[Report of the National Think Tank]

Plastic Pollution Prevention and Control in China

Principles and Practice

(Extracted version)

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Foreword

Since its invention, plastic has been widely used in production and daily life for its excellent performance and low cost, bringing great convenience to human beings. However, at the same time, the problem of plastic pollution is becoming increasingly serious, especially marine plastic pollution is becoming a focus of environmental concerns around the world, posing great challenges to the sustainable development of mankind. According to a report released by the United Nations Environment Programme, the amount of plastics in the oceans has been estimated to be around 75-199 million tons, with a 9-14 million tons increase year by year. And in the absence of necessary interventions, the amount of plastic waste entering aquatic ecosystems could nearly triple by 2040[1].

Plastic, similar to other industrial materials such as steel and rubber, is an important material for sustaining human survival and development, and the plastic itself is not a pollutant. However, if plastic products are not well managed and well disposed of after use and leaking into the natural environment and accumulating to a certain level, they may pose danger to human beings, plants, and animals' survival and development, therefore becoming a serious social and environmental issue. The essence of plastic pollution is its leakage into the natural environment caused by the mismanagement of plastic waste.

In the foreseeable future, plastics will still be widely applied for a long time. We need to pay great attention to plastic pollution and find out a sustainable development path that plastic use and the ecological environment could be balanced. As General Secretary Xi Jinping said, the international community is increasingly becoming a common destiny for all mankind. In the face of the complex world economy and global issues, no country can stand alone. At present, plastic pollution and climate change, biodiversity and other ecological and environmental issues are the severe challenge to all mankind.

As the world's largest developing country, China attaches great importance to plastic pollution control and has taken several actions. After consistent efforts, China has gradually formed the plastic pollution management system featured with Chinese characteristics based on its national conditions: conducting the whole-chain governance through plastic recycling economy, which means in the design and production process, it is required to constantly improve the performance of plastic, develop alternative materials, product eco-design, clean production; in the circulation and consumption process, a series of policies and measures are launched to promote green consumption. Recyclable products and alternative products are encouraged to reduce the consumption of disposable plastic products; in the after-use disposal process, it is proposed to enhance plastic recycling and energy utilization, strengthen the standardized disposal of plastic waste, and guard the bottom safety line of plastic leakage.

After decades of efforts, China has achieved remarkable results in plastic pollution control: Firstly, a recycling system covering a wide range of waste plastics has been established by the market voluntarily. The recycled waste plastics exceeded 45% of the total global recycling in the same period; Secondly, China has built a complete recycled plastics utilization system covering high, medium, and low ends based on its complete plastics industry system, of which the material and utilization rate is 31%; Thirdly, China has not only completely recycled the plastic waste produced domestically, but also disposed and recycled over 106 million tons of plastic waste from countries and regions such as the EU and the US during 1992-2018, transforming them into recycled plastic materials and making a significant contribution to the global plastic pollution control. With the plastics recycling economy, China has shown the world a feasible way for recycling plastics and maintaining the sustainable development of human beings.

The report aims to provide China's reference in plastic pollution control for other countries through summarizing the concept, practice, and experience of plastic pollution control in China, and make China's contribution to global plastic pollution control.

Disclaimer: *The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any agency of the Chinese government.*

1. From Polluyionto Solutiona Global Assessment of Marine Litter and Plastic Pollution[R]. United Nations Environment Programme,2021.

Messages from Experts

Human beings have been enjoying the functionality and economic benefits of plastics for years as society and technology have progressed. Now we've reached a stage where higher standards of health safety and recyclability are emphasized. China's actions are significant in the treatment of plastic pollution. This report presents a holistic and timely summary on the philosophy and practice of plastic pollution control in China. It is believed that China's experience can serve as a very important reference for the global treatment of plastic pollution.

——Yong JIN

Academician of Chinese Academy of Engineering, Professor of Tsinghua University

Plastics has become an indispensable and important material in production and daily life, but how to practically reduce or prevent the negative impact of its entire life cycle and explore a sustainable development still remains a question. China has accumulated valuable experience in the treatment of plastic pollution, and I believe it will definitely provide a useful reference for the management of plastic pollution around the world.

——Tieyong ZUO

Academician of Chinese Academy of Engineering

The invention of plastics brings great convenience to human production and daily life, but also harm to the ecological environment on which human beings depend for survival. We need to constantly maintain the balance between development and protection to achieve green and sustainable development. Plastic pollution treatment calls for the green circulation concept, extending from the traditional production process to the whole process of circulation, consumption, recycling, end disposal, and more. In the context of the construction of ecological civilization, it is an important exploration to strengthen national efforts and guide social forces to participate widely, strengthen international cooperation, and form global initiatives to jointly promote plastic pollution treatment.

——Guang XU

Chairman of China Environmental Protection Foundation

The World Economic Forum welcomes the initiative of the NDRC and leading Chinese think tanks to address best practices of plastic pollution. Aligned with the mission of the WEF to promote circular economy and address the challenges of plastic pollution, this report provides tangible and practical insights to plastic control practices that promote life cycle approaches to leveraging the benefits of plastic while protecting our common environment. These working methods represent opportunities for further collaboration between China, we look forward to further engagement building on this report and best practices developed across a range of WEF partnerships.

——Gim Huay Neo

Managing Board Member World Economic Forum

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Table of Contents

1.

Urgency of Strengthening Plastic Pollution Control

The invention of plastic is one of the symbols of modern industrial civilization, bringing great convenience to human production and daily life. However, the plastic pollution issue is becoming increasingly prominent, causing environmental concerns across the globe.

1.1 Global Pollution Issues Arising from Plastics are Increasingly Severe

Pursuant to the data from the Plastics Europe, global plastic production and consumption grew steadily at an average annual rate of 2% from 2015 to 2020. Plastic production is expected to double by 2035 and treble2 by 2050[2] (see Figure 1-1 for details).

According to a report released by the United Nations Environment Programme in 2021, approximately 9.2 billion tons of plastics were produced globally cumulatively between 1950 and 2017. By 2050, cumulative global plastic production is expected to grow to 34 billion tons, with an average annual growth rate of 7.9%(see Figure 1-2)[3].

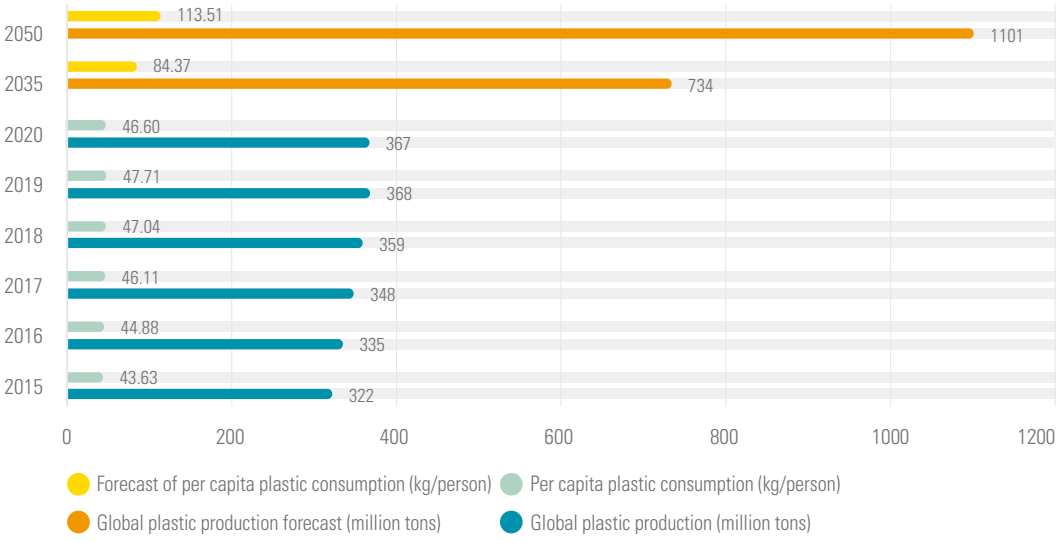

Figure 1-1. Global Plastic Production and Consumption
Source: Plastics Europe

2. Source: Plastics Europe. https://plasticseurope.org/knowledge-hub/
3. Source: From Pollution to Solution: Global Assessment of Marine Litter and Plastic Pollution[R]. United Nations Environment Programme, 2021.

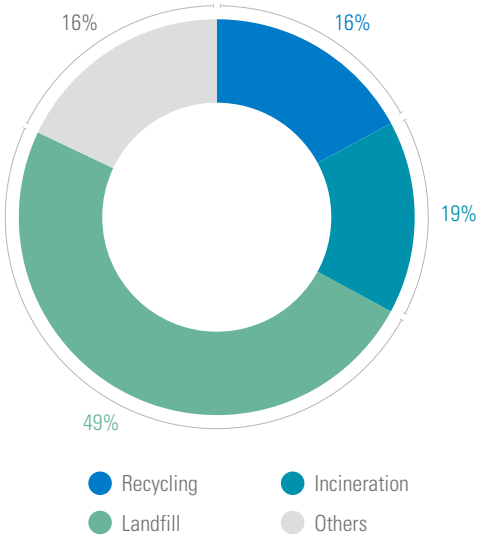

Figure 1-2. Composition of Global Plastic Disposal Methods
Source: Data from OECD

In 2019, some 350 million tons of plastic waste were generated globally.[4] Meanwhile, the discharge of plastic waste continues to grow year by year[5]. The global prevalence of serious plastic pollution problems urgently requires countries around the world to take extensive and effective measures to respond.

1.2 China is also Faced with the Plastic Pollution Concern

Although as a developing country, China's per capita plastic consumption is much lower than that of developed countries, it is still facing the same plastic pollution issue.

1.2.1 Plastic consumption is increasing year by year in China

With China's economic development and rising living and consumption levels, the consumption of plastics continues to grow. In addition, changes in people's consumption patterns and the rapid development of emerging sectors in recent years, as well as the massive increase in demand for disposable medical and protective supplies due to the New Crown epidemic have also led to rapid growth in the use of disposable plastic products.

4. Source: OECD https://stats.oecd.org/Index.aspx#
5. Reference: Lau W. W. Y. et al, Evaluating scenarios toward zero plastic pollution[J], Science, 2020, 369: 1455-1461

1.2.2 The pressure imposed on China concerning plastic pollution control is increasingly high

As China's economy and people's consumption continue to grow, so does the consumption of plastics and the demand for plastic products. The inevitable result of the rising plastic consumption is the gradual increase of plastic waste. As shown in Figure 1-3, in recent years, China has produced more than 60 million tons of plastic waste annually. In addition to materialization and energy utilization, the remaining was basically sent to landfills together with other domestic waste, bringing certain risks to ecological and environmental safety.

6. source: Compiled from the annual series of articles "China Plastics Processing Industry (2020)" published in the journal "China Plastics" by Ma Zhanfeng et al.

2.

The Nature and Manifestations of Plastic Pollution

Once plastic waste leaks into the natural environment, it will take hundreds or even thousands of years to completely degrade without human intervention, resulting into long-term adverse effects on the global soil environment, water ecology, climate change, biodiversity, etc.

2.1 The Nature of Plastic Pollution

Currently plastic is a prominently fundamental material in current society, bringing great convenience to people's daily life. The plastic itself is not a pollutant. The nature of plastic pollution is the leakage into the natural environment caused by improper control of plastic waste. The current severe plastic pollution is the result of long-term accumulation in history.

2.1.1 The nature of plastic pollution is plastic waste leakage into the nature environment

In 2019, the global volume of plastics is equivalent to 26% of steel and cement combined, and its consumption is growing at an average annual rate of 2%[7]. Plastic has become an essential and important raw material. Similar to other industrial materials such as steel and non-ferrous metals, plastics are inherently highly recyclable and are theoretically fully recyclable to avert leakage.

However, due to its wide application in different areas with various forms, certain categories of plastic products could be easily discarded after use but difficult to collect, with the risk of leakage into the natural environment such as waters and soil. Moreover, with high corrosion resistance quality, even a small plastic straws can stay in natural conditions for a long time and brings out serious pollution after years' accumulation. Compared to the environmental problems caused by other materials, the management of plastic pollution is more complicated.

2.1.2 Global plastic pollution has been chronically accumulated for decades

The plastic industry commenced its rapid development in the 1960s and 1970s, leading to the spike in global plastic production and consumption. However, the concept of sustainable development has not yet become a global consensus, and no related policies, regulations, and control measures for plastic waste were established, resulting in wide plastic waste leakage in a long period.

With legislation and regulations in place by various nations, wider promotion of the eco-design of products, improvement of waste management system and recycling infrastructure, and the application of recycling and utilization technologies, we believe that human beings are able to impose effective control over plastic pollution.

7. Reference: Zheng Qiang: Plastic and My Opinion about It, 2021

2.2 The Manifestations of Plastic Pollution

Once plastic waste leaks into the soil, water, and other natural environments, it is difficult to degrade, causing visual pollution, soil pollution, water pollution, and other environmental damage(see Figure 2-1), ending with permanent harm to the fragile ecological environment and biodiversity.

2.2.1 Visual pollution caused by plastic waste

The visual pollution of plastic waste refers to the damage caused by plastic waste scattered in the environment and natural landscape of the city[8]. Plastic bags, packaging films, waste agricultural films and other plastic products and packaging

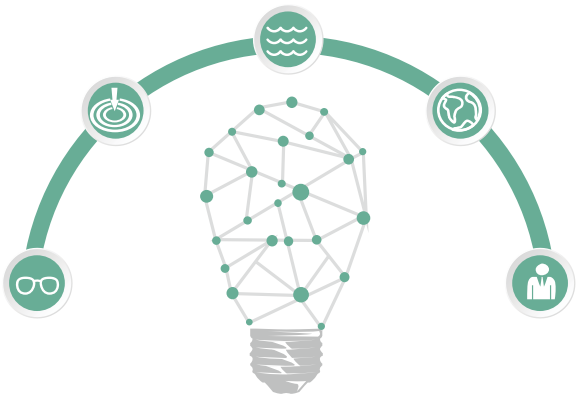

Figure 2-1. The Manifestions of Plastic Pollution

8. References: Han Lizhao, Wang Tonglin, Yao Yan. Study on the present situation and Control Countermeasures of White pollution [J]. Population, Resources and Environment of China, 2010 20 (S1): 402-404.

are relatively thin and easy to be blown up by the wind, floating in the air or hanging on branches, scattered in some scenic spots and on both sides of the roads, forming "white pollution".

It should be pointed out that the plastic waste in the stage of "visual pollution" has not been "irreversible". If people can effectively collect and properly dispose of the plastic waste scattered in the natural environment in time, this "white pollution" will be strangled in the stage of "visual pollution" without further disintegration in the natural system, forming microplastics[9], which will cause deeper harm to the ecology and environment.

2.2.2 Water pollution caused by plastic waste

The water plastic pollution caused by plastic waste refers to plastic waste leeching into rivers, lakes, oceans, due to poor management, affecting the water ecology and environment. The water pollution is mainly divided into land-sourced pollution and sea-sourced pollution. The former is mainly due to plastic waste directly leaking into various water bodies, or in the form of microplastics; sea-sourced pollution mainly refers to fishing and mariculture process of various fishing gear, shipping and marine operations using marine equipment and production of household waste, as well as plastic products carried by tourists are discarded into the ocean after use. Plastic pollution in water is more insidious than plastic pollution in soil, with wider consequences(see Figure 2-2).

These plastic waste in oceans, through the unceasing movement of the ocean and weathering, are always decomposed into microplastics to enter the material cycle, or suspended in the waters and accidentally eaten by marine organisms, therefore becoming part of the biosphere, causing great damage to marine biodiversity. The microorganisms and algae attached to the surface of plastic waste can release an appetizing smell to marine organisms, and its color and shape are similar to those of jellyfish, therefore lots of maritime animals have eaten them by mistake. It is estimated that about 118 of the 693 species on the International Union for Conservation of Nature's Red List are seriously threatened by plastic pollution[10].

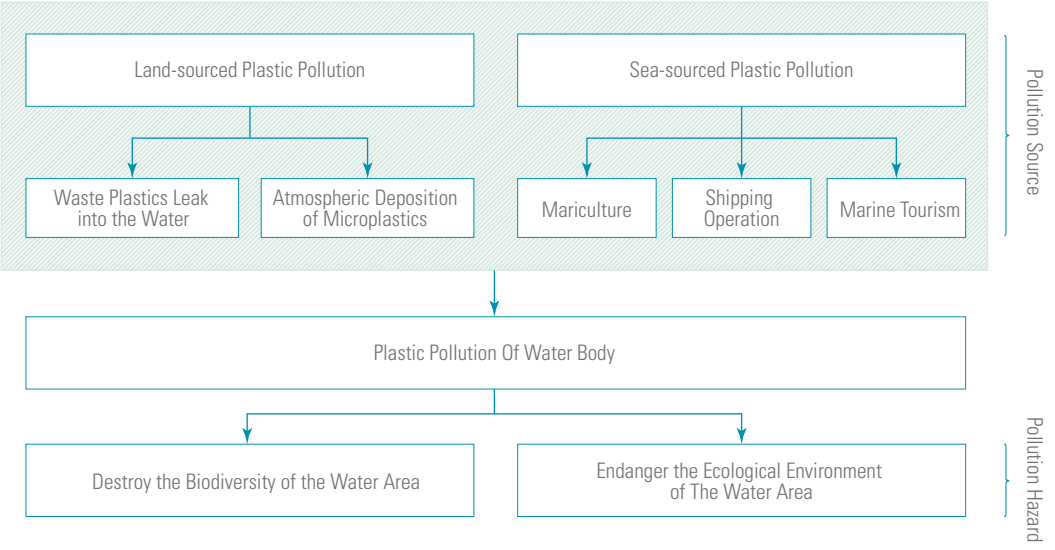

Figure 2-2. Marine Plastic Pollution Path Map

9. Microplastics: plastic fragments and particles smaller than 5mm in diameter
10. Data source: The global threat from plastic pollution, Matthew MacLeod etc, Science · July 2021.

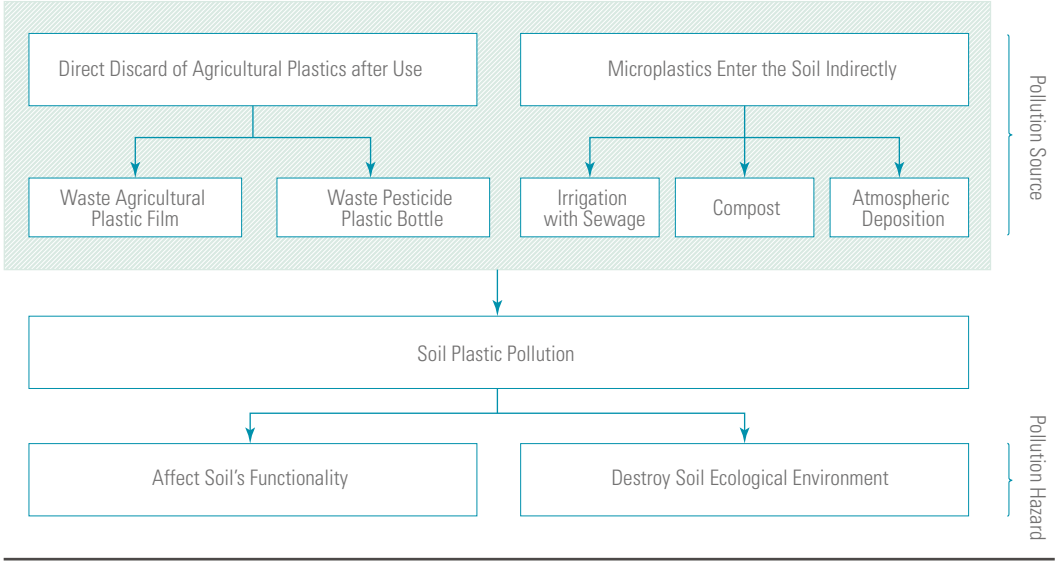

Figure 2-3. Soil Plastic Pollution Path Map

2.2.3 Soil pollution caused by plastic waste

Compared with "visual pollution", plastic pollution in the soil is rather non-tanglble. Plastic pollution in soils refers to the infiltrating of plastics into the soil in the form of plastic debris or microplastics, resulting in changes in the soil's original properties and state, leading to poor soil permeability or reduced fertility. Soil pollution mainly arises from plastic waste, tire wear particles in road runoff, and agricultural film and pesticide bottles and other agricultural materials used after the random discard. In addition, the use of microplastic-containing animal manure and sludge compost, the use of microplastic-containing sewage for irrigation, etc. will also bring microplastics into the soil(see Figure 2-3). It is estimated that the current plastic content of soil may be more than that in the ocean, and the plastic fraction of soil organic carbon has been as high as 0.1%[11]. A survey of wastewater treatment plants indicates that about 90% of microplastics accumulate in sludge after sewage treatment.

The continuous accumulation of plastic wastes in the soil will jeopardies its air permeability, but also hinders the growth of plant roots. What's worse, after microplastics enter the soil, they will absorb a large number of heavy metals and organic pollutants such as pesticides and herbicides in the soil and lock them in the soil environment. This will bring damages to the health of the soil ecosystem, and the activities of soil organisms will also accelerate the spread of microplastics, therefore causing a vicious circle of microplastics spreading in the soil[12].

11. Source: Matthew MacLeod, Hans Peter H. Arp, Mine B. Tekman, Annika Jahnke, *The global threat from plastic pollution*, Science, issue 6550, 2021
12. Source: Horton A. A., Walton A., Spurgeon D. J., et al.; *Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities*, Science of the Total Environment, Issue 586, 2017, 127-141.

2.2.4 Plastic waste disposal methods affect greenhouse gas emission

Plastics are essentially transformed from chemicals and fossil fuels, namely greenhouse gases are emitted throughout the life cycle of production, distribution, consumption, disposal, and utilization. Some data shows that 280-360 million tons of fossil fuels are used to produce plastics worldwide each year[13], and carbon in fossil fuels is transferred to plastics in the process. If these plastic wastes are degraded, incinerated or landfilled, the remaining carbon will eventually be released in the form of carbon dioxide, methane and other greenhouse gases into the air.

2.2.5 Microplastics may harm human health

Plastic pollution not only endangers the ecology and environment but also threatens against human health. Microplastics leached into the environment can easily be absorbed by plants and mistakenly eaten by fish and small animals, thus entering the food chain, passing through each step of it and eventually enter the human body(-see Figure 2-4). In addition, plastic microbeads are widely applied in toothpaste, body wash and other daily toiletries, while some microplastics can be directly ingested by humans. Some studies even suggest that the ingested microplastics will enter the body's circulatory system and reach specific tissues, potentially causing oxidative stress, inflammatory responses, and metabolic disorders, and even affecting the expression of DNA information and genetics[14].

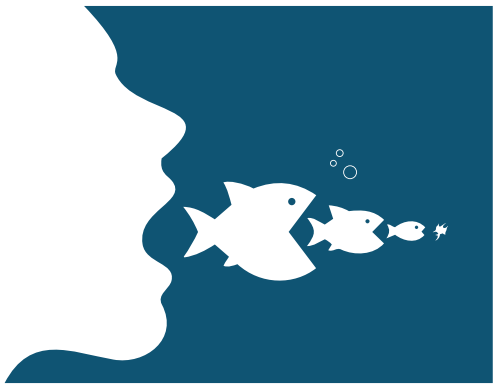

FIGURE 2-4.
Image: https://baijiahao.baidu.com/s?id=1691641723892993408&wfr=spider&for=pc.

13. Reference: Dees J. P., Ateia M., Sanchez D. L., *Microplastics and Their Degradation Products in Surface Waters: A Missing Piece of the Global Carbon Cycle Puzzle*, ACS ES&T Water, 1st Issue, 2020, 214-216.
14. Source: Landrigan, P.J., Stegeman, J., Fleming, L., Allemand, D., Anderson, D., Backer, L. et al., Human health and ocean pollution. Annals of Global Health, 1st issue of 2020,1-64

2.3 Causes of Plastic Pollution

There are a wide variety of synthetic materials widely applied in daily life, but why does plastic pollution attract global attention? To answer this question, we need to analyze from two aspects: the properties of plastic and improper disposal.

2.3.1 Plastics are difficult to resolve

Plastics are difficult to resolve under natural conditions, resulting in cumulative plastic pollution. With a stable physicochemical structure, plastic products are completely assimilated by microorganisms in the natural environment, degrading into CO_2 and water, and its inorganic mineralization may take 200-400 years. According to relevant researches, polystyrene degrades only 0.01%-3%[15] in 4 months in soil, sludge, decaying garbage, or manure microbial communities. The long resolving process of plastic is the root of becoming a "big hazard".

2.3.2 Low value of certain plastic products

Plastics are used in the production of major equipment like aircraft and ships but also in packaging and others. Some small food packaging weighs only a few grams, small and light. Recycling these plastic packaging in small sizes is relatively economically costly, but with little in return. Even considering the benefits of resource conservation and environmental protection, it is difficult to maintain such an effective operating mechanism. In addition, the huge variety of plastics products also poses a great challenge for sorting, collection, and recycling. A large amount of plastic waste are consequently leaked into the environment, becoming rampant pollution.

15. Yu Y, Yang J, Wu W M, et al. Biodegradation and Mineralization of Polystyrene by Plastic-Eating Mealworms: Part 2. Role of Gut Microorganisms[J]. Environmental Science & Technology, 2015, 49(20):12087-12093.

2.3.3 The excessive use and inappropriate disposal of plastic waste

(1) Plastic waste leakage into environment caused by improper human behaviors.

Plastic is very common nowadays yet is easy to discard at will, which brings great difficulties to the recycling and disposal of plastic waste, ending with plastic leakage into the environment. It can be said that the improper behavior of humans is the direct cause of plastic pollution.

(2) Disposal and recycling facilities of plastic waste need to be improved.

This is a common issue for most of the countries. Some countries don't have recycling facilities; therefore, their plastic waste still needs to be exported to other countries for recycling. But due to the high cost of long-distance transportation, those low-value plastic waste with little economic value for recycling will be neglected, resulting in an overall low recycling rate. Some countries don't have enough capacity in incineration facilities or standardized landfill facilities, and most of the waste are landfilled randomly.

Developed countries and regions such as the EU and the U.S face similarly aggravating situation too. In 2018, a total of 29.1 million tons of plastic waste was generated in 30 European countries, including 28 EU members and Norway and Switzerland, of which 12.4 million tons were disposed of by incineration for energy recovery, 9.46 million tons were recycled for materialization and 7.25 million tons were directly landfilled, accounting for 42.6%, 32.5% and 24,9%, respectively[16]. In 2018, the United States generated 35.68 million tons of various types of plastic waste, but only 3.09 million tons were materialized in recycling, accounting for only 8.66%; 5.62 million tons were recycled as energy, accounting for 15.75%; and the volume went for landfilling was up to 26.97 million tons, accounting for 75.59%[17].

(3) Cross-border transfer of plastic waste causes environmental risks.

At present, in the face of increasingly serious plastic pollution, some countries do not assume their responsibility of plastic pollution management, but export the plastic waste collected in their countries to other countries instead, bringing great pressure on other countries and regions to control plastic pollution. According to statistics, the total amount of global plastic waste exported in 2020 was as high as 3.85 million tons, of which the top ten exporting countries exported a total of 2.6 million tons, accounting for 67.5%. The United States has the largest exporting volume of 620,000 tons, followed by the Netherlands, 346,000 tons. The majority of these plastic wastes are exported to Turkey, Malaysia and other places, bringing certain threats to the local ecological environment[18].

16. Source: European Plastics production, demand and waste data Analysis report (2020)
17. Source: U.S. Environmental Protection Agency: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data.
18. Source: UN Comtrade Database

3.

The Concept and Path of Plastic Pollution Control in China

As the largest developing country in the world, China attaches great importance to the treatment of plastic pollution. By vigorously developing a circular economy for plastics and carrying out plastic whole-chain governance, a path on plastic pollution control featured with Chinese characteristics has been developed.

3.1 Historical Evolution of Plastic Pollution Control in China

In ancient times, China established the idea of "the unity of man and nature", advocating nature, respecting nature, and advocating the concept of harmonious symbiosis between man and nature. We began to pay attention to the problem of plastic pollution a long time ago, and take measures to deal with it actively.

(1) Early stage focusing on key sectors of plastic pollution.

After the reform and opening up, with the rapid development of China's economy and the continuous improvement of people's living standards, the consumption of plastics has increased rapidly, and the resulting "white pollution" problem has gradually emerged. China's plastic pollution control at this stage is mainly oriented by outstanding problems. Issued some opinions on strengthening the management of plastic packaging waste in key traffic lines, river basins and tourist scenic spots, "urgent notice on immediately stopping the production of disposable foamed plastic tableware", "Circular of the General Office of the State Council on restricting the production and sale of plastic shopping bags" and other restrictions or prohibit the use of plastic packaging waste, disposable foamed plastic tableware and plastic bags.

(2) Comprehensive solution stage with the *development of a circular economy for plastics.*

At the end of 1990s, the restriction of resources and environment on economic and social development has become increasingly prominent. China has gradually introduced the concept of circular economy and realized that the treatment of plastic pollution cannot be treated by piecemeal measures, and systematic treatment must be carried out. In 2005, relevant departments of the Chinese government launched a pilot project for the demonstration of circular economy, including the pilot project for the recycling of waste plastics. In 2009, China formally implemented the Circular economy Promotion Law, comprehensively promoting the construction of a resource recycling system covering the whole society.

(3) A new development stage with whole-chain governance on plastics pollution.

With the rapid development of emerging express, delivery and e-commerce, more and more disposable plastic products sre produced, and the plastic pollution is becoming increasingly serious as a consequence. In order to solve this issue, China has comprehensively strengthened the treatment of plastic pollution, issued *Opinions on Further Strengthening the Treatment of Plastic Pollution* and the *Action Plan for the Treatment of Plastic Pollution for the 14th Five-year Plan*, and further improved the plastic waste recycling system, so as to promote the treatment of plastic pollution in China into the whole-chain governance. In the practice of plastic pollution control for many years, the legal and policy system of plastic

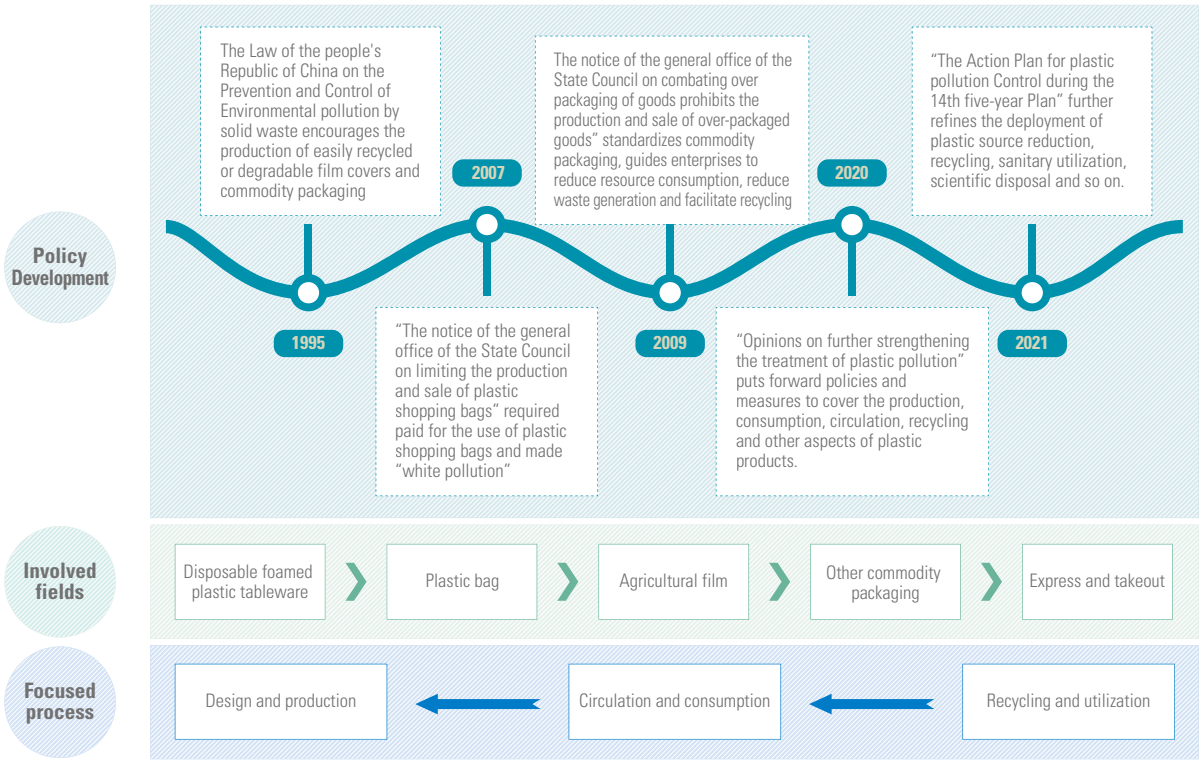

Figure 3-1. History of Plastic Pollution Control in China

pollution control in China has been continuously improved, the field and scope of coverage have been continuously expanded, and the control efforts have become stronger and stronger, and a closed-loop management system with whole-chain has been gradually formed(see Figure 3-1).

3.2 Overall Concept of Plastic Pollution Control in China

As the largest developing country in the world, China has faced more prominent resource and environmental constraints in the process of rapid development over the past few decades and is more determined to take the path of sustainable development. Under this background, China abandons the traditional linear economic growth model of "mass production, mass consumption, and mass waste" characterized by high consumption of resources and energy and high emission

of pollutants, and vigorously develops a circular economy. We will explore a sustainable development model in which economic growth is decoupled from resources and the environment.

China is the third country in the world to enact special laws on circular economy. Unlike Germany's circular economy, which focuses on solid waste management, China develops circular economy in production, circulation and consumption, and implements the "3R" principle in all links and the whole process of production, circulation and consumption, that is, " Reduce, Reuse, and Recycle", gradually building a circular economy development model of "resources-products-recycle- resources".

Plastic is an indispensable material. It is both unscientific and unrealistic to remove plastic from our production and life. In the face of the potential risk of plastic pollution, it is necessary to strengthen the recovery and utilization of plastic waste and develop a plastic circular economy. According to the "3R" principle of circular economy, the first is "reduction" to reduce the production and use of disposable plastic products as much as possible, and vigorously promote ecological design methods such as easy recycling and renewable plastic products from the source, followed by "reuse". In the link of circulation and consumption, explore recyclable plastic products and business models; The last part is "recycle". In the end disposal process, we should carry out the recovery and material utilization of waste plastic products, carry out energy recovery and utilization of those that do not have the conditions for material utilization temporarily and build a treatment system covering the whole-chain of plastics pollution(see Figure 3-2).

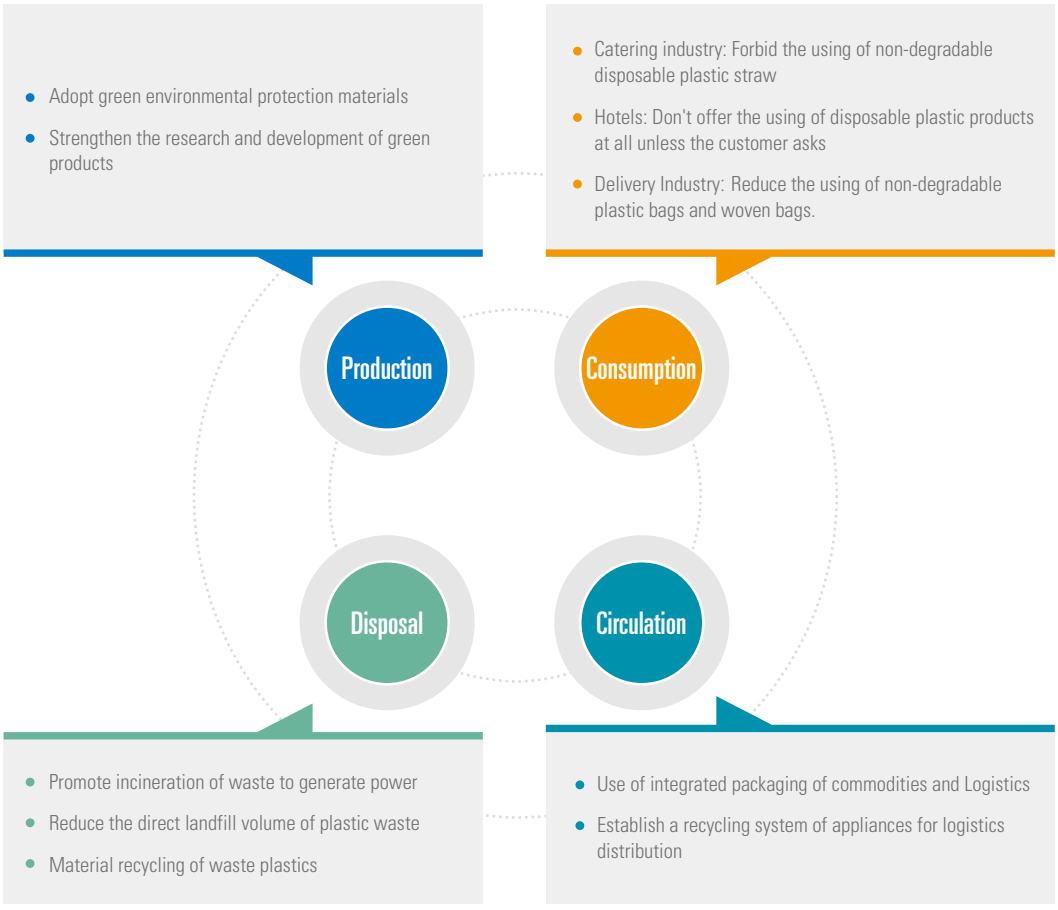

Figure 3-2. The Whole-chain Governance Concept of Plastic Pollution in China

3.3 The Fudamental Path of Developing a Circular Economy for Plastics in China

The development of China's plastics recycling economy has gone through a process of gradual improvement from short-term inhibiting measures to long-term recycling system construction, and from emphasizing end-of-life disposal to whole-chain governance. China has gradually explored a whole life cycle governance system and governance path with Chinese characteristics of plastic pollution, emphasizing effective governance in the whole process of plastic raw material production, ecological design of plastic products, plastic product consumption, plastic waste recycling, and final plastic waste safe disposal(see Figure 3-3).

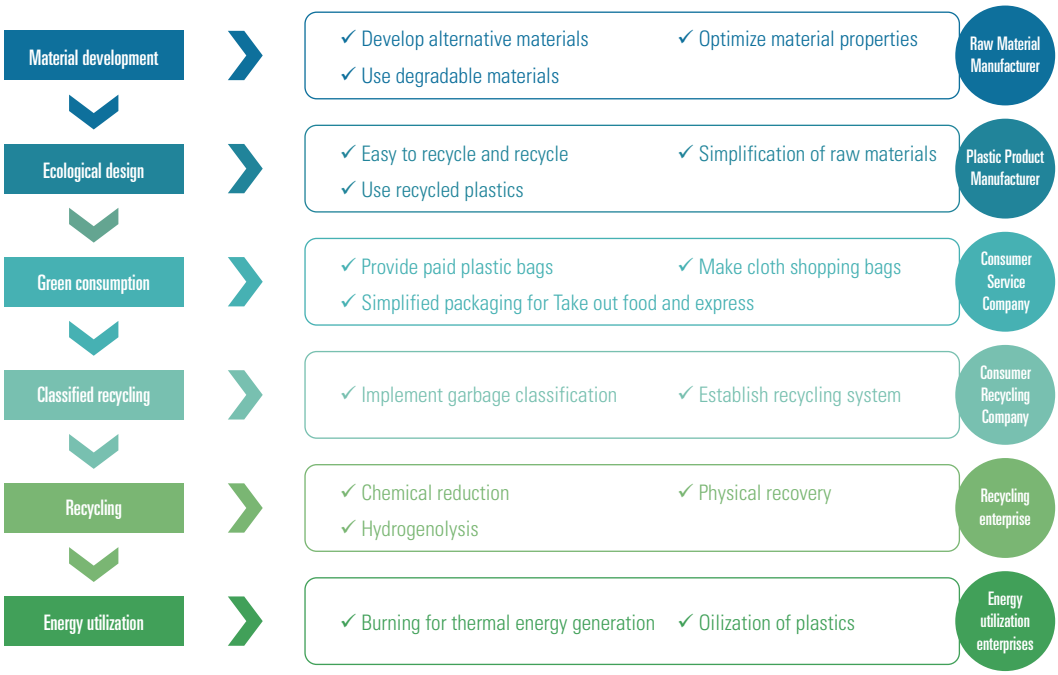

Figure 3-3. Basic Path Map for the Development of Plastic Circular Economy in China

3.3.1 Improving and innovating plasic materials

In the raw material production stage, through the improvement and innovation of plastic materials, the possible plastic pollution can be prevented and reduced from the source. First, it is necessary to reduce the addition of toxic and harmful substances, such as plasticizer[19], antioxidant[20], anti-adhesion agent[21] and other substances in the process of material production, or the use of high-performance, less toxic resin materials. In addition, it is necessary to improve the performance of plastics, add appropriate modifiers to plastics, improve the service life of plastic products, and effectively improve the recyclability of plastic products after being discarded, such as improving the toughness of agricultural plastic film to improve the recyclability of waste plastic film. so as to reduce the harm of plastic film residue to soil and so on.

3.3.2 Promoting eco-design of plastic products

At the design stage, if the existing technical conditions, raw material and other factors are fully considered to optimize the solution of resource and environmental issues in all aspects, it is possible to maximize resource conservation and reduce environmental pollution from the source[22]. Therefore, in the design of plastic products, integrate the concept of whole life cycle management, carry out systematic evaluation of the social, economic and environmental impacts of plastic products in the production, distribution, consumption and post-waste recycling or disposal, and take measures to improve product design, use more renewable and single plastic products raw materials, and adopt more reusable and easily recyclable product design solutions to achieve the purpose of minimizing the environmental impact of plastic products in the whole life cycle process.

Improve material properties to reduce plastics from beginning

Developing sustainable plastic materials is an essential part of circular economy. In recent years, a global materials science company has released a number of materials and packaging solutions that aid in promoting sustainable development and the use of these solutions in downstream industries, thereby helping the green transformation of the industry.

Extend the Service Life of Materials

As a more sustainable solution for renewable energy industry, ENGAGE™ PV polyolefin elastomer (POE) film helps extend the service life of solar modules from 25 to 30 years. This solution increases power generation, electrical efficiency, reliability, and service life, improves resistance to potential induced degradation (PID) with "PID Zero" performance meanwhile reducing the levelized cost of electricity (LCOE) as well as total system costs.

Adding AFFINITYTM polyolefin elastomer (POE) to the formula of reusable plastic pallets, the service life can be extended by 1.5 times. Compared to traditional wooden pallets or injection molding pallets, this durable plastic pallets can reduce 1821.779 kg of Carbon Dioxide Equivalent along life cycle, reducing carbon emissions significantly.

Enabling Mono Material Structure for Packaging

Enabled by INNATE™ TF Polyethylene Resin for Tenter Frame Biaxial Orientation (TF-BOPE), recyclable packaging with all-PE structures is an alternative to non-recyclable packaging with composite structures. The solutions have been commercialized and adopted by multiple products lines. It is estimated to save 50,000 – 60,000 Tons plastics every year, if all the packaging used in laundry industry is replaced by recyclable flexible packaging.

19. Used to enhance the plasticity.
20. Used to inhibit the oxidation of materials
21. Used to reduce friction coefficient or static interference
22. Source: "Guidance of the Ministry of Environmental Protection of the Development and Reform Commission of the Ministry of Industry and Information Technology on the Development of Ecological Design of Industrial products" (joint section of the Ministry of Industry and Information Technology (2013) No. 58) http://www.gov.cn/zwgk/2013-02/27/content_2341028.htm

The use of recycled materials to promote the development of "Circular Economy"

As the earliest enterprise practicing ESG in China, the Company actively promotes the innovation of product green and low-carbon design solutions in the field of product eco-design. The Company also collaborates with supply chain and industry forces to contribute to the green development of society.

Extensive Use of Recycled Plastics in Products

Despite the continuing challenges of using recycled plastics in the design and manufacture of ICT products, the Company uses recycled plastics in its notebooks, desktops, workstations, monitors, and options widely. Since early 2005, the Company's cumulative total use of recycled plastics in products has reached over 115 million kilograms.

Conduct Closed Loop Recycled Plastic Application Practice

The Company is participating in closed loop post-consumer recycled (CL PCR) activities by connecting its recycling suppliers with recovered and recycled plastic manufacturers for reuse in the manufacturing of new products. In 2017, through product design innovation, supply chain cooperation, material traceability management and other measures to achieve a closed loop of electronic waste and waste plastics, it introduced CL PCR materials in desktop and monitor products. In 2020, the Company expanded the use of CL PCR to 103 products. Currently, close to 9 million kilograms of recycled plastic materials from electronic waste has been used by the Company.

It was found that by using closed loop recycled plastic materials compared to virgin plastic materials (using Life Cycle Assessment method):

(1) Reduced demand for the fossil raw materials.

Reduced 0.81kg crude oil used for 1kg of JH960-6900 recycled material produced. Reduced 1.72kg crude oil used for 1kg GAR-011(L85) recycled material produced.

(2) Effectively reduces CO_2 emission throughout the product life cycle.

The carbon reduction per 1kg of JH960-6900 material is 2.67kg, which is 45.33% lower than the original material. The carbon reduction per 1kg of GAR-011 (L85) material is 2.923kg, which is 75.34% lower than that of virgin materials.

Reduce Plastic Use by Improving Packaging Design

Since 2017, a company has launched a global "Sustainability for a Generation" program. In the area of plastic packaging sustainability, It is actively exploring innovations in reducing plastic at source and reusing model pilot.

Reduce Plastic at Source

For years, the company have been focused on light-weighting packaging materials of all types, including plastics. It'll keep at that while also looking for ways to eliminate unnecessary layers of plastics and other materials in secondary and tertiary packaging. For example, in China the company removed 40% of the weight from gum bottles between 2015 and 2018. The China team also launched the "Slim Gum Bottle" project in 2020 by reducing the headspace of the gum packaging. This project has reduced 450 tons of virgin plastics use in China within one year. It will further expand the model to other products and aim to reduce virgin plastics use by 580 tons every year.

Reuse Model Pilot

In 2021, the company launched a reuse package business model for its M&M's Brand at 17 stores of BESTORE in 5 cities of China, including Shanghai, Guangzhou, Wuhan, Ningbo and Nanchang. A series of new metal reusable cans are developed for this new business model and cash redeem coupons are provided to consumers encouraging consumer to repurchase M&M's with this reusable package. At the same time, a new paper box packaging has been upgraded for M&M's vending machines locating in big shopping malls to replace the original plastic cups. The company forecast that this innovation model can contribute to 2.4 tons of virgin plastics reduction every year.

3.3.3 Reducing unnecessary consumption of certain single-use plastic products

Due to the low cost and ease of use of disposable plastic products, plastic pollution management has become a "small item, big trouble". In this regard, China has introduced a series of laws and regulations and regulatory requirements, requiring shopping malls, supermarkets and other operational services of a certain area, disposable plastic shopping bag charges; restrict the use of disposable plastic catering utensils in the restaurant industry, to encourage the provision of reusable catering utensils; require hotels, hotels and other business premises shall not take the initiative of a certain area to provide disposable toothbrushes, disposable combs, disposable toiletries and other disposable plastic products. And for e-commerce, courier, takeaway and other emerging areas introduced special provisions to encourage e-commerce, takeaway and other platform companies and courier companies to develop and implement plans to reduce the amount of single-use plastic products, and take a variety of measures to encourage consumers to reduce the use of single-use plastic products.

Green Mountain Project

With the rapid development of China's food delivery industry, online meal ordering has become a more popular way of dining while the environmental problems arising from online ordering has caused concerns at the same time. In order to drive the green development of the takeaway industry, a food delivery platform company has launched the "Green Mountain Project" in 2017. The project team has explored multiple approaches to solve the industry's environmental issues, from the production, consumption to the recycling of single-use takeaway packaging. Through the project, an industrial chain that encompasses reduction at source and recycling post disposal has been established. The team has also been actively looking into areas such as over-packaging, alternative green packaging materials and product applications of recycled takeaway plastics.

Encouraging Green Consumption among Users

It has taken the lead to add the "no cutlery" option in their application feature, implemented "mandatory option" for placing an order, combined with incentive mechanism applied to different product scenarios, such as "donating green energy" and "collection of Digital RMB bonuses". The project team has launched a monthly "green day" campaign, which has motivated more than 100 million consumers to choose the "no cutlery" option.

Encouraging Green Operation among Catering Merchants

With the "Green Mountain Profile", over 2 million merchants have demonstrated their efforts in plastic reduction and environmental protection. A guidebook on building a knowledge system for catering merchants to operate in a green way has been released, and the "Green Mountain Sustainable Restaurant Demonstration Street" has been launched in many provinces and cities.

Promoting Green Packaging Solutions

Green packaging solutions that meet the needs of catering merchants has been actively explored. Together with packaging manufacturers, the project team has incubated and pushed for innovative takeaway packaging products. A total of 28 models and 910,000 pieces of innovative & green products have been distributed to merchants for free.

Building Green Packaging Supply Chains

The "Green Packaging Recommendation List of Green Mountain Project" has been introduced, which incorporates 161 environmental-friendly products from 101 manufacturers in three categories; a green packaging sourcing platform for merchants has been built to sustain the development of green packaging.

3.3.4 Scientific sorting and recycling of plastic waste

Waste sorting is the key to realize the recycling of plastics. In the process of sorting and recycling, different recycling modes should be adopted according to the product characteristics, circulation characteristics, disposal destination and economic value of the waste(see Figure 3-4). For plastic parts of home appliances, automobiles and other high-value products, it is suggested to take the "accompanied recycling" model, build complete waste recycling system for electrical and electronic products, end-of-life vehicles and other waste products. Regarding to plastic packaging waste with a certain economic value, for example PET beverage bottles, HDPE daily products packaging barrels (bottles), PP plastic lunch boxes and other For PET beverage bottles, HDPE daily-use product packaging drums (bottles), PP plastic lunch boxes and others, China has adopted the "special recycling" model and established a large recycling network covering cities and villages, which can basically realize the "collection of all waste plastic bottles". For plastic waste, such as plastic pesticide bottles and mulch, which are widely used, difficult to collect with high risk of environmental leakage, China has adopted a "mandatory recycling" model and has formulated the "Measures for the Management of Agricultural Films" and "Measures for the Management of Pesticide Packaging Waste Recycling and Disposal" to stipulate the recycling obligations of producers. Now, companies have adopted the deposit system to collect and recycle pesticide bottles. For plastic bags, plastic packaging film and other low-value plastics with high recycling costs, it is required to collect and recycle with other household waste.

Figure 3-4. Different Types of Waste Plastics Recycling Mode

Takeway Box Recycling Demonstration Project

A leading online food delivery platform company is constantly exploring ways to recycle plastic takeaway boxes. Collaborating with local governments and enterprises, the company has carried out pilot projects on waste sorting and recycling of plastic takeaway boxes and has supported new sorting lines to promote a higher market value for the recycling of them. So far, it has established multiple sustainably-run takeaway box recycling system in several provinces, achieving an up-to-scale amount of plastic takeaway boxes recycled and "reshaped for new purposes".

Recycling Exploration by Multi-Scenarios

The pilot projects were launched in areas that were identified through data as feasible areas for recycling given their high volume of orders. The company has carried out more than 1,200 waste sorting and plastic takeaway box recycling pilot projects in Beijing, Shanghai, Guangzhou and other provinces and cities, covering seven types of scenarios, including cities, campuses, communities, office buildings, restaurants and scenic spots. The recycled plastics were made into bicycle fenders, calendar cases, business cards, key chains, etc.

Recycling Demonstration Practice at the City Level

In March 2021, the first city-level takeaway box recycling pilot project was launched in Xia'men, with an annual recycling rate of about 30% of Xiamen's plastic reduction from takeaway packaging; the project has covered four districts, eight streets and more than 1,000 communities and units in Xia'men.

Local Intelligent Recycling Paths

A "recycle at the door" function for plastic takeaway box was launched in Shanghai's demonstration project, where consumers could reserve and place door-to-door recycling orders via the takeaway APP- waste sorting - recycling reservation portal, so that their used plastic takeaway boxes would be collected and recycled. At the same time, the pilot communities also put in front-end intelligent recycling collection bins where consumers can go there to drop off their takeaway boxes.

Enhance recycling of waste mulch film by upgrading raw material

At present, mulch film is widely used in agricultural production, covering corn, potato, rice, cotton, tomato, tobacco and other crops, and plays an important role in ensuring food security and increasing farmers' income. However, due to the low performance on strength and aging resistance, the traditional mulch film breaks into scraps after harvest, which result in poor recyclability and causing serious plastic pollutions.

By introducing advanced raw materials, as known as the high-performance metallocene polyethylene (mPE), the performance of mulch film has been significantly improved, including strength, toughness and other properties. Through the mulching experiment of 300,000 mu of cotton fields in Kashgar, Xinjiang Uygur Autonomous Region, the recycling rate of the waste mulch film climbed to more than 90%, after 6 months of use, which is 30% higher than the traditional mulch film. At the same time, through the cooperation of the industrial chain, the utilization of recycled mulch film has been achieved, and the "white plastic pollution" has been turned into a "green renewable resource", which has fundamentally solved the problems of agricultural plastic pollution while increasing production and farmers' income. The recyclable mulch film made a great contribution to the sustainable development of agriculture.

3.3.5 Recycling and utilizing plastic waste

At present, plastic waste is mainly recycled in two ways: physical recycling and chemical recycling. Physical recycling[24] is the best choice for the disposal of waste plastic products. This method is simple and feasible and is mainly used to recycle cleaner waste plastics with single composition. Chemical regeneration[24] is mainly for plastic waste that is difficult to be physically recycled, such as plastic film waste, which can realize the recycling of resources, effectively improve the efficiency of plastic waste disposal and reduce the environmental pollution caused by landfills and incineration, and with chemical regeneration technology, companies can manufacture products of the same quality, and this is one way to realize the high-value valorization of plastic waste.

Making the Best Use of Plastic Through Cooperation Across the Whole Industry Chain

It is necessary to implement the concept of green, low-carbon and circular development and promote recycling and reutilization of waste plastic. To develop a circular economy for plastic is the critical path to achieve sustainable development of the plastic value chain as well as the optimum solution to plastic pollution control.

Wide Recycling Network Established

As the world-leading manufacturer and solution provider of advanced materials, the company has been dedicated to recycling plastic waste and providing integrated solutions to a circular economy for plastic since 2004. Collaborating closely with hundreds of waste collection partners globally, the company has been actively participating in collecting waste plastic feedstock from municipal waste, industry waste, agriculture waste, hazardous waste and marine waste, no matter small items such as waste beverage bottles or large items such as scrapped refrigerators and vehicles, among others. Upon preliminary sorting, the waste plastic will be sent to the pretreatment factories for series of technical process, including but without limitations, in-depth sorting, washing, pelletizing and modification. The waste plastic therefore will be renewed and turned into new green materials.

Downstream Utilization of Recycled Plastic Expanded

Currently, the company provides more than 10 categories of environmentally-friendly high-quality recycled plastics for the world every year, including rPP, rPE, rABS, rPC, rPS, rPA, rPET, rPBT, among others. These recycled plastics are applied widely to downstream sectors such as household electrical appliances, packaging (consumer goods, supermarkets, logistics, E-commerce, etc.), household products (furniture), textiles, automobiles, IT, electronics, electrical tool, construction, energy, etc. Company's solution, making the best use of plastic, aims to recycling plastic waste through a circular business model, and facilitating brand owners both in China and abroad in implementing their mid-long term sustainability strategies.

Contribution to Resource Conservation and Environmental Protection Achieved

Making the best use of plastic, not only prevents the plastic waste from leaking into the environment, but also saves them from landfills and incineration, synergizing economic benefits, environmental contribution and social effects. From 2004 to 2020, thw company provided more than 1.2 million tons of recycled plastic for the world in total, compared to virgin materials, approximately cutting back on the use of petroleum in the amount of 6.2 million tons and saving 1.68 million tons of coals, reducing the CO_2 emission by 1.52 million tons, saving 5.6 billion kWh of electricity and 80 million tons of water.

23. Physical recycling of plastic waste (also known as physical recycling or physical recovery) refers to the physical processing of pretreated waste plastics into recycled raw materials by physical means such as melting granulation, which is generally divided into melting regeneration and modified recycling.
24. Chemical regeneration of plastic waste (also known as chemical recycling or chemical recovery) refers to the use of chemical technology to convert plastic waste into resin monomer, oligomer, cracking oil or syngas, which can be divided into pyrolysis recovery method and chemical decomposition recovery method.

3.3.6 Processing energy recovery for plastic waste

Plastic waste that cannot be recycled as raw material will enter the domestic waste treatment system. These mixed plastics are difficult to sort, clean, and recycle under the existing technical, and can only be incinerated to generate energy. Through incineration, it can significantly reduce the amount of plastic waste accumulation and landfill land occupation, so that the waste plastic capacity reduction of 90%-95%[25]. But at the same time, the plastic waste in domestic waste also contains a small amount of polyvinyl chloride, polyacrylonitrile, etc., these plastics in the combustion of harmful substances and greenhouse gases, how to do a good job in the incineration process is also critical to control pollutants.

3.3.7 Strengthening the guidance on green consumption and education on eco-friendly lifestyle

The treatment of plastic pollution also calls for extensive participation of the public. China has always strengthened the promotion and guidance of consumer behavior and green education in plastic pollution control. As early as 2007, after the launching of China's plastic pollution control policy, the public has been suggested to use environmentally friendly cloth bags and reduce the using of plastic products. In 2020 after the launching of the new version of the plastic pollution control policy, a variety of green consumption week, DIY environmental protection bags, environmental protection bag design competition and other types of activities are numerous, so that the green concept of environmental protection to spread. In addition, to cultivate the successor of green consumption, ecological and environmental protection propagandists and practitioners, many schools to carry out "Plastic pollution control" publicity activities, so that the concept of green consumption could be passed on from generation to generation.

25. Reference: Hou Caixia. Study on degradation of plastics by supercritical water [D]. Tianjin: Tianjin University, 2003.

4.

Plastic Pollution Contol System and Accomplishments in China

After decades of efforts, China has established a relatively sound plastic recycling system through the development of a circular economy and the control of plastic pollution from its whole life cycle, with a great many accomplishments.

4.1 Plastic Pollution Control System in China

The Chinese government has introduced a series of incentive measures such as investment, finance and taxation to standardize and guide the recycling of plastic waste and promote the green, low-carbon and recycling development of the plastics industry. With the promotion of the government, enterprises and wide public participation, a wide range of recycling systems have been formed.

4.1.1 Formulating laws and regulations on plastic pollution control

(1) Incorprating the plastic pollution prevention and control into the fundamental law of the environment.

The Environmental Protection Law of the people's Republic of China and the Law of the people's Republic of China on the Prevention and Control of Environmental pollution by solid waste include the treatment of plastic pollution from the point of view of protecting the water environment, prohibiting the active provision of disposable plastic products, and encouraging the optimization of packaging.

(2) Promulgating departmental regulations and rules on plastic pollution control departments for key sectors.

The Chinese government has issued Measures for the Management of Packaging for the Delivery Industry, Measures for the Management of Agricultural Film and Measures for the Recycling and Disposal of Pesticide Packaging Wastes in the agricultural sector, and Regulations on pollution Prevention and Control of Waste Plastics Processing and Utilization in the industrial sector.

4.1.2 Improving standard system on the plastic pollution control constantly

(1) Improving the standards on the design and production of plastic products.

The Chinese government have formulated a series of national standards for ecological design, such as "General principles for Evaluation of Ecological Design products", "General principles for Evaluation of Electronic and Electrical Ecological Design products", "General principles for Ecological Design Product Identification" and "General principles for Design and Evaluation of easy Recycling and Renewable plastic products", in order to improve the recovery rate of plastics.

(2) Improving the standard on the recycling and utilization of plastic waste.

Chinese government have formulated the Technical Specification for Recycling and Utilization of waste Plastics, part 1 of recycled Plastics: general principles, and Technical specifications for pollution Control of recovery and Recycling of waste Plastics (for trial implementation). Specific requirements are put forward for environmental protection-related matters in the process of recycling and recycling of waste plastics.

4.1.3 Introducting incentive policies and measures to control plastic pollution

(1) Formulating financial policies on plastic recycling.

The Chinese government launched financial subsidies for the construction of plastic waste recycling projects and domestic waste collection and incineration facilities and subsidizes the price of electricity generated from the incineration of plastic waste and other domestic waste. The government has introduced the Guidelines for Issuing Green Bonds and Green Credit Guidelines to give priority to relevant environmental projects for financial support such as issuing bonds.

(2) Formulating preferential tax policies on plastic recycling.

The Chinese government has issued the Catalogue of Preferential Value-Added Tax for Products and Services for Comprehensive Utilization of Resources, granting a larger scale of preferential policy of immediate VAT refund for recycled plastics and other related products; and the Catalogue of Preferential Income Tax for Enterprises for Comprehensive Utilization of Resources, reducing the amount of income tax paid by enterprises in this industry.

4.1.4 Formulating the joint mechanism among the government, enterprises, and the public

(1) Government departments are responsible for overall planning and developing infrastructures.

Chinese government has formulated documents such as Opinions on Establishing a Complete and Advanced Recycling System for Used Goods and Guiding Opinions on Accelerating the Development of the Renewable Resources Industry to promote the construction of waste recycling systems. Under the guidance of the national and local governments at all levels, a relatively complete recycling system has been constructed with an integrated urban and rural waste collection and treatment system of "waste collected across villages, transferred through towns and treated in county level". The system can help with domestic waste removal and disposal, effectively preventing plastic waste from leaking.

(2) Enterprises are responsible for the whole life cycle control of plastic pollution.

Enterprises shall follow national regulations and rules in carrying out R&D and the innovation of alternative products and packaging in manufacturing plastic products. In circulation phase, enterprises shall stop offering disposable plastic shopping bags, etc. In the recycling phrase, enterprises are encouraged to build plastic waste recycling facilities, invest more on the R&D of recycled plastic production technology to reduce the risk of environmental leakage of plastic waste.

(3) The public are encouraged to participate in green consumption and garbage segregation.

The public is the practitioner of plastic pollution control, and more and more consumers voluntarily choose environmentally friendly products, bring their own toiletries when traveling, and refuse to over-package goods. The new trend of green consumption has therefore been gradually formed. In daily life, the generally public voluntarily sorts the garbage, litter plastic waste into designated bins , and give recyclable plastic waste to specialized recyclers, helping to recycle plastic waste.

4.2 Accomplishments of plastic pollution control in China

4.2.1 China has built the large-scale plastic waste recycling system with extensive coverage

China has established a comprehensive waste plastics recycling system consisting of recycling outlets, sorting centers and processing and utilization plants, and has made use of the Internet, the Internet of Things and other technological innovations in recycling models to promote the integration between the waste separation network and the recycling network. Remarkable results have been achieved. At present, China has the largest waste plastics recycling capacity in the world, and the number of enterprises engaged in waste plastics recycling and reclamation exceeds 15,000, with about 900,000[26] employees. In recent years, the average annual growth rate of waste plastics recycling in China has been remaining at a consistent 2.5%. In 2021, China produced about 62 million tons of waste plastics, of which the materialized recycling volume was about 19 million tons, 31% of that has been recycled as materials, which is nearly 1.74[27] times of the global average recycling rate (Figure 4-1). China's recycling capacity in this regard accounts for about 70% of the world. In 2018, the recycling rate of local plastic waste in the U.S. was only 5.31% and that in EU was only 17.18%. The number of Japan in 2019 was 12.50%[28] with the total amount of materialized waste was 7.78 million tons, and China's total materialized waste was 2.43 times of that in 2019.

4.2.2 A comprehensive recycling system for plastic waste has been established

China has established a comprehensive waste plastic recycling system, covering from low-value products such as flowerpots and garbage cans to high-value products such as home appliances and automobiles, so that recycled plastics are widely used in textiles, automobiles, packaging and many other areas. Different types of plastic wastes are used in different ways: firstly, we use physical regeneration methods to process plastic wastes into recycled plastics with the same or similar properties as virgin plastics for product production, such as the "bottle to bottle" utilization of waste beverage bottles; secondly, we use certain processing methods for some waste plastic products that are heavily polluted and difficult to clean. Plastic products, using certain processing methods, are processed into recycled plastics with slightly lower performance than virgin plastics, which are used to produce some relatively low-end products, such as flowerpots and garbage cans; again, the chemical components in the recy-

26. Source: Research Report on Employees in Recycled Plastics Industry, China material Recycling Association, 2022.
27. Source: China recycled Plastics Industry Development report, China material Recycling Association, 2022.
28. Source: China Recycled Plastics Industry Development report, Chins National Resources Recycling Association, 2022; Data Analysis Report on European Plastic Production, Demand and Waste (2020) / Plastics Europe; Ministry of Environment website (epa.gov) / US Bureau of Statistics US Census Bureau; Plastic Products, Waste and Resource Recycling in Japan2019, Japan Plastics Recycling Association (PWMI).

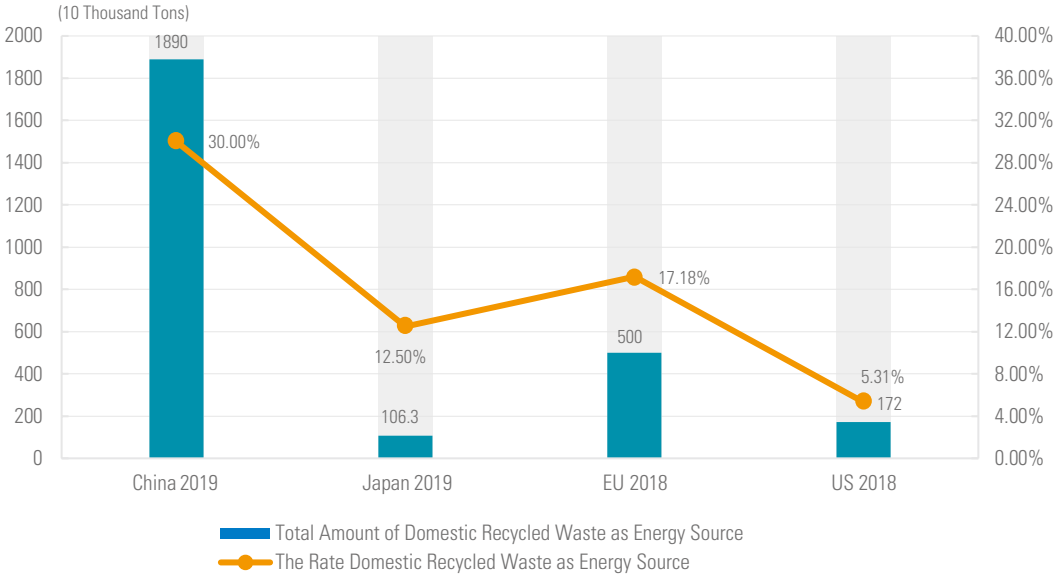

Figure 4-1. Comparison of Domestic Material Recovery Between China and Other Countries

Source: China Recycled Plastics Industry Development Report, Chins National Resources Recycling Association, 2022; Data Analysis Report on European Plastic Production, Demand and Waste (2020) / Plastics Europe; Ministry of Environment website (epa.gov) / US Bureau of Statistics US Census Bureau; Plastic Products, Waste and Resource Recycling in Japan2019, Japan Plastics Recycling Association (PWMI).

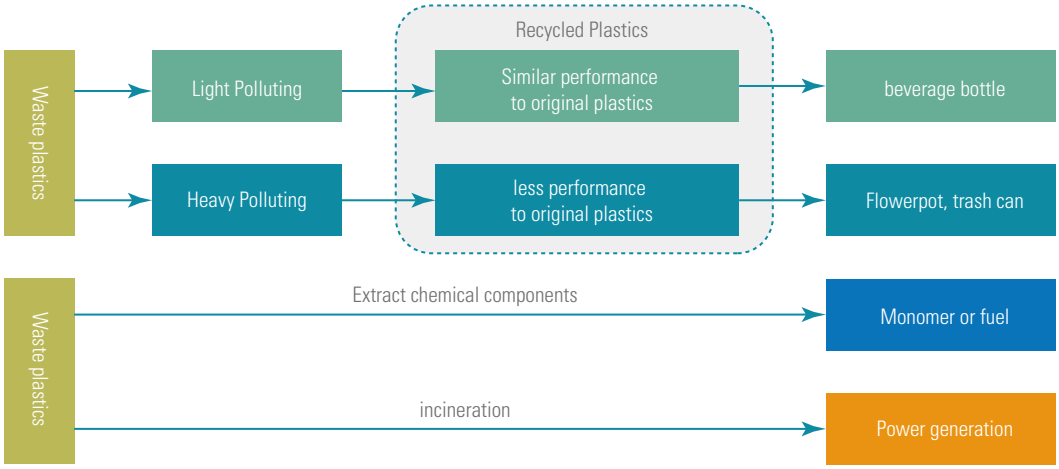

Figure 4-2. Differentiated Recycling of Waste Plastics

cled plastic waste are extracted to make them into monomers or fuels; finally, the energy in waste plastics is directly used for incineration and power generation through waste incineration(Figure 4-2).

Since 2016, China's solid waste incineration facilities in municipal levels have increased year by year, with the increasing daily processing capacity. As shown in Figure 4-3, the number of municipal solid waste incineration facilities has increased from 249 in 2016 to 463 in 2020, nearly doubled. The incineration capacity increased from 255,850 tons/day to 567,804 tons/day, increased by 1.2 times. The improvement of processing capacity has significantly increased the incineration treatment capacity of municipal solid waste. In the past five years, the incineration treatment capacity

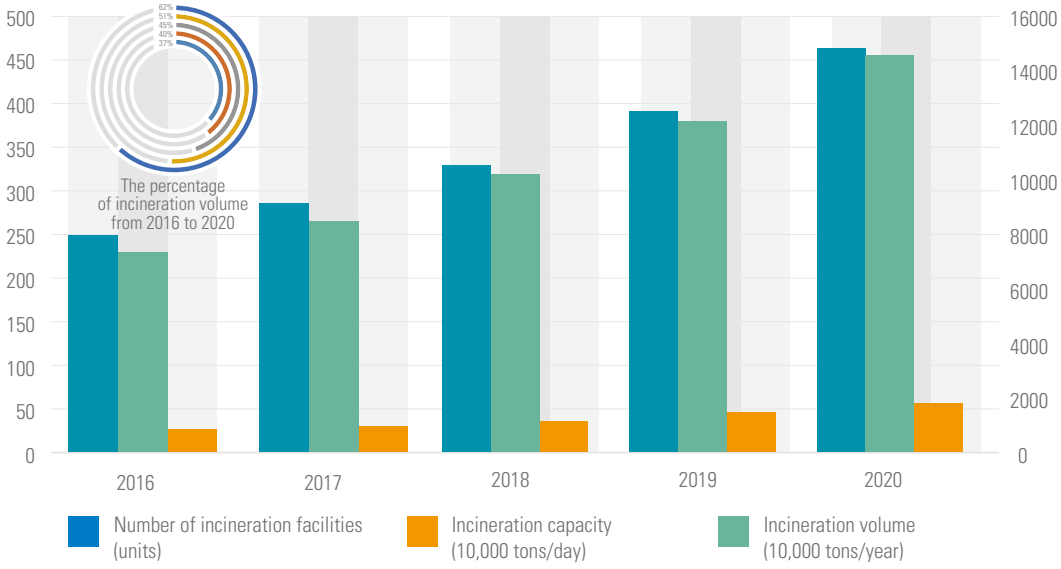

Figure 4-3. Statistics of Waste Incineration Facilities in China in 2016-2020 (Counties Not Included)

Note: The percentage of incineration volume in the calendar year is calculated according to the proportion of the actual treatment volume.

Source: Ministry of Housing and Urban-Rural Development Urban Construction Statistical Yearbook (2016-2020)

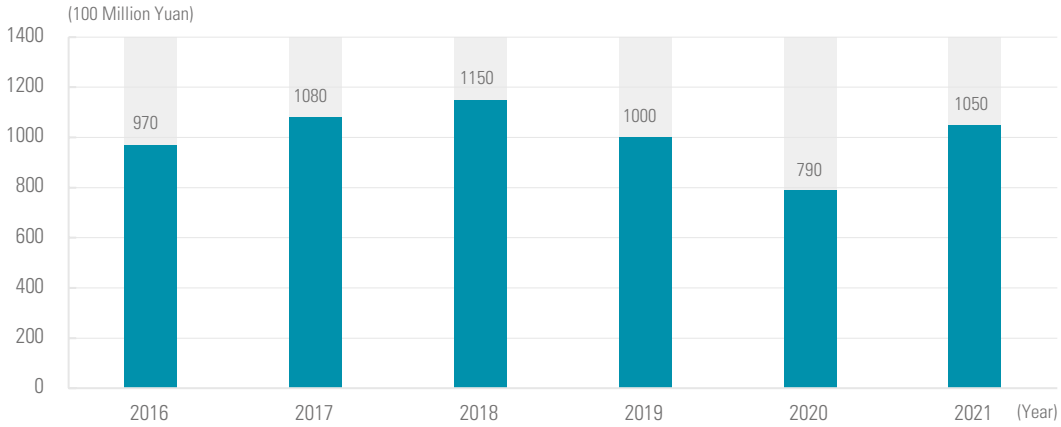

Figure 4-4. Recycling Value of Waste Plastics in China from 2016 to 2021

Source: Recycled Plastics Division of China National Resource Recycling Association, The Ministry of Commerce of the People's Republic of China

has increased from 73.78 million tons per year to 146.08 million tons per year, with a compound annual growth rate of about 30%. In 2020, the proportion of municipal solid waste incineration has reached 62.29% (see Figure 4-3). According to China Plastic Recycling Association's calculations, Among them, the annual energy utilization of plastic waste reached 27.4 million tons, and the energy utilization rate was 45.7%.

With the continuous improvement of China's plastic recycling industry, the output value of waste plastic recycling is also increasing. In 2019, the output value of waste plastics recycling in China reached 100 billion yuan; in 2021, that number reached 105 billion yuan, an increase of 33%[29] over the same period last year(Figure 4-4).

29. Source: China Recycled Plastics Industry Development Report, China National Resource Recycling Association, 2022

4.2.3 The utilization of recycled plastics effectively reduces the consumption of fossil raw materials

Plastic waste could be resources and also pollutants. If effectively recycled, it could be the recycled resource. If not handled properly, it will become pollutants. Therefore, we need to recycle the plastic waste in a practical way, "turning waste into treasure". This can transform waste into resources, and made great contribution to the economic and social development, thereby reducing the excessive consumption of non-renewable natural resources such as oil by humans.

From 2016 to 2020, China has recycled a total of 108 million tons of waste plastics, with a total value of more than 600 billion yuan. If we calculate that recycling 1 ton of waste plastics is equivalent to saving 3 tons of oil, China has saved 330 million tons of oil extraction and consumption[30]. At the same time, China also treated a large amount of plastic waste from other countries. Since 1992, China has imported and recycled 106 million tons of waste plastics[31], saving the world 318 million tons of crude oil extraction and consumption(see Figure 4-5).

4.2.4 Reducing pollutants and carbon dioxide emissions

The recycling of waste plastics can reduce crude oil consumption, solid waste generation, and emissions of pollutants such as CO_2, SO_2, and sewage. According to the relevant ratio conversion[32,33] (see Figure 4-6), China has recycled a total of 170 million tons of waste plastics of all kinds from 2011 to 2020, which is equivalent to a total reduction of 510 million tons of crude oil consumption, 0.9 billion tons of solid waste emission and 61.2 million tons of CO_2 emission.

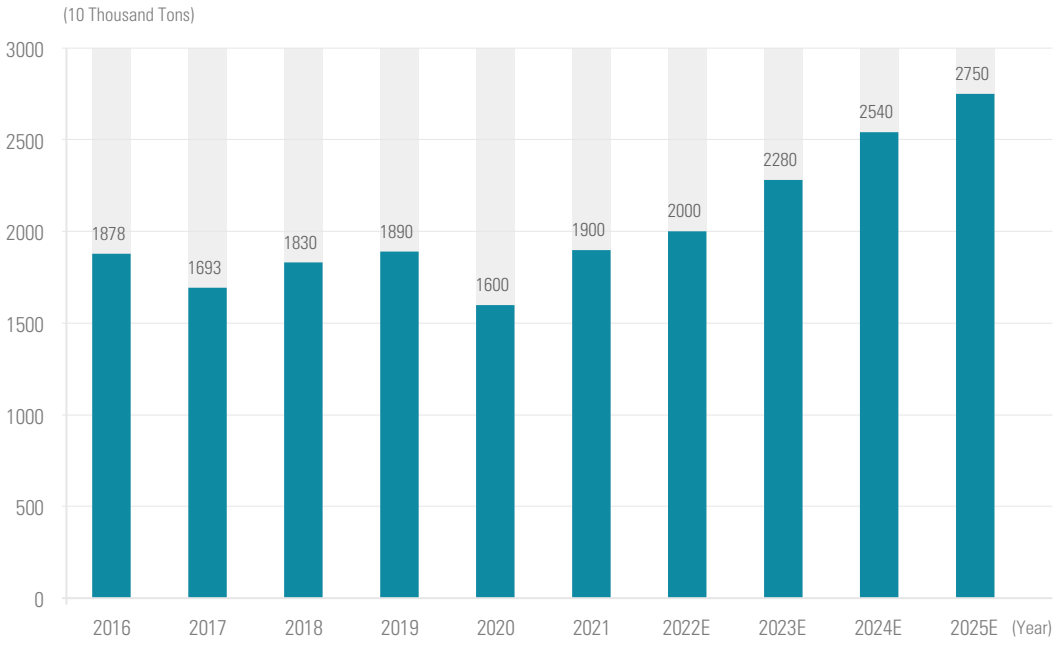

Figure 4-5. 2016-2025 Waste Plastics Recycling Quantity in China
Source: China National Resource Recycling Association

30. Source: The Ministry of Commerce of the People's Republic of China
31. Source: The Public data of major countries in the world and customs statistics of the People's Republic of China
32. Dai Tiejun. Recycling and management of packaging waste [M]. Beijing: science and Technology Press, 2016.05
33. Zou Qizhi. Study on emission reduction measures of waste paper and papermaking enterprises [J]. Resource Conservation and Environmental Protection, 2014 (06): 33-34

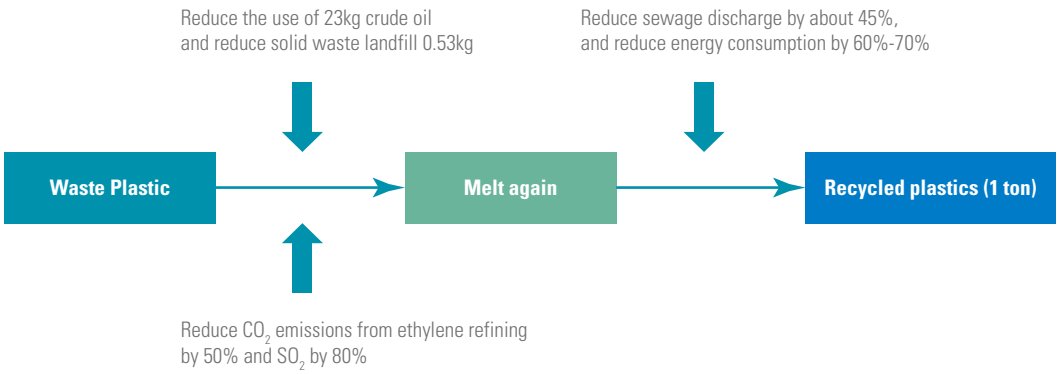

Figure 4-6. Emission Reduction in the Production of Recycled Plastics

Source: Zou Qizhi. Study on emission reduction measures of waste paper and papermaking enterprises[J]. Resource Conservation and Environmental Protection, 2014(06):33-34

5.

Experience from Plastic Pollution Control in China

China has gradually found an effective way to solve plastic pollution through the development of plastic circular economy. Its practice and experience have important inspiration and reference value for further improving and strengthening plastic pollution control and promoting global cooperation in plastic pollution control.

5.1 It is Necessary to Establish a Sound Life Cycle Management System to control plastic pollution

The treatment of plastic pollution is a complex system engineering, which involves multiple procedures such as product design, production, circulation, consumption, collection, treatment, recycling and so on.

(1) It needs to be recognized that the reduction and replacement of disposable plastic products is only one part of life cycle management.

At present, the laws and regulations on disposable plastic products issued by most of countries are beneficial and necessary in solving the plastic pollution. However, it must be recognized that the proportion of disposable plastic products in the whole plastic industry system is relatively low, and its reduction and replacement is only a part of the whole life cycle treatment of plastic pollution, and its contribution to plastic pollution control is limited.

(2) A comprehensive infrastructure for end collection and disposal of plastic waste is the key to the prevention and control of plastic pollution.

The treatment of plastic pollution needs to establish a comprehensive management system from the design and production of plastic products to end disposal and utilization, but the construction of effective collection and disposal facilities of plastic waste can directly prevent the plastic waste leakage. Therefore, countries should give priority to the construction of plastic waste collection and disposal facilities in the treatment.

5.2 To Develop Plastic Recycling Economy Calls for Home-based Recycling System

There are many kinds of waste plastics and various ways of utilization and disposal, so it is necessary to establish a perfect recycling system for all kinds of waste plastics.

(1) Plastic waste recycling system calls for continuous improvement.

We need to gradually improve the traditional recycling model based on private recycling, promote standardized recycling led by corporates, and take good advantage of new technologies such as the internet, intelligent recycling machines, intelligent sorting new equipment to try new recycling models and improve recycling efficiency, reduce recycling costs, strengthen the flow of waste plastics management, and improve the modernization of the recycling system.

(2) Recycled plastics grading is the key to improving recycling rates.

With proper technologies and financial support, conducting different grades of waste plastics recycling system will realize a full utilization of specific species, but also realize the differentiated utilization of waste plastics in wood plastic, express packages and other products for the best end application. In the way, the recycling rate of plastic products across the society could be effectively improved.

(3) The sorting of plastic wastes should base on its end disposal and utilization.

Plastics contained in consumers electronics, automobiles and other products should be separated before recycling. For the separated and individual plastic products such as beverage bottles and plastic lunch boxes, they should be taken as recyclables, and a perfect recycling system should be established to realize the classified recycling of these waste plastic products. For the hybrid plastics that are seriously polluted and difficult to sort, energy utilization is still a better way, and there is no need for classified recycling.

5.3 The Development of Circular Economy for Plastic Requires Comprehensive Consideration of Environmental and Economic Benefits

When developing circular economy for plastic, only considering environmental and economic benefits can we achieve sustainable development.

(1) It is necessary to establish a sustainable development model of circular economy for plastics.

In developing plastic circular economy, the economic benefits can help to stimulate stakeholders. The development model that only pursues environmental benefits while ignoring economic benefits is not sustainable. However, at the same time, it is necessary to establish a value compensation mechanism through levying funds and giving subsidies to ensure that the recycling behavior of stakeholders is economic and encourage the recycling of waste plastics with little economic value.

(2) Technological innovation is the key to waste plastics recycling.

Whether the waste plastics can be recycled or not depends to a large extent on the breakthrough of recycling technology, including technology and equipment for high-value utilization of recycled plastics, development and application of green modifiers, pollution prevention and control in the process of waste plastic regeneration, energy utilization and pollution prevention of low-value waste plastics can significantly improve waste plastics recycling, and achieve the balance between economic and environmental benefits to promote the development of plastic recycling economy.

5.4 Developing Circular Economy for Plastic Requires Scientific Comparative Analysis of Various Plastic Substitute Products and Schemes

Every new scheme and technology need its life cycle analysis to ensure that it will generate new pollution in the process of plastic pollution treatment.

(1) Chemical recovery still needs to further analysis on its sustainable business models and product solutions.

Under current conditions, chemical recycling is more costly than physical recycling. Therefore, physical recycling is still the best choice for those categories that are suitable. For other categories that physical recycling is not an option, chemical recycling technology should be carefully carried out after the classification of plastic waste by material at the source and to explore a reasonable and feasible commercial operation model. In addition, the comprehensive economic and environmental benefits of plastic waste recycling technology routes that simply use fuel oil as a product still needs scientific evaluation.

(2) Alternative products still need scientific comparative analysis.

At present, to reduce the use of disposable plastics in consumption, there are many alternative products made of paper, bamboo, and other materials. However, there are still space to improve for alternatives in many aspects such as technical feasibility, economics, and scalability. Compared with the use of plastic products, there is a need for a scientific comparison and analysis of various alternatives and programs, both in terms of economics and life-cycle environmental impact, including post-waste disposal.

(3) The use and popularization of biodegradable plastics need scientific proof.

At present, biodegradable plastics natural can't be completely degraded under natural conditions, which means its management process and cost structure are no different from ordinary plastics. In addition, biodegradable plastics mixed into ordinary plastics can make the ordinary plastics unable to be recycled. Therefore, biodegradable plastics should be assessed throughout the life cycle to determine where and under what conditions they should be used.

5.5 The Development of A Circular Economy for Plastics Calls for Cooperation between Government and Enterprises and a Holistic Participation

It is necessary to gather the government and enterprises to develop plastic circular economy and carry out plastic pollution control.

(1) The government should be the regulator and promoter of a circular economy for plastics.

The government needs to promulgate relevant laws and regulations on the treatment of plastic pollution, formulate product ecological design standards, strengthen the construction of long-term mechanisms such as the extension of producer responsibility, and introduce relevant supporting policy systems. and take practical measures to encourage and support the construction of relevant projects to provide necessary conditions for the development of plastic circular economy.

(2) Enterprises should take the initiative in developing the circular economy of plastics.

Plastic products manufacturers should take the initiative to reduce the use of plastic microbeads and bear in mind the principle of "easy to recycle, easy to regenerate" in design; For plastic products using enterprises, it is necessary to develop disposable plastic products and reduce the using of alternatives, while increasing the use of environmentally friendly products. Plastic recycling enterprises should accelerate the construction of a comprehensive waste plastic recycling system, innovative recycling technology and mode.

(3) The general public should be engaged in the circular economy for plastics.

Consumers should take the initiative to reduce the use of disposable plastic products and actively participate in garbage sorting. In addition, the vast number of social organizations and news media should become propagandists of plastic circular economy and popularization of related knowledge, so as to improve the scientific understanding of plastic problems from all walks of life.

5.6 The Plastic Pollution Control Calls for Extensive International Cooperation

No country can be left aside in the face of plastic pollution, and it is necessary to strengthen international exchanges and cooperation to help less developed countries and regions establish a plastic circular economy system as soon as possible.

(1) All countries shall establish their own plastic recycling and disposal system as soon as possible.

Building the holistic recycling system based on domestic recycling model can help reduce recycling costs and improve the recycling rate of waste plastics. Therefore, countries, especially developed countries and regions, shall gradually change the traditional practice of simply collecting plastic waste and exporting it to other countries and regions, and instead realize local recycling and scientific disposal of plastic waste within the country or region.

(2) It is necessary to pay close attention to the underdeveloped countries and regions with weak plastic recycling infrastructure.

Some less developed countries and regions don't have sound plastic waste collection and treatment facilities, and the plastic recycling rate is relatively low, the risk of environmental leakage is high, becoming the weak part of global plastic pollution management. Therefore, "plastic waste" should be prohibited to these countries and regions that do not have better recycling conditions for export. At the same time, developed countries and international organizations should give them appropriate help in terms of funding, technology, management and human resources.

(3) Build a global monitoring and evaluation system for the flow of plastic waste.

We should speed up the construction of a global monitoring and evaluation system for the cross-regional flow of plastic waste, and with the help of material flow analysis method, quantitatively and dynamically track the international flow of plastic waste in order to carry out effective evaluation of the disposal and utilization of plastic waste in various countries and predict future development trends and solve problems as timely as possible.

6.

Initiatives on Enhancing Global Control of Plastic Pollution Control

At present, countries are facing increasingly serious plastic pollution problem, especially the marine plastic pollution and it has increasingly become the focus of the world's environmental protection, bringing great challenges to the sustainable development of mankind.

According to a report released by the United Nations Environment Programme in 2021, of the approximately 9.2 billion tons of plastic produced globally between 1950 and 2017, about 7 billion tons became plastic waste, and the recycling rate of plastic was less than 10%. The annual production of plastic waste worldwide is about 300 million[34] tons, and a large amount of plastic waste leak into the soil and the sea, eventually causing white pollution and posing a serious threat to ecological protection and biodiversity.

Plastic pollution is a common challenge facing mankind, and no country can be left alone. Therefore, it is necessary to establish a sense of a community with a shared future for mankind, and the whole world should unite to take actions on it, so as to build a "plastic pollution control community" with the extensive participation of countries.

To this end, we'd like to propose the following initiatives:

1. *We believe that the essence of plastic pollution is the leakage into environment. Plastic itself is not a pollutant, and the focus of plastic pollution control is the recycling and disposal. But at the same time, we also realize that the whole life cycle management of plastics pollution is an important way to reduce the pressure of plastic end disposal.*
2. *We have observed that the global plastic pollution has been accumulating for many years and transferred across regions. Therefore, countries need to take immediate action not only to effectively control the current plastic waste, but also to take effective measures to control the historical plastic waste.*
3. *We believe that global plastic pollution control requires all countries to take immediate action to enhance their facilities on plastic waste collection, disposal and recycling to prevent plastic waste from leaking into the environment.*
4. *We believe that in developing plastic recycling economy, we should give priority to recycling waste plastics into raw materials and then energies, and finally the standardized landfill disposal. Random disposal of plastic waste should be strictly prohibited.*
5. *We believe that plastic pollution and control require extensive international cooperation and encourage all countries, including the private sector, to strengthen regional, national and local bilateral and multilateral cooperation among all stakeholders.*
6. *We believe that countries should exercise reasonable control over the cross-border transfer of plastic waste, and exporting countries should ensure that the receiving countries of plastic waste have sound disposal infrastructure and conditions to avoid secondary pollution, and provide support or assistance to the receiving countries when necessary.*
7. *We advocate that each country and region should formulate and introduce special laws and regulations and action plans for plastic pollution control according to their national conditions, put forward the milestones of plastic pollution control, and take effective actions for it.*
8. *We believe that to effectively deal with global plastic pollution control, developed countries and regions need to give necessary financial, technological and human resources support to less developed countries and regions in terms of infrastructure construction and management capacity enhancement.*
9. *We believe that plastic pollution, especially marine plastic pollution, requires the establishment of a scientific monitoring and assessment system to make scientific judgments on the formation and cross-regional flow of plastic pollution and to guide the scientific implementation of global plastic pollution control.*
10. *We believe that the global plastic pollution control needs to summarize the successful experiences and practices of various countries in a timely manner, form case studies and action guidelines for reference of each country and region and improve the comprehensive capacity of each country and region in plastic pollution control.*

34. Source: United Nations (UN) Environment, *Beat Plastic Pollution,* 2018, https://www.unenvironment.org/interactive/beat-plastic-pollution/.

Conclusion

At present, plastic pollution has become a global environmental problem second only to climate change, and has attracted great attention from various countries and regions. After decades of continuous exploration and efforts, China has explored a "Chinese solution" to plastic pollution management through the development of plastic recycling economy, making an important contribution to global plastic pollution management. However, we should also see that plastic pollution control is a complex system engineering, plastic pollution control still has many shortcomings and needs to be improved and enhanced, plastic pollution control needs more countries and regions to join, plastic pollution control is still a long way to go.

However, we also firmly believe that as long as all countries in the world cooperate and actively participate, the plastic pollution problem will be effectively solved in the near future, and the vision of sustainable development in which people and nature live in harmony will be realized!

Reference

[1] Dees J P, Ateia M, Sanchez D L. Microplastics and their degradation products in surface waters: A missing piece of the global carbon cycle puzzle[J]. ACS ES&T Water, 2020,1:214-216.

[2] From Pollution to Solution: a global assessment of marine litter and plastic pollution[R]. United Nations Environment Programme, 2021.

[3] Han Lizhao, Wang Tonglin, Yao Yan. Study on the present situation and Control Countermeasures of White pollution[J]. Population, Resources and Environment of China, 2010 20(S1):402-404.

[4] Horton A A, Walton A, Spurgeon D J, et al. Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities[J]. Science of the Total Environment, 2017,586:127-141.

[5] Hou Caixia. Study on degradation of plastics by supercritical water[D]. Tianjin: Tianjin University, 2003.

[6] Landrigan P J, Stegeman J, Fleming L, Allemand D, Anderson D, Backer L, et al. Human health and ocean pollution[J]. Annals of Global Health, 2020,1:1-64.

[7] Lau W, Shiran Y, Bailey R M, et al. Evaluating scenarios toward zero plastic pollution[J]. Science (New York, N. Y.), 2020,369(6510):1455-1461.

[8] Ma Zhanfeng, Jiang Wanjun. China Plastics processing Industry (2020)[J]. China Plastics, 2021 and 35 (05): 119-125.

[9] Macleod M, Arp H, Tekman M B, et al. The global threat from plastic pollution[J]. Science (New York, N. Y.), 2021,373(6550):61-65.

[10] Ministry of Industry and Information Technology, Development and Reform Commission and Ministry of Environmental Protection. Guidance on developing ecological design of industrial products[R]. Department of Energy Saving and Comprehensive Utilization, Ministry of Industry and Information Technology, 2013.

[11] Plastics - the Facts 2020: An Analysis of European Plastics Production, Demand and Waste Data[R]. Plastics Europe Association of Plastics Manufactures, 2020.

[12] Recycling of plastic products, wastes and resources in Japan 2019[R]. Japan Plastics Recycling Association

[13] Report of Plastic Recycling Industry in China (2019-2020)[R]. Recycled Plastics Association, China National Resources Recycling Association, 2020.

[14] Report of Plastic Recycling Industry in China (2020-2021)[R]. Recycled Plastics Association, China National Resources Recycling Association, 2021.

[15] Report on employees in recycled plastics industry[R]. China National Resources Recycling Association, 2022.

[16] United Nations (UN) Environment. Beat Plastic Pollution[EB/OL]. https://www.unenvironment.org/interactive/beat-plastic-pollution/.

[17] Wangliming. Development of recycling and utilization technology of waste household appliance plastics[EB/OL]. https://zhuanlan.zhihu.com/p/354754130, 2021/3/5.

[18] Yu Y, Yang J, Wu W M, et al. Biodegradation and Mineralization of Polystyrene by Plastic-Eating Mealworms: Part 2. Role of Gut Microorganisms[J]. Environmental Science & Technology, 2015,49(20):12087-12093.

[19] Zheng Qiang. Discussion on Plastics and “White pollution”[EB/OL]. https://mp.weixin.qq.com/s/qLPyAVI2xt49-QiUCOHdPA, 2021/11/19.

Appendix

Excerpts From the Summary of Chinese Regulations and Policies Regarding to Plastic Pollution Control Cver the Years

Type	Formulated/Revised Time	Policy Document	Main content
Laws and Regulations	Formulated in December 1989 Revised in April 2014	Environmental Protection Law of the People's Republic of China	The State Council and local people's governments at all levels in coastal areas shall strengthen the protection of the marine environment. The discharge of pollutants into the ocean, dumping of wastes, and construction of coastal and marine engineering shall comply with laws, regulations and relevant standards to prevent and reduce pollution and damage to the marine environment. The state encourages and guides citizens, legal persons and organizations to use products that are conducive to protecting the environment and recycled products to reduce the generation of waste. Local people's governments at all levels shall take measures to organize the classified disposal and recycling of domestic waste.
	Formulated in October 1995 Revised in April 2020	Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste	Any entity is prohibited from dumping, stacking and storing solid wastes on rivers, lakes, canals, channels, reservoirs and their floodlands and bank slopes below the highest water level, as well as other locations specified by laws and regulations. The local people's government at or above the county level shall speed up the establishment of a household waste management system for classified release, classified collection, classified transportation, and classified treatment, so as to realize the effective coverage of the domestic waste classification system. Any entity shall dump domestic waste at designated places in accordance with the regulation. It is forbidden to dump, scatter, pile up or burn domestic waste at will. Entities that produce agricultural solid waste such as straw, waste agricultural film and pesticide packaging wastes shall take recycling and other measures to prevent environmental pollution. E-commerce, express delivery, food takeaway and other industries should prioritize reusable and easy-to-recycle packaging materials, optimize the packaging, reduce the use of packaging materials, and voluntarily recycle the packaging materials. According to the law, the state prohibits and restricts the production, sale and use of disposable plastic products such as non-degradable plastic bags. The state encourages reducing the use of disposable plastic products and promotes the recycling of disposable plastic products such as plastic bags. The use of recyclable, easily recyclable and degradable alternatives are also encouraged. Entities in tourism and hotels should not offer disposable products in accordance with relevant state regulations.
	August 2008	Circular Economy Promotion Law of the People's Republic of China	Enterprises producing products or packages listed in the catalogue of articles subject to compulsory recycle must be responsible for recycling deserted products or packages.For those usable,the producers thereof shall be responsible for using them,while for those products which are inappropriate for reutilization due to the absence of technical or economic conditions,the producers shall make them harmless. For products or packages listed in the catalogue of articles subject to compulsory recycle,consumers shall deliver the deserted ones to the producers or the distributors or other organizations entrusted by the producers for recycle. Enterprises engaging in the design of products,equipment,products and packages shall,in accordance with the requirement of reducing the consumption of resources and the generation of wastes,give preference to the materials which are recyclable,dismountable,degradable,innocuous, harmless or slightly harmful or poisonous,and the compulsory requirements in the relevant state standards shall be satisfied. Enterprises in the catering, entertainment, hotel and other service industries shall use energy-saving, water-saving, material-saving and environment-friendly products and reduce or stop using energy-waste or contaminating products. The state sets restrictions on the production and distribution of one-off consumption goods under the precondition of safeguarding product security and sanitation.The specific directory of the one-off consumption goods under restriction shall be formulated by the administrative department of circular economy development under the StateCouncil together with the public finance department and the competent department of ecology and environment a and other relevant competent departments under the State Council. The state encourages and advocates the construction of a waste recovery system. The local people's governments shall,according to the urban and rural planning,reasonably position the waste recycling outlets and trading markets,and support waste recycling enterprises and other organizations in the collection,storage,transport and information exchange of wastes.

Type	Formulated/Revised Time	Policy Document	Main content
Laws and Regulations	April 2020	Measures for the Administration of Agricultural Film	It is prohibited to produce, sell or use agricultural films that are explicitly prohibited by the state or do not meet mandatory national standards. Encourage and support the production and use of fully biodegradable agricultural films. Agricultural film users shall pick up the non-biodegradable agricultural film wastes in the field before the expiration of the term of use and hand them over to recycling outlets or recycling workers, and shall not discard, bury or burn them at will. Agricultural film producers, sellers, recycling outlets, waste agricultural film recycling enterprises or other organizations shall cooperate and adopt various ways to establish and improve the recycling system of agricultural film, promote the recovery, treatment and reuse of waste agricultural film.
	August 2020	Administrative Measures for the Recovery and Disposal of Pesticide Packaging wastes	Pesticide producers (including enterprises exporting pesticides to China), operators and users should voluntarily fulfill their obligations to recycle and dispose of pesticide packaging waste, and promptly recycle and dispose of pesticide packaging waste. Pesticide producers and operators shall fulfill the corresponding obligations of recycling pesticide packaging wastes in accordance with the principle of "whoever produces and operates shall recycle". Pesticide operators shall set up pesticide packaging waste recycling devices at their business premises, and shall not reject the packaging wastes they sell pesticides. Pesticide users should collect pesticide packaging waste in a timely manner and return it to pesticide operators or pesticide packaging waste recycling stations (points), and must not discard them at will. The state encourages and supports the utilization of pesticide packaging waste as resources; other than the utilization of resources, it shall be disposed of in a harmless manner such as landfill and incineration in accordance with laws and regulations. The pesticide packaging waste disposal costs shall be borne by the corresponding pesticide producers and operators; if the pesticide producers and operators are unclear, the disposal costs shall be paid by the local county-level people's government.
	November 1990	Measures for the hygienic Administration of plastic products and Raw Materials for Food	Recycled plastics shall not be used for processing plastic tableware, containers and food packaging materials.
	December 2005	Guiding Catalogue for Industrial Structure Adjustment (2005 Edition)	It is encouraged to use composite materials and polymer materials, eliminate foam and disposable foamed plastic tableware.
	August 2012	Regulations on the Prevention and Control of pollution in the processing and Utilization of waste Plastics	It is forbidden to use waste plastics to produce ultra-thin plastic shopping bags with a thickness of less than 0.025mm and ultra-thin plastic bags with a thickness of less than 0.015mm. Waste plastic processing entities shall dispose of the residual garbage and filters generated during the processing and utilization of waste plastics in an environmental friendly way; it is prohibited to hand them over to entities that do not meet environmental protection requirements for disposal. It is forbidden to incinerate waste plastics in the open air and the residual garbage and filter screen generated during processing and utilization. The waste plastic processing and utilization distribution center shall establish a centralized recycling and disposal mechanism for the residual garbage and filter screens generated by the waste plastic processing and utilization retail households. Encourage waste plastics processing and utilization distribution centers to implement centralized park management of waste plastics processing and utilization retail households, and centrally treat waste water, waste gas and solid waste generated by waste plastics processing and utilization.

Type	Formulated/Revised Time	Policy Document	Main content
Normative Documents	September 1989	Opinions on strengthening the Management of plastic Packaging waste in key Traffic Lines, Watersheds and tourist Scenic spots	It is forbidden to use non-degradable disposable foam plastic tableware in railway stations and passenger trains, passenger ships and tourist ships in inland waters such as the Yangtze River and Tai Lake. Prevent plastic packaging waste and other solid waste from littering and accumulating in rivers, lakes and along the coast. In the Yangtze River, Taihu Lake, key tourist attractions (attractions) and other inland waters, the plastic packaging waste that has floated in the water and accumulated on the shore will be cleaned up within three months under the unified leadership of the local people's government in the jurisdiction. It is forbidden to dump garbage along the railway lines, along the Yangtze River and the Taihu Lake Basin. All types of ships shall be equipped with sufficient garbage storage containers according to relevant laws, and garbage shall be collected by classification and discharged into garbage reception facilities. Crew members and passengers are prohibited from dumping garbage and cargo residues into rivers (lakes). The competent departments of tourist attractions (attractions) at all levels are responsible for supervising and inspecting the management of plastic packaging waste in the scenic spots (attractions) under their jurisdiction. Each scenic spot (attraction) should be equipped with enough garbage collection containers to facilitate tourists to dispose of garbage. The management unit of tourist attractions (attractions) shall set up special personnel to clean, collect and transport garbage, and maintain garbage collection and storage facilities.
	April 2001	Emergency notice on immediately stopping the production of disposable foamed plastic tableware	All manufacturing enterprises (including domestic investment, foreign investment and Hong Kong, Macao and Taiwan investment enterprises) should consciously abide by state laws and regulations and implement national industrial policies, and immediately stop producing disposable foamed plastic tableware.
	January 2002	Notice on strengthening law enforcement and supervision over the elimination of disposable foamed plastic tableware	Local law enforcement departments for industry and commerce, quality inspection and environmental protection shall be conscientiously responsible and, from the date of issuance of this circular, strengthen supervision and inspection over the elimination of disposable foamed plastic tableware in this area in accordance with the law.
	December 2007	Notice on restricting the production and sale of plastic shopping bags from the general office of the State Council	From June 1, 2008, the production, sale and use of plastic shopping bags with a thickness of less than 0.025 mm (hereinafter referred to as ultra-thin plastic shopping bags) are prohibited nationwide. Since June 1, 2008, the system of paid use of plastic shopping bags has been implemented in all commodity retail places such as supermarkets, shopping malls and bazaars, and plastic shopping bags are not allowed to be provided free of charge.
	January 2009	Notice on the Control of excessive Packaging from Commodities of the General Office of the State Council	On the premise of meeting the basic functions of protection, quality assurance, identification and decoration, and in accordance with the principles of reduction, reuse and resource utilization, commodity packaging should be standardized from the aspects of the number of packaging layers, packaging materials, effective volume of packaging, the proportion of packaging costs, and the recycling of packaging materials, so as to guide enterprises to reduce resource consumption in packaging design and production, reduce waste production, and facilitate packaging recycling.
	May 2010	Notice on the Construction of Urban Mineral demonstration from the National Development and Reform Commission and the Ministry of Finance	Through five years of efforts, about 30 "urban mineral" demonstration bases with advanced technology, environmental protection standards, standardized management, large-scale utilization and strong radiation will be built in China. Promote the recycling, large-scale utilization and high-value utilization of key "urban mineral" resources such as scrapped electromechanical equipment, wires and cables, household appliances, automobiles, mobile phones, lead-acid batteries, plastics and rubber.
	October 2011	Opinions of the General Office of the State Council on the Establishment of a complete and Advanced waste Commodity Recycling system	It is suggested to give full play to the role of the market mechanism to increase the recovery rate of major waste commodities such as scrap metal, waste paper, waste plastic, scrapped automobiles, scrapped mechanical and electrical equipment, scrap tires, scrapped electrical and electronic products, scrapped glass, scrapped lead-acid batteries, and scrapped energy-saving lamps. Strengthen policy guidance and support, further clarify the responsibilities of producers, sellers, and consumers, and effectively recycle key waste commodities through methods such as garbage sorting and recycling.

Type	Formulated/Revised Time	Policy Document	Main content
Normative Documents	January 2013	Notice of the State Council on Printing and Distributing the Circular Economy Development Strategy and Recent Action Plan	It is suggested to implement relevant preferential policies and conduct recycling traditional renewable resources such as scrap metal, waste plastic, waste glass, and waste paper, and increase the recovery rate. The public is encouraged to carry their own shopping bags, and refuse using ultra-thin plastic shopping bags.
	April 2013	Notice on deepening restrictions on the use of plastic Shopping bags in production and sales	The development and reform departments, together with relevant departments, have adopted various forms to vigorously publicize the positive results achieved in saving energy and resources and improving environmental protection awareness since the implementation of the "plastic restriction order" through TV, Internet, radio, newspapers and other media, and advocate green and low-carbon. , saving consumption concept. The education department should promote the reduction of the use of disposable products such as plastic shopping bags in primary and secondary school students' education planning, and advocate primary and secondary school students to adhere to the concept of conservation and environmental protection in their daily behavior. The commerce department, price department, and industry and commerce department organized shopping malls, supermarkets, and bazaars to carry out "plastic restriction order" publicity activities, calling on consumers to consciously boycott ultra-thin plastic shopping bags, and promoting operators to consciously implement the paid use system. The business sector organizes relevant associations and enterprises to initiate initiatives to reduce the use of plastic shopping bags. The Ministry of Industry and Information Technology coordinated with telecom operators to send warm reminder text messages to local mobile phone users about the significance of the implementation of the "Plastic Restriction Order" during the fifth anniversary of the implementation of the "Plastic Restriction Order". During the fifth anniversary of the implementation of the "Plastic Restriction Order", the agency affairs management department should organize public institutions to carry out the "Plastic Restriction Order" publicity activities, and advocate the staff of the agency to take the lead in setting an example and reduce the use of plastic shopping bags. The environmental protection department should vigorously publicize the environmental problems caused by ultra-thin plastic shopping bags in conjunction with activities such as "World Environment Day", so that consumers can recognize the harm of ultra-thin plastic shopping bags, and make it a conscious behavior to not use or use plastic shopping bags less. . Through platforms such as "Women's Homes" in urban and rural areas, women's federations have adopted colorful and popular methods to publicize the significance of the "plastic restriction order" and the harm of white pollution to the environment and human health, and advocate "use your vegetable basket and you cloth bags"
	December 2015	Industry standard for comprehensive utilization of waste plastics Interim Measures for the Administration of the Announcement of Standard Conditions for the Comprehensive Utilization of Waste Plastics	It defines the threshold of waste plastic disposal capacity of the three key types of enterprises newly built and built in the industry.

Type	Formulated/Revised Time	Policy Document	Main content
Normative Documents	December 2016	Notice of the General Office of the State Council on issuing the implementation Plan of the extended producer responsibility system	Eco-design shall be carried out. Production enterprises should take overall consideration of the resource and environmental impact of raw and auxiliary materials selection, production, packaging, sales, use, recycling, and processing, and carry out in-depth product ecological design. Specifically, it includes lightweight, single, modular, no (low) pollution, easy maintenance design, as well as designs such as life extension, green packaging, energy saving and consumption reduction, and recycling. Use recycled raw materials. Under the premise of ensuring product quality, performance and safety of use, manufacturers are encouraged to increase the proportion of recycled raw materials used, implement green supply chain management, strengthen the guidance of upstream raw material companies, and develop and popularize technologies for the detection and utilization of recycled raw materials. Standardize recycling. Production enterprises can standardize the recycling of waste products and packaging through independent recycling, joint recycling or entrusted recycling, and dispose of them directly or by professional enterprises. Responsibility for product recycling and disposal can also be achieved by the production enterprises paying relevant funds in accordance with the law and subsidizing professional enterprises. Enhance information disclosure. Strengthen the information disclosure responsibility of production enterprises, and make product quality, safety, durability, energy efficiency, toxic and hazardous substance content and other content as mandatory disclosure information to the public; and other contents as targeted disclosure information, which is disclosed to the subjects of waste recycling and resource utilization. Encourage beverage paper-based composite packaging manufacturers, bottling companies and recycling companies to form alliances in accordance with market-oriented principles, and recycle waste beverages through sales channels of bottling companies, existing renewable resource recovery systems, and recycling companies' self-built networks. Paper-based composite packaging.
	December 2016	Guiding Opinions on Accelerating the Development of Renewable Resources Industry	Vigorously promote the construction of waste plastic recycling system, and support the diversified and high-value utilization of different quality waste plastics. Focusing on the current varieties with large resources and high recycling rate, encourage the demonstration of recycling and utilization of key varieties of waste plastics, promote large-scale waste plastics crushing-sorting-modification-granulation advanced and efficient production lines, and cultivate a number of leading enterprises . Actively promote the resource utilization of low-quality and easily polluting waste plastics, encourage the non-polluting energy utilization of domestic waste plastics, and gradually reduce waste plastics to landfill.
	April 2017	Circular development leads action	Formulate and publish a list of disposable consumer goods restricted from production and sales and management measures, implement classified management of products included in the directory, and formulate and improve relevant policies for restricting disposable consumer goods. Support the development of reusable alternatives. Research and formulate ecological design standards for disposable products and improve recycling rate.
	July 2017	Notice of the General Office of the State Council on Printing and Distributing the Implementation Plan for Prohibiting the Entry of Foreign Waste and Promoting the Reform of the Solid Waste Import Management System	Before the end of 2017, the import of domestic waste plastics, unsorted waste paper, textile waste, vanadium slag and other varieties will be prohibited.
	December 2018	Notice of the General Office of the State Council on Printing and Distributing the Pilot Work Plan for the Construction of "Waste-Free Cities"	Recycling, treatment and other parts are the main areas to improve the level of reuse of waste agricultural film and pesticide packaging waste. Establish a recycling system under the guidance of the government, the main body of enterprises, and the participation of farmers. Restrict the production, sale and use of disposable non-degradable plastic bags and plastic tableware, and expand the application scope of degradable plastic products. Accelerate the application of green packaging in the express delivery industry. Promote the use of recyclable items and limit the use of disposable items in hotel, catering and other service industries.

Type	Formulated/Revised Time	Policy Document	Main content
Normative Documents	January 2020	Opinions of the National Development and Reform Commission and the Ministry of Ecology and Environment on Further Strengthening the Control of Plastic Pollution	The production and sale of ultra-thin plastic shopping bags with a thickness of less than 0.025 mm and polyethylene agricultural mulch films with a thickness of less than 0.01 mm are prohibited. The manufacture of plastic products from medical waste is prohibited. The production and sale of disposable foam plastic tableware and disposable plastic cotton swabs are prohibited; the production of daily chemical products containing plastic microbeads is prohibited. Shopping malls, supermarkets, pharmacies, bookstores and other places, as well as food packaging and takeaway services and various exhibition activities, the use of non-degradable plastic bags is prohibited, and the bazaars regulate and restrict the use of non-degradable plastic bags. The use of non-degradable disposable plastic straws is prohibited in the catering industry. Non-degradable disposable plastic tableware is prohibited for catering services in built-up areas and scenic spots in cities above the prefecture level. Star-rated hotels, regular hotels shall no longer offer disposable plastic products, but can provide related services by setting up self-service purchase machines and providing refillable detergents. Postal express outlets are prohibited from using non-degradable plastic packaging bags, plastic tapes, disposable plastic woven bags, etc. In shopping malls, supermarkets, pharmacies, bookstores and other places, it is recommended to use environmentally friendly cloth bags, paper bags and other non-plastic products and degradable shopping bags. Promote the use of bio-based products such as straw-coated lunch boxes and degradable plastic bags that meet performance and food safety requirements in the field of food delivery. In key mulching areas, the degradable mulch will be promoted on a large scale in combination with agronomic measures. Recyclable and foldable packaging products are encouraged in logistics and distribution indurty. With garbage classification regulations in place, the collection and treatment of recyclables such as plastic waste shall be encouraged, and the random stacking and dumping of plastic waste caused by pollution is prohibited. Carry out actions to clean up plastic waste in rivers, lakes and harbors and clean beaches. Promote the cleaning and rectification of farmland residual plastic film, pesticides, fertilizers and plastic packaging, and gradually reduce the amount of farmland residual plastic film.
	July 2020	Notice on Actively Promoting Plastic Pollution Control	Published “Refinement Standard for Relevant Plastic Products Prohibition and Restriction Management (2020 Edition)”
	September 2021	14th Five-Year Action Plan for Plastic Pollution Control	China will proactively promote the reduction of plastic production and use at the source, including actively promoting the green design of plastic products, continuing to promote the reduction of the use of disposable plastic products, and scientifically and prudently promoting plastic substitute products. China will accelerate the promotion of standardized recycling and disposal of plastic waste, including strengthening the standardized recycling and removal of plastic waste, establishing and improving the collection, transportation and disposal system of rural plastic waste, increasing the recycling of plastic waste, and improving the level of harmless disposal of plastic waste, etc. . China will proactively carry out the cleaning and rectification of plastic waste in key areas, and deploy the tasks of cleaning and rectifying plastic waste in rivers, lakes and seas, tourist attractions and rural areas in a targeted manner.

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