing countries and regions of major biodegradable plastics**[12]

Resin	Raw material	Main raw materials producing countries and region	Main resin-manufacturing countries
PLA	Sugars	United States, Thailand	United States, Thailand
PHA (including PHBH)	Sugars and bio-oils	United States, China, Southeast Asia	United States, China, Japan
PBAT	Petroleum	-	Germany, China
Bio-PBAT	Sugars (1,4-butanediol part of the monomers)	Italy	Italy
	Petroleum (adipic acid and terephthalic acid part of the monomers)	Various countries	
PBS	Petroleum	-	China

11 Based on the domestic shipment volume (FY2018) survey of bio-based plastic products that have acquired certification marks, conducted with the cooperation of the Japan Organics Recycling Association and the Japan BioPlastics Association.
12 Reference: Bio-based Building Blocks and Polymers: Global Capacities, Production and Trends 2019–2024, Nova-Institute GmbH, 2020

Resin	Raw material	Main raw materials producing countries and region	Main resin-manufacturing countries
Bio-PBS	Sugars (succinic acid part of the monomers)	Thailand	Thailand
	Petroleum (1,4-butanediol part of the monomers)	Various countries	
Starch blends	Starch and its derivative	Italy, China	Italy, China
	Petroleum (polyester)	Various countries	

[2] Supply

Currently, PHBH, a type of PHA, is manufactured in Japan[13] . As for the others, as in the case of **bio-based plastics** (nonbiodegradable), there has been a little progress in the development of manufacturing facilities to increase the production volume because manufacturing technologies suitable for commercialization have not been demonstrated, and the future demand outlook is uncertain.

Some applications of cellulose acetate (e.g., microbeads)[14] and PVA (e.g., a coating film of liquid detergent for clothing)[15] , which have been manufactured in Japan for a long time, are used as biodegradable materials that replace conventional plastics.

[3] Cost

Biodegradable plastics in general and **bio-based plastics** (nonbiodegradable) are more expensive for users and consumers than conventional fossil-based plastics.

According to interviews with users in Japan, the unit price of each **biodegradable plastic** compared to general-purpose plastics is approximately two to three times higher for PLA, approximately two to two and one-half times higher for PBAT (fossil-based), and approximately four to five times higher for PBAT (bio-based)[16] . This is a major reason why the demand for **biodegradable plastics** is not increasing.

[4] Functions during use

Compared to **nonbiodegradable plastics**, it is often difficult to manufacture and use products made of **biodegradable plastics** because of the different properties of the resins, which limits their applications.

13 Kaneka Corporation Press Release: Completion of Kaneka Biodegradable Polymer PHBH™ Plant with an annual production of 5,000 tons. (December 19, 2019) (https://www.kaneka.co.jp/en/topics/news/nr20191219/)

14 According to interviews with resin manufacturers, more than 100,000 tons of cellulose acetate are produced in Japan annually. Major applications include polarizer protection film for LCDs, eyeglass frames, membranes for water treatment, textile and cigarette filters (acetate fiber), and photographic film.

15 According to the Japan Plastics Industry Federation's plastic raw materials production data (http://www.jpif.gr.jp/3toukei/conts/nenji/y_genryou_c_2.htm), 213,000 tons (2018) of PVA are manufactured in Japan. The main applications include vinyl on fiber raw materials, fiber processing glues, paper processing agents, film raw materials, adhesives, and polymerization stabilizers.

16 Based on information obtained from interviews with trading companies that sell bioplastics

Additionally, depending on the type of **biodegradable plastics**, quality deterioration may occur during long-term storage.

[5] Impacts on post-use flow, including the current plastic recycling system
The main post-use flows are assumed include recycling (mechanical/chemical) and degradation associated with fertilizer production, such as composting, anaerobic digestion, and waste incineration (including those with energy recovery). The impacts of the introduction of **biodegradable plastics** into these flows are discussed below.

As in the case of **bio-based plastics** (nonbiodegradable) described above, recycling is divided into multiple plastic type and single plastic type.

When **biodegradable plastics** are mixed into multiple plastic type recycling for which recycling technologies and processes, such as sorting, have not been established; thus, they become foreign substances in general-purpose plastic recycling, which can be an inhibitor for recycling. However, when single plastic type recycling is implemented, even **biodegradable plastics** may be recyclable.

When composting organic waste or converting organic waste into biogas, sufficient degradation of organic waste collection bags made of **biodegradable plastic** may not only save labor required for removing the bags or processing the bags separately but also reduce waste and have a positive impact on the post-use flow. However, when **nonbiodegradable plastics** are mixed into fertilizers, such as compost, they are treated as foreign substances and can be an inhibitor for fertilizer production.

In Japan, the number of facilities for composting and anaerobic digestion of organic waste owned by local governments is currently limited to 101 facilities[17] .

Biodegradable plastics have no adverse effects on the waste incineration process (including those with energy recovery).

17 Reference: The Waste Management in Japan (FY 2018 edition) - the status of facilities for resource recycling, etc. (90 facilities for waste-to-fertilizer conversion, two facilities for waste-to-feed conversion, and nine facilities for methanization).

Table 2-4 shows the impact of **biodegradable plastics** on the post-use flow to summarize the above points.

Table 2-4 Impact of biodegradable plastics on post-use flow

	Recycling (mechanical/chemical)		Degradation associated with fertilizer production, including composting	Anaerobic digestion	Waste incineration (including those with energy recovery)
	Multiple plastic type recycling	Single plastic type recycling			
Biodegradable plastics	Possibly inhibit recycling because technologies and processes have not yet been established *1	Recyclable by established technologies and processes *2	Positive impact if degraded properly		No adverse impact

Note : The organization of this table may be updated by future development of recycling technologies.
*1 May be recyclable with certain recycling methods
*2 In some cases, recycling technologies and processes have not been established for some thermosetting resins.

Regarding mulch films for agricultural use, those made of **biodegradable plastics** with biodegradable functions in the soil can be plowed into farmland under proper management as part of the agricultural procedure after a harvest.

Furthermore, there are cases where proper biodegradation in the natural environment is required for products, such as coating materials for controlled-release fertilizer and some fishing gear, which should not be allowed to flow out into the natural environment after use, but may unintentionally flow out because of their usage characteristics. With regard to biodegradability in the ocean, it will take time to establish technology to control the degree and speed of biodegradability. Currently, Japanese stakeholders are having discussions on international standardization to further improve the reliability of methods for evaluating marine biodegradability.

Regardless, there are various degradation environments, such as industrial composting, home composting, the soil, and the ocean, and it is necessary to select a **biodegradable plastic** suitable for a specific degradation environment.

In addition, when **biodegradable plastics** are combined with other materials, such as conventional fossil-based plastics, or when plasticizers or additives are added, factors may arise that inhibit biodegradability. Thus, it is necessary to pay attention to appropriate combinations that fully utilize their biodegradable functions.

Meanwhile, when the material is landfilled in a final disposal site after use, there is a risk of unintended biogas generation depending on the type of **biodegradable plastic** or its physicochemical changes.

[6] Environmental and social aspects

The issues of bio-based **biodegradable plastics** related to greenhouse gas emissions are the same as those with **bio-based plastics** (nonbiodegradable).

In the case of **biodegradable plastics** in general, life cycle assessment, including the degree and speed of degradation, is desirable for applications that take advantage of biodegradability. At present, however, few **biodegradable plastic** products take advantage of biodegradability, and few analysis examples have included degradation.

In addition, for bio-based **biodegradable plastics** as with **bio-based plastics** (nonbiodegradable), the issue is to ensure objectivity when confirming the sustainability of raw materials and manufacturing.

Additionally, regardless of whether the plastic is biodegradable or not, plastics should not be littered (illegally dumped), but care should be taken to avoid encouraging littering due to consumer misunderstandings that **biodegradable plastic** will degrade naturally, and therefore, it is acceptable to litter.

3 Principles and measures related to the introduction of sustainable bioplastics

1. Basic principles for introduction

In view of the fact that **bioplastics** use valuable resources, the following two points should be considered as general rules when introducing them.

- Rationalize the avoidable use of plastics, including single-use containers, packaging, and products, to completely reduce wasted resources.
- Maximize the value of **bio-based plastics** and/or **biodegradable plastics**, including their ability to reduce environmental impacts.

In addition, by contributing to the utilization of natural capital, such as those originating from local resources, and to the establishment of new supply chains, introduction of **bioplastics** is expected to lead to the creation of a sustainable circular and ecological society. Based on the issues identified in the previous chapter, basic principles for the introduction of **bioplastics** are provided below.

[1] Raw materials

The main usages of biomass include biofuels and raw materials for products, such as **bioplastics.** With regard to **bio-based plastics** (nonbiodegradable and biodegradable), even though no pressure on the supply of raw materials has been thus far identified, diversification efforts are needed to expand raw materials in anticipation of increased demand for **bio-based plastic** applications in the future. Therefore, we need to expand the scope of the raw material uses of domestic biomass (domestically grown resource crops, waste cooking oil, cellulosic sugars, such as wood pulp, rice straw, and rice husk) in a manner so that it will not interfere with securing a stable supply of food and feed.

[2] Supply

Although it is necessary to increase the supply of **bioplastics** produced both domestically and in abroad, in particular, to increase the amount of domestically produced **bioplastics** in the future, we need to increase the production by Japanese companies that produce **bioplastics** to expand the range of supply sources in Japan.

In addition, we need to develop a supporting system to enable domestic plastic manufacturers to increase the amount of **bioplastic** production.

[3] Cost

Although many **bioplastics** are more expensive than conventional fossil-based plastics due to the costly process, we aim to optimize the cost of **bioplastic** production via collaboration and cooperation among related entities in raw material procurement and production and provide support for development and installation of equipment.

In addition, we aim to promote the use of **bioplastics** in a way that takes their environmental value into account, e.g., by appealing to users by using their environmental value (reduction of the use of exhaustible resources and greenhouse gas emissions, rationalization of the waste disposal process by the degradation of **biodegradable plastics**).

[4] Functions during use

We aim to develop and introduce **bioplastics** with general-purpose functions (strength, heat resistance and processability) equivalent to those of conventional fossil-based general-purpose plastics to apply them in a wide range of product groups.

Additionally, we aim to further expand applications through the development and introduction of **bioplastics** with higher functionality, including durability and toughness.

In products for which applications are intended, we need to expand the use of **bioplastics** by flexibly considering the product performance required based on the characteristics of **bioplastics**, such as strength and heat resistance.

[5] Impacts on post-use flow including the current plastic recycling system

In product areas where recycling of multiple plastic types has been already implemented, we need to actively promote the use of bio-based general-purpose plastics with physical properties that are equivalent to those of general-purpose plastics for which recycling has already been established. Because sorting technologies, processes have not yet been established for other types of **bioplastics**, we should be aware of the risk of adverse effects when they are mixed into the recycling process. Moreover, we need to continue to improve technologies and processes to make recycling possible. However, this does not apply where single plastic type recycling is implemented. In either case, to promote recycling, cooperation between stakeholders is required.

When organic waste is processed by composting or anaerobic digestion, using plastics that have biodegradable functions suitable for degradation in organic waste collection bags may play a role in lowering the processing cost by omitting the process of separating and processing garbage bags in a separate process. Therefore, we should promote the use of **biodegradable plastics** for this application and require entities that implement composting, anaerobic digestion to implement management, such as the removal of non-degradable plastics and sufficient degradation of **biodegradable plastics**.

Among the mulch films for agricultural use, when mulch films that use **biodegradable plastics** that have biodegradable functions in the soil are used, they are plowed into the farmland under proper management as part of agricultural processing after harvesting. Thus, we need to expand the use of **biodegradable plastics** for this application.

Additionally, even though leakage into the natural environment after use must be avoided, for some products, there are possibilities of unintentional leakage into the natural environment, such as the ocean, due to their usage characteristics. Therefore, to promote the use of plastics with marine biodegradability for these applications, we should implement dissemination measures that focus on the development of technologies and the establishment of evaluation methods using Japan's advanced technologies, knowledge, and expertise.

[6] Environmental and social aspects

It is of utmost importance to use sustainable **bioplastics** during their entire life cycle. Thus, we need to create an environment in which consumers can purchase and use them with conviction and confidence, and we need to promote using **bioplastics** that have been confirmed to be more sustainable over their entire life cycle at least in terms of greenhouse gas emissions, land use change, biodiversity, labor, governance, competition with food.

Regarding **biodegradable plastics**, to prevent consumers from misunderstanding that it is acceptable to litter them because they degrade, we need to conduct educational activities to improve consumer understanding and create an environment that does not lead to moral hazards, such as littering.

In addition, the COVID-19 pandemic has led to an increased demand for essential uses of plastics, mainly for hygiene purposes. The role of plastics has been again recognized again, and there have been changes in the ways that plastic waste is disposed of. In light of this, we need to actively introduce **bioplastics** into applications where there is a strong need to use plastics.

Additionally, because the greenhouse gases emitted when **bio-based plastics** are incinerated are expected to be carbon neutral, (although carbon neutrality does not typically depend on the application from the perspective of being easily accepted by users) **bio-based plastics** will be actively introduced for applications, such as sanitary goods that require sterilization by a certain type of treatment, such as incineration, and for other applications in which there is no other choice but to be incinerated after use.

Based on the above basic principles, relevant entities are expected to implement the following actions.

3 Principles and measures related to the introduction of sustainable bioplastics

Bioplastic manufacturers

- Research, development, and commercialization of **bioplastic** businesses to provide biodegradability to plastics depending on their physical properties and applications and to reduce environmental impacts
- Investment in manufacturing facilities in Japan to increase the supply of **bioplastics**
- Proposals to businesses that use plastics for applications with low impact on current post-use flows, including plastic recycling systems
- Confirmation of the environmental impact and sustainability from raw material production to resin-manufacturing in terms of the environmental and social aspects
- Establishment of targets regarding the production of **bioplastics** and implementation of activities to achieve these targets

Plastics-using companies

- Shift to **bioplastics** based on basic principles
- Establishment of targets regarding the proactive use of **bioplastic** products and implementation of activities to achieve these targets
- Increasing awareness among consumers through appropriate labeling

Retail and service providers

- Establishment of targets regarding the proactive introduction of **bioplastic** products and implementation of activities to achieve these targets
- Increasing awareness among consumers
- Sales promotion of **bioplastic** products

Consumers

- Proactive purchasing of **bioplastic** products
- Development of understanding regarding symbols in labeling
- Contribution to appropriate sorting

Academic and research institutions

- Research on the expansion of raw materials and diversification of applications of **bioplastics** and improving recyclability during the post-use flow
- Development of technologies for specific types of **bioplastics**
- Accumulation of scientific knowledge on the actual leakage of plastics according to application

Local governments

- Proactive shift to **bioplastic** products through public procurement
- Support the research, development, and introduction of **bio-based plastic** products using locally available materials
- Use of **bio-based plastics** in designated combustible waste collection bags
- Development of composting and anaerobic digestion facilities to create a sound material-cycle society and introduction of **biodegradable plastics** for waste bags in conjunction with facility development
- Proactive use of **bioplastic** products and education of consumers to facilitate the correct understanding of **bioplastics**

2. Principles for the introduction of bioplastics for different plastic product areas

Based on basic principles [1] to [6] above, **bioplastics** suitable for introduction in each plastic product area have been categorized, and an overview is shown in Table 3-1, whereas details are in Table 3-2.

The six main product areas for plastics

1) containers and packaging
2) electrical and electronic equipment, wires and cables, and machinery
3) daily goods, clothing and footwear, furniture, toys, etc., used in households and offices
4) construction materials
5) transportation
6) agriculture, forestry, and fisheries

In addition, the following six products have been identified as subcategories of each product area:

3 Principles and measures related to the introduction of sustainable bioplastics

Subcategories of each product area

The area of containers and packaging
- plastic shopping bags

The area of daily goods, clothing and footwear, furniture, toys, and those used in households and offices
- combustible waste collection bags
- organic waste collection bags for composting and anaerobic digestion

The area of agriculture, forestry, and fisheries
- agricultural mulch films
- coating materials for controlled-release fertilizer
- production materials for fisheries, such as fishing gear

As a result, products are sorted based on a total of 12 product categories.

Table 3-1 Bioplastics suitable for introduction for different plastic product areas (overview)

Product area	Suitable bioplastics for introduction
(a) Among containers and packaging, electrical and electronic equipment, daily goods, construction materials, transportation, and agriculture, forestry, and fisheries, products other than the ones listed in (c)	Among the bio-based plastics (nonbiodegradable), those that fall under either of the following [1] or [2] with no adverse impacts on recycling: [1] Bio-based general-purpose plastics (At present, bio-PE, bio-PP, and bio-PET fall under this category, and PVC and PS will be added when their production from biomass is put to practical use.) [2] The same types of bio-based plastics other than general-purpose plastics that substitute for fossil-based high-performance plastics used for quality and performance required for the product (e.g., PA → bio-PA, PC → bio-PC)
(b) Combustible waste collection bags	Bio-based plastics (nonbiodegradable)
(c) Organic waste collection bags for composting and anaerobic digestion, agricultural mulch films (if plowed into agricultural soil), coating materials for controlled-release fertilizer, and production materials for fisheries, such as fishing gear (when high strength and durability are not necessarily required)	Biodegradable plastics *Plastics with appropriate biodegradability for the degradation environment

Note : Because changes in the status and characteristics of use, the composition of products, recycling technologies and systems, and development of new bioplastics may alter this categorization; thus, this table will be updated as required.

Table 3-2 Bioplastics suitable for each plastic product area (details)

Category : 1 Bio-based plastics (nonbiodegradable) that have no adverse effects on recycling and belong to either [1] or [2] below:
[1] Bio-based general-purpose plastics (At present, bio-PE, bio-PP, and bio-PET)
[2] The same types of bio-based plastics that substitute for fossil-based high-performance plastics (e.g., PA → bio-PA, PC → bio-PC)

Category : 2 Bio-based plastics (nonbiodegradable)

Category : 3 Biodegradable plastics (Plastics with suitable biodegradability in each environment)

Product area	Amount of waste[18] (thousand ton)	Main materials	Suitable bioplastics for introduction	Matters that need to be considered for each product area (Impacts on post-use flow, including recycling)
Containers and packaging	4,230	PP, PE, PS, PET	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the higher effect for environmental impact reduction is to be selected.	There must be no adverse effects when bioplastics are mixed into the recycling process.
Plastic shopping bags	(190)	PE		
Electrical and electronic equipment, wires and cables, and machinery	1,760	PS, PP, PU, ABS, PVC	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the higher effect for environmental impact reduction is to be selected.	There must be no adverse effects when bioplastics are mixed into the recycling process.
Daily goods, clothing and footwear, furniture, toys used in households and offices	670	PP, PE, PS	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the higher effect for environmental impact reduction is to be selected.	There must be no adverse effects when bioplastics are mixed into the recycling process.
Combustible waste collection bags	(a part of 288)	PE	Category : 2 Category 2, which contributes to reducing greenhouse gas emissions, is introduced.	There must be no inhibition of energy recovery.
Organic waste collection bags for composting and anaerobic digestion	(Less than 1)	PE	Category : 3 From the viewpoint of post-use functions, those with biodegradable functions such as composting or anaerobic digestion are introduced from Category 3.	These are required to have a biodegradable function that can be sufficiently degraded via composting or anaerobic digestion.

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Product area	Amount of waste[18] (thousand ton)	Main materials	Suitable bioplastics for introduction	Matters that need to be considered for each product area (Impacts on post-use flow, including recycling)
Construction materials	610	PVC, PE	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the stronger effect for environmental impact reduction is to be selected.	There must be no adverse effects when bioplastics are mixed into the recycling process.
Transportation	310	PP, PE, ABS, PU	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the stronger effect for environmental impact reduction is to be selected.	There must be no adverse effects when bioplastics are mixed into the recycling process.
Agriculture, forestry, and fisheries	120	PVC, PE	Category : 1 From the viewpoint of post-use impacts, Category 1 with low impacts on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; therefore, the one with the stronger effect for environmental impact reduction is to be selected.	There must be no adverse effects when bioplastics are mixed into the recycling process.
Agricultural mulch films	(40)	PE, PVC	**[For collection and recycling]** Category : 1 From the viewpoint of post-use impacts, Category 1 with a low impact on the current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; thus, the one with the stronger effect on environmental impact reduction is to be selected. **[For plowing into the soil of farmland]** Category : 3 From the viewpoint of post-use functions, those with biodegradable functions in the soil are introduced from Category 3. This is limited to cases where the plastic is plowed into the soil of farmland under proper management as a part of the farming process.	**[For collection and recycling]** There must be no adverse effects when bioplastics are mixed in the recycling process. **[For plowing into the soil of farmland]** These are required to have biodegradable functions in the soil.

Product area	Amount of waste[18] (thousand ton)	Main materials	Suitable bioplastics for introduction	Matters that need to be considered for each product area (Impacts on post-use flow, including recycling)
Agriculture, forestry, and fisheries				
Coating materials for controlled-release fertilizer	(6.7)	PE, PU	Category : 3 From the viewpoint of post-use impacts, plastics with biodegradability in both soil and ocean are introduced from Category 3.	These are required to have biodegradable functions in the soil and the ocean if they are leaked into the natural environment.
Production materials for fisheries, such as fishing gears	(20)	Polyester PA, PE, PS	**[For collection and recycling]** Category : 1 From the viewpoint of post-use impacts, Category 1 with a low impact on current plastic recycling system is introduced. However, if a single type of plastic is recycled through sorted collection and separation, all categories may be applicable; thus, the one with the higher effect on environmental impact reduction is to be selected. **[For cases where high strength or durability is not necessarily required]** Category : 3 From the viewpoint of post-use impacts, plastics with biodegradable functions in the ocean are introduced from Category 3.	**[For collection and recycling]** There must be no adverse effects when bioplastics are mixed in the recycling process. **[For cases where high strength or durability is not necessarily required]** These are required to have biodegradable functions in the ocean if they are leaked into the marine environment.

Note : Because changes in the status and characteristics of use, composition of products, recycling technologies and systems, and development of new bioplastics may alter the categorization, this table will be updated as required.

18 Containers and Packaging; electrical and electronic equipment, wires and cables, machinery; daily goods, clothing and footwear, furniture, toys, used in households, offices; construction materials; transportation; and agriculture, forestry, and fisheries - Plastic Products, Plastic Waste and Resource Recovery [2018], prepared by the Plastic Waste Management Institute was used as a reference (http://www.pwmi.or.jp/pdf/panf2.pdf) (accessed October 16, 2020)
Plastic shopping bags and combustible waste collection bags - The Dictionary of Packaging Materials Share - 2018 Edition by the Japan Center for Economic Research, was used as the reference. Note that the number of combustible waste collection bags in the referred document (288 thousand tons in 2017) was the total number of household waste bags, commercial waste bags, and municipal designated tender waste bags and not the number solely of combustible waste bags; thus, it is written as part of the total number.
Organic waste collection bags for composting and anaerobic digestion - The maximum amount of collection bags required was estimated based on the amount of waste brought to waste composting and methanization facilities from the Survey on General Waste Disposal, Ministry of the Environment of Japan.
Agricultural mulch film - "ABA News #7" (2020) by the Association of Biodegradable-Plastics for Agriculture was used as the reference. (http://www.aba-seibunkai.com/ABA_News-No.07.pdf) (accessed October 16, 2020)
Coating materials for controlled release - the Roadmap for Popularizing Development and Introduction of Marine Biodegradable Plastics by the Ministry of Economy, Trade and Industry, was used as a reference.
Production materials for fisheries, such as fishing gear - Footnote*2 on page 2 of the Future efforts to Address the Issues of Plastic Resource Circulation in Fisheries (April 2019) by the Council for Measures to Address Plastic Resource Circulation Issues in Fisheries was used as the reference.
Note that the number for the amount of waste for the six subcategories shown in () are included in the respective product areas.

3. Measures for introduction by the government

Based on the principles described in (1) above, the government will implement the following measures in coordination with actions of relevant entities. In implementing the measure, support for the introduction of **bioplastics** in line with the basic principles will be provided.

Promotion of use

- Compile a collection of examples of corporate use of **bioplastics** published as "**Bioplastics** – Good Application Practices in Japan," and a collection of advanced introduction targets published as "**Bioplastics** – Collection of Corporate Commitments and Targets in Japan" to link them to the smooth supply by presenting examples of advanced initiatives and forecasting demand and facilitate business matching between companies through the Japan Clean Ocean Material Alliance[19] and the Plastic Smart Campaign[20]
- Focus on the environmental value of **bioplastics**, strengthen, e.g., the evaluation criteria for the designated procurement items to promote government-led procurement under the Act on Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities to stimulate demand and consider measures to stimulate demand for bio-based products taking, e.g., the Act into account and promote proactive procurement by local governments using the Green Procurement System
- Design a fair and equitable recycling system that promotes the use of **bioplastics**
- Examine international standardization to further improve the reliability of methods for evaluating marine biodegradation functions

Appeal and awareness-raising activities to target consumers

- For **bioplastics** introduced by companies to be able to attract consumers and users with their environmental impact reduction effects and sustainability through labeling and other measures, examination of the rationalization of certification and the establishment of a new certification system in cooperation with related parties is required. In the certification process, a method for confirming the sustainability through the entire life cycle should be considered, while also referring to studies on the sustainability of biomass fuels. In addition, an evaluation method for bio-based synthetic polymer content, including the mass balance approach, and a method for evaluating functions after use, including biodegradability, should be examined.
- Raise awareness of consumers toward proactive use of **bioplastic** products and correct understanding through measures, including environmental education

19 Japan Clean Ocean Material Alliance (CLOMA) was established in 2018 as a new platform that helps various cross-sectoral stakeholders to collaborate and accelerate innovation.
20 The Ministry of the Environment is conducting the Plastic Smart Campaign to encourage and further expand initiatives that enable the use of plastics in a wise manner.

3 Principles and measures related to the introduction of sustainable bioplastics

Development of R&D and production systems

- Strongly support R&D and demonstration projects the areas, such as production of **bioplastics** with higher functionalities, reduction of costs, diversification of raw materials, improvement of recycling technology, installation of recycling systems, and improvement and evaluation of biodegradability in natural environments, including marine environments; in particular, we need to provide focused support for the use of biomass within Japan and the manufacturing of **bioplastics** in Japan.
- Support the introduction of manufacturing facilities by **bioplastic** manufacturers to promote the production of **bioplastics** in Japan and to reduce costs.
- Provide support to facilitate financing for corporate **bioplastic** R&D and introduction of manufacturing facilities through the promotion of ESG (Environment, Social. and Governance) finance.

For marine **biodegradable plastics**, facilitate cooperation with the measures shown in the "Roadmap for Popularizing Development and Introduction of Marine Biodegradable Plastics" (May 7, 2019, Industrial Science and Technology Policy and Environment Bureau, Manufacturing Industries Bureau, and Commerce and Service Industry Policy Group, Ministry of Economy, Trade, and Industry).

Research and follow up

- In cooperation with the related parties, we should periodically survey the introduction status of **bioplastics** by applications and materials in Japan and collect information, including international trends and technological trends related to **bioplastics**.
- Based on the results from the above research and surveys, follow up and update this Roadmap, the "**Bioplastics** – Good Application Practices in Japan," and the "**Bioplastics** – Collection of Corporate Commitments and Targets in Japan."

We need to also implement individual measures for the following subcategories of the product areas categorized in (2) above. In implementing the policy, support will be provided for the introduction of **bioplastics** in line with these basic principles.

Plastic shopping bags

While the basic principle concerning plastic shopping bags is to curb their excessive use by introducing fees, the shift to shopping bags with certain environmental performances, such as **bio-based plastics** should be promoted. Considerations will be made to increase the bio-based synthetic polymer content in plastic shopping bags that are not subject to the Ministerial Ordinance under the Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging while taking into account the available supply. Considerations will also be made to increase the bio-based synthetic polymer content of plastic shopping bags in the criteria for procurement for retail business in accordance with the Act on Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities.

Combustible waste collection bags and organic waste collection bags used for composting and anaerobic digestion

We aim to incentivize local governments to start using **bio-based plastics** in waste collection bags for household and commercial waste treatment using the "Guide to the Introduction of Fee-based Household Waste Treatment," and a guideline for the introduction of waste collection bags with **bio-based plastics** will be developed.
In particular, for combustible waste collection bags, considerations will be given to adding the maximum bio-based synthetic polymer content to the evaluation criteria, while taking into account the amount that can be gradually supplied under the Act on Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities. In addition, we will promote local governments to use them by utilizing the Act.

Coating materials for controlled-release fertilizer and production materials for fisheries, such as fishing gears

To minimize the environmental impact of unintentional leakages into the ocean and other natural environments, R&D of innovative technologies and materials, such as those with switch functions to control the speed and timing of marine biodegradation, will be promoted for the introduction of plastics that have biodegradable functions in appropriate marine environments.

Table 3-3 **Measures for the introduction of bioplastics**

Promotion of the use

Measures	2020 – 2025 – 2030 – 2050
Compilation of examples and commitments of bioplastics introduction by companies, Business matching	Compilation of examples and commitments of bioplastics introduction Promotion of business matching (CLOMA, Plastics Smart)
Proactive procurement using the Green Procurement System, and measures to stimulate demand for bio-based products	Examination of evaluation criteria for designated procurement items under the Act on Promoting Green Procurement, consideration of measures to increase demand for bio-derived products, promotion of proactive procurement by local governments
Fair and equitable recycling system that promotes the use of bioplastics.	Examination of recycling systems
Improvement of reliability related to marine biodegradability	Examination toward the international standards for evaluation methods

3 Principles and measures related to the introduction of sustainable bioplastics

Appeal to consumers, Awareness-raising

Measures	2020 — 2025 — 2030 — 2050
Certification that takes sustainability through an entire life cycle into account	Start of operation Examination of certification and labeling systems
Increasing awareness among consumers	Promotion of the proactive use of bioplastic products and correct understanding

Development of R&D and production system

Measures	2020 — 2025 — 2030 — 2050
R&D and demonstration projects to improve functions, reduce manufacturing costs, and diversify raw materials	Support for research and development, demonstration projects
Expansion of manufacturing facilities in Japan	Support for the installation of manufacturing facilities
Facilitation of fundraising for R&D and the installation of manufacturing facilities	Support for smooth fundraising

Research and follow up

Measures	2020 — 2025 — 2030 — 2050
Survey on the introduction status of bioplastics and follow up	Research and follow up on introduction status of bioplastics by applications and materials, international trends and technological trends related to bioplastics

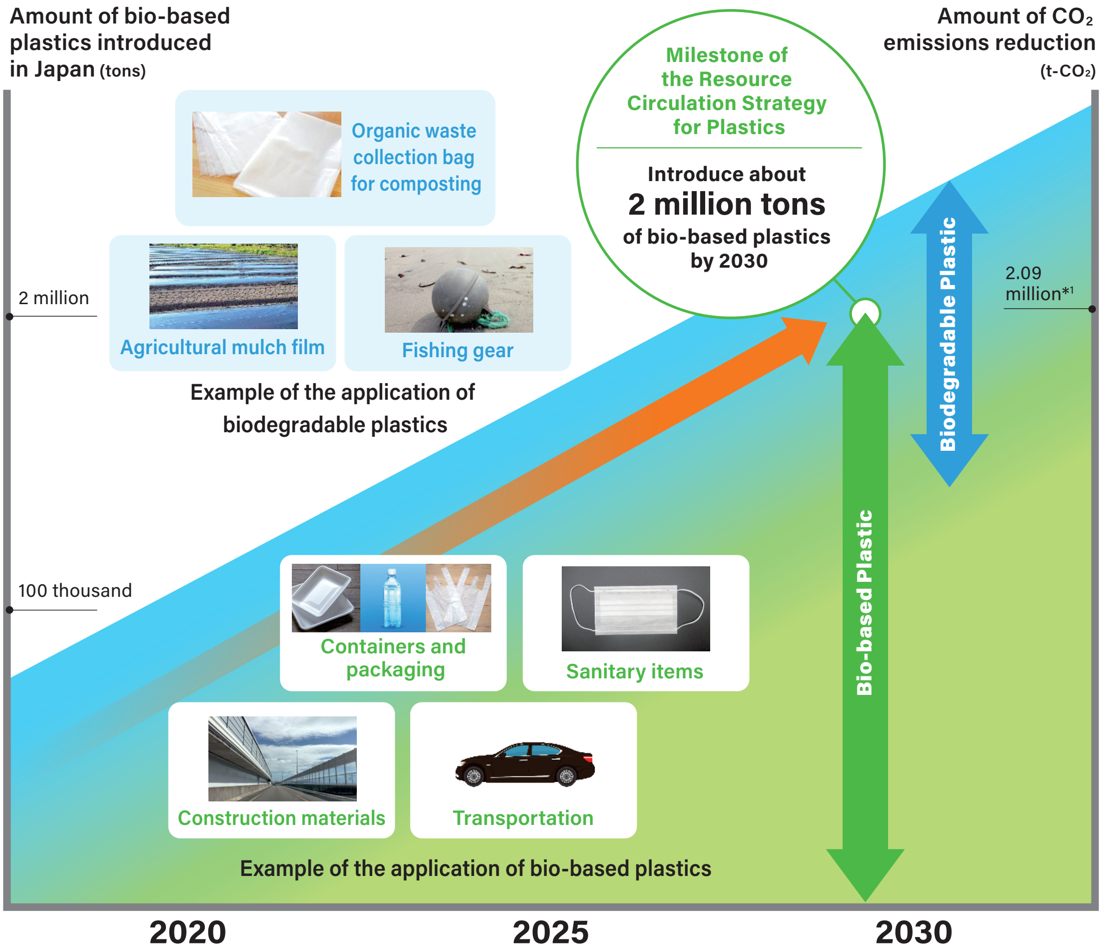
3 Principles and measures related to the introduction of sustainable bioplastics

Measures for the introduction in individual product areas

Measures	2020 – 2025 – 2030 – 2050
Plastic shopping bags	Increase of bio-based synthetic polymer content, examination of evaluation criteria for designated procurement items under the Act on Promoting Green Procurement, promotion of proactive procurement by local governments
Combustible waste bags, organic waste collection bags used for composting and anaerobic digestion	- "Revision of Guide to the Introduction of Fee-based Household Waste Treatment" for local governments - Development of the Bioplastics Introduction Guideline Examination of decision criteria for designated procurement items under the Act on Promoting Green Purchasing, and promotion of proactive procurement by local governments
Coating materials for controlled-release fertilizer and production materials for fisheries (fishing gear etc.)	Research and development of innovative technologies and materials

3 Principles and measures related to the introduction of sustainable bioplastics

Figure 3-1 Schematic of the timeline for introducing bioplastic products



*1 Target in the Plan for Global Warming Countermeasure: Reduce emissions of non-energy originated carbon dioxide by 2.09 million tons in 2030 through the introduction of bio-based plastics (including bio-based alternative materials other than bio-based plastics).

Major values of bio-based plastics such as effect for environmental impact reduction

- Reduction of greenhouse gas emissions
- Reduction of the use of exhaustible resources

Major values of biodegradable plastics such as effect for environmental impact reduction

- Rationalization of waste treatment
- Reduction of marine plastic litter

4 Other alternative materials to plastics

Because entities that use **bioplastics** (material producers, brand owners) consider and select materials, including various alternative materials, when replacing conventional fossil-based plastics, information about other alternative materials to plastics besides **bioplastics** are summarized below. Based on the premise that sustainability will be enhanced, these alternative materials to plastics need to be introduced adequately.

Paper

Paper is replacing plastic in straws, cups, containers, and packaging because it is bio-based and biodegradable. Pulp, the raw material, is supplied in large quantities (16 million tons per year) and is stable, coming from approximately 30% domestic and 70% imported wood[21]. In addition, a certification scheme for the sustainability of raw materials is widely applied, and it is expected that the utilization of this scheme will be appropriate.

However, in the field of packaging, there has been a shift from paper to plastic for functional reasons (strength, barrier, and water resistance) and cost reasons. To shift to paper again, it is necessary to clear these functional and cost issues.

In addition, in many cases, paper is coated with plastics and used as combined materials with plastics; thus, the plastics used for paper coatings must also be biodegradable to adequately demonstrate biodegradability of combined materials.

Furthermore, in paper recycling, it is necessary to pay attention to the negative impacts of plastic-laminated and plastic-coated paper. These plastics must be properly removed to promote the recycling of papers.

Cellulose-molded products (nonwoven fabrics, films, and microbeads)

Because cellulose-molded products are biomass and biodegradable, they are beginning to replace plastics in nonwoven fabrics, films, and microbeads. In particular, Japanese companies account for 70% to 80% of the world's total production of cellophane, which is approximately at 18,000 tons per year[22]. These can be used in a variety of forms, such as in films and nonwoven fabrics. In the case of film, because the texture is similar to that of plastic film, it should be noted that cellulose is a foreign substance in the recycling process of other plastics and can inhibit plastic recycling (mechanical/chemical) when it is mixed into the recycling route of plastics after use. Therefore, it is necessary to specifically collect and sort such cellulose-molded products for recycling and other processing.

21 Website of the Japan Paper Association: Trends in pulp material collection and import ratio (https://www.jpa.gr.jp/states/pulpwood/index.html) (accessed October 16, 2020)
22 Based on information obtained through interviews with cellophane manufacturers in Japan

4 Other alternative materials to plastics

Nonwoven fabrics (currently made mainly of PP) are expected not to be mixed with plastics during sorting and recycling because of their texture. Additionally, because microbeads are products that are often unintentionally discharged into the natural environment, this is a product area that can take advantage of the marine biodegradability of cellulose. The development of applications in these areas is also supported by national R&D and verification projects.

Others

(1) Paper powder, wood powder, rice as raw material, industrial starch, shell powder, limestone, CNF, as composite materials with plastics

These materials are replacing plastics in various applications, as shown in the following examples.

- ·Paper powder mixed plastic composites: containers, packages, and as substitutes for PE, PP, PS
- ·Wood powder mixed plastic composites: wood decking as a substitute for PP
- ·Rice as a raw material mixed plastic composite: garbage bags as a substitute for PE
- ·Industrial starch mixed plastic composites: garbage bags, etc. as a substitute for PE
- ·Shell powder mixed plastic composites: daily goods (such as chopsticks) as substitutes for PP
- ·Limestone mixed plastic composites: containers and packages as substitutes for PE, PP, PS
- ·CNF-reinforced plastic composites: cars, home appliances as substitutes for engineering plastics and other high-performance plastics

Composite plastics other than CNF-reinforced plastic composites do not provide much improvement in terms of physical properties, and their main effect is to reduce the amount of plastic in products while maintaining certain physical properties. Meanwhile, CNF-reinforced plastic composites have improved performance and can be used as a substitute for high-performance plastics, such as engineering plastics. However, when any of the composite materials are mixed into the recycling route as plastics after use, alternative materials other than plastics (paper powder, wood powder, rice as raw materials, industrial starch, shell powder, limestone, CNF) become foreign substances in the recycling of other plastic types and thus inhibit plastic recycling (mechanical/chemical). Thus, it is necessary to specifically collect and sort out such composite materials and implement recycling and other processing methods.

The development of applications of paper powder mixed plastic composites for packages and containers and of CNF-reinforced plastic composites for automobile parts is being supported by national R&D and verification projects.

(2) Silica

Silica and other materials are being used to replace some of the cosmetic microbeads used in wash-off scrub products. As with the substitution of marine **biodegradable plastics**, this would help reduce the amount of microplastics released into the ocean.

5 Next steps

This Roadmap provides policies and measures for the introduction of **bio-based plastics** to achieve one of the highest and most ambitious milestones in the world, which is introducing the maximum amount of **bio-based plastics** (approximately 2 million tons) by 2030 as stated in the Resource Circulation Strategy for Plastics. It is necessary to comprehensively and promptly consider and implement budget and institutional responses as necessary policy for introducing **bioplastics** in Japan in accordance with this Roadmap.

Regarding the amount of **bioplastics** to be introduced in Japan in the future, the status of **bioplastics** introduction toward the 2030 milestone will be revisited in the future. Moreover, progress on the effect on reduction of the use of exhaustible resources, greenhouse gas emissions, and waste and marine plastic litter will be regularly updated.

Additionally, it is important to respond in a flexible manner to this Roadmap in accordance with technological progress of **bioplastic** production, progress regarding the introduction of **bioplastic** products, and changes in recycling. Therefore, at the interim timing toward the 2030 milestone, this progress will be compiled, evaluated, and updated as necessary.

It is important to promote social innovation and technological innovation because increased introduction of **bioplastics** will be required as a long-term direction toward 2050.

Finally, while implementing initiatives in line with this Roadmap, it is necessary to keep a firm grasp on international trends and keep pace with them while also actively working toward realization of a sound material-cycle society that can act as a leader in the world.