CLOMA

CLOMA VISION

Alliance Creates New Innovation

Japan Clean Ocean Material Alliance

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Chapter 1 Objectives of CLOMA's Vision and Background

1. Roles of Plastic and Changes in Social Problems

These days, plastics are indispensable in our daily lives. They make various innovations possible and enrich our lives while serving a wide array of purposes ranging from automobiles and aircraft to consumer products. This is due to the variety of plastics that are available, such as those with high heat resistance, and great durability. Moreover, the ability to combine different plastics greatly increases their versatility.

Invented in the early 20th century and called Bakelite, the first plastic was made from coal, and was widely used for kitchen utensils and telephone receivers. Later, a host of new plastics, such as polyvinyl chloride and polystyrene were introduced, and their manufacturing started one by one. Meanwhile, advances in chemical composition and production methods added new functionality to plastics, which in turn increased their attractiveness. With greater versatility, came broader applications.

On the other hand, as the volume of plastic manufacturing surged, an issue of management of used plastics has been actualized. Japan was forced to revisit its disposal methods, not just because plastics do not decompose in landfill soil, but because they emit a large amount of heat when incinerated. Prompted by the lack of waste disposal sites back then, Japan built incineration facilities that enabled the country to recover energy from plastic waste after the 1970s energy crisis.

When the concept of "sustainable development" was first proposed at *the 1992 Rio Earth Summit*, touching on global warming among other issues, resource constraint became an important global challenge, along with the problem of waste disposal. Given Japan's scarce resource, the country in 1991 put into force legislation aimed at encouraging better use of resources. For instance, by-products from factories began to be considered recyclable resources. Together with the country's long-held cultural values, such as treating things with appreciation and the spirit of *Mottainai,* efforts to achieve a sound and sustainable cycle of resources grew rapidly. In 1995, Japan passed *the Containers and Packaging Recycling Law* (hereafter referred to as the *Container Recycling Law*) on plastic packages and containers, modeling after a recycling system in Europe. The legislation aimed to recycle and thereby restrain the amount of used containers and packages that constituted a major part of general, non-industrial waste. In 2000, *the Basic Act for Establishing a Sound Material-Cycle Society* was enacted, with a goal of breaking away from the economic system that sought *mass-production, mass-consumption and mass-disposal,* and instead embraced the 3Rs (reduce, reuse and recycle) and the proper disposal of waste. Connected to the above-mentioned legislation, is *the Act on Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities* (*Act on Promoting Green Purchasing*, 2010), which required that public institutions including the State take the initiative to use eco-friendly goods and services. In response to these movements, businesses made their own efforts to develop recycling technologies and spurred manufacturing and fabrication practices that made effective use of resources. Such actions in turn led to further enhancement of both the legal system and businesses' voluntary action.

A sound cycle of resources took place not only domestically, but on a global scale. China and ASEAN nations imported recyclable resources including plastic waste, thereby meeting the vigorous demands of their rapidly growing domestic economies. However, China announced in 2017 that it would partially ban the import of waste plastics, a plan that was put into practice six months later. This was partly because significantly low-quality waste had been imported by some businesses. The trend has also spread to ASEAN nations, urging countries that had previously exported waste plastics to find alternative ways of disposal.

In order to solve other social issues, further responses regarding plastics are required. For example, plastic made from biomass feedstock is being promoted alongside the development of an international framework to combat global warming. In addition, there are high hopes that recent efforts related to plastics will help the quest to concurrently solve multi-sectoral social challenges addressed in the 2015 UN Sustainable Development Goals (SDGs).

2. Marine Plastic Litter Issue and CLOMA's Mission

In recent years, there has been a focused attention on the issue of marine plastic litter as an emerging global challenge surrounding plastics. Reports In 2015[1] have indicated that at least 8 million tonnes of waste plastic have flowed out from land to ocean. The following year, estimates stated[2] that by 2050 the volume of plastics in the ocean will surpass that of fish, posing a further threat to sustainability. Marine plastic litter is often discussed according to its two broad classifications: *macro-plastics,* which maintain the original form of a plastic product such as a PET bottle; and *micro-plastics* which are composed of tiny plastic shards and smaller than 5 mm in size. The environmental impact of each category of plastics differs as well. The main features of macro plastics' major items existing in the environment are introduced in Chapter 2, together with micro-plastic beads. Besides these, other microplastics that end up in the ocean, such as tire scraps, resin pellets and garment fibers, have also become a matter of concern[3].

Japan has a long history of focusing on ways of effectively using finite resources and reducing negative environmental impact, and doing so through innovations in both technology and social

[1] Source: Plastic waste input from land into the ocean, Science (2015. Feb, *Science*)
[2] Source: New Plastic Economy (The Ellen MacArthur Foundation)
[3] Source: Plastics in the Marine Environment (2016. June, euromia)

systems. With regard to the problem of marine plastic litter, it is our firm belief that Japan can contribute to solving this problem by enhancing the technology and knowhow it has so far accumulated. To reduce marine plastic litter, it is a fundamental first step to stop inappropriate disposal such as illegal dumping and littering. Next, it is also crucial to take action against waste plastic that is unintentionally flowed out into the environment, while stepping up efforts on the 3Rs. In other words, it is necessary to promote a sustainable cycle of plastic products by a social system that properly collects and disposes of the waste plastic, while improving technology to make the system even more effective. To further reduce environmental impact, it is also essential to develop materials and products that can properly decompose in the environment. Looking overseas, it is important to contribute to the reduction of marine plastic litter originating from abroad, namely by expanding these institutional mechanisms, technologies, products and business models outside Japan according to the needs of respective countries. Moreover, in the effort to solve the marine plastic litter issue, it is hoped that other social challenges listed in the SDGs (such as combating climate change by reducing CO2 emissions and averting food shortages by utilizing non-edible material) will be addressed concurrently by optimizing recycling systems and promoting alternatives to conventional plastics made from fossil resources.

In order to find a solution to the issue of marine plastic litter, there is a need to combine and build on CLOMA member's knowhow and technologies, while sharing knowledge for technological development. This requires understanding and cooperation among various stakeholders to address this issue as a whole society. Reflecting on the current status, the CLOMA Vision identifies a direction in which its members can join and share our future endeavor toward solving the challenges ahead. The Vision therefore aims to promote collaboration among businesses that constitute products' value chains and deliver from Japan a new solution that will help achieve *clean oceans.*

Chapter 2 Current State of Plastic Use and Disposal, and Technological Trends

1. Japan's Current Efforts for Reducing Environmental Load

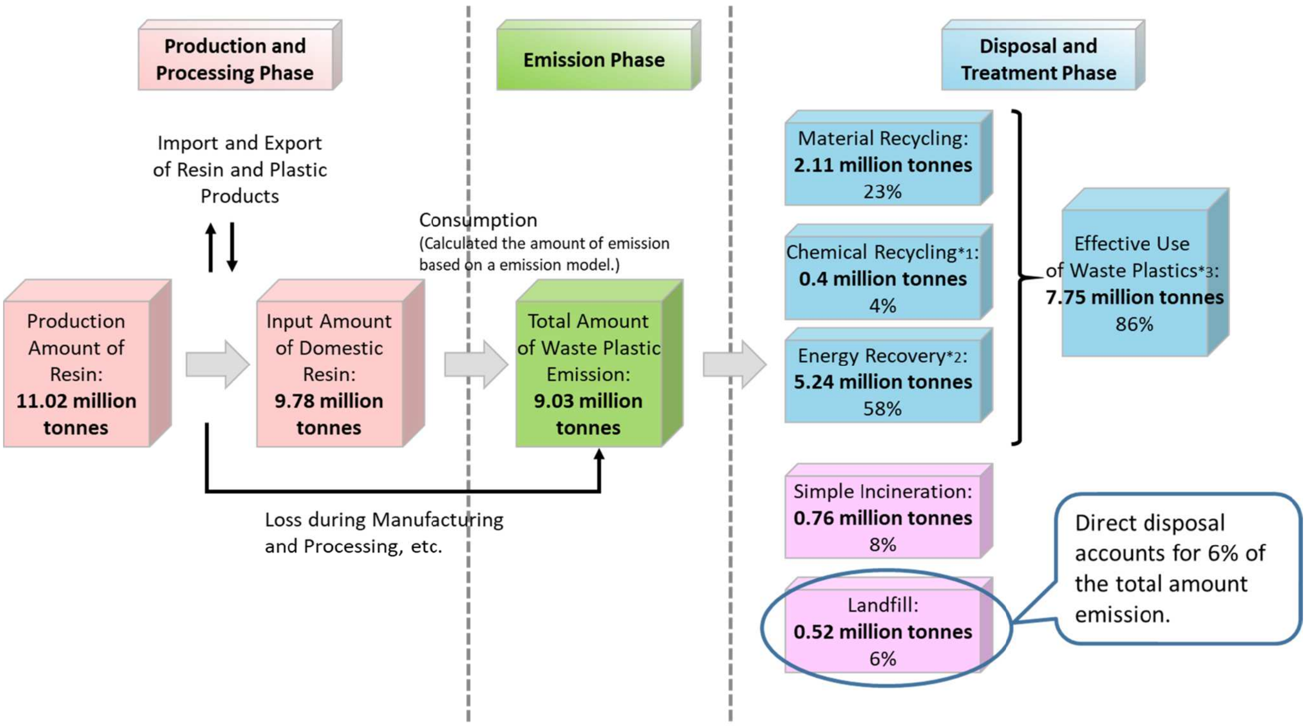
Japan has coped with its scarce natural resources and limited land area over time. For this reason, we established a system which uses its resources efficiently and reduce environmental load prior to the worldwide discussion on the issue of marine plastic litter. Further, in addition to material recycling for use as recyclable materials, Japan beneficially combines chemical recycling and energy recovery utilizing a broad field of industrial infrastructure to use as a feedstock, and we have achieved 86% of effective use rate[4] with plastic waste, and realized a society with a relatively small amount of waste disposal in landfills that should be called the Japan Model. A notable feature

[4] Effective use refers to the three types of treatment methods, namely material recycling (recycling into raw plastic materials or plastic products after shredding, melting and consolidating waste plastics, etc.), chemical recycling (using waste plastics as raw materials by decomposing them chemically), and energy recovery (collecting energy by incinerating waste plastics, or transforming into solid fuel).

of this model is that industry (with business associations at its core) takes aggressive and voluntary initiatives that pay attention to details, beyond just following regulatory measures set by the government. Another aspect of the Japanese model is the presence of consumers who, with their high awareness of sustainability, take proactive action for sorting and disposal, thereby supporting the above-mentioned effort.

Drawing upon technology and knowhow accumulated in these fields over many years, Japan is committed to further accelerating efforts to solve the new challenge brought by marine plastic litter. This chapter includes basic information such as the necessary functionality of plastic products and their lifecycles, before giving an overview of various ongoing efforts.

Current Status of Japan's Plastic Recycling (2017) [5]



Notes:

※1) Chemical Recycling: raw materials for blast furnaces and coke ovens; gasification, etc.

※2) Energy Recovery: solid fuel; raw materials and fuel for cement; power generation through incineration; incineration with heat utilization

※3) Effective use of waste plastic includes the amount of export

[5] Compiled by Japan's Ministry of Economy, Trade and Industry using the data of the Plastic Waste Management Institute. Inconsistent figures in some parts of the chart are due to rounding of numbers.

Voluntary Efforts on Reducing and Recycling by Industry

Efforts	Goals
Reducing PET Bottles	By the fiscal year 2020, lighten the weight of designated-PET bottles combined by 25% (Rate in FY2017 was 23.9% versus FY2004)
Recycling of PET Bottles (for beverages and designated seasoning)	Maintain the level of recycling rate of 85% (FY2017: 84.8%)
Reducing plastic containers and packages	By FY2020, reduce the amount of emissions by 16% (FY2015：15.1％ versus FY2004)
Recycling of EPS (Styrofoam fish boxes, packages for household electronics)	Achieved the goal of 75% recycling rate in FY2010（including thermal recycling） （2017：recycling rate 90.4%（including thermal））
Recycling of vinyl chloride film for agriculture	Achieved the goal of 70% recycling rate in FY2006 (including thermal) （FY2011：recycling rate at about 74.6% (including thermal)）
Recycling of vinyl chloride pipes and joints	Achieved the goal of 70% recycling rate in FY2010

2. Characteristics of Plastic Products and their Lifecycles

(1) General Overview

Plastic has spread into people’s lives rapidly ever since it was first introduced following the advancement of industrialization, and is now indispensable to us. This is not only because plastic’s lightness and durability make it highly functional, but also it can be mass-produced. In particular, even if an existing plastic doesn’t have a needed trait, one can blend and multi-layer different plastics to create a plastic product that exhibits the advantageous traits of its constituents. This is a noteworthy characteristic of plastics. For example, it is possible to create plastics with high-impact and long-term storage properties by multi-layering polyethylene (which is high-impact resistance but inferior gas-barrier properties), with high-barrier plastics such as ethylene-vinyl alcohol copolymer (EVOH). These advanced-function products offer not only high-convenience, but contribute to extending food expiration dates and reducing packaging materials, thereby playing an important role in helping solve a serious social challenge.

Many of the plastic products are made from fossil resources as their feedstock. In Japan, it is customary to equip raw plastic materials with desired functions by polymerizing basic chemicals such as ethylene, propylene, etc., which are obtained mainly from naphtha's thermal decomposition, and blending additives. Raw plastic material will be used for a final intended application after being molded and processed. Plastic products are classified broadly into two categories: single-use products such as shopping bags and PET bottles which are usually discarded after being used once for initially-intended purpose; and others that are repeatedly used multiple times. In either case, after serving their roles and are discarded, plastics will be treated and disposed of by recycling, incineration and landfill among other methods.

In Japan, if plastics follow proper routes for collection and disposal at the time they are discarded, more than 80% of them can be effectively used again. If not, plastic products will end up flowing out into the natural environment. As plastics typically have low decomposition rates in the natural world, they could remain for a long period of time, posing a threat to the environment.

(2) Specific Characteristics of Respective Products

Below are concrete examples of plastic products. As plastics are used for various functions and applications, below are details of ten representative items[6] that CLOMA members handle in large volume, as well as those products that are highly likely to end up in the ocean: a) PET bottles, b) plastic bottles, c) tubes, d) pouches, e) food trays, f) plastic cups, cutlery and straws, g) plastic shopping bags, h) paper cups and paper containers, i) fishing equipment, and j) microplastic beads.

①PET Bottles

PET bottles need to be water-resistant, impact-resistant, airtight, have workability (processability). In addition, they have to be able to resist heat and pressure in order to hold hot beverages and carbonated drinks. A higher level of barrier properties is needed for wine and fruit juice. The body of a PET bottle is made from PET (polyethylene terephthalate) resins, while caps and labels are made from polyethylene, polypropylene, polystyrene, and PET among plastics. For sodas and hot beverages, higher-barrier properties are achieved through multi-layering PET resins with other materials such as nylon.

Typically, PET bottles are usually made at beverage manufacturers by blow molding of preforms which are molded by molding manufacturers from PET resin produced by chemical manufacturers. Next, the drink is added to the PET bottle. After aseptic processing, they are sold at retail shops among other venues. In general, designated-PET bottles[7] specified by the Container Recycling Law, are discarded after a single-use. In line with the Container Recycling Law, used bottles are collected by municipalities or recycling businesses. After that, they are

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6 According to the monitoring results on drifted waste at 10 different locations across Japan (Wakkanai, Nemuro, Hakodate, Yuza, Kushimoto, Kunisaki, Tsushima, Goto, Tanegashima and Amami), the volume-based ratio of drifted waste by the type is as follows: drink bottles (12.7%), other bottles (6.5%), containers (containers for seasoning, trays and cups, etc., 0.5%), cutlery (0.5%), plastic bags (0.3%), fishing nets and ropes (26.2%), buoys (8.9%), Styrofoam buoys (14.9%). Additionally, paper cups, paper containers, and microplastic beads are not included in the results of this monitoring. Nevertheless, we decided to include these products as the 10th item of this paper, because paper cups and paper containers contain plastic film and are often used outdoors, while microplastic beads likely end up in rivers and in the ocean after being used if the purpose of the products is designed to be rinsed off.

7 Designated-PET bottles refer to items used for such products as soft drinks, alcohol, soy sauce, and vinegar that are specified by the Act on the Promotion of Effective Utilization of Resources.

separated according to resin type and impurities are removed. In this way, PET bottles are recycled into raw materials for items such as new PET bottles, plastic sheets, and fibers for clothing.

In Japan, recycling system of PET bottles are said as one of the most advanced recycling system led by collaboration of stakeholders. Since 1997, PET bottles have been subject to *the Container Recycling Law*, which set up a system under which PET bottles from households across the country are sorted, collected, and disposed. Since PET bottles are collected separately from other plastics, there is a supportive environment for material recycling to take place. Thanks to these efforts, Japan's recycling rate of PET bottles for the fiscal year 2017 reached a record-high level of 84.8%[8]. Recently, recycling businesses have established a new effort in which collection boxes are installed in retail shops, and stores are awarded points according to the number of bottles they collect.

In addition, other efforts are made on eco-designs to ensure a smooth recycling process. In 1992, the Council for PET Bottle Recycling, after several revisions, compiled *the Voluntary Design Guidelines for Designated PET Bottles.* The Guidelines standardized technical matters concerning bottles, caps and labels, which included the following: no colored bottles to be used; plastic labels need to be easily removable from the bottles; and no aluminum closures. In 2018, the Japan Soft Drink Association issued the *Soft Drink Business Plastic Resource Reclamation Declaration 2018,* which aims to achieve 100% rate of effective utilization of PET bottles by the fiscal year 2030. Furthermore, recycling technologies such as *Bottle-to-Bottle* (an initiative of chemical companies, recycling businesses, beverage manufacturers, and so on) and *F-to-P Direct Recycling* (making pre-forms directly from flakes that are from shredded PET bottles and then cleansed) are being developed. Social implementation is underway as well to apply such technologies to help solve the social problem. From now on, there is also a need to promote effective utilization of caps and labels.

② Plastic Bottles

Plastic bottles are used for application such as containers for detergents. In general, they need to exhibit various qualities, including resistance to water, oil, and acid and impact, as well as have high barrier properties, and be strong, stiff, and airtight, and easy to work with (processability). Since these products are occasionally stored for long periods of time not just at retail shops but in homes, the containers are designed to prevent their contents from deteriorating for several years.

[8] Recycling rate is calculated by the total amount of recycled bottles both in Japan and overseas, divided by the number of designated-PET bottles sold. Source: The Council for PET Bottle Recycling

Plastic bottles are made from polyethylene and polypropylene, which are produced by chemical manufacturers. Before reaching the market, they are at first melted and molded by processing manufacturers and then provided to consumer goods manufacturers, where they are filled.

With the spread of refillable products, detergent bottles can now be used multiple times. When discarded, they follow the route of waste disposal treatment in line with *the Container Recycling Law*. In many cases, bottles' contents remaining on the inner wall when bottles are collected. To be processed effectively, the labor-hours needed to clean them have to be factored in, as well as the environmental load of the cleaning solution. In Japan, bottles are made smaller, and refillable products (i.e. pouches) are gradually spreading, as the functionality of bottle content improves. This has helped to significantly reduce the amount of plastic containers and packages used per product shipment volume.

③ Tubes

Tubes are used as containing food (e.g. seasoning in paste form), daily items (e.g. toothpaste), medicines and cosmetics. Tubes must exhibit various qualities, mainly water-resistance, oil-resistance, high-barrier properties, and be self-standing. In case tubes are used for food items, transparent property is often needed as well.

Tubes are classified into different categories including laminate tubes, blow tubes, and pultrusion tubes, whose manufacturing processes differ respectively. For example, laminate tubes are made by multi-layering plastics such as polyethylene with barrier films that are coated with aluminum foil, evaporated aluminum or inorganic oxide, and by processing with lamination. Raw materials made by chemical manufacturers are laminated by laminate film manufactures and then supplied to tube manufacturers. Tube manufacturers subsequently cut the lamination films raw material, welding it into round cylinders, which are then supplied to consumer goods manufacturers. After they are filled, they are put on the market. In some cases, tube manufacturers produce laminate films.

After tubes serve their single use in households, they are discarded and follow the route for waste disposal treatment in line with the *Container Recycling Law*. As residues remain on consumed products, it is often difficult at this time to conduct *material-recycling*.

④ Pouches

Pouches are used to hold processed food (e.g. retort-packed/boil-in-the-bag-food, and frozen food), perishable food, other foods and beverages (e.g. soft drinks), and products for daily use (e.g. refillable detergents). Changes in the social structure (i.e. the aging society, the increase in the number of dual-income households, and the shift to nuclear families) boosted the production of pouches for food items. That is to say, as more people eat meals alone, there is a growing demand for retort-packed food. In addition, production of refillable pouches for daily commodities has also increased with the spread of refillable products in general. Between the fiscal years 1995 and 2017, the number of plastic containers and packages used per product shipment volume was reduced by 42%[9]. The penetration rate of refillable items for daily commodities is not high outside Japan, therefore, it is an area in which Japan is making a unique contribution.

Key qualities that pouches need to exhibit are high-barrier properties, resistance to impact, water and oil. For those items requiring retort sterilization, there must be additional properties, namely pressure-resistance and heat-resistance. If the content of the pouches is susceptible to light, then a light-blocking effect is also required. Moreover, it is necessary to have other characteristics, such as easy-to-cut, easy-to-refill and be self-standing, depending on their applications and shapes.

Pouches are made from laminated films on which plastic films such as polyethylene and aluminum foil, among other materials, are multi-layered. In particular, aluminum foil plays an important role in ensuring high-barrier properties and an ability to block light. Raw materials made by chemical manufacturers are laminated at processing manufacturers, and supplied to food manufacturers or consumer goods manufacturers. After being filled and sealed, they are sold at retail shops. In the case of retort-packaged food, it is sterilized by adding pressure and heat after being sealed. When aluminum is used for coating lamination, it significantly decreases the recyclability of the item. Therefore, efforts are made in recent years to replace aluminum foil with aluminum-evaporated and/or deposition-coated barrier-films with inorganic oxide.

After being used once, pouches are discarded and follow the route for waste treatment in accordance with the Containers and Packaging Recycling Law. For those items with residues, and/or aluminum lamination, it is still difficult in many instances to recycle using the material-recycling method.

⑤ Food Trays

Depending on application, food trays require stiffness, toughness, resistance to water, heat, cold and oil. In some cases, design properties (e.g. transparency, luster) are also required.

[9] Source: Japan Soap and Detergent Association

A variety of raw materials are found in food trays, depending upon whatever functions are needed based on application. Yet, most food trays are made from a single material: either PET, polystyrene or polypropylene. For example, the most widely circulated PSP (polystyrene paper) tray is made by foaming polystyrene 5-20 times. More specifically, polystyrene resins made by chemical manufacturers are melted, foamed and transformed into PSP sheets by sheet manufacturers. Then, they are heated, molded, and punched at molding and processing manufacturers, and supplied to supermarkets or food manufacturers. In some instances, molding and processing manufacturers consistently handle the production processes from sheets to trays.

Food trays get thrown away after a single-time use in some instances, but many of them are recycled, collected at retail shops such as supermarkets, and through sorting and collection of household waste in line with *the Container Recycling Law*. About thirty years ago, a united initiative was launched by food tray manufacturers, packaging material wholesalers, retailers, and consumers with a goal of creating a recycling loop. The cycle works as follows: Used food trays are lightly rinsed at each household and are brought to collection boxes at supermarkets. A delivery truck run by a packaging material wholesaler delivers commodities to a retail shop, and then into the empty trucks are loaded used food trays, which are returned to food tray manufacturers. This initiative has now grown into a nationwide recycling system supported by understanding and cooperation from consumers. Under the system, used food trays are recycled into new types of food trays; thus the value of the material is not lowered through material recycling. In future, there is a need to increase the rate of collection by promoting sorting and collection of quality plastic resources, proper collection at retail shops by various actors, and developing collection hubs. It is also necessary to establish a method for sorting and recycling trays that are made with more than a single material.

⑥ Plastic Cups, Cutlery and Straws

Plastic cups are made mainly from PET and polypropylene. They need to be resistant to water, acid and impact, and be strong and stiff, and have workability. Raw materials for plastic cups are procured from chemical manufacturers. Processing manufacturers, in turn melt and mold the raw materials, and print on the cups as well. Then, the plastic cups are provided to the food service industry (including ready-made meals and restaurants) and retail stores. Sheet manufacturers may play a role between chemical manufacturers and processing manufacturers. After a single use, the product may be discarded, but it is typically sorting and collected by the food- service industry. Because plastic cups are often made with a mono-material, they have a high recyclability.

Cutlery is made from polystyrene. They need to be resistant to water, heat, acid and impact, and have other properties such as workability, strength, and stiffness. Straws are made from raw plastic materials such as polypropylene, and need to have water-resistance, acid-resistance, workability and strength. Raw materials produced by chemical manufacturers are melted, molded, and then supplied to food manufacturers and retail businesses. They are often discarded without being recycled. Many of them end up being incinerated or disposed of in landfills.

Since the autumn of 2018, plastic straws have become a symbol of the issue of marine plastic litter. As a result, a growing number of businesses, mainly in the food industry, have started to refrain from using plastic straws. However, the straw has a high social need, for instance, it is an indispensable commodity when infants and the infirm have a meal. Although plastic cups, cutlery and straws are often used outdoors, it is important, as it is with other plastics, to direct them into proper collection and disposal routes, after making maximal efforts to reduce the quantity of plastics used in the first place. It is critical to prepare adequate facilities for sorting and collecting these products at events and at camp sites. It is also essential to promote a business model that encourages their re-use.

⑦ Plastic Shopping Bags

Almost all plastic shopping bags are made from high-density polyethylene. They need to exhibit qualities such as water-resistance, strength, and workability. Polyethylene made by chemical manufacturers are melted and then made into tubular films by processing manufacturers. After being shaped into the form of bags, they are commercialized. Once the plastic bags are manufactured, they are sold to retail businesses, which then provide them to consumers either free of charge or for a fee. In Japan, most plastic shopping bags are used a second time as garbage bags, before being collected and incinerated.

Starting in 2000, plastic grocery bags have been included for collection and recycling under *the Container Recycling Law*. However, this has burdened local municipalities' waste management capabilities, prompting discussions on the prospect of charging for plastic bags as part of an effort to reduce plastic waste, while aiming to lower related social costs. In 2008, Suginami Ward in Tokyo was the first municipality in the country to establish and implement an ordinance that charged for plastic bags. In addition, under *the Container Recycling Law*, businesses, such as retailers, that handle packages and containers were obligated to encourage the reduction of waste disposal itself instead of just charging a fee. Also, prices of plastics' raw materials rose during this time, which subsequently forced bags to be thinned 30%. As a result, the quantity of plastics used for grocery bags is currently declining. Incidentally, retail businesses purchase plastic bags from multiple suppliers in different locations. Outside Japan, however, the technology in this field is not necessarily advanced, thus it leaves room for making them even thinner using Japanese technology. In March 2019, the Resource Recycling Strategy for Plastics(draft) was reported by the Central Environmental Council to Japan's Minister of the Environment, calling for fees to be charged for plastic bags, as well as encouraging a change in consumers' lifestyle. Even if the use of plastic bags is reduced through charging, it is unimaginable that the product totally disappears due to its high convenience and selling price (at a nominal fee). Therefore, there is a need to efficiently collect the used plastic bags, and make them available for effective use, while continuing to work for reducing the quantity of plastics used. Currently, a new initiative named "*Plastic Bag-to-Plastic Bag*" is being launched by plastic bag manufacturers and retailers. Under this initiative, only the designated types of bags that meet pre-set specifications (e.g. printed in white) get collected. Yet, the recycling rates remain low, largely because plastic bags are used secondarily as garbage bags. Even if plastic bags are collected, many of them may be dirt or foreign objects adhered. In such cases, they are hardly recyclable. From now on, it is hoped that a proper way of disposal will be established in society by getting across a right message to consumers.

⑧ Paper Cups and Paper Containers

For paper cups and paper containers, essential properties include water-resistance, acid-resistance, workability, impact-resistance, strength and stiffness. To increase their water-resistance, barrier-materials made with polyethylene are multi-layered with paper-based materials during manufacturing. Likewise, aluminum foil is used in the barrier-materials to increase their moisture-proof properties, gas-barrier properties, and their ability to block light. The process begins with paper manufacturers or chemical manufacturers that make raw materials and other base materials. Then, processing manufacturers laminate these materials and provide them to food manufacturers and the food-service industry.

These paper products are normally discarded after a single use, but they usually get sorted and collected by the food-service industry. Most of the products end up being incinerated or disposed of in landfills. However, paper packages such as milk cartons can be recycled into paper pulp by removing the lamination and by re-dissolving the cardboard part. After recycling, they are re-used in different applications including a toilet paper. This is an area in which a unique recycling system is established in Japan.

⑨ Fishing Equipment

Among various kinds of fishing equipment, fishing nets, ropes and buoys (including Styrofoam buoys) constitute a major portion of marine plastic litter. Different raw materials are used for various types of fishing nets. Typically, trawl nets are made from polyethylene, gill nets and fixed nets from nylon, and purse-seines from polyester. Original yarn is manufactured using these raw materials and multiple strands of the yarn are combined to make twine. Twine gets twisted and woven to produce fishing nets.

Due to the aging of fishers and the lowering cost of fishing equipment, an increasing number of used fishing equipment is being abandoned in the ocean without being collected. Ideally, the equipment should be sorted, collected, and recycled through recycling businesses etc. Nevertheless, there are cases where fishing nets end up being flowed out into the ocean unintentionally due to weather conditions. While promoting the need to sort and collect, there is also a need to consider the development of biodegradable plastic materials suited for fishing equipment.

⑩ Microplastic Beads

Microplastic beads are used for scrubs, such as facial washes. They need to exhibit qualities for exfoliating and cleansing. Many of them use polyethylene as their main ingredient, and are molded into spheres.

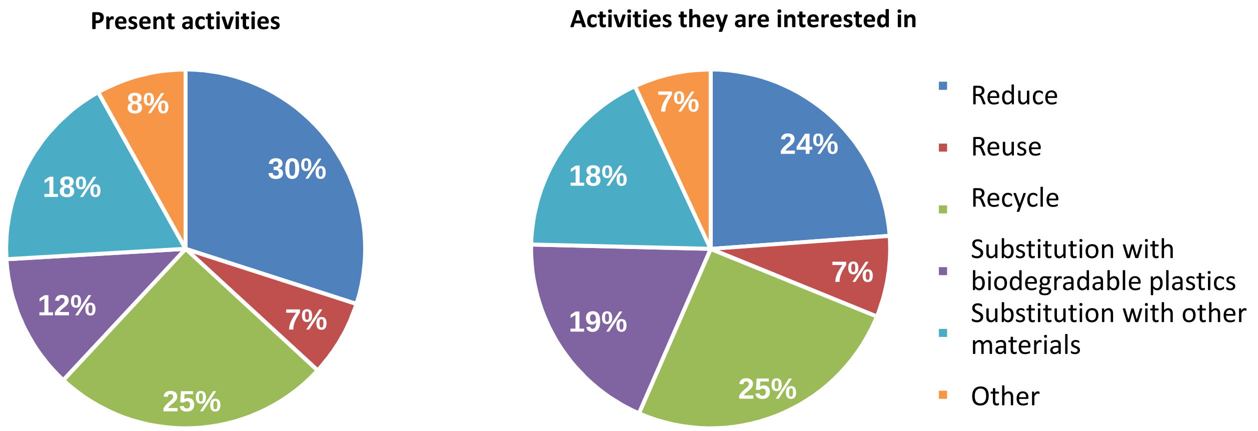
Microbeads in scrub products for washing likely find their way into rivers and the ocean. To combat this problem, industries are taking voluntary action to stop the use of microbeads in washing scrubs. Other initiatives are also underway, such as replacing the microbeads with naturally-derived materials, namely cellulose materials designed for scrubs.

3. Current Efforts for Solving the Issue of Marine Plastic Litter

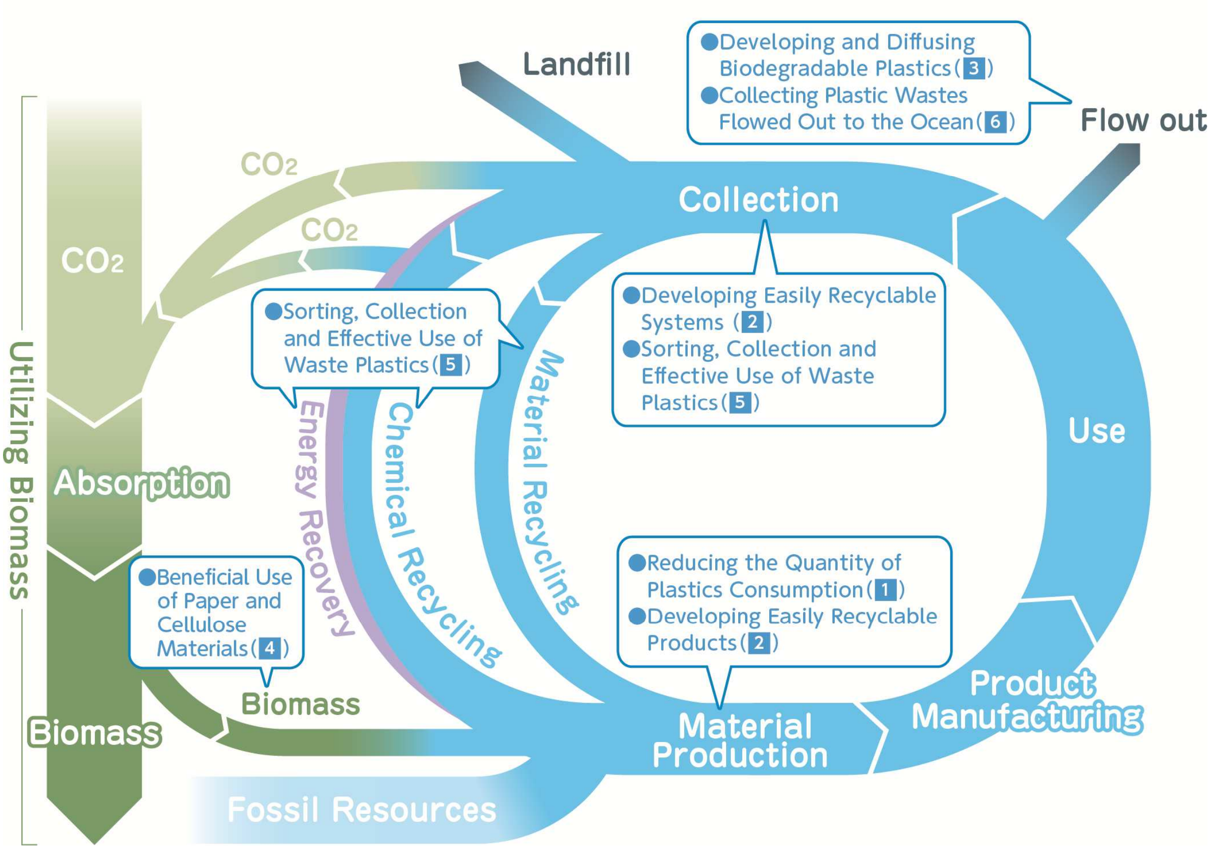
(1) General Overview

Japan has been developing society where waste is not disposed inappropriately by raising the awareness of consumers on appropriate sorting and disposal of waste and promoting collection and treatment by the local governments and business operators. Japan has also been promoting the 3R (reduce, reuse and recycle) from the viewpoint of resource circulation. Recently, as the issue of marine plastic litter came under the spotlight, these activities are even more accelerating along with disruptive innovation initiatives. According to a survey, CLOMA members are engaged in the following activities: ① reduction of the amount of plastic used, ② development of easy-to-recycle products, technology and systems, ③ substitution with biodegradable materials (biodegradable plastics, paper and cellulose materials), ④ sorting, collection and effective use of waste plastics, and ⑤ collection and treatment of plastic waste in the ocean. This section will focus on the technological aspects and current trends.

Activities of CLOMA members



Relationship between Current Efforts and the Lifecycle of Plastic Products



(2) Technological Trends and Future Challenges

① Reducing Use of Plastics

One of the key ways to reduce the amount of plastic use is to thin, which means to thin the thickness of plastic products while keeping the original functionality and product values or keeping the accepted level. Thinning is already approached by many companies, since it does not necessarily require the development of new materials. However, thinning is not fit for some products whose usability will be significantly reduced (e.g. seasoning tubes). For package design, it is important to consider functionality such as stable preservation of contents, as well as psychological values (including brand values) that appeal to consumers. As material recycling such as bottle-to-bottle becomes more common, the amount of repeatedly recycled plastic is expected to increase. However, if the amount of plastic that deteriorates during use or recycling increases, thinning becomes difficult.

In order to further reduce use of plastics used for already thinned plastic products, further sophistication is needed, such as innovating the functionality or structure of plastic products and using more functional plastic.

② Developing Easily Recyclable Products, Technologies and Systems

To sophisticate the recycling system, easy-to-recycle products and recycling technology are developed, and effective sorting and collection systems for waste plastics are implemented.

②–1 Development of Products Easy for Material Recycling

Traditionally plastic products had multiple plastics combined or multi-layered to provide required functionality. If a single plastic can provide the same functionality, or if the structure of plastic products can be modified, recyclability can be improved. However, if a mono material is collected or treated with other waste, sorting by material becomes necessary in the recycling process. In order to truly benefit from mono materials, it is necessary to examine both the sorting technology and the sorting and collecting system.

In case of multi-layered plastic, recyclability can be maintained if each material can be separated after use. It is thus important to design, develop and spread products whose plastic materials can be easily separated for recycling after use. It is also important to expand the use of recycled materials.

②–2 Developing Chemical Recycling Technology

Chemical recycling, which means to recycle waste plastics chemically, uses methods such as gasification and raw materialization for blast furnace or coke furnace. Unlike material recycling, chemical recycling can be used for multi-layered plastic products and those with debris attached. It is superior to material recycling that chemically recycled plastic is also allowed to be used for food packages under the Food Sanitation Act.

Currently, technology for recycling waste plastics into monomers and producing recycled plastic is in development. The key is to produce products that are not inferior to virgin products in terms of costs, quality, stable supply and environmental values.

Classification of chemical recycling technology

Method	Characteristics
Blast furnace raw materialization technology	Plastic is used as a reducing agent in blast furnaces. Unlike coke, plastic's main components are carbon and hydrogen, so less CO_2 is generated while producing pig iron.
Coke oven chemical raw materialization technology	Waste plastic is pyrolyzed under pressure at a high temperature (600–1300° Celsius) to obtain coke (used as reducing agent for blast furnace), hydrocarbon oil (used as raw chemical material) and coke oven gas (used for power generation).
Gasification technology	Plastic is heated while limiting the amount of oxygen. A large part becomes hydrocarbon, carbon monoxide and then hydrogen, which is used as a raw material of chemical products such as methanol, ammonia and acetic acid.
Oilification technology	Plastic is completely pyrolyzed using reforming catalysts at about 400° Celsius to obtain hydrocarbon oil.
Raw materialization / monomerization technology	Used plastic products are chemically degraded and returned to raw materials or monomers, which are again used for plastic products.

(Source) "Plastic Chemical Recycling Trend Survey Report" (2004, METI)

②–3 Using Biomass Plastics

Plastic products which remaining dirt and impurities after use are not suitable for material recycling and chemical recycling and are incinerated. In order to use waste plastics as effectively as possible, it is best to improve the recycling technology and collect the energy generated during the incineration. CO_2 is discharged into the air during the incineration, but biomass plastics are made from plants that absorb CO_2 in the air while growing, so they can create carbon neutrality. Biomass plastics are expected to be increasingly used for applications that do not suit material recycling or chemical recycling. Biomass plastics can be recycled like plastic made from oil; for example, it is also approached that PET bottles made with biomass plastics are recycled into PET bottles.

③ Substitution with Biodegradable Materials

On the premise that a sophisticated recycling system cannot reduce to zero the waste plastics that goes out of the separation and collection routes, environmentally sound biodegradable materials that degrade in the natural environment (in particular, materials that degrade under specific conditions) are developed to replace existing plastic products.

③–1 Biodegradable Plastics

Use of biodegradable plastics that degrade in the natural environment is anticipated. Research and development of biodegradable plastics are carried out around the world; in Japan, plastics such as PBS and PHBH are already in use, and marine biodegradable plastics are being developed. Kinds of biodegradable plastics are still limited, but technology for combining or multi-layering biodegradable plastics is developed to improve their functionality. Depending on the purpose of use, disruptive innovation for functions such as control of degradation speed and timing is necessary. Biodegradable plastics are still produced in small quantities and the production costs must be improved, so they cannot replace all plastic products. Therefore, it is necessary to enhance the supply capacity and increase the penetration rate step by step while improving the functionality and expanding the market. For food and medical products, it is necessary to develop technology considering the strict rules regarding the transfer of packages to the contents must be considered.

Biodegradable plastics must be collected and treated appropriately; it is important to distinguish different conditions of degradation and establish certification standards to implement appropriate collection and treatment methods. In the popularization stage, it is necessary to take measures against inappropriate disposal such as littering because of biodegradable plastic. It is also necessary to evaluate the impact that new materials entering the market bring to the current recycling system, and apply appropriate recycling technology and systems.

As biodegradable plastics are micronized in the degradation process, it is sometimes difficult to evaluate their environmental values. Therefore, standards for appropriate, scientific evaluation of the degradation process and efficacy must be established. For marine-biodegradable plastics, there is no standard to evaluate their biodegradability yet; it is necessary to carry out research regarding the evaluation methods and support the technological development.

Green Plastics (biodegradable plastics) certified by Japan Bio Plastics Association

Major resins listed in Positive List		Manufacturers
Starch polyester		Novamont
Polylactic acid	PLA	Nature Works Total Corbion Zhejiang Hisun Biomaterials Toyobo
Poly (3-hydroxybutyrate-co-3-hydroxyhexanoate)	PHBH	Kaneka
Polyglycolic acid	PGA	Kureha
Polybutylene adipate terephthalate	PBAT	BASF BULERIDGE
Polyethylene terephthalate succinate	PETS	DuPont
Polyethylene terephthalate copolymer		DuPont
Polybutylene succinate	PBS	Mitsubishi Chemical
Polybutylene succinate adipate	PBSA	Mitsubishi Chemical
Polyvinyl alcohol	PVA	Mitsubishi Chemical

(Source) Website of Japan Bio Plastics Association

③–2 Paper and Cellulose Materials

Providing alternatives to plastics is also important, which are derived from biomass and are highly degradable in the natural environment, namely papers and cellophanes. Conventionally paper-based materials have been laminated with plastic film for them to realize similar functions of plastic products. Currently, research and development of processing technologies have been conducted on coating paper-based materials with aqueous paint to improve their barrier properties. In case of coating, the coated layer can be loosened in water while keeping the composite state, so recycling is easier than in the case of laminated materials. However, most water-based paints that are used today contain petrochemical products, and the development of biodegradable paints is anticipated.

It is also conceivable to provide paper and cellulose materials with functions that they cannot provide alone by multi-layering them with biodegradable plastics instead of oil-origin or non-biodegradable plastics. However, the priority is to reduce the plastic use by replacing some part of plastic with paper. For example, a container called Bag-in-Box, which reduce the amount of plastic combining a plastic inner container and a cardboard outer container, is already available in the market.

④ Sorting, Collection and Effective Use of Plastic Wastes

Currently, designated PET bottles are collected separately, and polypropylene, polyethylene and polystyrene are sorted by type and used for producing recycled plastic. However, a lot of plastic products remain unsorted and unrecycled; the Resource Recycling Strategy for Plastics (draft) aims to double the use of recycled plastic by 2030.

Biodegradable plastics cannot be collected separately in the current recycling system. Considering that they may replace the existing plastic products in the future, it is necessary to coordinate the current recycling system and apply appropriate separation and collection technology depending on the composition of plastic used in society.

In the future, it will be necessary to increase the ratio of horizontal recycling as well as efforts in cascade recycling, which is the mainstream in container and packaging plastics. It is important to develop recycling infrastructure and sophisticated sorting technology, stabilize supply and quality of recycled plastic products, and provide high added-value to expand the market of recycled materials and create a virtuous cycle that further promotes recycling.

⑤ Collecting Plastic Litter Flowed Out to the Ocean

It is also an essential effort to treat plastics already flowed out to the ocean. For example, marine litter collection machines are installed in ports and marinas to collect the marine litter slowly but steadily. In case of commercial facilities such as marinas, the owners have a relatively narrow management scope and it is easy to provide them with incentives for installing waste collection machines. In case of facilities managed by local governments, it is necessary to develop a system for implementation, including the sharing of costs arising from the waste collection. In order to collect and treat more ocean waste effectively, the cooperation with related countries and the development of collection and treatment technology in ships are anticipated.

The Alliance to End Plastic Waste (AEPW), which was founded by world business enterprises tackling the plastic issue, has announced that it plans to finance clean-up of rivers and around areas where waste plastics are flowed out to the ocean. Japanese companies are also participating in this effort.

Chapter 3 Ideal Vision

1. Realizing the World with the Clean Ocean by Building a Sustainable 3Rs System and Contributions with Material Technologies

Plastic made our life convenient and richer and are indispensable in today's society. In order to solve the issue of marine plastic litter, it is essential to contribute to attaining SDGs without damaging various benefits plastic brings to our lives. Therefore, we aim to ensure appropriate collection and treatment of used plastic products and improve the 3R to produce and use environmentally sound plastic products or replace plastic with other environmentally sound materials.

Japanese industries have been making efforts to reduce the dependence on fossil resources and the amount of waste. CLOMA will share the activities and knowledge accumulated by the members and cooperate with the whole value chain to create larger-scale innovation and aim the solution of the issue of marine plastic litter in Japan and around the world. To achieve this, it is necessary to optimize social system approaches such as effective waste sorting, collection and treatment, as well as technology for developing new products and business models. Although it is said that reflecting environmental values in product prices is difficult in Japan, we will maximize the areas of collaboration between the members and enable early social implementation through appropriate cost sharing.

It is also crucial to communicate and expand CLOMA's activities to the world, with emphasis on the countries where a relatively large amount of waste plastics ends up in the ocean. When doing so, we will carry out detailed actions based on each country's situation including different business customs, social situations, and laws and awareness related to waste.

CLOMA Principles

To solve the marine plastic litter problem, it is essential to ensure the thorough collection and disposal of used plastic products. In addition to this, it is also important to promote developing, manufacturing and using environmentally sound plastic products, and using alternatives that are environmentally sound materials/products.

CLOMA and its members will strive to solve the issue of marine plastic litter based on the following five principles.

1. We will contribute to the attainment of SDGs and clean ocean through the development, production and use of materials and products.
2. We will proceed with the following goals as two wheels: thoroughly implement proper

collection and disposal of used plastic products, while deepening efforts on the 3Rs and using alternatives that are environmentally sound materials/products.

3. We will share technology, knowhow and experiences among our members at the maximum level, and create larger-scale innovations including new business models.

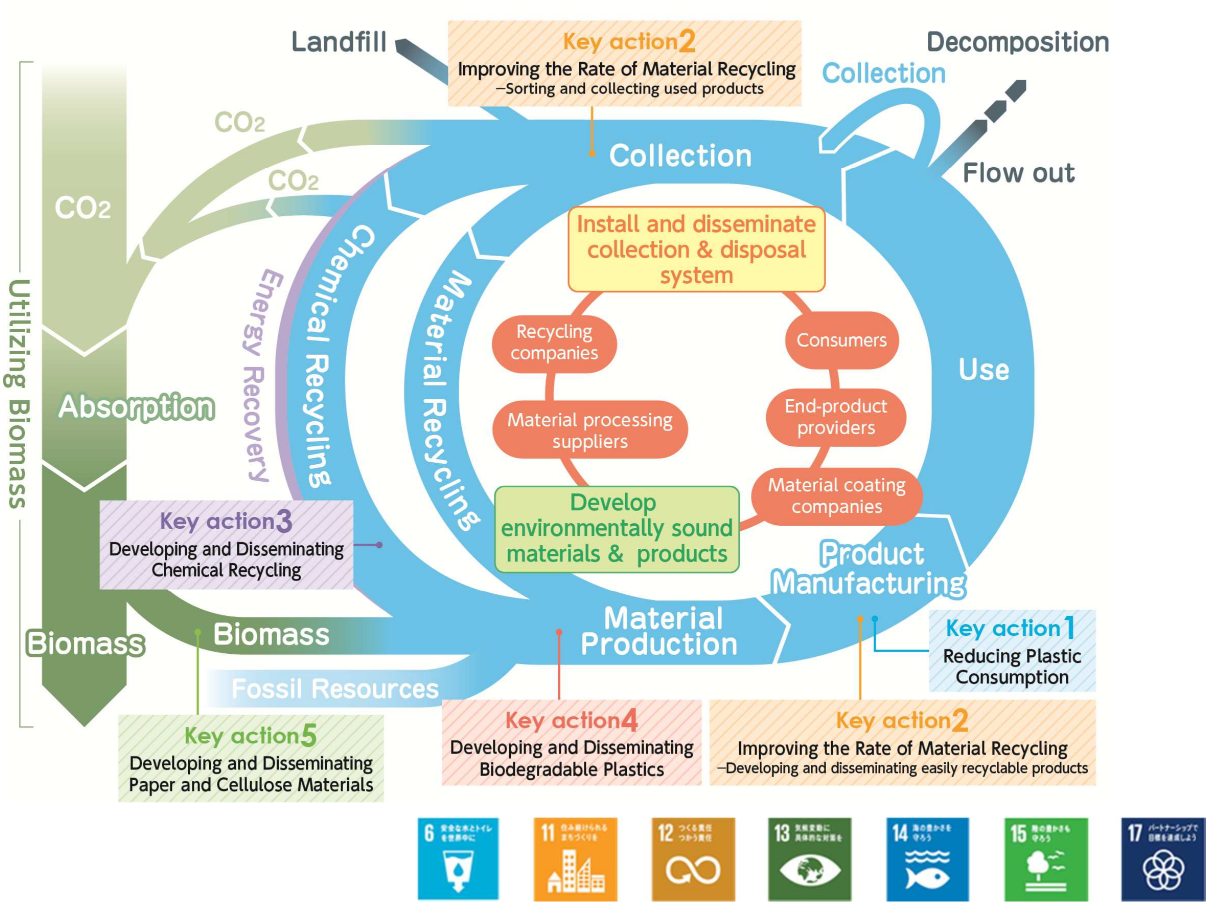
4. We will optimize the combination of technology development and social systems, and gain understandings from stakeholders to accelerate social implementation.

5. We will disseminate a "Japan model" to the world which enables circular use of materials and reduction of environmental load by accommodating our model to the situation and needs of each country.

2. Technologies to be realized, Services and Social Systems, and Examples of Action

Based on the CLOMA Principles, CLOMA and its members will implement the following five key actions: reducing use of plastics, improving the rate of material recycling, developing and disseminating chemical recycling, developing and disseminating biodegradable plastics, and disseminating paper and cellulose materials. The following diagram shows the life cycle of plastic products in which each action is implemented.

Relationship between the five Key Actions and the Lifecycle of Plastic Products



The five key actions can be divided into three categories: reducing use of conventional plastics, promoting recycling, and developing and disseminating alternative materials. Considering that there is no absolute solution today and that there will be new social issues in the future, it is important to optimize the combination of multiple actions considering specific advantages and disadvantages of materials and products according to the situation of the time. For instance, biodegradable plastics, papers and cellulose materials are effective at solving the issue of plastic litter leaked into the environment, while expanded use of biomass plastics is beneficial for curbing global warming and reducing fossil resources dependence. Therefore, it is important to implement those measures effectively to match the situation. At CLOMA, we have a comprehensive perspective in considering different characteristics of various materials as well as progress of relevant efforts. By substantiating the key actions, we pursue not only realization of the Clean Ocean but also concurrent achievement of the SDGs.

Key action 1 Reducing Use of Plastics

We will minimize the amount of plastic necessary for providing required functions. We will pursue a new approach such as promoting efforts to thin PET bottles and review the structure of products (e.g. replacing bottles with film containers) to reduce use of plastics. We will reduce the social costs by expanding the areas of cooperation between CLOMA members regarding these activities. We will also develop and promote international standards as needed.

< Direction of technological development >

- Make innovative changes in the structural designs of products, such as replacing bottles with packaging films for containers
- Promote diffusion of returnable containers and other items by changing business models
- Develop technologies of vapor deposition and coating layers (i.e. vapor deposition/coating technologies and the like) that enable plastics to exhibit superior barrier properties
- International standardization or de facto standardization
- Expand application of technologies overseas which attain reduction of plastic use

< Action example: Use of returnable containers, change of container structures >

We will reduce the amount of plastic used by replacing bottle containers, which are generally used for daily items, with returnable containers and changing the structure of containers (e.g. switching to film containers). In case of returnable containers, we will reduce the environmental load in the whole life cycle, from collection to washing and transportation. In the case of changing the structure, by using alternatives such as film containers to bottle containers, we will significantly reduce the amount of plastics used. Standardization and de-facto standardization of the structure of new containers can expand the range of cooperation and improve the convenience for consumers.

Key action 2 Improving the Rate of Material Recycling

We will raise awareness among the consumers and improve morale in the whole society to ensure the appropriate collection and treatment of used plastic. We will accelerate the technological development and establish social systems for material recycling which social implementation is most in progress of using waste plastics effectively.

In terms of technology, we will develop material recycling technology for composite materials such as multi-layered films made from multiple materials. We will also advance monomaterialization by developing deposition and coating layers with high barrier properties, and promote the use of recycled plastic products for appropriate purposes depending on the plastic's post-use or post-recycling deterioration level. In terms of social systems, we will establish systems to collect products by kind of plastic in cooperation among stakeholders, in order to develop a material recycling cycle. In particular, we will stabilize the supply and quality of recycled plastic products and provide high added-value to develop more sophisticated social systems.

We will aim to reduce the environmental load in the whole life cycle compared to virgin products, including the environmental load of water used in the washing process and the energy consumption in transportation, separating and recycling processes.

< Direction of technological development >

- Further advance the technology for recycling mixed/multi-layered materials
- Develop a technology to change multi-layered film into a single material, and search for possible combinations
- Establish a recycling system that facilitates collection of plastic wastes at retail stores and the returning of plastic wastes to their manufacturers
- Devise methods to encourage users to sort wastes according to plastic types
- Develop technologies capable of sorting, collection and high-accuracy sorting according to plastic by types
- Expand use and applications of, and add a higher value to, recycled plastics
- Develop technologies to optimize the recycling methods by the applications of recycled plastics based on the level of plastics' deterioration

< Action example: Monomaterialization + establishment of sorting and collection system >

We will develop technology for recycling composite materials such as laminated materials that cannot provide the required functions alone. We will also improve deposition and coating technology, as well as deposition and coating materials, so that a single material can provide the required functions. Simultaneously, we will sophisticate the sorting and collection system and disseminate it to take advantage of recyclability that improves through monomaterialization. It is also conceivable to expand the already established food trey recycling system to other products.

Key action 3 Developing and Disseminating Chemical Recycling

In addition to chemical recycling methods such as gasification and raw materialization using blast furnace or coke oven, other methods are taken, such as using waste plastics as raw materials of ammonia and returning them to monomers to produce recycled plastics. Instead of cascading, which has been common in chemical recycling and had limited use, we will produce high-quality recycled plastic products with wider use and high added-value. We will pursue the best mix of chemical recycling and material recycling, while taking advantage of the former's capacity to recycle plastics composed of multiple materials or with residue adhered to. As in the case of material recycling, we will aim to reduce the environmental load in the whole life cycle compared to virgin products.

For products that are discarded with debris attached and cannot be accepted even for chemical recycling, it is important to continue collecting the energy generated during the incineration. Based on the Resource Recycling Strategy for Plastics (draft) which aims to maximize the use of biomass plastics to two million tonnes by 2030, we will also expand the use of biomass plastics for purposes that are easily incinerated.

< Direction of technological development >

- Develop technologies to transform waste plastics back into monomers through chemical recycling and promote its social Implementation
- Develop technologies that can produce quality renewed plastics regardless of high residual content
- Reduce recycling costs
- Pursue the best mix of material recycling and chemical recycling such as optimization of sorting waste plastics

< Action example: Production of monomerization >

In addition to technology for recycling plastic into monomers which is already used today (e.g. bottle-to-bottle), we will develop technology for transforming waste plastics composed of multiple materials or with residue adhered to back into monomers. And by making monomers equal to or better than virgin products in terms of price, quality, stable supply and life cycle costs, we will make them widely accepted by society.

Key action 4   Developing and Disseminating Biodegradable Plastics

Despite various initiatives, some of the used plastic products can go out of appropriate waste treatment routes and end up in the ocean via land or rivers. Therefore, it is important to develop and apply biodegradable plastics which are highly degradable in the natural environment. Based on the Roadmap for Popularizing Development and Introduction of Marine Biodegradable Plastics, formulated by the Ministry of Economy, Trade and Industry in May 2019, it is necessary to make balanced realization of expansion of their use by improving and reinforcing their functionalities and control of production cost and stable supply by developing production process technology, and advance social implementation of marine biodegradable plastics simultaneously. We will set standards regarding biodegradable plastics and promote de-fact standardization toward the expansion of demand. Biodegradable plastics should be disposed and treated appropriately; we will establish a recycling system for both biodegradable and existing plastics using composting, bio gasification, energy collection etc. depending on the degree of dissemination of biodegradable plastics.

< Direction of technological development >

- Develop new biodegradable plastics that can complement and reinforce the physical properties of existing biodegradable plastics
- Develop new materials that will complement and reinforce their physical properties when mixed into biodegradable plastics
- Develop processing technologies for products made using biodegradable plastics
- Application of biodegradable plastics to purposes that suit their physical properties
- Standardization and de-facto standardization with regard to content of biodegradable plastics and their decomposition abilities
- Develop production processes that ensure steady provision at a reasonable price; and reinforce facility
- Establish recycling methods including the separation of biodegradable plastics, expanding the applications of recycle plastics
- Develop materials that are capable of controlling degradation speed, and other materials that are equipped with a switch function, enabling the material to start decomposing at an intended timing
- Develop plastics that are highly degradable in the marine environment

< Action example: Utilization of biodegradable plastics >

We will increase the kinds of biodegradable plastics and expand their application range to reduce the sales price and stabilize the supply. Simultaneously, we will establish appropriate treatment methods depending on their degree of dissemination and technological advancement. While the use of biodegradable plastics is limited, we will employ chemical recycling, energy collection or composting to use waste effectively; as their use expands, and when material recycling technology is popularized, we will promote cooperation between waste collection stakeholders to recycle them into raw materials.

There is a concern that consumers will misunderstand that biodegradable plastics can be inappropriately disposed. Therefore, it is necessary to provide signs or carry out awareness activities to teach appropriate ways to dispose of biodegradable plastics.

Key action 5 Developing and Disseminating Paper and Cellulose Materials

Use of biomass or biodegradable paper and cellulose materials is also anticipated. By developing the coating technology or combining them with biodegradable plastics, we can improve their functionality for various purposes. For example, paper and cellulose materials have great biodegradability in the soil and are expected to be used for agricultural films.

Simultaneously, we will accumulate evidence data regarding the biodegradability of paper and cellulose materials, clearly indicate it and increase their recognition to accelerate their popularization.

On the other hand, if paper and biodegradable plastics are combined, there is a possibility that the amount of paper products that are unfit for the existing paper recycling system will increase. We will enable recycling of such paper products to maximize the effective use.

We will also solve the problem of production costs and stable supply, and develop and popularize cellulose microbeads as an alternative to plastic microbeads.

< Direction of technological development >

- Develop technologies for providing papers with advanced function such as water-resistance
- Develop and diffuse cellulose materials including cellophanes and the like
- Develop technologies on mixing and multi-layering with biodegradable plastics among other highly degradable materials
- Improve the recycling rate of papers and other products that are difficult to recycle under the existing recycling system
- Accumulate evidence data on the biodegradability of cellulose materials, and raise awareness on this issue

< Action example 1: Utilizing papers >

Paper is less water-resistant than plastic, but this can be overcome with the development of technology for coating highly water-resistant materials. We will also develop coating materials and processing technology to improve oil-resistance and other functions and expand the range of paper products. We will also expand the application of paper by combining it with biodegradable plastics to complement functionality.

< Action example 2: Utilizing cellulose microbeads >

Plastic microbeads, used in exfoliating agents, are being replaced by cellulose microbeads. We will improve the functionality to expand their application, and promote dissemination by organizing the systems for lowering production cost and stable supply.