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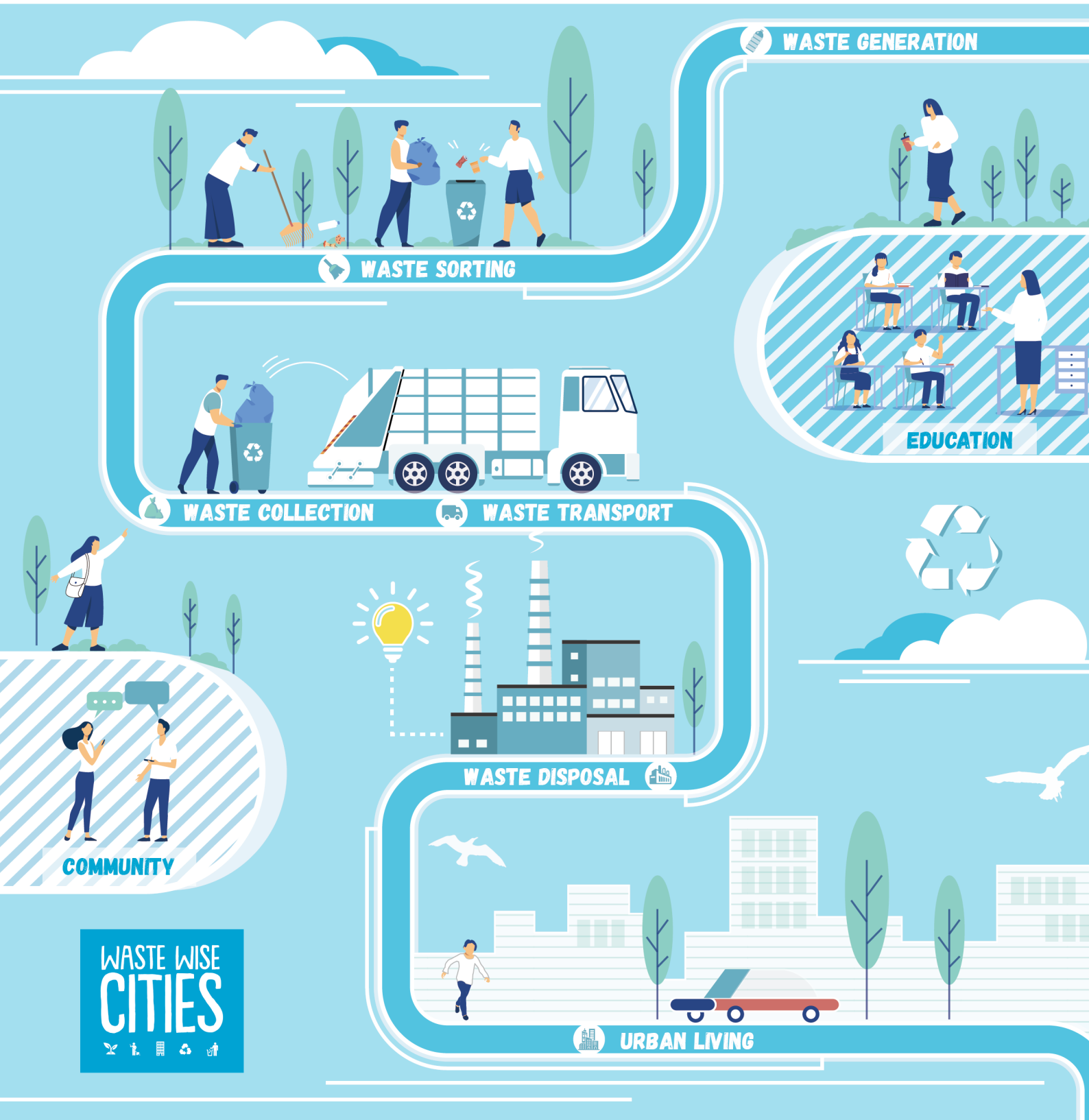
CHINA WASTE WISE CITIES GOOD PRACTICES

Series I



WASTE WISE CITIES

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CHINA WASTE WISE CITIES GOOD PRACTICES

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FOREWORD

Sustainable Development Goal 11 (SDG 11) of the 2030 Agenda for Sustainable Development sets out to "make cities and human settlements inclusive, safe, resilient and sustainable", and Target 11.6 seeks to “by 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management”. The importance of improving the sustainable management of municipal solid waste (MSW) has also been highlighted in the New Urban Agenda and the UN-Habitat Strategic Plan 2020-2023, which aim to tackle the challenges of urban-rural linkages, functional supply, and value chains from the perspective of environmental impacts and sustainability, ultimately achieve the transition to a circular economy.

As one of the essential public services that supports our society in the 21st century, waste management is a basic human need and a critical infrastructure, especially in urban areas. Waste management is a cross-cutting issue that affects many aspects of society and the economy, and it has strong links to many other global challenges, including health, climate change, poverty reduction, food and resource security, and sustainable production and consumption. Waste management is a key component of the Sustainable Development Goals (SDGs) and is considered as an entry point for achieving a range of SDGs.

With the development of China's economy and the acceleration of urbanization, the urban population has been growing continuously, resulting in an urbanization rate of 65.22% by the end of 2022.[1] As a result, the total amount of waste generated in the process of urban production and living increases gradually over the years, the coverage of waste collection and management is increasing, and the waste composition and disposal systems are becoming more complex. To ensure urban development, the ecological environment, and residents’ quality of life, China is continuously improving its waste management policy system, promoting the waste management system, gradually realizing a high-quality transition from not only waste treatment and disposal but also to a refined waste management based on waste sorting. In this report, three representative municipalities/districts in China, including Suzhou, Ningbo, and Yantian District of Shenzhen, are selected and analyzed. By summarizing their experiences in MSW management, this case study report has been compiled to provide insights and serve as a reference for other cities that facing challenges of MSW management.

1. National Bureau of Statistics: http://www.stats.gov.cn/xxgk/sjfb/zxfb2020/202301/t20230117_1892123.html

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CHAPTER 01

CHAPTER ONE:

Current Status of MSW Management in China

01

1.1 A guide to China's MSW management policies

With the continuing urbanization and rapid population growth in China, the MSW generation and collection amount has increased correspondingly, and the MSW disposal and management system has improved during the past decades. After 40 years of progress since the 1980s, China's MSW management system has evolved from simple landfills to integrated and environment-friendly management. According to the China Urban-Rural Development Statistical Yearbook 2020, the MSW harmless treatment rate in China (including both city areas and county areas) reached 99.41% in 2020, with a total MSW harmless treatment capacity of 1,321,779 tons per day.

As an important urban infrastructure, waste management has received great attention in the development of Chinese cities. Meanwhile, China has devoted great efforts to control soil, air, and water pollution, and has striven to achieve its National Determined Contributions. Since the promulgation and implementation of the Law on Environmental Pollution Prevention and Control by Solid Waste in 1995, China's policy system for waste management has been developing and improving. The major policies are summarized below:

1995

The ***Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution*** was promulgated and implemented, marking a new stage in the legal and procedural management of solid waste.

2000

The ***Technology Policy on Municipal Solid Waste Treatment and Pollution Prevention*** stated that MSW disposal shall follow the 3Rs (Reduce/Reuse/Recycle) principle.

2005

The ***Renewable Energy Law*** stipulates that renewable energy subsidies should be granted to waste incineration plants that incinerate waste to produce energy.

2009

The ***Circular Economy Promotion Law*** was enacted to promote the efficient use of resources.

2010

The ***Technical Guidelines on Municipal Solid Waste Treatment and Disposal*** were promulgated, focusing on the integration of urban and rural waste treatment and the improvement of treatment capacity.

2011

The State Council approved the ***Opinions of the Ministry of Housing and Urban-Rural Development and Other Departments on Further Strengthening Municipal Solid Waste Treatment,*** stating that waste treatment is an important responsibility of the government in public services and explicitly supporting the development of waste incineration technology.

2016

The ***Opinions of the Central Committee of the Communist Party of China and the State Council on Further Strengthening Urban Planning and Development Management*** set the target for achieving MSW recycling rate (over 35%) in 2020 and proposed to promote public-private partnerships in the MSW sector.

In the ***Thirteenth Five-Year Plan for the Construction of Municipal Solid Waste Harmless Treatment Facilities***, China aimed to increase the MSW incineration capacity to more than 50% by the end of 2020 compared to the whole MSW treatment capacity, and for eastern China, the target was higher of more than 60%. A relatively complete system for monitoring and regulating MSW treatment system shall be established with a focus on promoting real-time monitoring of the operating conditions of the key facilities at incineration plants. The document also called for accelerating the construction of MSW treatment facilities, waste sorting at source, and encouraging the separated treatment of biological food waste.

The ***Implementation Plan for Extended Producer Responsibility*** proposes that, by 2020, the extended producer responsibility policy system will be in place and significant progress will be made in the eco-design of the products in key areas, including electrical and electronic products, automobiles, lead-acid batteries and composite packaging.

2017

In the ***Implementation Plan of the Municipal Solid Waste Sorting System***, China aims to establish laws, regulations and standards for waste sorting at source by the end of 2020. Waste sorting pilot projects will be carried out in 46 key cities, with a target of MSW recycling rate of 35% to be achieved by the end of 2020.

2018

The ***Opinions on Comprehensively Strengthening Ecological Protection and Controlling Environmental Pollution*** call for the urgency of promoting waste sorting.

The ***Work Plan for the Pilot Program of Building Zero Waste Cities*** proposes to promote green living styles, reduce solid waste generation at source, and increase resource utilization efficiency.

A ban on solid waste imports came into force, aimed at reducing the inflow of mixed waste with high levels of impurities and low recyclability from other countries.

2019

The ***Notice on the Implementation of Municipal Solid Waste Sorting in Cities at the Prefecture Level and Above*** issued by the Ministry of Housing and Urban-Rural Development (MoHURD) stipulates that, by 2025, all prefecture-level cities (293 in total) and 4 municipalities directly under the central government (Beijing, Tianjin, Shanghai, and Chongqing) will have fully established MSW sorting system.

2020

According to the ***Implementation Plan for Improving Municipal Solid Waste Sorting and Treatment Facilities***, China will improve its capacity for MSW incineration, achieve zero landfill of primary solid waste by 2023, encourage cross-regional incineration facilities, and improve the existing incineration standard. To get a full picture of the remaining capacity of landfill sites and to make scientific plans for new landfill construction.

The ***Opinions on Further Strengthening Plastic Pollution Control*** propose banning and restricting the production, sale, and use of several selected plastic products in specific areas to control plastic pollution.

2021

The ***14th Five-Year Plan for the Development of Municipal Solid Waste Sorting and Treatment Facilities*** sets out a series of targets by the end of 2025, including increase the MSW recovery rate to 60%; increase the MSW sorting, separated collection, and separated transportation capacity to 700,000 tons/day; fulfill the demand for MSW sorting, collection, transportation and disposal in cities at the prefecture level and above; encourage counties that meet the necessary conditions to promote the MSW sorting and treatment facilities.

The ***Action Plan for Carbon Dioxide Peaking before 2030*** sets out the "10 key actions for peaking CO2 emissions", of which stepping up efforts to promote the MSW reduction and recovery is an important part of the "Circular Economy for Carbon Reduction Action".

On July 2nd, 2021, the National Development and Reform Commission and MoHURD jointly issued the ***Guiding Opinions on Promoting Metering and Charging for Non-resident Food Waste Disposal***, which calls for the establishment of a sound food waste collection and treatment system as well as a charging mechanism. These measures are conducive to guide food waste reduction at source in commercial area, and to promote food conservation. Establishing an effective food waste collection, treatment, and recovery system is one of the key components to the promotion of sustainable production and lifestyles.

Since the 12th Five-Year Plan, the integrated management and high-quality development of MSW has become a new development focus in China.

During the 12th Five-Year Plan (2011-2015), China selected 100 pilot cities to promote food waste reuse and harmless treatment, which increased the food waste treatment efficiency in China. During the 13th Five-Year Plan (2016-2020), "waste sorting" has become a hot topic. In 2017, the General Office of the State Council issued the Implementation Plan for the Municipal Solid Waste Sorting System, and 46 cities across the country launched pilot programs for mandatory MSW sorting accordingly. In 2019, MoHURD committed to the implementation of MSW sorting in cities at the prefecture level and above across the country, which marks a turning point from waste treatment to resource reutilization. The 14th Five-Year Plan period (2021-2025) will be an important stage for establishing waste management system in China. China will focus on optimizing the waste treatment structure, further improving the MSW recovery rate, and establishing the waste charging system.

1.2 MSW Collection, treatment, and disposal in China

1.2.1 MSW Sorting in China

China started MSW sorting at the end of 2016. According to the current policies and requirements, MSW is categorized into four types, including recyclables, hazardous waste, food waste, and other waste. In most cities, construction waste, bulky waste, and garden waste are collected and treated in a separate system.

By the end of 2022, the average coverage rate of waste sorting systems in residential areas had reached 82.5% in 297 cities, and most of the residents started to participate in waste sorting activities. The MSW treatment capacity reached 530,000 tons per day, with incineration treatment capacity accounting for 77.6%. The MSW recovery rate has increased notably, and residents are gradually embracing the habit of waste sorting.[2]

1.2.2 MSW Collection in China

By the end of 2020, the MSW collection amount reached 303 million tons in China for the city and county area, including 235 million tons from cities, reflecting a 23% increase compared to the 191 million tons reported in 2015. The remaining 68 million tons were collected in counties. Compared to pre-2019, there is only a small increase in MSW collection amount, which proves that China has established a well-organized waste collection system. Nevertheless, there was a slight decrease in the amount of MSW collection in 2020 due to the Covid-19 pandemic which limited social and economic activities and the introduction of waste sorting policy in that year. In conclusion, the growth rate of waste collection in cities and counties is slowing down and reaching a stable stage. The future focus of MSW management will shift one level up, from harmless treatment such as landfills to waste reduction, energy recovery and resource recycling, including waste sorting and incineration. With the ongoing urbanization and waste collection coverage expansion, MSW management in rural areas and counties is expected to enter the rapid development period (Figure 1-1).

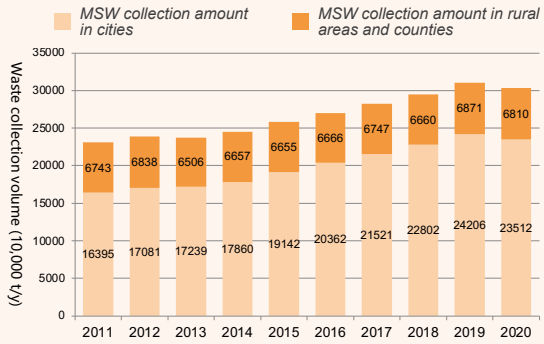
Regarding regional distribution[3], the MSW collection amount in the eastern, central, and western regions has increased year by year except for the

2. Source: "National On-site Meeting on Sorting of Municipal Solid Waste" held by the Ministry of Housing and Urban-Rural Development in Qingdao, China Association of Urban Environmental Sanitation, https://mp.weixin.qq.com/s/z5kedsITGNcbhaHqf3kLUQ

3. Eastern region: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, Hainan, Chongqing, Dalian, Ningbo, Xiamen, Qingdao, Shenzhen;
Central region: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan;
Western region: Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang;
Northeast region: Liaoning, Jilin, Heilongjiang

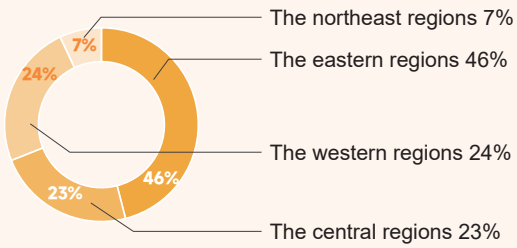
MSW is separated into four categories, including recyclables, hazardous waste, food waste, and other waste.

Figure 1-1 MSW collection amount in China, 2011-2020 (10,000 t/y)



Source: China Urban-Rural Construction Statistic Yearbook (2011-2020)

the MSW collection amount in the eastern region is higher than other regions.



northeast region. The MSW collection amount in the eastern region is significantly higher than in other regions, accounting for 46% of the total amount. The central, western, and northeast regions account for 23%, 24%, and 7% respectively, which is directly related to the population distribution in China.

1.2.3 MSW Treatment and Disposal in China

As of the end of 2020, there were a total of 685 cities and 1,483 counties (including autonomous counties, banners, autonomous banners, forest districts, and special districts) in China, across 31 provinces, autonomous regions, and direct-controlled municipalities. The total MSW collection amount in cities and counties has reached 303 million tons, and the harmless treatment rate achieved 99.41% which is 301 million tons. The MSW harmless treatment capacity has reached 1.32 million tons per day, which is carried out by 1,871 sanitary landfills, 619 incineration plants, and 225 other treatment facilities nationwide. The MSW incineration rate of 13 provinces and direct-controlled municipalities, including Jiangsu, Shandong, and Shanghai, has exceed 50% of the total MSW treatment amount.

Among these, 235 million tons of MSW were collected and treated, and the harmless treatment rate reached 99.7%. The treatment capacity of city areas reached 963,500 tons per day, supported by 644 sanitary landfills, 463 incineration plants, and 180 other treatment facilities. Incineration has become the main technique for MSW treatment in China, accounting for 59% of the total capacity, while sanitary landfills account for 35%, and other treatment technologies make up the rest 6%, which increased by 4% compared to 2015 (mainly food waste treatment facilities). Waste sorting became the driving force that promoted the diversification of treatment technologies. Only 0.3% of MSW is not treated in a harmless treatment facility, indicating a decrease of 5.6% compared to 2015. This also indicates that the MSW harmless treatment goal has been achieved (Figure 1-2).

In county areas, the MSW collection amount reached 68 million tons, and the MSW treatment amount is 67 million tons, with a harmless treatment rate of 98.3%. The MSW treatment

capacity in county areas is 358,000 tons per day, supported by 1,227 sanitary landfills, 156 incineration plants, and 45 other treatment facilities. It is worth noting that sanitary landfills continue to be the primary method for MSW disposal in the counties, accounting for 72% of the total capacity.

In 2019, the proportion of MSW incineration exceeded the sanitation landfill for the first time. Additionally, the overall incineration capacity in both cities and counties has reached 50% of the total treatment capacity in 2020. As the incineration capacity continues to grow, the requirement for pollution control of the incineration plants also raised (Figure 1-3).

Starting in 2016, MoHURD and the Ministry of Ecology and Environment (MEE) launched a "3-step" initiative focused on waste incineration facilities pollution monitoring. Firstly, install the automatic pollution monitoring equipment in all waste incineration facilities in compliance with the pollution control regulation. The facilities were encouraged to enhance environmental management and take responsibility accordingly. Secondly, set the display screens in prominent and accessible locations to disclose relevant pollution discharge data to the public, encourage public supervision to ensure governance effectiveness. Thirdly, the automatic monitoring system should be connected with the environmental protection department to further strengthen the supervision of environmental law enforcement. On October 11, 2019, the ***Administrative Provisions on the Application of Automatic Monitoring Data of MSW Incineration Power Plants*** were published and implemented. Starting from January 2, 2020, MEE started to disclose the automatic monitoring data of five conventional air pollutants to the public, including particulate matter, sulfur dioxide, nitrogen oxides, hydrogen chloride, and carbon monoxide, along with the incinerator furnace temperature for waste incineration plants nationwide. The ecology and environment authorities can use the automatic monitoring system to collect data as crucial evidence to determine whether there are any excessive emissions of pollutants from the waste incineration plant. As of December 31, 2020, a total of 494 incineration plants proactively participated in the data disclosure platform, demonstrating their commitment to information transparency. Remarkably, the compliance rate for the daily average value of the five conventional pollutants and furnace temperature (calculated at 5-minute intervals; with less than five times per day of lower temperature) reached an outstanding 99.9%. This monitoring platform has proven to be a crucial tool in regulating incineration operators throughout China, providing crucial support to competent authorities in their supervision and management efforts while driving overall improvements in the waste incineration industry (Figure 1-4).

From 2011 to 2015, China launched 100 pilot projects focused on food waste treatment and utilization. Financial support was provided to the pilot cities, urging them to invest in appropriate treatment projects. This initiative promoted the construction of food waste treatment facilities across the country. As a result, the anaerobic digestion has emerged as a dominant and mature approach. The construction of household food waste and other food waste treatment facilities began after the implementation of waste sorting schemes in 2016. With the promotion of waste sorting, more than 250 large-scale food waste treatment facilities were established with a combined capacity of approximately 70,000 tons per day. Anaerobic digestion is the primary technology (accounting for over 85% of the total food waste).

MSW treatment

Figure 1-2 MSW collection amount and harmless treatment rate in China, 2011-2020

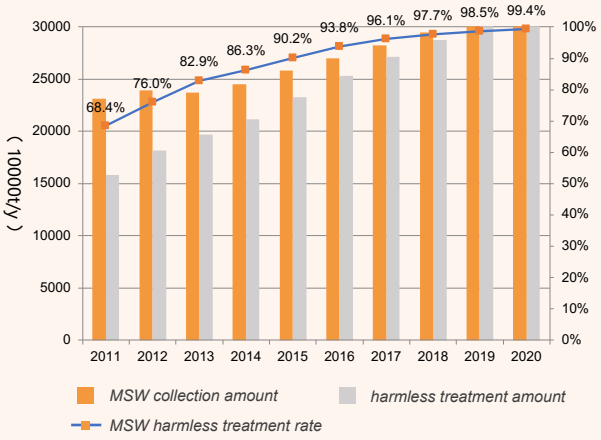


Figure 1-3 MSW treatment capacities in China over the past decade (t/y)

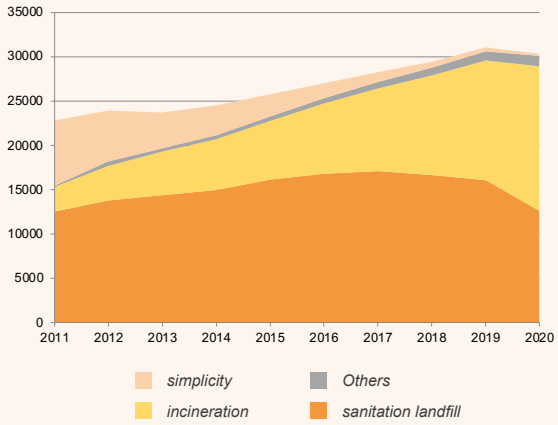
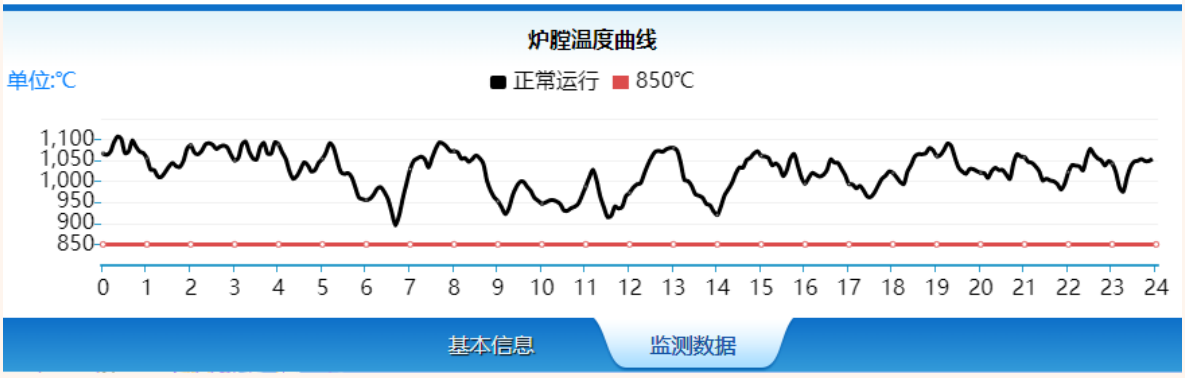


Figure 1-4 Real-time monitoring data from a typical MSW incineration power plant (April 22, 2023)

#2炉废气排放口 | #3炉废气排放口 | #4炉废气排放口 | #5炉废气排放口 | #6炉废气排放口 | #7炉废气排放口

2023-04-22 日均值 (单位:mg/m³)

监测因子	折算浓度	标准值	CEMS备注
颗粒物	1.834	20	--
氮氧化物	121.828	250	--
二氧化硫	22.146	80	--
氯化氢	4.7	50	--
一氧化碳	1.608	80	--
说明	--		



基本信息 | 监测数据

1.3 Investment of MSW treatment facilities in China

Since 2005, the MSW management in China has undergone significant transformation and adopted public-enterprise cooperation which established the foundation for a new MSW treatment infrastructure investment partnership. The total investment in waste treatment facilities grew significantly, escalating from USD 8.4 billion during 2006-2010 to USD 33.6 billion in 2016-2020 (Figure 1-5). A series of important policies have contributed to the transformation of China's waste management sector, including the introduction of the Renewable Energy Law in 2005, which introduced preferential feed-in tariff subsidies for energy generated by waste incineration plants.

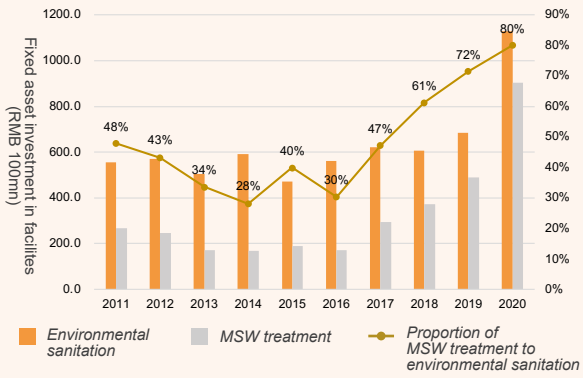
Most private MSW management sector in China are focused on the "back end" of the whole industry chain, such as waste incineration and energy recovery. When the incineration plants are privately owned, they are usually established based on the public-private partnership agreements. The government provides the land and ensures a constant supply of MSW, while the investment institution offers the capital for the project.

In recent years, waste management-related investment in China has been progressively shifting towards the “front end”. An overall urban environmental sanitation management system was established, which encouraged new industry growth point to services such as road cleaning and general services. In 2020, the annual contract value for the urban environmental sanitation sector reached nearly 20 billion USD. These investments are supported by the local government, which also drives the environmental sanitation sector as an emerging and promising market.

In addition, the policy is leading the investment to the 'front-end' of the waste management system, aimed to implement the country’s targets in pilot cities. In Ningbo, for example, the World Bank's China Plastic Waste Reduction Project was launched in 2023 and approved a loan of 150 million USD to the Ningbo Municipality. Ningbo was also seeking to attract 82 million USD from the private sector as supplementary funding. The project is focused on MSW source sorting, transportation, and recycling, with a special focus on plastic and high valuable recyclables.

Investment

Figure 1-5 Fixed asset investment in environmental sanitation and MSW treatment facilities in China (RMB 100mn)



1.4 Summary of MSW management in China

1 MSW collection, transportation and treatment

Since the construction of the first sanitary landfill in 1991, China has made significant accomplishments in MSW collection, transportation, and treatment in the past 30 years. By 2020, urban road cleaning covered 9.76 billion square meters and the MSW harmless treatment capacity reached 1.32 million tons per day. These accomplishments have contributed to the creation of a clean and pleasant living environment with reliable urban infrastructure, while contributing to the Sustainable Development Goals (SDGs), including SDG3 Good Health and Well-being, SDG6 Clean Water and Sanitation, and SDG11 Sustainable Cities and Communities (Figure 1-6).

2 MSW management techonology and practices

Through continuous technological advancement, strict emission regulations, and effective management, the MSW management sector in China has successfully prevented waste leakage, pollutant emissions from informal waste treatment facilities, and mixed waste entering landfills. These have great contributions to the reduction of greenhouse gases, especially methane emissions. Additionally, these strategies are highly aligned with the objectives of SDG13 Climate Action, SDG14 Life Below Water, and SDG15 Life on Land.

3 Waste management market

The waste management sector has made remarkable progress as a result of the successful market-based approach, which has attracted substantial public and private investments. Approximately 100 billion USD were invested, fostering a vibrant market and nurturing healthy competition. The high-quality development of the industry has not only supported sustainable growth, but also created various green jobs, aligning perfectly with the objectives of SDG8 Decent Work and Economic Growth, as well as SDG9 Industry, Innovation, and Infrastructure.

4 Community public participation

Under the guiding principle of "waste sorting as the new fashion of low-carbon lifestyle", the waste management industry has permeated deeper into the community and the public. Waste sorting has become an integral aspect of community governance and the establishment of a socially conscious civilization. Moving from the concept of waste sorting to the pursuit of a conservation-oriented society, the ultimate aim is to promote sustainable living and responsible consumption and production (SDG12). China's waste management has thus entered a new phase of sustainable development.

Figure 1-6 Sustainable Development Goals (SDGs)

CHAPTER 02

CHAPTER TWO:

MSW Management in Suzhou:

Establishing an Integrated Low-Carbon Waste Management System via Efficient Waste Sorting

02

2.1 Basic information of Suzhou Municipality

Suzhou, located in Eastern China, southeast of Jiangsu Province, and at the heart of the Yangtze River Delta, holds a significant position within this vital economic region. It has a subtropical monsoon oceanic climate featuring four distinct seasons, mild temperatures, and abundant rainfall, with an average annual precipitation of 1,100 millimeters. The average yearly temperature is 23°C, while July has an average temperature of 28°C. Suzhou has numerous canals and lakes, including Taihu Lake, Caohu Lake, Dianshan Lake, Yangcheng Lake, Jinji Lake, and Dushu Lake. Beijing-Hangzhou Canal and the Yangtze River run through the northern part of the city. Suzhou was praised as the Oriental Venice in the 13th-century book "Travels of Marco Polo" (Figure 2-1).

As of the end of 2021, Suzhou has five districts under its jurisdiction, which are Gusu, Huqiu, Wuzhong, Xiangcheng, and Wujiang districts, as well as Suzhou Industrial Park. Additionally, there are four county-level cities under Suzhou's jurisdiction, which are Changshu, Zhangjiagang, Kunshan, and Taicang. In 2020, the nominal gross domestic product (GDP) of Suzhou was RMB 2,395.8 billion, and the GDP per capita amounted to RMB 186,000. Equipment manufacturing and electronic information sectors are the major drivers of the regional economy.

The waste management data presented in this case covers the entire Suzhou Municipality and has been sourced from the Suzhou Environmental Sanitation Management Division.

Figure 2-1 Suzhou cityscape
© 58pic

2.2
MSW generation and treatment in Suzhou

Table 2-1 below presents the MSW collection data for Suzhou between 2020 and 2022. The overall collection remained stable throughout the years, accompanied by a notable increase in food waste collection and a successive decline in other waste collection after the implementation of waste sorting policies. In 2022, the amount of MSW collection reached 7,826,000 tons in Suzhou (excluding construction/demolition waste and bulky waste). The MSW recycling rate is 40.9%, including recyclables, household food waste, and commercial food waste. Among these, the food waste recycling rate is 19.5%, and the recyclables recycling rate is 21.4%. The recycling rate has a dramatic increase from 26.3% in 2020, which demonstrates Suzhou's waste sorting accomplishments (Figure 2-2).

It is worth mentioning that the significant increase in recyclables in Suzhou is attributed to the merging of the statistical data from both the commercial department and the waste management department. This action effectively supplemented the missing data on recyclables and improved the MSW data system. Furthermore, the collection of household food waste, commercial food waste, and hazardous waste has demonstrated a consistent increase, which indicates the improvement of the waste sorting and collection system in Suzhou. In 2020, the collection amount of other waste decreased accordingly, which also benefited from the implementation of waste sorting. However, in most cities in China, the data on recyclable does not include informal or commercial recycling activities, which means the actual MSW recycling rate is likely higher than the current data.

In 2022, the MSW collection amount per capita of Suzhou is 1.66 kg/day, of which 0.35 kg/day is recyclables, with paper accounting for the highest proportion of recyclables at 71.1%, followed by glass at 15.1% and plastics at 6.5%. As mentioned above, the existing statistical data recorded in the system is based on the official system. Informal and commercial data are not included, therefore the actual recycling rate is higher.

Since the formal initiation of waste sorting in 2020, Suzhou has adhered to the guiding principle of "separate waste drop-off, separate collection, separate transportation, and separate treatment". Recyclable waste, hazardous waste, food waste, garden waste, and bulky waste are transported directly to their respective terminal processing sites. For the other waste, due to the substantial volume, they are transported to the transfer station before further processing. All MSW generated is required to be disposed on the same day.

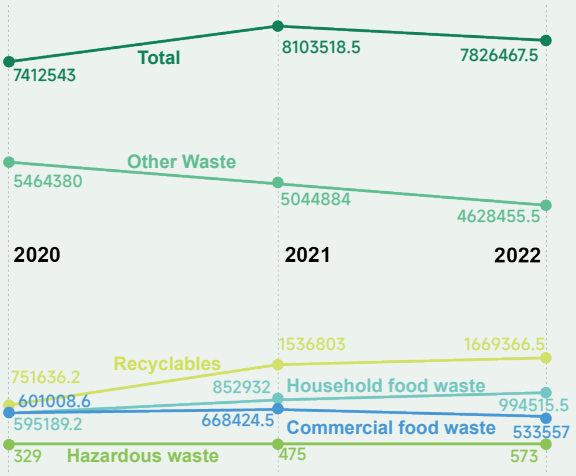
Currently, there are 3,654 MSW collection vehicles in Suzhou. This includes 152 vehicles dedicated to recyclable waste, 120 for hazardous waste, 831 for food waste, 2,120 for other waste, and 268 for garden and bulky waste. Other waste

MSW collection data in Suzhou

2020 to 2022

- The overall collection **remained stable** between 2020 and 2022, accompanied by **a notable increase in food waste collection** after the implementation of waste sorting policies.
- **The recycling rate** has a dramatic increase from 26.3% in 2020 to 40.9% in 2022.

Table 2-1 MSW collection in Suzhou (2020-2022)



Note: Food waste is classified based on its origin into two main categories: household food waste, originating from households, and commercial food waste, generated by restaurants and similar establishments.

MSW collection amount in Suzhou

In 2022

- In 2022, the MSW collection amount per capita of Suzhou is **1.66 kg/day**.
- Of which **0.35 kg/day is recyclables**, with paper accounting for the highest proportion of recyclables at 71.1%.

- ***3,654** MSW collection vehicles.*
- ***11** large and medium-sized transfer stations offering a daily transfer capacity of **4,300 tons.***
- *By 2022, recyclables have increased by **513%.***
- *The total treatment capacity of Suzhou constructed terminal facilities reached nearly **40,000 tons** per day.*

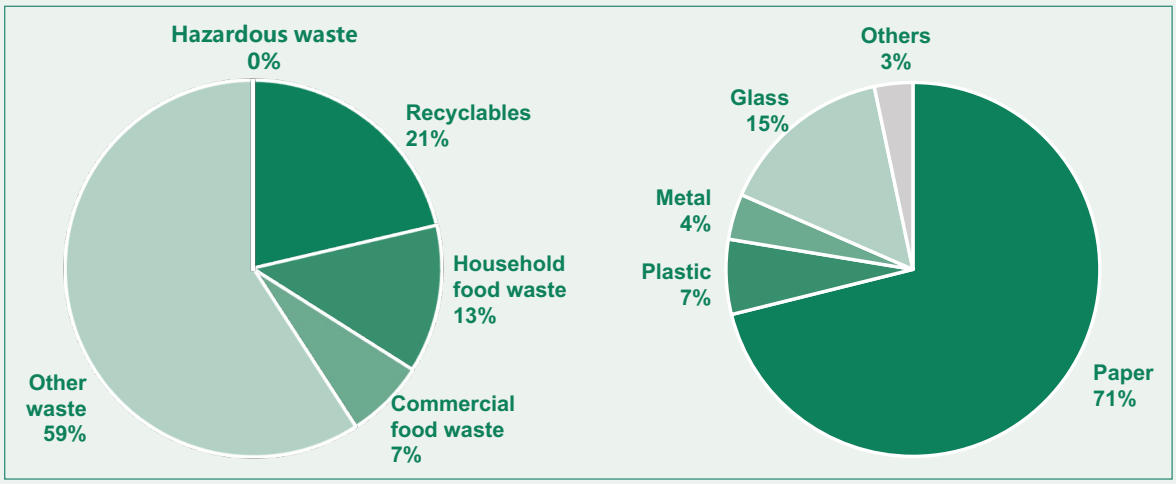


Figure 2-2 Composition of MSW and recyclables in Suzhou (2022)

Figure 2-3 Daily average sorted waste collection and disposal in Suzhou, 2022

has the greatest need for vehicles. Considering collection density, environmental impact, and transport efficiency, Suzhou has strategically consolidated its MSW transfer stations and gradually abandoned smaller-scale transfer stations. Suzhou currently has 11 large and medium-sized transfer stations offering a daily transfer capacity of 4,300 tons.

Suzhou's development strategy is guided by forward-looking planning with appropriate advancement considering the possibility of future growth. According to the principle of "general grouping and precise sorting" [4], taking into account factors such as population growth and urban development, Suzhou has planned and constructed the MSW treatment facilities based on seven distinct waste types, which are construction and demolition waste, garden waste, bulky waste, food waste, hazardous waste, recyclables, and other general waste.

By 2022, driven by the implementation of waste sorting policies, Suzhou has achieved a remarkable accomplishment in waste management with "three increases and one decrease" [5] (Figure 2-3). After Suzhou implemented waste sorting, other waste increased by 11.7%, while the collection and disposal rate of many other waste types had a sharp increase: recyclables increased by 513%, hazardous waste increased by 117.4%, food waste increased by 187.5%.

Currently, the total treatment capacity of Suzhou constructed terminal facilities reached nearly 40,000 tons per day, which can meet the present disposal requirements of "general grouping and precise sorting". Suzhou has established a comprehensive closed-loop waste management system with sufficient waste sorting facilities to cover the needs of the whole municipality. In 2020, the MSW harmless treatment amount of central urban area is 2.22 million tons (excluding recycled

4. "General grouping" entails the specific categorization of MSW based on its origin and attributes. This includes segregating construction (renovation) waste, landscaping waste, and bulky waste at the point of generation, leading to the creation of an autonomous system for their collection, transport, disposal, and utilization. Conversely, "precise sorting" involves a more intricate breakdown of daily waste into hazardous waste, recyclables, food waste, and other forms of waste.
5. "Three increases and one decrease" signifies an upsurge in the collection of recyclables, food waste, and hazardous waste, coupled with a reduction in the collection of other waste.

waste). Of these, 1.82 million tons were treated by incineration, 270,000 tons by anaerobic digestion, and 110,000 tons by sanitary landfill. Recyclable in the urban area of Suzhou undergoes a separate collection and transport process, coordinated by recycling enterprises for subsequent recycling and reuse. Garden waste is predominantly processed using both centralized and decentralized approaches, and tree branches and leaves are crushed for resource utilization. Bulky waste items are disposed through a decentralized approach. Hazardous waste, on the other hand, undergoes centralized disposal through specialized landfilling and incineration under the hazardous waste treatment requirements.

2.3 Summary of MSW management policies in Suzhou

The country-level legislation that governs MSW management includes the Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution, Circular Economy Promotion Law of the People's Republic of China, and the State Council's Regulations on the Urban Appearance and Environmental Sanitation Management. Based on these national legislations, Jiangsu Province enacted the Regulations on the Urban Appearance and Environmental Sanitation Management of Jiangsu Province in 2003. In Suzhou, the Regulations on Urban Appearance and Environmental Sanitation were initially formulated in 2006, followed by two revisions in 2012 and 2016. The third revision is currently undergoing in 2023. These regulations specifically clarified the division of environmental sanitation management responsibilities, designated accountable individuals, outlined assessment criteria and methodologies, and clarified legal obligations.

Additionally, it is worth noting that Suzhou published Suzhou MSW Sorting and Management Regulations in 2019, with the target to strengthen MSW sorting management, improve the living environment, reduce MSW generation, improve utilization and treatment, and promote ecological civilization and sustainable economic and social development. Through the issuance of this regulation, waste sorting was upgraded from ethical management to legislation. This regulation delineates specific responsibilities and obligations for waste sorting at source, collection, transportation, treatment, and source reduction. For instance, the regulation explicitly states that "in urban residential areas where property management is entrusted to property service enterprises, these enterprises shall be responsible for waste sorting management. In cases where owners undertake self-management, executing agencies and administrators shall be responsible for waste placement management". This regulation provided a legal basis for further waste sorting implementation.

In alignment with the Suzhou MSW Sorting and Management Regulations, Suzhou has diligently enhanced its policies, guidelines, and local standards between 2020 and 2022, addressing various waste sorting processes. A selection of these documents are listed below:

2020

- *2020 Action Plan for MSW Sorting in Suzhou*
- *Notice on the Issuance of the Guide to the Configuration of MSW Sorting Facilities in Suzhou*
- *Notice on the Issuance of the Suzhou MSW Sorting and Collection Regulations*
- *Notice on the Issuance of the Guiding Opinions on the Development of MSW Sorting and Collection Facilities in Residential Communities in Suzhou*
- *Notice on the Issuance of Guidelines for the Enforcement Work for Waste Sorting Management in Suzhou*
- *Notice on the Issuance of Guidance on Implementing Waste Sorting in Shopping Malls and Supermarkets in Suzhou*
- *Notice on Promoting Waste Sorting in the Hotel Industry of Suzhou*

2021

- *2021 Action Plan for MSW Sorting in Suzhou*
- *Notice on Issuing the Supervision and Evaluation Measures for MSW Sorting in Suzhou*
- *Notice on the Issuance of Assessment Method for Star-Rating Residential Compound in MSW Sorting*
- *Measures for the Management of Bulky Waste in Suzhou*

2022

- *2022 Action Plan for MSW Sorting in Suzhou*
- *Implementation Rules for the Quality Control of Sorting, Collection, and Transport of MSW in Suzhou*
- *MSW Sorting Management Standards*

The establishment and development of the above policies system demonstrated Suzhou's dedication to waste sorting. Suzhou has continuously improved its management criteria for all aspects of waste sorting, and has clarified the responsibilities of stakeholders and relevant entities. This comprehensive policy framework serves as a crucial foundation for Suzhou's development of waste sorting.

2.4 Institutionalization, Digitalization, Normalization

— Suzhou's experience in developing the waste sorting system

Waste sorting represents a significant milestone in MSW management in China during the 13th Five-Year Plan period. Since the mandated implementation of waste sorting in Suzhou in 2020, the city has diligently refined the entire process of waste sorting (waste sorting at source, separated collection, transportation, and treatment), through innovative institutional mechanisms, full-process monitoring, and regular management, which contributed to substantial progress in waste sorting.

Waste sorting links to every resident in the city. How to activate public participation, how to establish a proper sorting system, and how to ensure the effectiveness of sorting? Suzhou's answer is establishing a systematic, digitalized, and normalized waste sorting system. Meisong Phase III community will be introduced below as an example to illustrate how Suzhou promote waste sorting:

1 Institutionalization

Located in Xietang District, Suzhou Industrial Park, the Meisong Phase III community (hereinafter referred to as the "Meisong") consists of 280 households and approximately 1,000 residents. Following the Suzhou MSW Sorting Management Regulations, the property service enterprise take the lead as the responsible entity for MSW source separation management. The responsible entity are mandated to provide waste collection containers based on the required MSW separation categories, labels, and specifications. According to the Guidelines for MSW Sorting Facilities in Suzhou, Meisong has set up waste sorting kiosks in the community. These kiosks include designated collection facilities for "Recyclables", "Food Waste", "Hazardous Waste", and "Other Waste". Moreover, a supervision system has been put in place with fixed schedule, location, and personnel (Figure 2-4).

The scheduled waste placement timeslots are as follows: on week-

Figure 2-4 Waste collection kiosks in Meisong Phase III Compound
© LIU Xiao

days, from 07:00 to 09:00 and from 18:30 to 20:30; on weekends, from 11:00 to 13:00 and from 18:30 to 20:30. During these specified time slots, the waste sorting kiosks are accessible with supervision and assistance from sanitation personnel. Afterward, waste collection vehicles collect the sorted waste. Food waste and other waste are cleared daily, and hazardous waste and recyclables are transported based on requirements. The waste sorting kiosks displayed the responsible companies for waste collection (recyclables, food waste, other waste, and hazardous waste), collection schedules, as well as treatment procedures and processing entities (Figure 2-5).

When waste sorting was first launched in 2020, this regulation posed great challenges as residents needed to establish new habits of drop-off waste at fixed timeslots and locations instead of the original 24-hour arbitrary drop-off. Government authorities, community workers, and property entities undertook comprehensive communication efforts. While providing detailed daily guidance and education, they also established a regulatory mechanism. They utilized the legal framework of the Suzhou MSW Sorting Management Regulations as the guiding principle to enforce the waste sorting implementation at Meisong. Suzhou fully respects the public needs with a people-centered management approach. To solve the problem of people dropping-off garbage outside of the fixed timeslots, Suzhou reassessed the residents' needs and added extra timeslots accordingly, for instance, adding one more timeslot during noon time, consequently improving residents' experience and strengthening residents' willingness to participate.

Figure 2-5 Drop-off schedule/sorted collection and disposal signage
© LIU Xiao

2 Digitalization

Ms. CHEN Sujin, as the Cleaning Supervisor of Meisong's property management, has taken on the role of waste sorting supervisor since the initiation of community waste sorting. Next to the sorting kiosks is the waste collection area, she thoroughly introduced: "Our community has 280 households, generating approximately 4-5 bins (240L) of food waste every day, while other waste is roughly three times of food waste. There is only a small amount of hazardous waste and limited recyclables. Residents usually will take the recyclable to the separate recyclable collection point within the community, and sell the recyclables for money".

During the initial stages of waste sorting, manual entries were made in sorting ledgers for waste measurement. Starting in 2023, Suzhou has intensified efforts to enhance the quality and efficiency of waste sorting through source-based measurement. Dedicated "QR codes" have been assigned to 14,700 waste collection kiosks in all the communities. Furthermore, 63.8% of the kiosks have been equipped with weighing devices. Through sensor chips on the waste bins, real-time data of each waste category are automatically collected from the consumer end. This reliable data serves as a basis for evaluating the effectiveness of residential waste sorting and lays the ground for future MSW charging mechanisms.

Consequently, Ms. Chen's daily work has slightly changed. Once the waste bins are filled up, she adeptly drags them to the weighing scale at the collection point. On the display screen, she selects "Food Waste - Weighing - Data Upload". At the same time, relevant information is transmitted to the Suzhou Waste Sorting Management Platform. This platform enables visual analysis and presentation by integrating the daily waste generation data (Figure 2-6, Figure 2-7).

Since 2008, Suzhou has been building an advanced environmental sanitation management system. With more than a decade evolvement, Suzhou has established a digitalized and automated information system for environmental sanitation management. Apart from source-based collection and measurement, this system allows real-time monitoring of waste collection processes for all the 8,363 waste collection vehicles, monitoring the standardized procedures, and utilizing data analysis for informed evaluation. This system allows real-time tracking of vehicle location and operational routes. It enables continuous monitoring of waste collection progress and disposal locations. Moreover, it oversees the operational status and capacity utilization of waste sorting processes, effectively preventing mixed collection and transportation while addressing irregularities in collection management.

Figure 2-6 Waste weighing and data upload
© LIU Xiao

Figure 2-7 Control screen of community source-based weighing equipment
© LIU Xiao

In addition, all 6 waste incineration facilities, 6 construction waste disposal sites, 12 food waste treatment facilities, and 251 small-scale food waste treatment facilities are all included in the digital supervision platform. This integrated system ensures real-time monitoring of processing quantities and operational conditions. It is worth mentioning that the data from the information system is directly utilized for assessing waste sorting effectiveness for different communities in Suzhou, accounting for 30% of the total evaluation scores. This shift to the smart data systems enhances precision and transitions towards a results-driven assessment approach (Figure 2-8, Figure 2-9, and Figure 2-10).

Figure 2-8 Suzhou Waste Sorting Management Platform
© Suzhou Environment Sanitation Management Division

Figure 2-9 Suzhou Waste Sorting Management Platform - Source Management
© Suzhou Environment Sanitation Management Division

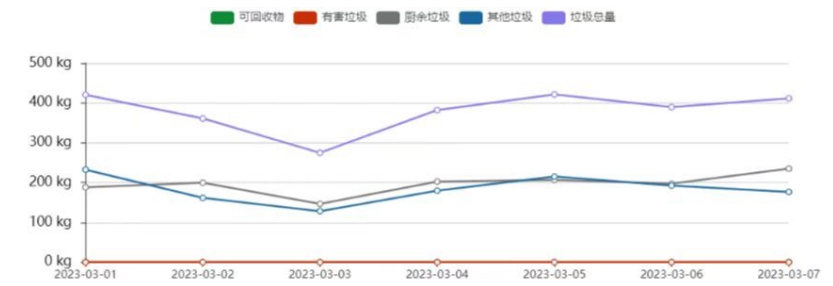


Figure 2-10 Waste Collection Data in Meisong Phase III Compound (March 1, 2023 - March 7, 2023)
© Suzhou Environment Sanitation Management Division

3 Normalization

The key objective of waste sorting is to cultivate new habits and foster modern civility. In Suzhou, the focus of promoting waste sorting is to establish sustainable behaviors and normalized waste sorting management system. Suzhou continuously enhances the waste sorting evaluation framework, refines criteria, and establishes long-term mechanisms, to achieve tangible results.

Waste sorting efforts are evaluated with a result-oriented approach, especially focusing on daily evaluations on districts/communities. The Suzhou Waste Sorting Task Force conducts over 30,000 evaluations annually for residential areas, public institutions, and public spaces. In addition, Suzhou established quarterly performance ranking list for the city (district), sub-district monthly performance rankings, community assessments, etc. Furthermore, waste sorting effectiveness is integrated into local performance evaluation systems, reinforcing accountability for waste sorting stakeholders.

All of the related departments in Suzhou, including the Municipal Office Affairs Bureau, Education Bureau, Housing and Urban-Rural Development Bureau, Culture, Broadcasting, Tourism and Sports Bureau, and Commerce Bureau, have also clarified their management responsibilities and evaluation criteria for waste sorting. Daily assessments for public institutions, schools, property enterprises, hotels, and supermarkets are also covered in the action plan. The performance of these institutions is integrated into the yearly evaluation systems, enhancing their responsibility and collaboratively implement the waste sorting initiatives.

To further enhance public supervision, Suzhou established the public engagement and evaluation mechanism. On the government service application "Su Zhou Dao", a specialized "waste sorting" section was added, allowing the public to assess the effectiveness of waste sorting through the "Snap and Report" function. Suzhou Television hosts a "Waste Sorting Observation" segment, promptly addressing issues and promoting corrective solutions. Ultimately, public supervision results are integrated into regional and district assessment, and this mechanism can greatly promote collaborative governance and normalize waste sorting (Figure 2-11).

Figure 2-11 “Su Zhou Dao" application - Waste Sorting
© Suzhou Environment Sanitation Management Division

2.5
People Centered
— Experiencing high-quality waste management services in Suzhou

With the advancement of societal and economic level, accompanied by improving standard of living, heightened expectations have been put forward to urban waste management. Beyond the daily collection of household waste, the management of bulky waste, construction and demolition waste, and garden waste has become a vital aspect of urban environmental management. In Suzhou, construction and demolition waste, garden waste, and bulky waste are managed through separate waste “streams.” Each waste type has designated collection and processing facilities based on their volume, composition, and treatment methods.

Taking bulky waste as an example, the majority are discarded furniture, which generally are large in size, occupy large space, inconvenient to transfer, and cannot be mixed into the regular domestic waste disposal system. "Difficult to sell, challenging to discard" mirrors the reality of dealing with bulky waste. For items such as furniture and appliances, once they become wastes, proper disposal becomes a genuine challenge especially in megacities.

In Suzhou, guided by the “People Centered” service principle, free bulky waste centralized collection and transportation service is easing the public’s “garbage throwing issues”. Since August 29, 2021, the last Sunday of each month has been designated for free collection day of bulky waste. Residents could use the website or the "Su Zhou Dao" app to find designated drop-off points, the list of collection service providers, and their contact details. On the designated day, the residents can put the bulky waste in the designated locations and related service providers will then collect and transport bulky wastes for disposal.

In terms of collection and transportation costs, the fees of transferring waste from upstairs to the ground are borne by the residents themselves, and if residents chose government-appointed service agencies, and detailed charges can be found from the government guidance of third-party price-list. The transportation cost from the residential communities to the disposal facility is covered by the local financial department on the designated collection day. Sub-district authorities select collection service providers through bidding or commissioning process. Apart from the centralized collection and disposal day, residents also have the option to individually pay for doorstep pickup and disposal of bulky waste, with fees around RMB 200-300 per truck (3-5 tons).

A typical bulky waste collection process is as follows:

- On May 13, 2023, in Suzhou's Huqiu District, Shishan Hengtang Sub-District, Mr. Liu scheduled a bulky waste collection service through the Su Zhou Dao app. The collection included 5 items, such as sofas and mattresses.
- At 9:30 AM, with assistance from the property management, Mr. Liu brought the bulky waste to the ground floor lobby.
- By 10:00 AM, the collection team from the Hengtang Sub-District bulky waste disposal station arrived and completed the collection.
- At 11:00 AM, the collection vehicle returned to the disposal station. The weighbridge indicated a gross vehicle weight of 8.5 tons, net weight of 5 tons, and the collected bulky waste weighed 3.5 tons (Figure 2-12).

Figure 2-12 Weighing of bulky waste collection vehicle entering the disposal station
© UN-Habitat | BAO Meng

At the disposal station, the collected bulky waste will be dismantled and crushed. Hengtang Sub-District has established one bulky waste disposal station with a total capacity of 30 tonnes per day, which can serve about 300,000 residents. The primary function of the station is to crush and package bulky waste, along with certain park waste (mainly wood), which then transport to incineration plant for incineration and power generation. The Hengtang Sub-District disposal station is also currently exploring the possibility of using the shredded wood as biomass fuel for biomass boilers in the surrounding areas.

Building on the initiative, the Suzhou City Management Bureau and the Suzhou Environment Sanitation Management Division, as the industry competent authorities, are actively exploring the possibility of further promoting activities such as second-hand markets and item exchanges at the sub-district level. This aims to rejuvenate certain waste/bulky items before they enter the disposal process, effectively advancing MSW management to a higher level transformation. For instance, in Wujiang District, the City Management Bureau is encouraging the establishment of a "Trunk Recycling Market" in the Songling Sub-District. Every Sunday from 12:00 to 19:00, residents can bring their idle items to the Sasseur Outlet Plaza for trading, with free parking provided to the participants. This breathes new life into old items and fosters a new fashion of recycling and reuse (Figure 2-13).

Figure 2-13 "Trunk Recycling Market" in Wujiang Distict on May 21, 2023
© https://mp.weixin.qq.com/s/ceSovxvrPs467ZhGLVKZtw

2.6
Sustained low-carbon practice
— Proactive response of waste management to address climate change

To further achieve the reduction, recycling, and harmless treatment of MSW in China, and to propel green and low-carbon transition of waste sector, the China Integrated Waste Management National Appropriate Mitigation Action Project (IWM NAMA Project) was officially approved and launched in September 2017. This initiative is a collaborative effort supported by MoHURD, sponsored by the NAMA Facility, and jointly implemented by the German International Cooperation Institution (GIZ) and the China Association of Urban Environmental Sanitation (CAUES).

Suzhou was selected as a pilot city for the IWM NAMA project in 2018. After five years of pilot work with project support, Suzhou has seamlessly integrated low-carbon management into its comprehensive MSW management practices. The achievement was made possible by establishing a pilot coordination mechanism, formulating effective work plans, conducting ongoing dynamic assessments, and actively engaging in collaborative exchanges. This dedicated effort has consistently improved the city's MSW management.

Under the Grenn House Gas (GHG) evaluation Monitoring Reporting and Verification (MRV) methodology developed by IWM NAMA project, the accounting boundary of MSW management in Suzhou is identified. This includes the transportation vehicles, transfer stations, waste disposal facilities (such as MSW incineration power plants, sanitary landfills, food waste treatment facilities, and agricultural market waste disposal stations), as well as recycling points for the collection of recyclable materials. However, in the practical accounting process, GHG emission reductions from the collection and recycling stages are not factored in, due to lack of data availability because most of the recycling process are through the commercial recycling systems.

Taking the three-year average from 2015 to 2017 as the baseline, and the baseline scenarios of sanitary landfills and MSW incineration power plants. The emission reduction scenario entails an expanded MSW incineration power plant (replacing the Qizishan landfill), food waste treatment facilities, and the newly established agricultural market waste disposal stations. Specific details are provided in Table 2-2.

Compared to the baseline, from 2019 to 2022, Suzhou achieved consistent GHG emission reductions of 1.288 million tons of carbon dioxide equivalent in MSW management (Figure 2-14), which attributed to the evolving technological changes and optimized management within the waste management system. For example, in 2022, 68.2% of the reduction stemmed from improved incineration capacity and the transition from mixed waste landfilling to incineration. Additionally, 26.5% resulted from the establishment and operation of large-scale food waste treatment facilities, carried out effective disposal of sorted household food waste. Lastly, 2.9% came from the expansion and enhancement of the landfill gas collection system at the landfill site.

This showcases that in numerous Chinese cities, with Suzhou as an example, have largely completed the initial phase of emission reduction, effectively avoiding methane emissions from mixed waste. Yet, ongoing monitoring of GHG emissions in waste management sector in Suzhou reveals that shifting waste composition could pose greater challenges on further GHG emissions reductions. Notably, the increasing presence of plastics, particularly in incineration, significantly increases direct emissions. Therefore, in Suzhou's ongoing waste sorting efforts, a heightened focus is on separated sorting and recycling of plastic waste. Through strategies like awareness campaigns, public education, and policy guidance, there is an active drive to amplify plastic waste recycling, with particular attention to schools and workplaces. Vigorous efforts are also being made to promote the recycling of plastic bottles and food containers, moving from centralized collection points to more widespread community participation, thereby streamlining and improving the re-use of plastic waste.

Furthermore, Suzhou has proactively conducted a thorough analysis of the entire waste management life cycle using Life Cycle Analysis (LCA). This analysis identified the key factors driving the low-carbon transition, with a primary focus on enhancing the energy efficiency of waste treatment facilities and promoting synergistic energy use among different facilities, and the household food waste has notably reduced in the other

Baseline scenario (three-year average 2015-2017)
Suzhou Qizishan MSW Landfill
Everbright Environment Energy (Suzhou) Co., Ltd
Emission reduction scenarios (2018-2022)
Agriculture market waste disposal station
Suzhou Qizishan Landfill Power Generation Project
Newly constructed food waste treatment plant in Suzhou Industrial Park
Newly constructed food waste treatment plant in Hi-Tech District
Everbright Environment Energy (Suzhou) Co., Ltd - Expansion of Suzhou MSW Incineration Power Plant
Newly constructed food waste treatment plant in Xiangcheng District

Table 2-2 Comparison of emission reduction scenarios for MSW management in Suzhou

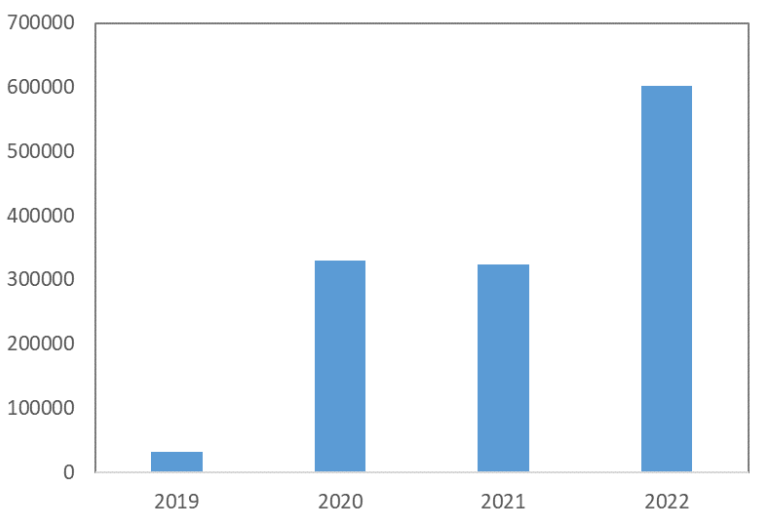


Figure 2-14: Annual greenhouse gas emission reductions in Suzhou's urban solid waste management (baseline: three-year average from 2015 to 2017)
Vertical coordinate: GHG emission reductions (tons of carbon dioxide equivalent)

For specific methodology and detailed accounting, please see:
https://iwm-nama.caues.cn/zh-hans/topic/%e4%b8%ad%e5%9b%bd%e5%9f%8e%e5%b8%82%e7%94%9f%e6%b4%bb%e5%9e%83%e5%9c%be%e7%ae%a1%e7%90%86%e6%b8%a9%e5%ae%a4%e6%b0%94%e4%bd%93%e5%87%8f%e6%8e%92mrv%e6%a8%a1%e5%9e%8b/

waste stream since implementation of waste sorting Suzhou's Qizishan Waste Incineration Plant has dynamically adjusted its operating conditions, achieving an impressive waste-to-energy conversion rate of up to 600 kilowatt-hours per ton (Figure 2-15). Furthermore, Suzhou has proactively promoted anaerobic digestion of food waste for biogas power generation or refining the biogas to the natural gas grid. This initiative provides a sustainable source of green energy for urban operations (Figure 2-16). As part of its innovative strategy, Suzhou incorporated carbon emission assessment as one of the evaluation indicators of integrated waste management, effectively propelling emissions reduction efforts across the whole sector.

By promoting precise waste management and pursuing high-quality development, Suzhou has achieved a consistent low-carbon transition in waste management, providing a classic case practice in addressing climate change within the MSW management sector, with positive promotion and demonstration significance.

Figure 2-15 Suzhou Qizishan Waste to Energy Plant
© Suzhou Environment Sanitation Management Division

Figure 2-16 Huayan Food waste treatment plant in Suzhou
© Suzhou Environment Sanitation Management Division

2.7 Summary of MSW management practices in Suzhou

"Waste management, a small piece of waste but not a small issue". Suzhou has focused on promoting integrated waste management practices covering the whole value chain and processes, reflecting the concept that even minor waste management efforts contribute to significant advancements in social civilization, ecology improvement, industry development, and technology innovation. Summarizing MSW management practices in Suzhou, the key points are as follows:

1 ***Involve the people and be people centered in the MSW sorting process to ensure the effective waste sorting at the frontline.***

Taken streets or communities as units, Suzhou aims to strengthen in-depth communication with the public, through fully function the core role of community-level workers. Before initiating the waste sorting, thorough assessments of the team capabilities on community level, public acceptance analysis, and waste collection and disposal capacities analysis are conducted, ensuring the steady implementation of waste sorting strategies. Suzhou set the waste sorting requirements of "fixed collection time at fixed locations by fixed supervising personnel", and these are supported by volunteer teams and public service personnel. Effective oversight against improper drop-off behaviors further ensures the establishment of a high-quality front-end waste sorting system in Suzhou.

2 ***Through integrated planning, coordination and digitalization process, Suzhou elevated the waste collection and transportation process..***

This includes the establishment of standards to unify the waste sorting and collection, and the identification and management process of sorted transportation. By utilizing digital systems, Suzhou achieved the standardized whole process monitoring for the waste sector, from source collection, transportation, and to final treatment and disposal, enhancing the efficiency and quality of waste sorting and collection. Through the integration of sorted waste collection and recycling systems, Suzhou defined clear pathways for recycling and resource recovery. Additionally, the city introduced supportive policies for lower-value recyclables and strengthened recycling efforts of recyclable materials.

3 ***Suzhou is driving the low-carbon transition of MSW treatment and disposal process through strategic planning and proactive measures.***

Suzhou emphasized on strategic planning to guide the continuous improvements in waste disposal capacity, which further promoted front-end waste sorting and streaming, ensuring effective waste disposal and treatment. In present, Suzhou has a aggregated daily waste disposal capacity of 38,590 tons, including other wastes, food wastes, and construction wastes. By consistently employing advanced technology and equipment, adhering to elevated construction standards, enforcing rigorous pollution control measures, and prioritizing aesthetic designs, Suzhou ensures practices of clean production and low-carbon transition.

CHAPTER 03

CHAPTER THREE:

MSW Management in Ningbo:

AI-based Waste Sorting Empower Plastic Recycling and Plastic Pollution Control

03

3.1 Basic information of Ningbo Municipality

Ningbo is located in the northeast of Zhejiang Province, along the central part of mainland coastline, with south of mountains and north to the Hangzhou Bay. The coastline of Ningbo is straight, and its terrain is entirely of coastal silt plain. Ningbo is an important port city on southeast coast of China and the economic center of the Yangtze River Delta region. The city's topography is characterized by high elevation in the southwest and lower elevation in the northeast, featuring rolling hills and expansive plains. Ningbo has a mild, humid subtropical monsoon climate with four distinct seasons. It is a typical waterfront city and seaport located in Jiangnan, which is south of the lower reaches of the Yangtze River (Figure 3-1).

As of 2021, Ningbo has six districts, two counties, and two county-level cities under its jurisdiction, covering a total area of 9,816 square kilometers. By the end of 2022, Ningbo has a registered household population of 6.211 million and a permanent resident population of 9.618 million, with an urbanization rate of 78.9% It is a thriving industrial and commercial city, and it serves as one of the significant financial and economic centers of Zhejiang Province. In 2022, Ningbo's Gross Regional Product (GRP) stood at RMB 1,570.43 billion, with a per capita GDP of RMB 163,900. The ratio of the three industries was 2.4:47.2:50.4.

The waste management data presented in this case encompasses the entire Ningbo City and has been sourced from the Ningbo MSW Sorting Guidance Center.

Figure 3-1 Ningbo cityscape
© Visual China Group, https://www.vcg.com/

3.2
MSW generation and treatment in Ningbo

Between 2020 and 2022, the total amount of MSW collected in Ningbo is shown in Table 3-1. Overall, the total MSW volume has been stable, accompanied by a notable surge in sorted household food waste collection and a significant decline in other waste collection. In 2022, the total MSW collected reached 4,732,000 tons in Ningbo (excluding construction/demolition waste and bulky waste). The recycling rate (including recyclables, household food waste, and commercial food waste) was 36.7%. In particular, the recycling rate of household food waste/commercial food waste reached 22.3% and the recycling rate of recyclables reached 14.4%. The marked increase from the recycling rate of 23.6% in 2020 underscores the success of Ningbo's waste sorting efforts. It is worth noting that currently, a substantial portion of recyclable statistics in China does not include informal or commercial recycling activities. As such, the actual MSW recycling and utilization rate is likely higher than the current data (Figure 3-2).

In 2022, the amount of MSW collected per capita of Ningbo is 1.35 kg/day, which. recyclables accounted for 0.19 kg/day, with paper forming the majority of at 55.2%, followed by plastics at 15.9%. The variation in per capita waste collection between Ningbo and Suzhou is primarily because of the unequal distribution of per capita recyclables, which could be due to the inconsistent statistical scales of recyclables. This issue requires further enhancement. During the 14th Five-Year Plan period, one of Ningbo's crucial tasks in waste sorting is to promote the integration of the waste collection and sorting system with the commercial recycling system.

In 2022, the treated and disposed amount of MSW in Ningbo is 4.732 million tons in total, with 100% of harmless treatment and disposal rate. 682,000 tons of the MSW were recycled, 457,000 tons of household food / commercial food waste were disposed, and 3,592,000 tons of the MSW were incinerated. Ningbo achieved zero landfill of other waste by 2021.

In 2023, Ningbo released the Ningbo Special Plan for Environmental Sanitation Facilities (2021-2035), which outlines the following general goals: By 2025, the city will significantly improve the capacity and operation quality of the environmental sanitation facilities and further establish waste management facilities for waste sorting and refined management. By 2035, the city will develop an advanced, practical, and eco-friendly system of environmental sanitation facilities that are highly efficient, intelligent, safe, and reliable. Furthermore, the short and long-term environmental sanitation planning goals for Ningbo are clearly presented in the table below. In addition to high-quality sanitation renovation, increasing the comprehensive utilization of construction waste and the recycling rate of MSW are the key focuses for Ningbo's environmental sanitation management in the medium and long term (Table 3-2).

MSW collection data in Ningbo

2020 to 2022

Table 3-1 MSW collection in Ningbo (2020-2022)

(Unit: ton)	2020	2021	2022
Hazardous waste	396.7	279.8	318.9
Recyclable waste	590,321.0	680200.0	682,000.0
Household food waste	228,397.1	318254.8	746,853.1
Commercial food waste	286,722.9	359378.7	307,689.5
Other waste	3,575,918.0	3483800.0	2,995,329.5
Total	4,681,755.7	4,841,913.3	4,732,190.9

Note: Food waste is classified based on its origin into two main categories: household food waste, originating from households, and commercial food waste, generated by restaurants and similar establishments.

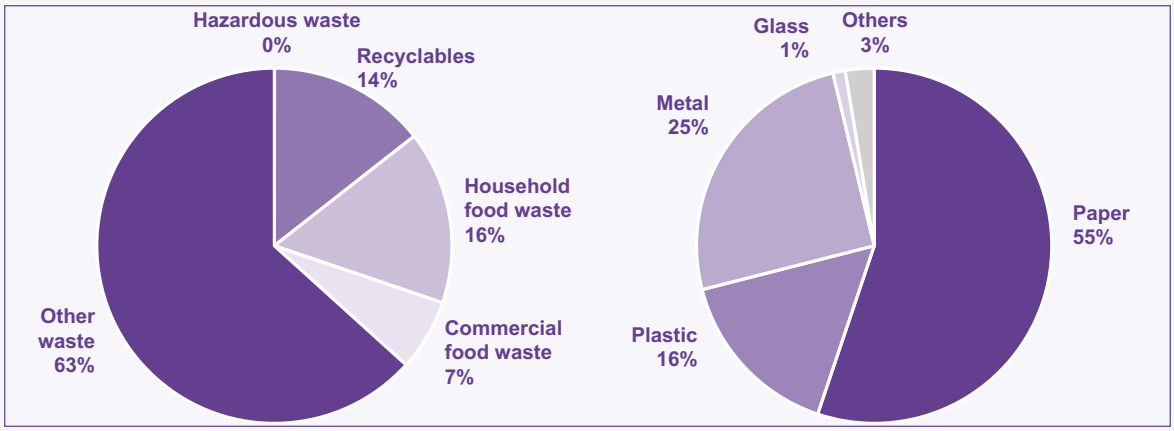


Figure 3-2 Composition of MSW and recyclables in Ningbo (2022)

Table 3-2 Indicators of Ningbo environmental sanitation planning (non-exhaustive)

	Indicators	Unit	Status quo	2025	2035	Nature
1	MSW sorting	%	100	100	100	Binding
2	Harmless treatment of MSW	%	100	100	100	Binding
3	Raw refuse landfill	%	0	0	0	Binding
4	Harmless treatment of excrement	%	100	100	100	Binding
5	Comprehensive utilization of construction & demolition waste	%		90	95	Binding
6	MSW recycling	%	33.32	≥40	≥48	Expected

Notes:
1. Status quo data is for 2020
2. Recycling rate of MSW is the percentage of recyclables and food waste (including commercial food waste) compared to the total amount of MSW

3.3 Summary of MSW management policies in Ningbo

The overarching legislations governing MSW management encompass the Law of the People's Republic of China on Prevention and Control of Environmental Pollution by Solid Waste, Circular Economy Promotion Law of the People's Republic of China, and the State Council's Regulations on the Administration of City Appearance and Environmental Sanitation. Based on the laws and regulations, Zhejiang Province adopted and issued the Implementation Measures for the Administration of City Appearance and Environmental Sanitation in Zhejiang Province, which was later amended as the Regulations on the Administration of City Appearance and Environmental Sanitation in Zhejiang Province. Ningbo enacted the Regulations on the Administration of City Appearance and Environmental Sanitation of Ningbo in 2003, which was updated and published as the Regulations on the Administration of City Appearance and Environmental Sanitation of Ningbo in 2012 (Difference in Chinese). These regulations meticulously delineate responsibilities, designate accountable persons, outline assessment criteria and methodologies, and clarify legal obligations pertaining to urban amenities and environmental sanitation management.

In 2019, Ningbo enacted the Ningbo Municipal Regulations on the Municipal Solid Waste Sorting Management to enhance MSW management, improve the urban and rural environment, and further promote ecological civilization. These regulations mandate waste sorting, which includes requirements for separate at source, collection, transportation, and treatment of MSW, and source reduction responsibilities. For example, responsible areas and personnel are designated to manage sorted waste in municipalities. These individuals must comply with regulations set by the appropriate urban environment and sanitation department. In addition, they should establish garbage rooms, waste collection points, and collection containers within the designated areas and organize the waste collection and sorting.

On the policy front, the central government, Zhejiang Province, and Ningbo have made continuous efforts to improve relevant policy systems to guide the development and optimization of the waste management industry. From 2020 to 2021, top-down policy guidance continued to be implemented in the urban area, and the policies are more accurate and target-focused. The main policy documents are as follows:

1 Ministry of Housing and Urban-Rural Development

2 Zhejiang Province

- *Opinions on Promoting the Management of Municipal Solid Waste at a High Standard*
- *Notice on the Issuance of* ***Guidance Catalog of Low Value Renewable Resources in Zhejiang Province***
- *Notice on the Issuance of* ***Implementation Plan of Zhejiang Province on Deepening the Special Rectification of the Municipal Solid Waste Incineration Power Generation Industry***
- *Notice on the Issuance of* ***Zhejiang Province Two-Year Action Plan on Securing a Decisive Victory in All Aspects of Municipal Solid Waste Management (2021-2022)***
- *Notice on the Issuance of* ***Zhejiang Province Action Plan on the Comprehensive Management of Municipal Solid Waste Landfills***
- *Notice on the Issuance of* ***Zhejiang Province Action Plan on the Renovation and Upgrading of Municipal Solid Waste Transfer Stations***
- *Notice on the Issuance of* ***Zhejiang Province Two-Year Action Plan on the Construction of Life-Source Renewable Resources Sorting Center Facilities***

3 Ningbo

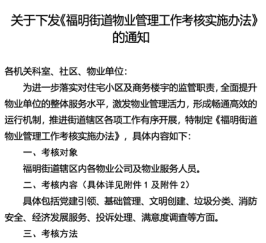
- *Notice on the Issuance of* ***Action Plan of Ningbo Municipality on Promoting Municipal Solid Waste Management with High Standards***
- *Notice on the Issuance of* ***Implementation Plan of Ningbo Municipality on the Construction of Recycling and Treatment System of Renewable Resources***
- *Notice on the Issuance of* ***Implementation Plan of Ningbo Municipality on Further Strengthening the Control of Plastic Pollution***
- *Notice on the Issuance of* ***Three-Year Action Plan of Ningbo Municipality on Plastic Pollution Control (2021-2023)***
- *Notice on the Issuance of* ***14th Five-Year Plan of Ningbo Municipality on the Construction of Harmless Municipal Solid Waste Treatment Facilities***
- *Notice on* ***the Further Specification of the Sectoral Authorities Responsible for the Sorting of Municipal Solid Waste in Specific Places***
- *Notice on* ***Strengthening the Fine Management of Sorted Collection and Transportation of Municipal Solid Waste***
- *Notice on the Issuance of* ***Guidelines of Ningbo Municipality for the Operation of Municipal Solid Waste Sorting by Property Service Companies in Residential Compounds***
- *Notice on the Issuance of* ***Several Opinions on Further Promoting the Classification of Domestic Waste***
- *Notice on the Revision of* ***Guidelines of Ningbo Municipality for the Sorted Municipal Solid Waste Drop-off***
- *Notice on the Implementation of* ***the Integration of Collection, Transportation and Disposal of Waste Edible Oil and Grease in the Central Urban Area***
- *Notice on the Issuance of* ***Work Plan of Ningbo Municipality on the Campaign of "Identifying, Cleaning and Disinfecting Garbage Cans" in the Central Urban Area***
- *Notice of* ***Ningbo Municipal Bureau of Comprehensive Administrative Law Enforcement on the Comprehensive Implementation of Epidemic Prevention and Control in Ningbo Urban Environmental and Sanitation Management Industry***
- ***Implementing Opinions of Ningbo Municipal Bureau of Comprehensive Administrative Law Enforcement on the Establishment of a Regular Law Enforcement and Inspection Mechanism for the Municipal Solid Waste Sorting***
- *Notice on the Issuance of* ***Implementation Opinions of Ningbo Municipality on the Construction of the Collection and Transportation System for Renovation (Bulky) Waste and Park Waste (Trial)***

3.4 Multi-stakeholder co-governance

— Construction of the MSW sorting management system in Ningbo

On June 26, 2013, a signing ceremony was held for the "Demonstration Project for Urban MSW Collection and Recycling in Ningbo" financed by the World Bank loan. This event marked the official launch of waste sorting in Ningbo and the transition to integrated waste management. Since July 2013, waste sorting has officially started in Baiyun Sub-District in Haishu District, Baizhang Sub-District in Jiangdong District, and Wenjiao Sub-District in Jiangbei District. For the last ten years, Ningbo has made waste sorting a critical initiative to promote ecological civilization and enhance the living environment. International cooperation programs have supported Ningbo to adhere an international perspective and integrate international concepts fully into its work on waste management and sorting. In order to establish an efficient and user-friendly waste sorting and integrated management system, Ningbo has specified multi-actor roles in waste sorting from the perspectives of "community-level governance" and "social governance" to build a brand of waste management that showcases multi-stakeholder co-governance.

The core of multi-stakeholder co-governance relies on establishing a positive sense of responsibility. Especially, to implement joint development responsibilities of "government leading; property companies, neighborhood committees, and communities enforcing; and residence implementing" in the waste collection and sorting procedure. The neighborhood committees and property companies have formulated daily management and operation rules in accordance with the Regulations on MSW Sorting Management of Ningbo Municipality. In May 2022, Fuming Sub-District reestablished the Measures of the Sub-District for the Assessment of Property Management (Figure 3-3) to evaluate and score the property management of the area under its jurisdiction. The sub-district has also established red, yellow, and blacklists. Managers and service personnel who demonstrate exceptional performance are recognized as outstanding property talents. Organizations on the blacklist are subjected to measures such as rectifications within a fixed period, restrictions on financial assistance, and property withdrawal. One of the evaluation criteria for property management is the implementation of waste sorting, which accounts for 20% of the total score. The evaluation criteria consist of the installation of waste collection rooms and sorting facilities, guidance and monitoring of waste sorting and collection, and the quality of waste sorting. Property owners



关于下发《福明街道物业管理工作考核实施办法》的通知

各机关科室、社区、物业单位：

为进一步落实对住宅小区及商务楼宇的监管职责，全面提升物业单位的整体服务水平，激发物业管理活力，形成畅通高效的运行机制，推进街道辖区各项工作有序开展，特制定《福明街道物业管理工作考核实施办法》，具体内容如下：

一、考核对象

福明街道辖区内各物业公司及物业服务人员。

二、考核内容（具体详见附件 1 及附件 2）

具体包括党建引领、基础管理、文明创建、垃圾分类、消防安全、经济发展服务、投诉处理、满意度调查等方面。

三、考核方法

社管办	垃圾房、垃圾桶以及垃圾点位等周边干净整洁，无垃圾包，定期消杀；垃圾桶外观整洁、破桶及时更新；堆放点设置围挡，标识明确，大件垃圾清运及时。	4	符合 4 分，基本符合 2 分，不符合 0 分
	定时定点、撤桶并点、桶边督导三项机制均落实到位。	4	符合 4 分，基本符合 2 分，不符合 0 分
	生活垃圾定点、分类收集、清运，无混收混运行为，日常分类质量达标。	4	符合 4 分，基本符合 2 分，不符合 0 分
	配合社区提前做好各项迎检准备工作，检查时期确保人员在岗，积极有序应对。	4	符合 4 分，基本符合 2 分，不符合 0 分
	定时定点做好垃圾分类桶边督导员工作，指导居民破袋投放垃圾。	4	符合 4 分，基本符合 2 分，不符合 0 分

Figure 3-3 Implementation Measures of Fuming Sub-District on Property Management Assessment and Scoring Criteria Related to Waste Sorting
© http://www.nbyz.gov.cn/art/2023/7/7/art_1229737549_8853.html

must fulfill their obligations as responsible individuals for sorting the wastes. This can be achieved via a dual incentive approach of favoring superior methods of waste sorting and eliminating inferior ones.

Encouraging internal motivation and creating synergies is essential for successful multi-stakeholder co-governance. Waste sorting has become a trendy practice that has gained widespread popularity in Wandi Village, Xiaying Sub-District, Yinzhou District, Ningbo. Every day from 8:00 to 10:00 in the morning, villagers arrive at the waste collection points at a steady pace to dispose of their waste. Most of them are able to accurately sort their wastes. Waste sorting is a mandatory aspect of village rules and regulations in Wandi Village, as it is directly linked to the welfare of the villagers. The local villagers provided their feedback: "We have developed a regular practice of sorting our trash, and we feel uneasy when we don't comply with proper segregation." Following the implementation of the waste sorting program, Wandi Village removed the majority of the original garbage cans and reduced the number of waste collection points from over 40 to only 3. The waste collection points were also upgraded. The smart waste sorting room includes infrared scanning, monitoring and hand washing stations. It is also furnished with intelligent systems, including cameras, air exhaust, and drainage, and timed power-ups for breaking and dropping off bags. Despite the reduction in waste collection points, the waste collection points are cleaner, which enhances the experience for the residents.

In addition, a "Carbon Neutral" hut for waste sorting was established in Wandi Village to promote better community engagement. The "Carbon Neutral" hut includes a credit-earning area for waste sorting and drop-off, a viewing deck, a wall for photo-taking and other functional areas. A "Dual-Carbon Hut" has been set up beside the credit-earning area for waste sorting and drop-off to encourage the villagers to better sort the hazardous waste and recyclables (Figure 3-4 and Figure 3-5). The hut contains 12 blue and red waste collection baskets. Each basket is labelled with a specific catalogue of items that can be placed in it, such as glass bottles, newspapers, expired medicines, plastic bags, etc. The front-end sensing system and intelligent processing hub of the waste collection room will weigh and analyze the coefficients to calculate carbon credits for residents participating in waste sorting, which gives them senses of achievement.

Wandi Village has also developed a waste sorting study program that leverages its strengths in agricultural cultivation. Visitors can witness the entire process of sorting, collection, treatment, and recycling of the food waste. Composting facilities are utilized to treat organic waste like food waste and rotten vegetable leaves. Compost products resulting from the process are used in

Figure 3-4 Carbon Neutral Hut for Waste Sorting in Wandi Village
© LIU Xiao

Figure 3-5 Waste Sorting Publicity Wall
© LIU Xiao

Figure 3-6 Food waste treatment and utilization site
© LIU Xiao

agricultural fields and monitored. The waste management program called "Traveling with the Waste", which is immersive and interactive, has successfully raised people's awareness and motivated their initiative to participate in waste sorting (Figure 3-6).

Multi-stakeholder co-governance has a positive impact on service sharing and quality improvement. Waste sorting has proved to be a practical means of strengthening community cohesion and promoting change in the Cuidong community of Wenjiao Sub-District, Jiangbei District, Ningbo. The Cuidong Community is situated at the junction of Jiangbei District and Haishu District. It occupies an area of 120,000 square meters and is home to 1,262 households and 3,155 residents. The residential compounds in the area include the Cuidong Community, the Cypress Garden Residential Compound, and four houses located close to the Old Cypress Bridge.

In the initial phase of the waste sorting programme, Cuidong Township set up a waste sorting credit scheme to motivate residents to participate in the waste sorting process. It is stipulated that residents who participate in waste sorting, drop-off, or volunteer services can earn credits, and they can redeem these credits for various daily necessities on the last day of each month. In addition, each building has established an honor roll for waste sorting to commend residents who excel in dropping off food waste bags and waste sorting, thus elevating their sense of honor. Moreover, each building has established an honor roll for waste sorting to commend residents who excel in dropping off food waste bags and waste sorting, thus elevating their sense of pride. The community also encourages other residents to join waste sorting, to advocate others to also contribute to public hygiene and fostering healthy public hygiene values. The waste sorting pro-

gram is implemented with the help of community staff and volunteers, who provide one-on-one guidance to certain households, thereby promoting waste sorting to all households.

As the secretary of Cuidong community, Mrs WANG Mengxia has actively led and participated in the community's waste sorting efforts. According to Wang, coordination and cooperation are crucial in executing waste sorting. The community collaborated with the respective departments to designate a portion of the public space as an area for waste segregation and temporary storage of bulky waste to improve the community's surroundings. In addition, businesses in the community worked with the community management to consolidate resources, resulting in better waste management facilities in the community.

"Waste sorting serves as a touchstone for social governance," summarized by Wang, "Education and public awareness of residents form the foundation for proper waste sorting. Waste sorting has made the Cypress Garden Residential Compound more beautiful, and it has strengthened the unity among the residents. Furthermore, due to its exceptional waste sorting performance, the community has garnered recognition and commendation from Ningbo and Haishu District. The members of the community have significantly improved their senses of self-worth and fulfillment, uplifted their mental well-being, and created a favorable, virtuous cycle within the community." Government authorities, community workers, residents, companies, and other stakeholders collaborate to encourage waste sorting, contributing to the creation of a civilized society and an environmentally conscious civilization, leading to a mutually beneficial outcome for all parties involved.

Figure 3-7 WANG Mengxia, Secretary of Cuidong Community (Location: Waste Collection and Sorting Hut of Cypress Garden)
© LIU Xiao

3.5
Urban gardens
— An aesthetic expression of waste management

NIMBY (Not in My Back Yard) effects are often a challenge in the waste management development process, particularly in the selection of sites for treatment facilities. The public is worried about the adverse effects of construction projects (e.g., facilities such as refuse transfer stations, waste incineration plants, etc.) on health and environmental quality. In contrast to "NIMBY", "PIMBY effects" (Please in My Back Yard) refer to the phenomenon where people not only accept but also welcome projects that are believed to bring benefits to the development of the community. In Ningbo and in many other cities in China, the construction and upgrading of urban garden waste disposal facilities exemplifies the transition from NIMBY to PIMBY.

1 *The Yinzhou District MSW Sorting Transfer Station*

The Yinzhou District MSW Sorting Transfer Station (Dingqiao Solid Waste Transfer Station) is situated in Dingqiao Village, Jiangshan Town, Yinzhou District. It can transfer up to 680 tonnes of waste per day, including 160 tonnes of food waste and 520 tonnes of other waste. The building occupies an area of 5,956 square meters. The transfer station was built in 2016 with the total investment of RMB 110 million. It serves the purpose of waste compression and transfer in Yinzhou District. It contains various facilities such as the waste transfer workshop (including the garbage sorting workshop), the complex building, the environmental protection education base, the mechanic workshop, the ramp, the ground scale, the river revetment on-site road, the off-site road that has been requisitioned by the government, green spaces, comprehensive pipelines and other auxiliary facilities (Figure 3-8).

The transfer station was designed and built according to the concept of integration with nature. It is situated in a lovely environment surrounded by lush greens. The operation area is managed in accordance with the requirements of "being free from dust, odors, and unpleasant tastes". In terms of odor-free management, the Dingqiao Solid Waste Transfer Station adopts negative pressure operation and has installed an air curtain system to effectively control gas leakage.

Furthermore, the transfer station implements several methods, including a high-pressure water mist gun, an ionized fresh air system, spraying plant liquid, and a two-stage washing process, to guarantee a fresh environment for operation.

Moreover, utilizing the intelligent collection and transportation supervision platform, the Dingqiao Transfer Station can precisely monitor the status of collection vehicles, weighing and measuring, dispatching and unloading, and reduction and compression. It is also able to collect and analyze collection and transportation data in real-time, which enables visualization of the operation trajectory. The transfer station can implement a detailed schedule for MSW collection of the communities, similar to a routine bus, to maximize the efficiency of waste collection and transfer while reducing the residence time of garbage trucks.

Figure 3-8 Yinzhou District MSW Sorting Transfer Station (Dingqiao Solid Waste Transfer Station)
© LIU Xiao

2 The Haishu District MSW Incineration Plant

At the other end of the city, Ningbo Haishu District MSW Incineration Plant is another city landmark for green development, which was put into operation in June 2017, with a total investment of RMB 1.42 billion. It is presently the largest waste incineration power plant in Ningbo with a treatment capacity of 2,250 tons/day and an installed power generation capacity of 2×25MW.

The Haishu District Municipal Solid Waste Incinerator is set amidst lush mountains and clear waters. It stands out with its striking red and white honeycomb structure that exudes dynamism and spaciousness. The facade design of the Haishu District Municipal Solid Waste Incinerator was created by AIA, a world-renowned architectural design organisation based in France. The honeycomb represents the process of collecting and transferring MSW from each household to the waste-to-energy incineration power plant. This process is similar to bees collecting pollen to make honey and reflects the concept of converting waste to energy in the incineration plant (Figure 3-9).

Haishu District MSW Incineration and Treatment Plant is an outstanding facility in China that emphasizes aesthetic appeal. Aside from its architectural aesthetics, the plant has made significant investments in state-of-the-art waste incineration facilities, employs cutting-edge O&M management technology, and effectively controls pollutants. These factors collectively position it as one of the most advanced incineration power plants in China. China has set stringent requirements for flue gas emissions in waste incineration facilities. Local ecological and environmental protection agencies can monitor flue gas emission data online in real-time and share it on the websites of local environmental protection bureaus, ensuring transparency and accountability.

Figure 3-9 Haishu District MSW Incineration Plant
© SUS Environment

Educational exhibition halls have been constructed at the Dingqiao Solid Waste Transfer Station and the Haishu District MSW Incineration Plant. Visitors can observe the entire waste management process through VR videos, projections, informative explanations, and interactive games. In addition, the dumping, compressing and packing of garbage trucks, as well as the process of refuse crane grabbing the waste into incinerator and incinerator are presented, which further achieves zero-distance understanding of the waste disposal process. By experiencing the flow of waste in-depth in the context of urban gardens, the overall misunderstanding of the public could be effectively reduced, and the familiarity with waste management could be enhanced. Aesthetically and artistically designed waste disposal facilities stand out among other public structures in cities, showcasing the value of proper waste management and enhancing the standard of living for those in urban areas.

3.6

The era of AI

— Breakthroughs in the development of recyclable systems and plastic recycling

The China Plastic Waste Reduction Project (Phase I), financed by the World Bank, was launched in China in 2023 It aims to improve plastic waste management at national and local levels in China and minimise plastic pollution from municipal solid waste, with a total loan amount of USD 150 million. Ningbo as one of the implementing entities, its project is named the "Demonstration Project for Intelligent Sorting, Collection and Recycling of Urban MSW in Ningbo". The project aims to establish a demonstrative system of intelligent sorting, collection and recycling of MSW covering the central urban area of Ningbo. The existing system of collection, transportation and disposal of MSW will be intelligently upgraded, to promote the comprehensive digital development in the field of waste sorting and achieve the goal of accurate waste sorting at source. The city will gradually achieve full coverage of real-time collection and transportation mode to enhance the operational efficiency of the collection and transportation system, and strive to build into a national demonstration city of circular economy.

The project will be carried out in eight districts in the central urban area of Ningbo: Haishu, Yinzhou, Jiangbei, Beilun, Fenghua, Zhenhai, Gaoxin and Dongqianhu. These districts have a permanent population of 4.55 million residents and 1.2 million households. Through the investment and implementation of the project, the current system for collecting and disposing of MSW will be intelligently upgraded.

The city plans to install and use nearly 4,000 smart waste collection bins equipped with AI graphic recognition algorithms to help residents sort household waste accurately at the source within three years. Automatic weighing, AI recognition, and blockchain bookkeeping will enable real-time evaluation of sorting quality and effectiveness. Applying AI technology will effectively boost the precision of front-end sorting, which is a key highlight of the project (Figure 3-10). The city plans to build three new and upgrade five existing collection and transfer stations for recyclables at the terminal, with a daily capacity of 70 tons each. At the end of resource utilization, the city will establish centralized facilities for sorting and processing plastic waste. These facilities will have a capacity to process 40,000 tons/year, handling all types of plastics including PET, HDPE, PP, films, and miscellaneous plastics from the dismantling of household appliances. A complete industry chain for plastic collection, transfer, and processing will be established to achieve plastic waste recycling.

Figure 3-10 Dabashou intelligent waste separation bins in Ningbo
© Ningbo Dabashou Eco-Digital Technology Co., Ltd.

To enhance the management system and capacity during the project implementation, it is proposed to establish an intelligent integrated management center for waste sorting. The centre will include a municipal solid waste management information platform and a research and development centre for plastics recycling, as well as the establishment of a command information management system to manage all types of waste and hierarchical responsibilities in the central urban area. Intelligent information systems will be used to enhance both management capacity and efficiency. In addition, the project includes improvement of technical support and capacity building activities that focus on plastic waste management, including formulation of Ningbo's plastic emission reduction action plan, and development of Ningbo's plastic emission reduction result assessment methodology, charging policies for local waste disposal, and rules on waste sorting in compliance with Ningbo's regulations. Therefore, a precise incentive mechanism will be put in place in the management system to effectively promote and enhance public awareness of waste sorting and plastic reduction.

Moreover, the project proposes further core indicators, aimed at effectively achievement of the project objective of plastic waste reduction through implementation. Indicators are outlined below.

- *Coverage of quality MSW separation at source (percentage of urban households)* ***80%***
- *Improved resource utilization (percent of MSW diverted from incineration/landfills)* ***60%***
- *Percentage of plastic recyclables in total recyclables after MSW sorting* ***20%***
- *Recovery of* ***20%*** *of plastic recyclables through home appliance dismantling*
- ***50%*** *reduction in plastic in food waste, using 2019 data as the baseline*

Since waste management was expanded to include waste sorting, it became a systematic programme with social implications. Infrastructure construction, collection and transportation systems as well as laws and regulations could be further improved and completed within a certain period of time. However, it would take considerable effort to make a noticeable impact on the public. Over the past decade, Ningbo has em-

ployed sociological, psychological, and communication expertise to improve public participation, as a typical subject in socio-educational governance. The city also launched public awareness campaigns to promote the reduction of plastic waste and improvement of waste segregation. The charitable program "Where's the Garbage?", dedicated to environmental protection expedition, received the China Habitat Environment Example Award in 2017. The school education case study "Little Babies, Big Moves" received the 2018 ISWA Communication Award. The Creative Textile Waste Creative Recycling project won the first place in the 2021 ISWA Communication Award, aimed to promote eco-friendly waste management based on the unique heritage of Ningbo, China both nationally and internationally. Posters promoting the reduction and limitation of plastic waste, as well as the creation of blue oceans could be seen at many bus stops throughout Ningbo. Supported by the World Bank project, all waste management stakeholders in Ningbo, together with the public, have jointly implemented the "Reduce Plastic and Limit Plastic, Ningbo on Its Way" project with the assistance of AI technology (Figure 3-11).

Figure 3-11 A bulletin board on plastic reduction on Sanzhi Street in Ningbo
© LIU Xiao

3.7 Summary of waste management practices in Ningbo

The transition from waste disposal to integrated waste management represents an ongoing enhancement of the MSW management and system. The features of MSW management in Ningbo are summarized as follows:

1

Establishing an efficient and user-friendly waste sorting and management system that involves multi-stakeholder co-governance.

From the perspectives of “community-level governance" and "social governance”, Ningbo fully specified the role of various actors, constantly motivating the internal momentum of society to build a waste management brand with multi-stakeholder co-governance. The city strengthened the relationship between the public and community-level management through successful waste management practices that promote community involvement in social activities and enhance their senses of belonging and worth, which demonstrates social progress.

2

Creating a waste sorting and integrated management system with an international perspective and aesthetic appeal for gardens.

Ningbo has always prioritized waste sorting as an essential component in building ecological civilization and improving living environment. International cooperation programs have enhanced Ningbo's global outlook on waste management. Many cities, including Ningbo, are emphasizing the aesthetic components in waste management, showcasing the Chinese urban waste management sophistication and quality.

3

Assisting in refining the management of MSW using AI technology.

AI technology can accurately identify the impact of various aspects of waste management and make comprehensible evaluations. Ningbo's technological innovation has led to the development of quantifiable and detailed evaluation indicators, including the percentage of accurately sorted waste and the proportion of plastic recyclables. These indicators facilitate the tracking and management of different waste categories, demonstrating a constructive and encouraging measure.

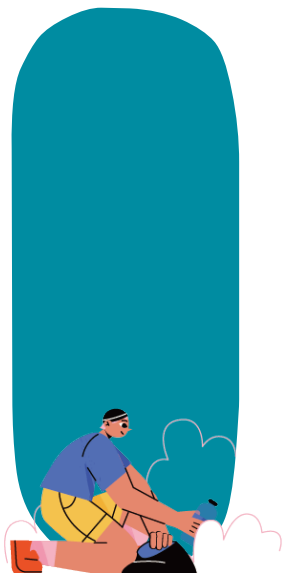
CHAPTER 04

CHAPTER FOUR:

MSW Management in Yantian District, Shenzhen:

From Smart Waste Management to Collaborative Social Governance

04



4.1 Basic information of Yantian District, Shenzhen

Yantian is a coastal district under the jurisdiction of Shenzhen, Guangdong. It spans over 74.99 square kilometers, with a built-up area occupying 23.21 square kilometers surrounded by mountains. Situated in the east of Shenzhen, Yantian neighbors Dapeng New District (Shenzhen) in the east, Luohu District (Shenzhen) in the west, Longgang District (Shenzhen) and Pingshan District (Shenzhen) in the north, New Territories (Hong Kong) in the south, and its Sha Tau Kok Port is directly connected to Hong Kong. Yantian enjoys a subtropical monsoon climate, which provides year-round pleasant weather, abundant rainfall and long hours of sunshine. Yantian has an average annual temperature of 22.2℃ and a cumulative average annual rainfall of 1,500mm-2,500mm (Figure 4-1).

As of 2021, Yantian held jurisdiction over four sub-districts with a permanent resident population of 215,400, including more than 120,000 migrants. In terms of gender structure, around 110,000 (54 percent of the total population) were male, and over 100,000 (46 percent of the total population) were female. In 2022, the GDP of Yantian reached RMB 82.06 billion, and the GDP per capita was RMB 183,300. The ratio of the thrice industrial structure is 0.04:18.45:81.51.

The waste management data presented in this case study encompasses the entire Yantian District and has been sourced from the Urban Administration and Law Enforcement Bureau of Yantian District.

Figure4-1 Urban landscape of Yantian District
© UN-Habitat | BAO Meng

4.2
MSW generation and treatment in Yantian District

Between 2020 and 2022, Yantian has established a complete MSW source sorting and collection system based on four categories. The MSW collection and sorting amount is shown in Table 4-1. The collection of household and commercial food waste has increased significantly; the collection of recyclables (especially glass) witnessed a significant increase based on the statistics from the municipal governmental collection provider. In 2022, the MSW collection amount in Yantian was 118,000 tons (excluding construction/demolition waste, bulky waste, and landscape waste), and the recycling rate (including recyclables, household food waste and commercial food waste) was 33.5%. In addition, the recycling rate for household food waste was 21.8% and the recycling rate for recyclable materials was 11.7%. The marked increase from the 2020 recycling rate of 21.4% underscores the success of MSW sorting efforts in Yantian. It is worth noting that currently, a substantial portion of recyclable data in China does not encompass informal sector and commercial recycling activities. As such, the actual resource utilization rate of waste is likely higher than the available data (Figure 4-2).

In 2022, MSW collection amount per capita of Yantian is 1.53 kg/day. Among this, recyclables accounted for 0.18 kg/day, with glass forming the majority of 60.1%, followed by metal and plastic at 22.1% and 7.0%, respectively. It is noteworthy that the share of glass in the recyclables is high, which may be due to the fact that high value recyclables such as paper and plastic are still collected through market-oriented channels. Guidance should be prepared for the collection of relatively low-value recyclables such as glass. In Yantian, 1 carbon credit (equivalent to RMB 0.1) can be earned for 1 kg of recyclables put into the intelligent waste sorting bins. The collection of low-value recyclables has been enhanced by adopting intelligent systems and incentivizing a reasonable credit-earning approach.

Regarding the treatment and disposal of MSW, there is one MSW incineration power plant in Yantian. All of the other waste goes to the incineration plant for harmless treatment and energy utilization, with a 100% harmless treatment rate. For the food waste, it is transported to other food waste treatment plant in Shenzhen. It is worth mentioning that, as an innovator and pioneer in waste management in China, the first sanitary landfill and the first MSW incineration plant of China were all constructed in Shenzhen. The city has played a groundbreaking demonstration role in demonstrating waste management, treatment, and disposal in China.

In addition, in Yantian District, the changes in MSW incineration amount per capital and MSW incineration amount per unit GDP from 2013 to 2022 are shown in Figure 4-3 below. The figure indicates a decrease in per capita waste inciner-

ation after the implementation of waste sorting in Yantian in 2019, as evidenced by the tracking of other waste treated by the incineration treatment facilities. From the perspective of economic development, the MSW incineration amount did not increase linearly with GDP, but the MSW incineration amount per unit GDP decreased year by year. In 2022, the MSW incineration amount per unit GDP is around 50.7% compared with 2013 (Figure 4-3).

Yantian District, Shenzhen

Table 4-1 MSW Collection in Yantian District (2020-2022)

(Unit: ton)	2020	2021	2022
Hazardous waste	2.3	1.7	2.6
Recyclable waste	2,290.4	8,404.6	13,835.8
Household food waste	8,285.6	11,463.0	10,612.7
Commercial food waste	9,723.0	12,997.8	15,158.9
Other waste	74,703.7	75,918.7	73,180.2
Total	95,005.0	108,785.7	112,790.2

Note: Food waste is categorized according to the source of waste generation into household food waste generated by household sources and food waste generated by restaurants and other food service establishments, known as commercial food waste.

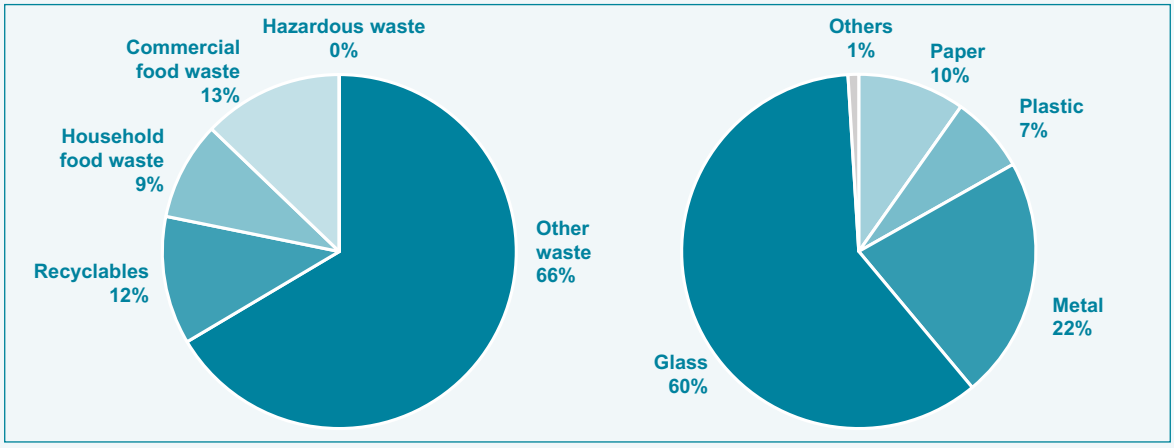


Figure 4-2 Composition of MSW and recyclables in Yantian District, Shenzhen (2022)

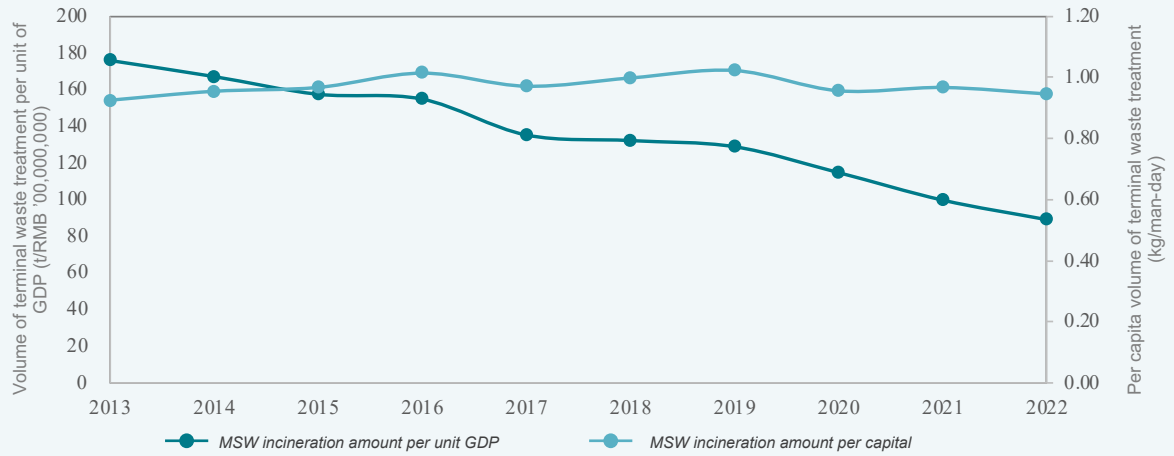


Figure 4-3 MSW incineration amount per capital and MSW incineration amount per unit GDP of Yantian District (2013-2022)

4.3 Summary of MSW management policies in Shenzhen

1 The overarching legislations governing MSW management

- The ***Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution, Circular Economy Promotion Law of the People's Republic of China***, and the State Council's ***Regulations on the Management of Urban Amenities and Environmental Sanitation*** are the overarching laws and legislations for MSW management.

- The corresponding laws and regulations issued by Guangdong Province includes the ***Regulations on Municipal and Rural Solid Waste Treatment in Guangdong Province*** and the ***Implementation Plan for MSW Sorting in Guangdong Province***.

2 The policies and regulations of MSW management issued by Shenzhen City

- The ***Regulations on the Management of City Appearance and Environmental Sanitation in Shenzhen Special Economic Zone*** were adopted on June 30, 1999 and most recently amended on April 26, 2023. The regulations clarify carrying out a primary responsibility system for managing Shenzhen's urban appearance and environmental sanitation. The regulations also advocate for combining government leadership with social engagement while also balancing punishment with education. The regulations also clarify the division of responsibilities, responsible persons, management requirements, assessment methods, and legal obligations related to the management of city appearance and environmental sanitation.

- The ***Regulations on MSW Sorting and Management in Shenzhen*** were adopted on December 31, 2019, and became effective on

September 1, 2020. The regulations aim to enhance the MSW sorting and managemen for reducing, recycling, and harmless disposal, while also improving urban civilization and the residents' living. The regulations also specify the sorting methods and require the establishment of a MSW sorting and management system to collect MSW on a fixed schedule and fixed treatment administrators. In addition, the regulations encourage and recommend source reduction and recycling. In terms of supervision and management, it requires the establishment of a supervision system for MSW sorting and management, and the implementation of several measures to punish violations of waste sorting regulations.

- In 2020, the Shenzhen Urban Management and Law Enforcement Bureau issued a series of supporting policy documents, including the ***Special Law Enforcement Action Plan for MSW Sorting in Shenzhen***, the ***Guidelines for Refusing to Collect, Transport and Treat MSW Inconsistent with the Sorting Standards (Trial)***, and the ***Management Measures for MSW Sorting Public Supervisors in Shenzhen (Trial)***. These regulations aim to facilitate the effective implementation of the ***Regulations on MSW Sorting and Management in Shenzhen***. In addition, the CYLC Shenzhen Municipal Committee and other organizations jointly issued the ***Implementation Plan on Establishing a Volunteer Service Team for Waste Sorting*** and the ***Administration Measures for the Volunteer Service Team for Waste Sorting in Shenzhen***. These regulations can encourage social forces in Shenzhen to actively participate in MSW sorting and foster better MSW management.
- In addition, Shenzhen issued the ***Regulations on Promoting the Circular Economy in Shenzhen Special Economic Zone*** in 2006, which aim to restrict the output and sale of disposable products and encourage waste recycling. These regulations allow the city to promote the circular economy in Shenzhen and become more eco-friendly and resource-efficiently. In this way, the city will realize a sustainable, coordinated, and comprehensive growth in the economy, society and environment.

3 The implementation plan for MSW management issued by Yantian District

- In accordance with the aforementioned policies and regulations, Yantian has issued the ***Implementation Plan for MSW Sorting and Reduction in Yantian District (2016-2020)*** and the ***Action Plan for Comprehensively Promoting the Mandatory MSW Sorting in Yantian District (2019-2021)***. The district aims to achieve fine front-end sorting, specialised middle-end collection and transportation, site-based final treatment and digital supervision of the whole process. It emphasizes the importance of promoting awareness of proper sorting practices by clarifying the publicity requirements for media and other channels of communication. Meanwhile, the district suggests the formation of a professional volunteer team to promote awareness, and tasks schools and other entities with the responsibility of waste sorting/waste management.

The overall policy development provides top-down guidance. From the provincial and municipal levels to the district level, increasingly precise and targeted policies have been adopted and implemented. They focus on different core aspects to represent local characteristics.

4.4

"Digital Governance"

— A new stage of modern MSW Management

In Yantian, the digital journey begins with the disposal of waste in intelligent separate collection bins. Since 2018, the district has led the way in developing a complete intelligent management system for MSW sorting in Shenzhen. Supported by the Internet of Things (IoT), big data and AI technology, the system covers all aspects of solid waste management, including source collection, transit and transportation, treatment and disposal, public participation, management, and supervision. Equipped with advanced features such as information perception associated with MSW sorting, real-time processing, and efficient command, the system enables real-time intelligent management and control across the entire region, category, and chain (Figure 4-4).

Integrating advanced technologies like 5G, IoT, and big data, the intelligent system acts as the "brain" of MSW management, and various applications and functions are developed in the "brain" including public participation, collection, transportation, and disposal supervision, as well as IoT center, video center, and AI centers. These applications cover the entire waste sorting process and the process of public participation (Figure 4-5).

Figure 4-4 Intelligent MSW collection equipment in Yantian District
© Shenchuan Technology, https://www.shencom.cn/

At the source collection stage, 618 sets of intelligent waste sorting and collection bins featured with infrared sensing, face recognition, automatic weighing, overflow alarm, etc., have been installed for real-time data upload and overall control of operations. At the transfer and transportation stage, digital information is provided to the MSW transporting personnel, equipment and facilities through RFID, intelligent vehicle weighing, GPS and other advanced technologies. These technologies enable the district to achieve the intelligent perception and scheduling on the entire collection and transportation chain. At the terminal disposal stage, the district has successfully implemented automated operation for the entire process, including vehicle access, weighing, unloading and task completion. These outcomes are achieved through precise weighing, video surveillance, early warning systems, etc... In addition, GPS tracking alerts for vehicle arrival and departure times are provided to optimize the whole logistic efficiency. They are also used to monitor the frequency and quality of imported treated waste and the quality of exported materials. Additionally, they enable intelligent analysis of treatment performance at each stage.

How to transfer the intelligent monitoring into the intelligent management, the key concept is to empower the social governance and government management by information systems and data systems, and the influence of data for the decision-making analysis and societal development. That is to reflect the improvement of efficiency from “**traditional governance**” to “**digital governance**”. Taking the collection and transportation of furniture waste in Yantian as an example, the intelligent “brain” system coordinates and the whole process from placing and setting up the orders, , coordinating vehicle schedules, tracking routes, surveying the service satisfaction. “Qualified” and “Excellent” results are awarded to the work orders completed within 72 hours and 48 hours respectively.

In addition, “**people-oriented digital management**” is crucial for intelligent management. Intelligence and IT applications are considered as service tools. However, their value and goal orientations deserve more attention. Yantian is placing more emphasis on the public participation in digital services and has effectively integrated voluntary services with waste sorting in an innovative way. A platform has been created for voluntary supervision appointments focused on

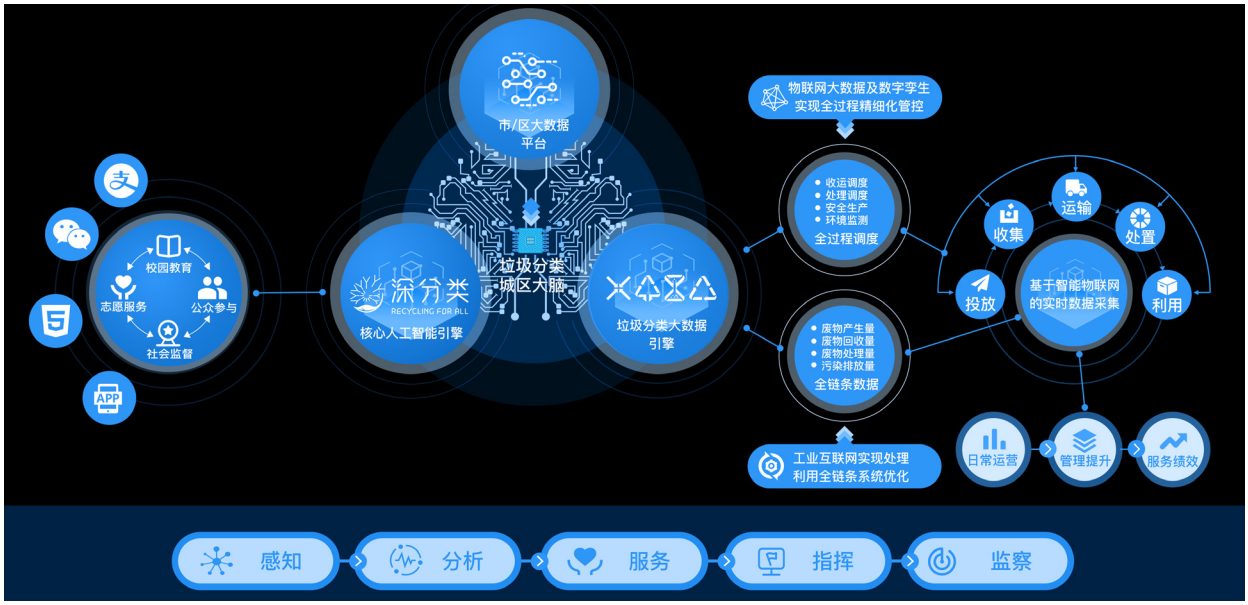


Figure 4-5 Intelligent waste management "brain" in Yantian District
© Shenchuan Technology, https://www.shencom.cn/

waste sorting. Additionally, the platform has enabled data sharing and integration with volunteer systems located in Shenzhen. Through these features, Yantian has achieved automatic data collection of volunteer services for waste sorting, a 24-hour reservation system for volunteer activities, one-click appointment scheduling intelligent navigation, volunteer registration, and automatic tracking of service hours. In addition, based on the regulations on MSW the residents' sorting behaviors were punished if they does not meet the regulation. On the volunteer supervision platform, residents can choose opt for " Doing the Activity Instead of Penalty", which means they can participate in waste sorting services instead of being punished. Yantian guides its public participation by intelligent systems which assists the government decision-making, and promote social civilization. Yantian's MSW management has developed into a new stage called "digital governance" (Figure 4-6).

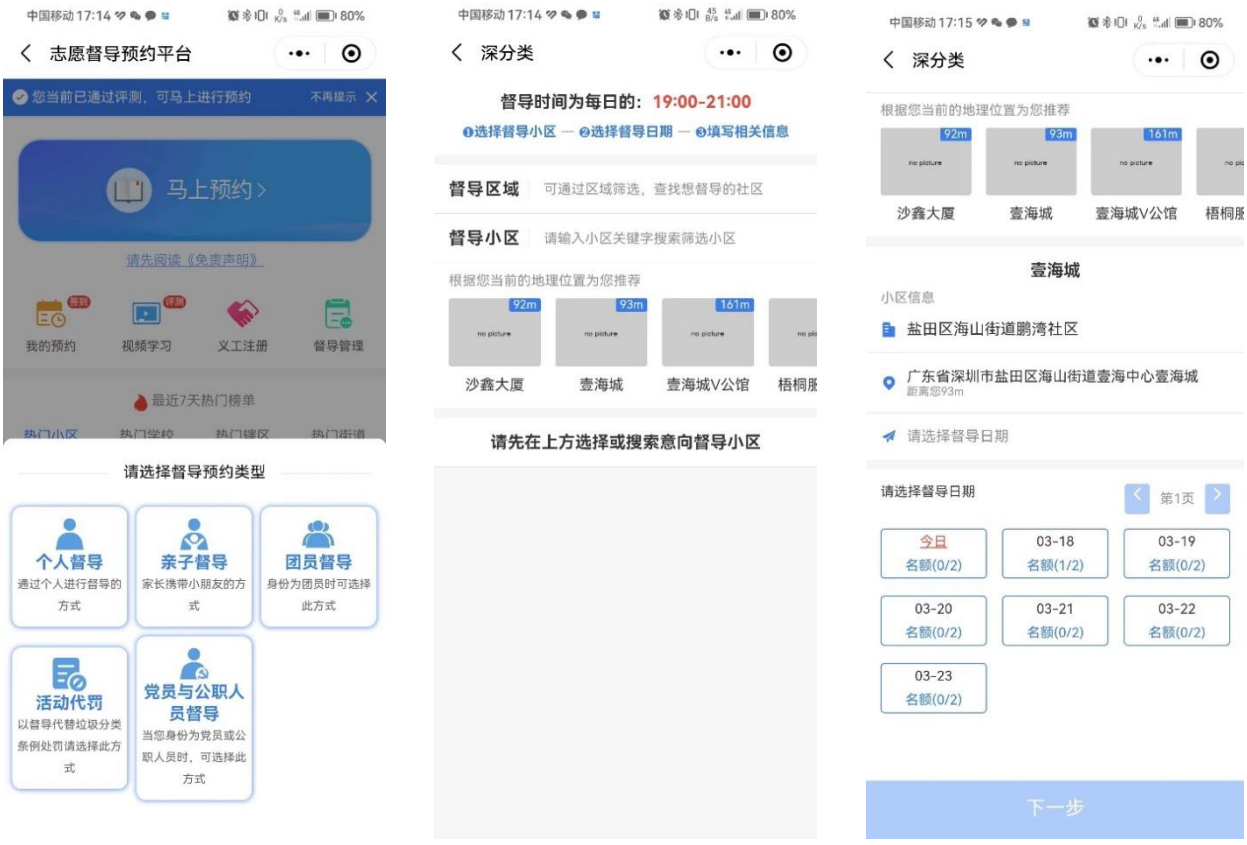


Figure 4-6 Volunteer supervision services on the waste sorting platform in Yantian

4.5 Innovation — Exploration of waste management in sustainable communities

Surrounded by mountains on three sides and facing the sea on the fourth, Dameisha sub-district is located on the shores of Mirs Bay in Yantian District. It is a significant scenic area of the Gold Coast in the east of Shenzhen. People's perception of Dameisha in the past was limited to its beach and seaside. Over the past two years, however, changes have taken place in the Meisha sub-district. The residents and tourists here can feel the new atmosphere and vitality of the sustainable community. Dameisha sub-district, who has a new identity as Meisha Carbon Neutrality Demonstration Zone, offers a innovative perspective for the future of the community and the city. It is featured by low-carbon transition contained in traditional culture, thousand-year-old forest communities that contribute to urban health, and a variety of animals and plants coexisting with residents. In addition, Dameisha Sub-district provides answers on how to realize carbon neutrality at the community level and further practice sustainable development beforehand from different dimensions. The solutions include zero-carbon buildings and communities, zero-carbon and zero-waste lifestyle, and community culture, etc.

Zero-carbon Vanke Center — the model of zero-carbon building and zero-carbon community

About 1 kilometer away from Dameisha Beach Park, Vanke Center covers an area of 61,729.7 m^2 and an overall construction area of 80,200 m^2. It is a large building complex that combines office, residential and hotel functions. Built and put into operation in 2009, Vanke Center has received LEED Platinum certification, the highest award of the U.S. Green Building Rating System, and the three-star logo of China Green Building. Various green ecological technologies have been used in the architecture, including solar photovoltaic power generation, recovery of reclaimed water, rainwater collection, electric shading louvers, and roof gardens. (Figure 4-7)

The main body of Vanke Center features an exterior facade adorned with horizontally arranged shading louvres made of perforated aluminum panels. The hollowed-out shapes of varying sizes on the panels

allow natural light to pass through. The external shading system can automatically adjust the angle through a computer control system to optimize indoor shading and lighting, based on different sun exposure times and intensities. Secondly, the roof of Vanke Center is outfitted with solar photovoltaic panels covering an area of 8,000 m^2. The converted solar energy can supply around 710,000 kWh annually, which accounts for 85% of total electricity usage of Vanke Center. Besides, the Center can save approximately 45,700 tons of water annually by gathering all roof rainwater and infiltrating all ground rainwater. Rainwater and sewage are collected via the landscape pool and constructed wetland, and then treated through the biodegradation and reclaimed water treatment system installed within the wetland. This enables Vanke Center to treat 100 tons of reclaimed water and sewage daily, effectively recycling the water resources. Vanke Center aims to achieve carbon neutrality for the Center operation in 2023 by purchasing the green electricity to cover the other 15% electricity usage.

Figure 4-7 Bird's eye view of Vanke Center
© Vanke Foundation

Zero-carbon lifestyle — from zero-carbon energy to zero-carbon resources utilization

Vanke Center is also a “zero-waste” laboratory that expands the concept of zero carbon from clean energy to resource recycling and to zero-waste lifestyle. The waste here will be collected and treated with care to become the valuable resource and to be circulated in the Center. Everyone here is not only just a spectator or user, but also a crucial participant in recycling resources.

In Vanke Center, the black soldier fly is the most famous star in household food waste reduction. There are four cafeterias located in the park, serving more than 1,000 individuals and producing about

200 kg household food waste every day. The household food waste is transported to the black soldier fly station (Figure 4-8), and then undergoes pre-processing and pulping, becoming the food for black soldier flies. As a result, 40 kg black soldier fly larvae (wet weight) are generated every day. These larvae serve as high-protein feed for the fish in the park's landscape pond. Furthermore, the feces of black soldier flies, along with the green waste in the park, as well as various organic wastes such as coffee grounds, tea leaves, paper scraps and fallen leaves, will be broken down through 28 days composting process to create a high-quality soil conditioner. In this way, Vanke Center can produce 50 kg compost every day, which can be used in the gardens to improve soil quality. The park has achieved a 100% recycling rate for household food waste and a 40% recycling rate for garden waste within Vanke Center.

Figure 4-8 Black Soldier Fly Treatment Station in Vanke Center
© LIU Xiao

There is a hidden gem known as the Roof Garden located at Vanke Center. This petite wonderland is bursting with flowers, birds, plants and trees. Despite its small size, the garden includes a desert plant area, a vanilla area, a scientific pilot area, a composting area and a family planting area. The employees who are interested can claim a 5 m2 garden on the roof and plant by their own. Soil conditioners made from mixed composting in the park help lettuce, tomatoes and citronella thrive. In this way, Vanke Center has access to organic lifestyle in the city and has realized the recycling of household food waste (Figure 4-9). The "Black Soldier Fly — Community Composting —

Co-building Garden" recycling model in Vanke Center was chosen as one of the Top 10 Co-building Gardens (First Batch) by Communities in Shenzhen.

Figure 4-9 Roof Garden at Vanke Center
© CHEN Yongming

Figure 4-10 Zero-Waste Lifestyle of Gen Z
© Vanke Foundation (http://www.vankefoundation.com/)

In addition to recycling resources from household food waste, Vanke Foundation has launched more "Zero Waste" activities at Vanke Centre to reduce waste generation, including Zero Waste Office, Zero Waste Tourism, Zero Waste Hotel and Zero Waste Lifestyle initiatives. Based on the above practices, Vanke Foundation has also launched a series of zero-waste guidelines to promote innovative activities focused on "low carbon", "sustainability" and "zero waste" in Dameisha Community. These diverse activities and practices have become a new lifestyle among residents here.

Figure 4-11 Zero Waste Handbook Series
© Vanke Foundation (http://www.vankefoundation.com/)

Zero-carbon community culture —— Creating "a beautiful and shared future home"

Zero-carbon and zero-waste concepts encompass not only actions or behavioral changes, but also the development of community-based culture. To this end, stakeholders in the Dameisha community, including government, businesses, schools, social organisations and individual residents, have all made their own contributions.

Since 2022, Dameisha Community has been inspiring public enthusiasm for sustainable low-carbon development through a variety of zero-carbon activities every summer, including community composting, secondhand markets, wetland restoration in Dameisha Lake Park, Meisha Biodiversity Exhibition and Meisha Natural Observation Year, etc. The concepts of zero-carbon and zero-waste have been widely spread in Meisha. Among them, the Food Waste Recycling Journey at Vanke Center has become a classic for community visits and a vital component of the zero-waste community's cultural growth since 2023. By June 2023, a total of 610 individuals have experienced this activity in the park (Figure 4-12). Additionally, in July 2023, the Carbon Neutrality Experimental Park of Vanke Center received several awards, including the designation as the Nature Education Base of Guangdong Province, the National Nature Education School of the Chinese Society of Forestry, the Off-campus Practice Base (Camp) of Shenzhen Young Pioneers and the Dandelion Off-campus Practice Base for MSW Sorting of Shenzhen Young Pioneers.

Black Soldier Fly → Composting Demonstration Zone I → Spiral Garden → Earthworm House → Composting Demonstration Area II → Roof Garden → Professor Workstation

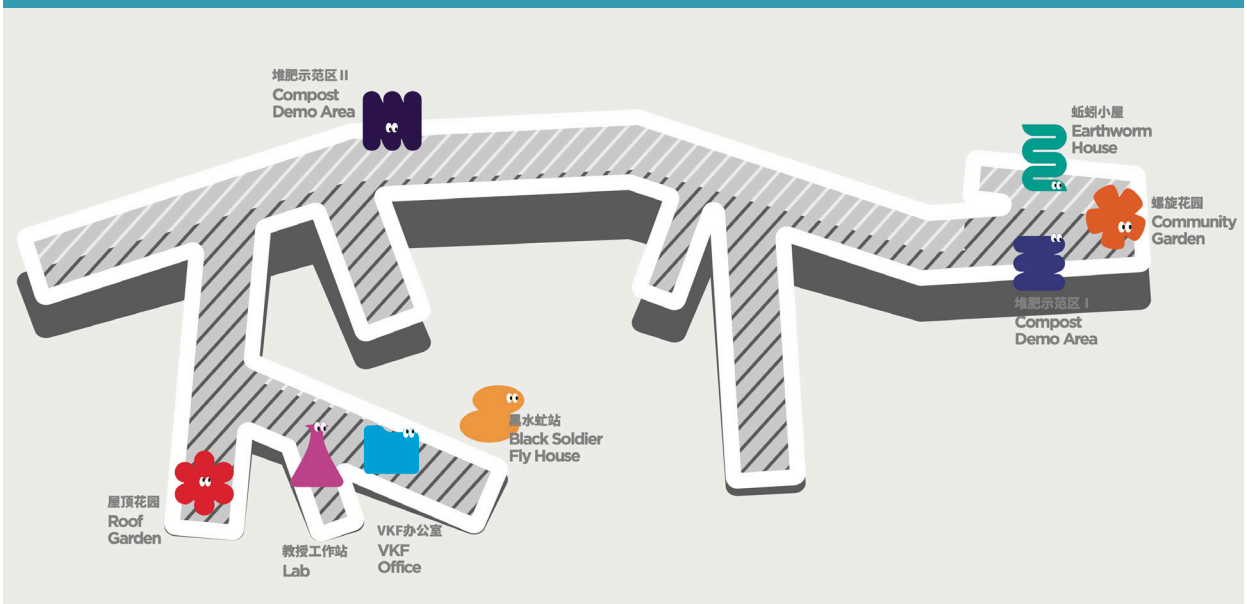


Figure 4-12 Organic Waste Recycling Journey at Vanke Center
© Vanke Foundation

At the end of 2021, Dameisha Community in Meisha Sub-district was chosen as one of the near-zero carbon emission communities in Shenzhen. In 2022, the 14th Five-Year Plan of Shenzhen to Tackle Climate Change proposed to build the "Dameisha Carbon Neutrality Demonstration Zone". The development of the Dameisha Carbon Neutrality Community provides significant and applicable reference to Shenzhen and other regions.

In addition to promoting recycling and sustainable, low-carbon behaviors within the community, Vanke Foundation has also organized a variety of communication and promulgation activities. Through these efforts, the foundation disseminates typical cases studies summarized in Dameisha. It also shares more interesting, greener, and more active low-carbon living practices with a wider audience. In 2023, the Shenzhen Net-Zero Carbon Science Museum was opened to the public, jointly established by the Shenzhen Ecology and Environment Bureau Yantian Branch, the Yantian Urban Management and Law Enforcement Bureau and Vanke Foundation. Featured in a transparent and eco-friendly space, the science museum offers a comprehensive exploration of the proper sorting and utilization of household food waste within in the community. Through this initiative, it has raised public awareness about waste sorting and carbon emission reduction, especially among young people.

Figure 4-13 Shenzhen Net-Zero Carbon Science Museum
© Vanke Foundation

4.6 Inclusion

— A model of collaborative social governance for public participation

In Yantian, social organizations and the public play a crucial role in actively participating and collaboratively promoting waste sorting. Established in 2008, Vanke Foundation upholds the mission of "Facing the Future, Daring to Initiate" and aims to achieve the vision of "A Beautiful and Shared Future Home". Registered with the Ministry of Civil Affairs, the foundation pursues the goal of "creating a sustainable community" and focuses on waste management technologies and mechanisms on the community scale. By collaborating research, piloting and promotion, the foundation has supported different projects covering 27,000 communities nationwide from 2018 to 2022.

Volunteers in Yantian

In Yantian, innovative social organizations are driving change, and volunteers and the public are noted for the active involvement of waste management. Shenzhen is an inclusive and vibrant city where volunteer culture holds significant importance. The Shenzhen Volunteer Association, the first corporate volunteer organization in Chinese mainland, was founded in the city in 1989. Currently, there are 3.51 million registered volunteers and more than 15,000 volunteer teams in Shenzhen. One of the mottos of Shenzhen is “When you become a Shenzhen citizen, you are also a volunteer at the same time ". Volunteering fills Shenzhen citizens with pride but it also showcases the city's cultural influence.

Figure 4-14 Ms. XU Xian, a volunteer representative of Yantian District (left); daily sharing of the "Clear Your Plate" campaign (right)
© XU Xian

As a model of collaborative social governance, volunteers in Yantian have actively led waste sorting efforts. Ms. XU Xian is a representative of the waste sorting volunteers. Since 2013, she has organized and participated in over 3,000 volunteer activities related to public welfare, environmental protection and civilization. She dedicates all her free time to volunteer activities. “Public welfare has already become an essential part of my daily life, as crucial as eating and sleeping,” said XU Xian (Figure 4-14).

On November 8, 2018, Shenzhen initiated the “Clean Plate Day” campaign. As the ambassador of Yantian, XU Xian encouraged the public to participate in the campaign by sharing their experiences. The “clean plate” jigsaw puzzle before and after meals still continues today, and hundreds of individuals continue to participate in the daily “clean plate” sharing in WeChat groups. These participants have transformed the slogans into actions, and developed “clean plate” campaign into a habit. Since 2016, XU Xian has been organizing key volunteers in Yantian to carry out awareness campaigns on resource recycling and waste sorting every Saturday in different communities. On 21 April 2020, Shenzhen re-launched the platform for voluntary supervision appointments for waste sorting. Every evening, XU Xian mobilizes volunteers, students and parents in Yantian to participate in local voluntary supervision and services to assist residents in accurately sorting their household waste. Additionally, she regularly provides waste sorting training called "Little Supervisors” for teenagers.

In 2022, a total of 101,132 individuals participated in the voluntary supervision for waste sorting in Yantian, of whom 92,675 successfully completed their voluntary supervision. The time spent by the volunteers in service totals 185,350 hours (calculated based on an average of 2 hours per volunteer).

"Dandelions" in Yantian

In addition to the dedicated volunteers, there are 50 Dandelion Volunteer lecturers and 48 Dandelion Teachers who work in all primary and secondary schools in Yantian. They promote the values of waste management and social responsibility on campus, integrating them into the local culture. In July 2018, the Shenzhen Municipal Administration and Law Enforcement Bureau, and Vanke Foundation jointly launched the "Dandelion Plan" for waste sorting. It means to disseminate waste management practices across society and campuses, akin to the behavior pattern of dandelion seeds. This approach encourages every resident or student to become a supporter and practitioner of waste sorting (Figure 4-15). The campaigns aim to explore a feasible model for the MSW sorting by residents in Shenzhen. After four years of

promotion, it has established a comprehensive system contains public education, training for volunteer lecturers, school education, and training for dandelion teachers. The dandelion volunteers are required to complete a total 18-hour classes of centralized theoretical and practical training in 9 courses. These courses include MSW Treatment Technology, Waste Sorting and Education, and Waste Sorting Practices in Households, Schools and Communities and also supplemented with site visits. In this way, the campaign enables volunteers to become acquainted with the fundamental principles and elements of the waste management process, thereby gaining a thorough comprehension of waste management expertise.

Yantian has established the first "Dandelion Campus" and the first "Little Dandelion" volunteer team in Shenzhen. The volunteer team consists of 48 students from all primary schools and kindergartens throughout the district. These students have completed the "Little Dandelion" lecturer training and established the inaugural "Little Dandelion" lecturer in Shenzhen. These "Dandelion" and "Little Dandelion" volunteers collaborate to create standardized courses and activities with the goal of promoting waste reduction and sorting across on campus. The campaign aims to educate young people about waste sorting and motivate them to take action. Its goal is to empower students to impact their families, drive their communities, and ultimately promote society. In October 2021, the Department of Housing and Urban-Rural Development of MoHURD published a special article in News Release on Construction Work (No. 82) to promote the experience and practices of the Dandelion Plan to the whole country. The title of the article is "Shenzhen Launches the Dandelion Plan for Public Education to Disseminate and Promote Waste Sorting".

Figure 4-15 Group photo of Dandelion Lecturers in Yantian District in 2021
© Urban Management and Law Enforcement Bureau of Yantian District

"Little water drops" in Yantian

In 2021, the Urban Administration and Law Enforcement Bureau of Shenzhen Municipality launched the "Milk Cartons Collecting Action" in collaboration with the Little Water Drop Environmental Protection Center on the school campus. With Yantian as a key practice site, the action is a hands-on initiative to investigate the milk carton collection and resource utilisation process. Once the students drink off their milk, they need to pre-process their cartons by removing the straws, flattening, cutting, cleaning, drying, and packing. Subsequently, the school schedules an appointment via the "Shenzhen Waste Sorting" mini program. Upon approval, a designated vehicle will arrive at the school to weigh and collect the cartons. In the end, the school's account in the environmental bank will earn points based on the weight of these milk cartons. Each 1 kg milk carton can be exchanged for 5 points, which can be redeemed for gifts in the point store of the "Shenzhen Waste Sorting" mini program. The Little Water Drop Environmental Protection Center has since expanded the channels by entrusting professional service providers to treat and recycle milk cartons. The waste will be recycled to create cultural and creative items, such as exercise books and photo frames, and then, these items will be donated to schools and students. As of June 18, 2023, a total of 8,155.8 kg milk cartons has been collected in Yantian through the "Milk Carton Collection Action" (Figure 4-16).

Figure4-16 Collection of milk cartons by primary schools in Yantian District © Urban Administration and Law Enforcement Bureau of Yantian District

Social forces such as volunteers, "Dandelions" and social organizations are active on the open platform of Shenzhen, a pioneering demonstration zone for socialist reform and opening up. They play a unique and valuable role in MSW management in Yantian. The new stage of waste management, exemplified by waste sorting, enables greater public participation in waste management. This represents a shift from simple waste management to social governance. The extensive public involvement serves as an excellent example of collaborative social governance and illustrates the current state of social civilization.

4.7 Summary of waste management practices in Yantian District, Shenzhen

Shenzhen, the "city of innovation", is highly regarded for its innovative spirit and welcoming atmosphere. As an innovator and pioneer in waste management, the city has established the first sanitation landfill and the first waste incineration plant in China. The city is pioneering in promotion of waste management, treatment and disposal. The characteristics of MSW management in Yantian are summarized as follows:

1 ***Digital governance empowers MSW management.***
The growing demand for environmental and operational management underscores the necessity for regulatory supervision of waste collection, transportation and treatment process. As a result, the waste management sector has adopted digitalization and intelligent systems. The digitalisation system supports Yantian to achieve a highly efficient decision-making and social governance process. Centered on the needs of the people, digital governance has become the defining feature of waste management in Yantian.

2 ***Sustainable community is the pivotal unit in sustainable urban development.***
To reflect a commitment to sustainable community development, the Dameisha Carbon Neutrality Community has implemented various transformational practices for sustainable urban development. Particularly, Yantian considers waste management as a starting point to improve the community environment and to develop a sustainable material/energy cycle within the community. Yantian district also motivates the community to enhance the spiritual culture of sustainable development through nature education and community activities. These practices exemplify endeavors to build an ecological civilization within the community.

3 ***Open and inclusive social participation reflects the attribute of social civilization of waste management.***
Volunteers and social participation are significant highlights in waste management in Yantian District. The new stage of waste management exemplified through waste sorting, enables greater public participation in waste management. This transition represents a shift from waste management to social governance. The diverse social organizations and extensive public participation from various perspectives are excellent examples of collaborative social governance and best represent the reality of social civilization.

CHAPTER 05

CHAPTER FIVE:

Experiences And Challenges Of MSW Management In China

05

MSW management sector in China

After several decades of development, MSW management sector in China has witnessed continuous growth. It includes the road cleaning, waste treatment, integrated urban cleaning services, and source-based waste sorting. The business continues to expand that MSW management has become an essential part of urban infrastructure. In terms of policies and regulations, the Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes and the Regulations on the Management of Urban Amenities and Environmental Sanitation make up a fundamental core, complemented by various management measures and policy documents. In terms of the development of the technology it formulated a high-standard core-technology system represented by the sanitary landfills, waste incineration and food waste anaerobic digestionIn terms of ecological civilization, China's continuous improvement on social governance by MSW management has constantly improved. These are the key points which can be summarized as the references to global waste management practices.

This report summarizes the current status of MSW management in China through three typical cities/districts practices. It can be concluded that the evolution of urban MSW management practices in various cities following the same experiences fordeveloping effective waste management systems:

1 Well-structured strategic planning and clear target forms the basis for MSW management development.

Urban environmental sanitation has always played a prominent role in China's five-year plans. Starting with the 11th Five-Year Plan (2006-2010), specific plans for environmental health and waste management have been introduced at the national level. These plans outline key development objectives and tasks for the planning period, including investments and fund raising approaches. They act as fundamental guiding principles for the waste management industry. Aligned with national strategic planning, cities have also devised their own environment sanitation development plans and urban waste sorting strategies, laying the essential groundwork for MSW management.

2 Market-driven models attracts the capital

Since 2005, collaborative efforts between government and private sectors have laid the groundwork for investment in waste management infrastructure, facilitating the rapid establishment of Build-Operate-Transfer (BOT) and Public-Private Partnership (PPP) models. This shift has led to a significant increase in investments, with final-stage

investments and promoting the rapid growth of MSW industries.

waste treatment facilities seeing a surge from USD 8.4 billion in 2006-2010 to USD 33.6 billion in 2016-2020. The evolving demands in waste management and urban environment sanitation have stimulated the emergence of new markets, transitioning from end-stage treatment facilities to integrated "urban environment management services" and also to the "waste sorting and recyclable management sector". The waste collection and disposal approaches highlighted in this report from the three cities exemplify China's core experiences in MSW management, functioning within market-oriented models.

3 ***Environmental monitoring and public engagement are critical foundations for promoting the sector's robust growth.***

The change in perception of waste treatment facilities from 'unwelcome neighbours' to 'community assets' is mainly due to stringent emission standards, transparent data disclosure and ongoing public communication. Take waste incineration facilities as an example, collaborative "3-step" efforts have enabled real-time disclosure of automated monitoring data for common air pollutants like particulate matter, sulfur dioxide, nitrogen oxides, hydrogen chloride, carbon monoxide, and furnace temperature. This transparency effectively engages the public and is a noteworthy example of environmental information disclosure.

4 ***Digital governance empowers MSW management.***

As the demands for environmental and operational management increase, the need for regulatory oversight of waste collection, transportation, and processing within government governance processes has also grown. This has consequently driven the application of digitized and intelligent systems in the waste management industry. All three city cases emphasize the development of digital systems for domestic waste. From the initial phase of GPS positioning and video monitoring to enhance sanitation efficiency and accuracy, to the second phase of comprehensive monitoring across sorting stages, and finally to the third phase of utilizing digital information to aid government decisions and support social governance, people-centered digital governance has become a new hallmark of China's waste management.

5 ***Waste sorting supports ecological and social civilization development.***

The implementation of the mandatory waste sorting policy since 2019 marks China's decisive shift towards resource management in waste management. It also marks an essential phase of waste management's integration into communities and daily life. Cities have explored diverse models, all rooted in innovative grassroots social governance and public engagement. Unlike other regions relying on economic or policy tools, China uniquely employs tools of civility and the influence of social civilization to promote and establish waste sorting habits. "Waste sorting is a touchstone of social civilization" underscores China's key lesson in waste management.

Looking into the future, it's still has the new challenge for promoting the China MSW management to the high-quality development and refined management, which includes as follows:

1

Unbalanced regional development of MSW treatment.

By 2020, the harmless disposal rate is 99.4% for China cities and counties, which essentially meets the goal of harmless waste management. Nonetheless, the lack of capacity of harmless waste management in central and western China due to the limitation of economic conditions, transportation, and population. Therefore, it is crucial to seek the solutions for sparsely populated and remote regions in the central and western China. It is one of the key tasks of future MSW management to establish a mature, efficient, economical and effective waste sorting and treatment technology model that is compatible with the local economic development level, scientifically and reasonably select the treatment technology route, disposal method and implementation path, and solve the problem of regional imbalance in waste treatment.

2

New technologies demand within the context of waste sorting.

With the development of MSW and improvement of the refined management, it should be upgraded the technologies in upgrading the efficiency and quality of existing incineration facilities; upgrading and rehabilitating existing landfill facilities; choosing appropriate resource utilization techniques and disposal methods for food waste; sorting and utilization of low-value recyclables; and exploring diverse, sustainable operational models.

3

Establish a scientific and reasonable waste charging system.

The waste charging system is a favorable guarantee for long-term and stable waste management in the future. At present, separate pricing and charging mechanisms based on waste sorting are not yet complete in China. Most cities adopt a fixed billing model with low rates. At present, the costs and expenses of waste management are mainly borne by local governments through financial subsidies. It is necessary to improve the waste charging policy in accordance with the producer pays principle, and reflect the differentiated pricing based on the different waste categories, which can better promote the waste sorting and promote high-quality development of the whole industry.

4

Establish a consistent and sustainable mechanism for MSW sorting.

Waste sorting and management are essential for cultivating residents' civilized habits and quality promotion, improving urban and rural human settlementss, and promoting social and ecological civilization. It is a long-term endeavor and a crucial aspect of social governance relevant to the public. Social governance requires the concerted and collaborative efforts of various stakeholders, such as the governments, enterprises, and non-profit organizations, as well as the commitment of communities and the public. During this process, it is important to fully leverage the role of social organizations and other third-party institutions to provide robust support for the healthy and sustainable development of domestic waste sorting and management.

China Waste Wise Cities Good Practices

中国智慧减废城市优秀案例

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