

Solid Waste Management— Briefing on China Green Development

December 2019





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1. China Solid Waste Overview

The world is accelerating urbanization and the population is keeping growth. But the rubbish growth far exceeds the population growth. Solid waste has become a very common concern in lots of cities across the globe. China is one of the countries with the largest population and produces the largest amount of solid waste in the world. On the one hand, due to its extensive production and consumption, it faces problems such as large solid waste generation, high pollution intensity, inadequate utilization, and poor refinement and disposal, etc. Its solid waste management is still going far behind from the developed countries. On the other hand, however, with the rapid flow of waste streams in the past three decades, China cities' solid waste treatment technology has also kept improving. And the country has erected an environmental legal framework, and raised its public environmental awareness. Despite of the achievements, China still faces many challenges ahead in urban solid waste management.

Production volume - According to the statistics from the *2018 Annual Report on Urban Solid Waste Pollution Prevention and Control in Large and Medium-sized Cities in the Nation* published by the Ministry of Ecology and Environment of China, the general industrial solid waste generated in large and medium-sized cities nationwide was 1.31 billion tons; the industrial hazardous waste was 40.101 million tons; the medical waste was 781,000 tons; and the domestic waste was as high as 201 million tons. In July 2019, Verisk Maplecroft, a British global risk and strategy consulting company, released a research report entitled *Waste Generation and Recycling Indices 2019*, which states that every year, the total of global urban solid wastes generated has exceeded 2.1 billion tons. Although China's solid waste production per capita is less than that of the United States, Canada, and western European countries, the total amount of solid waste it produced has far surpassed that of India and the United States, which ranked second and third respectively, and has become the largest producer of solid waste. The total wastes it generated account for 15% of the global urban wastes. According to World Bank estimates, China's urban population will reach 883 million and solid waste will reach 480 million tons in 2030.

Composition—Most of China cities' solid waste is composed of putrescible wastes, which has remained at about 40% to 60% over the years. In recent years, as affected by the increase in entertainment and education spending, the proportion of paper in urban solid wastes also started to rise. This is partly due to the factor of paid use of plastic bags, a factor that results in that people have gradually turned to paper or paper-fiber shopping bags instead of plastic bags. In the future, the proportion of paper in urban solid wastes in China may increase further. In addition, as the state vigorously promotes the policy of replacing coal with clean energy and natural gas, the kinds of other wastes,

especially grey bricks, will sure be further reduced.¹ According to World Bank estimates, all urban residents in China will use natural gas as energy for heating and cooking in 2030, and the proportion of ash in urban solid wastes will further decrease in the future.

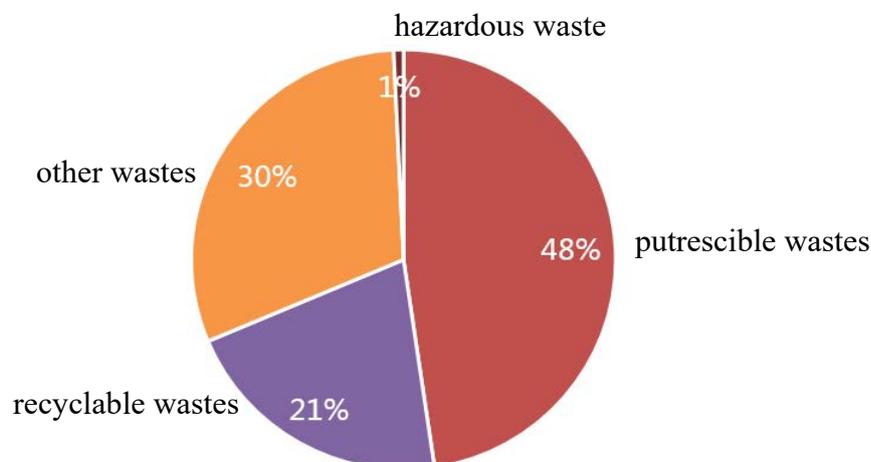


Figure 1-1 The Main Components and Proportions of Solid Waste in China (by the author)

Disposal—At present, China takes 3 main ways of waste disposal, including landfill, incineration & power generation, and composting. Although composting can achieve resource utilization to a certain degree, it has problems of high construction costs, low efficiency, and pollution as it is processed without strict sorting. This composting approach is gradually being withdrawn in China. According to the National Bureau of Statistics, as of 2017, the rate of harmless treatment of urban domestic waste in China has accounted for 97.74%, of which, sanitary landfill accounts for the majority. Compared with the landfill, waste incineration has the advantages in terms of “reducing waste amount, enhancing resource utilization, and harmless treatment”. It will be the top choice for future domestic waste treatment in large and medium-sized cities in China. After massive construction of waste incineration and power generation plants, China’s solid waste incineration treatment capacity has accounted for more than 40% of the treatment capability, and will reach 50% in 2020. At the same time, the country also improved its standards for solid waste treatment. In addition, it shifts from simple construction of large-scale waste incineration projects, to the refined classification and recycling of waste. China’s solid waste treatment is being upgraded from a developing

¹ 2019 Analysis of the Development Status and Future Development Prospects of China's Solid Waste Treatment Industry

stage to an improving stage.



2. Regulatory Framework

2.1 Regulators

According to the administrative management system, China has national, provincial and county (city) three-level governments who are administrative departments in solid waste management. A provincial ecological and environmental administrative department is under the dual leadership of the provincial people's government and the national Ministry of Ecology and Environment, but it is mainly affiliated to and under the guidance of the provincial people's government. A county (city) level ecological and environmental department is directly managed by the county (city) people's government, and the higher government's ecological and environmental department only guides its business. The specific competent authorities and functions in the solid waste management are as follows:

(1) Ministry of Ecology and Environment

The Ministry of Ecology and Environment of the People's Republic of China (formerly Ministry of Environmental Protection) is the highest department responsible of administration of ecological and environmental protection affairs directly under the State Council. According to the State Council institutional reform plan approved by the first meeting of the Thirteenth National People's Congress in March 2018, the Ministry of Ecology and Environment was established that superseded the Ministry of Environmental Protection at the same time. The main responsibilities of the Ministry of Ecology and Environment include: establishment and improvement of a basic rule

system for improving the ecosystem and environment; overall coordination and supervision and management of major ecological and environmental issues; supervision and management of environmental pollution prevention and control; and guidance, coordination and supervision of ecological protection and restoration.²

(2) Local people's governments and local ecological and environmental departments

Local people's governments are responsible for the local environmental quality. The main responsibilities of a local ecological and environmental department are to formulate local environmental quality standards or pollutant discharge standards, to regularly issue announcements on environmental conditions, to conduct on-site inspections of pollutant dischargers within its jurisdiction; to investigate and evaluate the environmental conditions within its jurisdiction; and to formulate ecological and environmental protection plans.

(3) Other administrative departments

Other administrative departments also participate in related work on ecological and environmental management. For example, the Department of Resource Conservation and Environmental Protection under the National Development and Reform Commission is responsible for formulating and coordinating to implement policies of energy resource conservation, comprehensive utilization and circular economy; proposing energy consumption control targets and organizing its implementation; organizing and coordinating major energy conservation demonstration projects; coordinating to promote green undertakings such as energy conservation, environmental protection, clean production and others. The customs and quality supervision, inspection and quarantine department are responsible for the control of waste import and export.³

(4) Local people's governments and local ecological and environmental departments

Local people's governments are responsible for the local environmental quality. The main responsibilities of a local ecological and environmental department are to

² Official website of the Ministry of Ecology and Environment of the People's Republic of China: <http://www.mee.gov.cn>

³ Official website of the National Development and Reform Commission of the People's Republic of China: <https://www.ndrc.gov.cn>

formulate local environmental quality standards or pollutant discharge standards, to regularly issue announcements on environmental conditions, to conduct on-site inspections of pollutant dischargers within its jurisdiction; to investigate and evaluate the environmental conditions within its jurisdiction; and to formulate ecological and environmental protection plans.

China Association of Environmental Protection Industry was established in 1984. It is a national industrial organization composed of voluntary enterprises, institutions, social organizations and individuals registered in China and engaged in production, service, research and development, management and other activities related to ecological and environmental protection. The organization is a non-profit social group registered with the Ministry of Civil Affairs. It is under the watch of the Ministry of Ecology and Environment and the Ministry of Civil Affairs. The association participates in formulation of laws and regulations on ecological and environmental protection, development planning, economic policies, technical policies, etc.; and when authorized by relevant government departments, it organizes industry surveys, researches, studies and statistics, and collects, analyzes and releases industry information.⁴

2.2 Laws and regulations

Environmental Protection Law of the People's Republic of China

The *Environmental Protection Law of the People's Republic of China* was passed and enforced on December 26, 1989, and was revised on April 24, 2014. The revised law was dubbed the “strictest law in history”. The law outlines China’s environmental supervision and management system, the responsibilities in protection and improvement of the environment, the obligations in preventing environmental pollution and other public hazards, as well as other relevant legal duties. It is the first law of China that defines the responsibility of protection of the environment, prevention of pollution, and promotion of modernization of the country.

Law of the People's Republic of China on Prevention and Control of Environmental Pollution Caused by Solid Wastes

The *Law of the People's Republic of China on Prevention and Control of Environmental Pollution Caused by Solid Wastes* was approved on October 30, 1995 and enforced the following year. The bill was amended for the fifth time on June 5, 2019. It makes specific provisions on supervision and administration of prevention and control of

⁴ Official website of the China Association of Environmental Protection Industry: <http://www.caepi.org.cn>

environmental pollution caused by solid wastes; on prevention and control of environmental pollution caused by solid wastes; and on prevention and control of environmental pollution caused by hazardous wastes. In the latest revision, the law further takes accountable of the responsibility of industrial solid waste producers, improves the pollutant emission permit system, and requires establishing a system for classification throwing, collection, transportation, and treatment of domestic waste.

Renewable Energy Law of the People's Republic of China

The *Renewable Energy Law of the People's Republic of China* came into force on January 1, 2006. The enforcement of the law has effectively promoted the development and utilization of renewable energy, increased channels for energy supply, and improved the country's energy structure. The law clearly lists research of technologies for renewable energy development and utilization and their industrialization as a priority in China among technologies and high-tech industries, and states that the state government encourages and supports renewable energy.⁵

Circular Economy Promotion Law of the People's Republic of China

The *Circular Economy Promotion Law of the People's Republic of China* came into effect on August 29, 2008. The law regulated such aspects as reductions in resource and waste in the process of production, distribution, consumption, and waste re-utilization, and in addition, it stipulated an extension of the responsibility system that will be primarily focused on producers. In particular, Article 36 clearly stipulates the re-utilization of industrial waste: "If an enterprise does not have the capabilities for comprehensive utilization of the wastes generated in its production process, it shall provide them to a qualified production operator for comprehensive utilization". Article 37 clearly states that "The state government encourages and promotes construction of a waste recycling system, and local people's governments should rationally arrange waste recycling outlets and trading markets in accordance with their urban and rural planning, and support waste recycling enterprises and other similar organizations to carry out wastes collection, storage, transportation and information communication".

Environmental Protection Tax Law of the People's Republic of China

On January 1, 2018, China officially enforced the *Environmental Protection Tax Law*

⁵ Source : Official website of the National Energy Administration: http://www.nea.gov.cn/2017-11/02/c_136722869.htm

of the People's Republic of China. For solid waste, the law clearly stipulates that “the discharge amount of taxable solid waste is the balance of the amount of taxable solid waste produced in current period minus the amount of taxable solid waste that are stored, disposed, and comprehensively utilized in current period.” The law also provides a number of favorable tax and fee measures that provide environmental protection tax exemptions to enterprises and projects that meet the preset conditions and requirements in accordance with the law.

Soil Pollution Prevention and Control Law of the People's Republic of China

In August 2018, the Fifth Session of the Standing Committee of the 13th National People's Congress adopted the *Soil Pollution Prevention and Control Law of the People's Republic of China*. There are 7 provisions on solid waste and hazardous waste in this law, including: intensive monitoring of construction lands that have once been used for storage and landfill of solid waste; and prohibiting industrial solid waste, domestic waste or polluted soil, that contains heavy metals or other toxic and hazardous substances that exceed the standards, from being used for land reclamation, etc.

3. Latest Policies

According to the press conference of the Ministry of Ecology and Environment held in March 2019, the Ministry of Ecology and Environment will promote a number of priorities in the next few years, focusing primarily on the “a rule system construction” (revision of the *Law of the People's Republic of China on Prevention and Control of Environmental Pollution Caused by Solid Wastes*), the “two major reforms” (the reform of the solid waste import management system, and the pilot of “zero-waste city” construction), the “two major special actions” (solid waste investigation and rectification, and waste lead battery pollution prevention and control), and four key areas to improve the environmental supervisory capabilities, utilization and disposal capabilities and risk prevention capabilities.⁶

3.1 Strengthening the rule system on solid waste management

The amendments to the supporting laws and regulations such as the *Law of the People's Republic of China on Prevention and Control of Environmental Pollution Caused by Solid Wastes*, the *Measures for Administration of Permit for Operation of Hazardous Wastes*, and the *Measures for Administration of Hazardous Waste Transfer Billing*, are

⁶ Summarized according to the speech of QIU Qiwen, director of Department of Solid Wastes and Chemicals under the Ministry of Ecology and Environment, at the press conference.

important measures of strengthening waste management rule system. The continuous improvement of the laws, regulations, policies and standards can help effectively shut down the rule system loopholes of illegal activities such as illegal movement, transfer and dumping of hazardous waste, and improve the capabilities of hazardous waste risk prevention. The Ministry of Ecology and Environment plans to promote developing and revision of hazardous waste identification standards, technical specifications for hazardous waste identification, and technical specifications for hazardous waste pollution control in key industries in 2019, and promote to establish a rule system of hazardous waste classification and management, aiming to overcome the difficulties in hazardous waste identification, address the problems of incomplete rule system for classification-based management, and address the problems of poor re-utilization and disposal.

3.2 Continuing to Promote Two Major Reforms

3.2.1 Prohibition of entry of foreign garbage

In 2017, the General Office of the State Council issued the *Implementation Plan for Prohibiting Entry of Foreign Waste and Promoting Reform of the Solid Waste Import Rules*. In 2018, the Ministry of Ecology and Environment, the Ministry of Commerce, the National Development and Reform Commission, and the General Administration of Customs jointly issued an announcement on adjusting the *Imported Waste Management Catalogue*, which shifted 16 types of solid wastes, including waste hardware, abolished ships, compressed piece of scrap automobile, smelting slag, and waste plastics from industrial sources, to the *Catalogue of Solid Wastes Prohibited from Import*, from the *Catalogue of Solid Wastes that can be Used as Raw Materials under Import Restrictions*. In the same year, the General Administration of Customs issued the *Implementation Rules on Registration of Foreign Suppliers of Imported Solid Wastes that can be Used as Raw Materials*.

The Ministry of Ecology and Environment, in conjunction with relevant departments, diligently implemented the decisions and assignments of the CPC Central Committee and the State Council. They perform their respective duties and coordinate to actively improve the rule system on management of solid waste import, strengthen the control of illegal entry of foreign garbage, and establish a long-term mechanism for prohibiting the entry of foreign garbage. In addition, they put efforts to improve the capability of solid waste recycling and utilization, properly dealt with various problems arising in the reform process, and promoted to make key progress in the reforms. In 2018, the total import volume of solid waste was 22.63 million tons, a year-on-year decrease of

46.5%.

3.2.2 Promoting the construction of zero-waste cities

On December 29, 2018, the General Office of the State Council issued the *Work Plan for Pilot Construction of “Zero-waste Cities”* (G.B.F. [2018] No. 128), which can be considered a version of overall improvement in regarding to the targets set out in the *Action Plan for Implementation of the National Domestic Waste Classification Rules* that was jointly released in March 2017 by the National Development and Reform Commission and the Ministries of Health and Human Resources. The pilot project is a concrete action plan to thoroughly implement the decisions and assignments of the Party Central Committee and the State Council. It is a powerful tool in deepening the reform of comprehensive management of solid waste and promoting the construction of “zero-waste communities” in terms of overall city planning. It is also an important measure to enhance ecological civilization and build a beautiful China.

The following will make an introduction from the aspects of top-level design to the launching of pilot project. It will sort out a host of vigorous action plans taken by Chinese governments in building “zero-waste cities”. These policies also mark China’s “zero-waste cities” construction officially drives onto the fast track.

(1) Interpretation of policies

Definition — The *Work Plan for Pilot Construction of “Zero-waste Cities”* (hereinafter referred to as the *Plan*) defines the “Zero-waste City” as a city development mode in which, by applying the new development concept that is based on innovation, coordination, green, openness and sharing, it will greatly promote solid waste source reduction and re-utilization, minimizing landfill and minimizing environmental impact of solid waste, to promote pivoting to a total green development mode and lifestyle.

Objectives — The *Plan* aims to build a “zero-waste city” construction indicator system by 2020. It will choose around 10 cities nationwide which are with proper conditions, foundations and appropriate scales, to start the pilot project of “zero-waste city” throughout such cities, and to deepen the reform of comprehensive management of solid waste in such pilot cities. It will then summarize the pilot experiences and practices, to create a batch of models that are replicable, scalable and demonstrative and to lay a good foundation for promoting construction of a “zero-waste society” in the country.

Main tasks— 6 main tasks in the *Plan*: 1) Toughen up guidance role of the top-level design to play out the government’s macro guidance role; 2) Implement green industrial

production to promote a zero-growth of total storage and disposal of bulk industrial solid waste; 3) Promote a green agriculture to promote full use of major agricultural wastes; 4) Practice a green lifestyle, promote the source reduction and re-utilization of domestic waste; 5) Improve risk curbing capabilities, and strengthen comprehensive management and control of hazardous waste; and 6) Stimulate vitality of market players and foster a new model for industrial development.

Core work — Rule system construction, technology system construction, market system construction, and supervision system construction. Rule system construction: mainly including formulation of local regulations or policy documents. Technology system construction: including technical standards, specifications, and tech demonstrations for reduction, re-utilization and harmless treatment of major solid wastes such as bulk industrial solid wastes, agricultural wastes, domestic wastes, hazardous wastes, etc. Market system construction: including economic measures, application of financial instruments, cultivation of key enterprises, etc. in relation to construction of “zero-waste cities”. Supervision system construction: construction of solid waste supervision capacity, and construction of information management system, etc.

It can be seen that the *Plan* just carried out the early-stage goal for construction of “zero-waste cities”, focusing primarily on improving the rule system planning, which is figuratively equivalent to the process of “laying out a ground or foundation”. The pilot scheme is just like building a model, which is tested and planned in advance in order to create the final “building” of “zero-waste cities”.

(2) “11 + 5” pilot cities

On May 5, 2019, the Ministry of Ecology and Environment issued the *Announcement on Announcing the List of Pilot “Zero-waste Cities”*, formally establishing 11 + 5 cities and regions for constructing the pilot “zero-waste cities”, respectively: Shenzhen City, Guangdong Province; Baotou City, Inner Mongolia Autonomous Region; Tongling City, Anhui Province; Weihai City, Shandong Province; Chongqing City (Main Urban Districts); Shaoxing City, Zhejiang Province; Sanya City, Hainan Province; Xuchang City, Henan Province; Xuzhou City, Jiangsu Province; Panjin City, Liaoning Province; Xining City, Qinghai Province, totally 11 cities. In addition, in order to better serve the country’s major development strategies and the construction of national ecological civilization experimental zones, it additionally takes Hebei Xiongan New Area (A representative of New Areas), Beijing Economic and Technological Development Area (A representative of Development Areas), China-Singapore Tianjin Eco-city (A

representative of international cooperation), Guangze County (A representative of counties) in Fujian Province, and Ruijin City (A representative of county-level cities) in Jiangxi Province, as special cases on promoting their own pilot projects by referencing to the pilot project of “zero-waste cities”. The scope of the pilot is, in principle, the entire area under the jurisdiction of the city or region, and the pilot period is 2 years, lasting from January 2019 to December 2020.



Figure 3-1 11 + 5 Pilot Zero-waste Cities and Regions

Geographically, it can see the 16 cities and regions are located in 16 different provinces and regions, and they are evenly distributed. Judging from the perspective of the four major economic divisions in China, we see in the eastern division, barring Shanghai, all 9 provinces or equivalents have counties (cities) being elected, occupying over half of the list. In the central and western divisions, there are 4 cities elected, respectively. While in the northeast division, Panjin City is selected as a first pilot city representing the Northeast.

Judging from the current urban domestic waste classification and treatment in the “11 + 5” pilot cities and regions, we see most of them adopt the common categorization approach that categorizes waste into “4 classes”. Shenzhen uses the fine classification and Tianjin uses three-class classification. While in county-level regions, the waste classification is lagging, and their classification criteria are simple comparatively.

Among the selected cities, there shows obvious differences in their capability in solid waste management and information disclosure. Among the 11 pilot cities, most are with millions of people, and are typical representatives of most prefecture-level cities in China. At present, most of them have, or are constructing, domestic waste incineration facilities and kitchen-garbage-centralized treatment facilities. For the five special regions, they vary greatly as they show large differences in actual local conditions. The Xiongan New Area has a significantly better planning and processing capacity and technical advantages. In the two development areas of Beijing and Tianjin, due to their limited population and limited land area, they use the way of regional cooperation and the small, decentralized treatment method, however their level of harmless treatment is high. While for the county and the county-level city, their capabilities of centralized waste disposal needs to get improved.

Table 3-1 List of Domestic Waste Classifications in the “11 + 5” Zero-waste Cities and Regions⁷

⁷*City Construction: Current Situation of Solid Waste Management in “11 + 5” Zero-waste Pilot Areas*

Province	City	Waste classification principles	Policy ground of waste classification	Whether one of the 46 key cities designated for
Guangdong	Shenzhen	“13 classes”	<i>Shenzhen Special Economic Region Domestic Waste Classification Regulation (Solicitation for Public Commentation)</i>	Yes
Inner Mongolia	Baotou	“4 classes”	<i>Implementation Scheme of Domestic Waste Classification and Collection in Baotou City</i>	No
Anhui	Tongling		<i>Domestic Waste Classification Management Method of Tongling City</i>	Yes
Shandong	Weihai		<i>Implementation Scheme of Domestic Waste Classification for Party and Government Organs and Other Public Institutions in Weihai City</i>	No
Chongqing Main Urban Areas		“4 classes”	<i>Domestic Waste Classification Management Method of Chongqing Municipality</i>	Yes
Zhejiang	Shaoxing		<i>Implementation Scheme of Urban and Rural Domestic Waste Classification in Shaoxing City</i>	No
Hainan	Sanya		<i>Implementation Scheme of Domestic Waste Classification and Collection and Treatment Pilots in Sanya City</i>	
Henan	Xuchang		<i>Implementation Scheme of Domestic Waste Classification, Collection and Treatment in Urban Areas</i>	
Jiangsu	Xuzhou		<i>Implementation Scheme of Urban and Rural Domestic Waste Classification and Governance in Xuzhou City</i>	
Liaoning	Panjin		<i>Implementation Scheme of Urban and Rural Domestic Waste Classification and Recycling Utilization in Panjin City</i>	
Qinai	Xining		<i>Urban Domestic Waste Classification Management Method of Xining City</i>	Yes
five special regions				
Hebei	Xiongan New Area	“4 classes”	<i>Opinions on Strengthening the Classification of Urban Domestic Waste</i>	No
Beijing Economic and Technological Development Area		“4 classes”	<i>Action Plan of Beijing Municipality on Classification Governance of Domestic Waste (2017-2020)</i>	Yes
China-Singapore Tianjin Eco-city		“3 classes”	<i>Implementation Opinions on Classification Management of Domestic Waste in Tianjin City</i>	
Fujian Province	Guangze County	“2 classes”	<i>Three-year Action Plan for Governance of Rural Domestic Sewage and Waste in Guangze County</i>	No
Jiangxi Province	Ruijin City	/	/	No

Table 3-2 List of Domestic Waste Generation and Treatment in “11 + 5” Zero-waste Cities and Regions⁸

Province	City	Permanent resident (In 10 thousand)	Domestic waste generation (Ton/day)	Designed Capacity of Domestic Waste Treatment		Domestic waste incineration rate (After facility construction)	Kitchen waste generation (Ton/day)	Designed Capacity of Kitchen waste treatment (Ton/day)	Kitchen waste treatment rate (After facility construction)
				Incineration capacity (Ton/day)	Landfill capacity (Ton/day)				
Guangdong	Shenzhen	1302.66	22227	13625	5940	61%	1482.9	1130	76%
Inner Mongolia	Baotou	287.77	2005	1600	1400	80%	287.77	350	100%
Anhui	Tongling	162.9	484.4	600	640	100%	162.9	200	100%
Shandong	Weihai	282.56	3422	1900	1550	55.5%	282.56	100	35%
Chongqing Main Urban Areas		865.06	10000	12700	Discontinued operations	100%	994.82	1000	100%
Zhejiang	Shaoxing	501	4300	5950	500	100%	501	360	72%
Hainan	Sanya	76.42	1800	1200	500	66.7%	87.89	150	100%
Henan	Xuchang	495.63	5000	2250	600	45%	495.63	/	/
Jiangsu	Xuzhou	880.2	8300	7950	1500	95.8%	880.2	200	23%
Liaoning	Panjin	129.6	1600	1300	1150	81%	129.6	80	62%
Qinghai	Xining	233.37	4526	1800	3800	40%	233.37	200	86%
Hebei	Xiongan New Area	104.71	1209	5300	815	100%	105.71	300	100%
Beijing Economic and Technological Development Area		16.7	280	No big treatment facility in the district			20	No big treatment facility in the district	
China-Singapore Tianjin Eco-city		7	100	2000	/	100%	7		

⁸City Construction: Current Situation of Solid Waste Management in “11 + 5” Zero-waste Pilot Areas

Fujian Province	Guangze County	13.7	100	250	200	100%	13.7	10	73%
Jiangxi Province	Ruijin City	63.7	1800	800	/	44.4%	63.7	No big treatment facility in the district	

In September 2019, the Ministry of Ecology and Environment organized an expert committee to review the “zero-waste cities” plans of the “11 + 5” cities and regions, and approved them. Since then, the “zero-waste cities” program has officially entered the implementation phase. In the promotion of “zero-waste cities” in “11 + 5” pilot areas, the plans that were established in each area take accounts of local special conditions and peculiarities in order to provide better solutions. Weihai City emphasized the sustainable development of its marine and tourism economy, hoping to achieve a green marine economy and “zero-waste scenic spots”; it worked hard on marine hazardous waste patrol and control. Shaoxing City will create a solid waste data platform in the form of “Internet +”. Meanwhile for Guangze County, Fujian, the government will focus on exploration of an ecological circular agriculture. It can be said that each pilot area shows its unique characteristics and advantages, and will make use of their regional advantages to create a “zero-waste city” with its own characteristics.

(2) Indicator system

On May 8, 2019, the Ministry of Ecology and Environment issued the *Guidelines for Developing Pilot Implementation Schemes for the Construction of “Zero-waste Cities”* and the *Indicator System for the Construction of “Zero-waste Cities” (Trial)*. The development of the *Indicator System* is guided by the development concepts of innovation, coordination, greenness, openness and sharing, adheres to the principles of “scientific, systematic, operable and forward-looking”, and takes solid waste reduction and utilization as its core. The indicator system includes 5 aspects: source reduction of solid waste, re-utilization, final disposal, supporting ability, and mass sense of gaining, in its designing.

The *Indicator System* consists of level-1 indicators, level-2 indicators, and level-3 indicators, including 5 L-1 indicators, 18 L-2 indicators, and 59 L-3 indicators (see Table 3-3 for details). The L-3 indicators are broken into three categories: The first category (marked with ★) is mandatory indicators with a total of 22 items, which is a category that all pilot cities should conduct investigation for it. The second category is optional with a total of 37 items, for which the pilot cities may select that reflect their city type, characteristics, and tasks and arrangements. The third category is a category of indicators that the pilot cities can self-make and determine by looking at their city’s characteristics and uniqueness, like development positioning, development stage,

resource endowment, industrial structure, and economic and technological foundation.⁹

Table 3-3 Indicator System for the Construction of “Zero-waste Cities” (Trial)

No.	L1 indicator	L2 indicator	L3 indicator	Source*
1	Reduction of solid waste at source	Industrial source reduction	Industrial solid waste generation intensity★	Municipal Ecological and Environmental Bureau, Municipal Bureau of Statistics
2			Proportion of industrial enterprises that implement cleaner production★	Municipal Ecological and Environmental Bureau, Municipal Development and Reform Commission
3			Number of enterprises that build green factories	Municipal Industrial and Information Technology Bureau
4			Number of industrial parks which construct eco-industrial parks and engage in circular economy transformation ★	Municipal Ecological and Environmental Bureau, Municipal Development and Reform Commission
5			Number of mines that undertake green mine construction	Municipal Natural Resources Bureau
6		Agricultural source reduction	Number of counties that are engaged in constructing demonstrative counties of ecological agriculture and demonstrative counties of reconciling grass and livestock development	Municipal Agriculture and Rural Affairs Bureau
7			Amount of pesticide and fertilizer used	Municipal Agriculture and Rural Affairs Bureau, Municipal Bureau of Statistics
8			Proportion of land areas that promote production of green food and organic agricultural product	Municipal Agriculture and Rural Affairs Bureau

⁹ Official website of the Ministry of Ecology and Environment of the People’s Republic of China: <http://www.mee.gov.cn>

9		Construction source reduction	Percentage of green buildings among new constructions	Municipal Housing and Urban-Rural Development Bureau
10		Domestic source reduction	Daily garbage generation per capita ★	Municipal Housing and Urban-Rural Development Bureau, Municipal Agriculture and Rural Affairs Bureau
11			Coverage rate of the domestic garbage classification, collection and transportation system	Municipal Housing and Urban-Rural Development Bureau, Municipal Development and Reform Commission, Municipal Agriculture and Rural Affairs Bureau
12			Number of organizations (governmental organs, enterprises, institutions, restaurants, shopping malls, bazaars, communities, villages, towns, families) that undertake the efforts of constructing “zero-waste cities”	Relevant departments
13			Proportion of green package use for express delivery	Municipal Post Bureau
14	Recycling utilization of solid waste	Recycling utilization of industrial solids waste	Rate of comprehensive utilization of general industrial solid waste★	Municipal Ecological and Environmental Bureau
15			Rate of comprehensive utilization of industrial hazardous waste	Municipal Ecological and Environmental Bureau
16		Recycling utilization of agricultural waste	Coverage rate of the agricultural waste collection, storage and transportation system★	Municipal Agriculture and Rural Affairs Bureau
17			Rate of comprehensive utilization of straw	Municipal Agriculture and Rural Affairs Bureau
18			Rate of comprehensive utilization of livestock and poultry manure	Municipal Agriculture and Rural Affairs Bureau
19			Plastic film recovery rate	Municipal Agriculture and Rural Affairs Bureau
20		Recycling utilization of	Rate of comprehensive utilization of construction waste★	Municipal Housing and Urban-Rural Development Bureau

		construction waste		
21		Recycling utilization of domestic solid waste	Utilization rate of domestic waste ★	Municipal Housing and Urban-Rural Development Bureau
22			Growth of renewable resource recovery	Municipal Bureau of Commerce
23			Growth of the recycling utilization rate of kitchen waste	Municipal Housing and Urban-Rural Development Bureau, Municipal Development and Reform Commission
24			Growth of recycling of major waste products	Identify relevant departments based on the industry to which the product belongs
25			Recovery rate of recyclable resources in medical institutions ★	Municipal Health Commission, Municipal Bureau of Commerce
26	Final disposal of hazardous wastes ★	Safe disposal of hazardous wastes ★	Safe disposal of industrial hazardous waste ★	Municipal Ecological and Environmental Bureau
27			Coverage of the medical waste collection and disposal system ★	Municipal Health Commission
28			Coverage of the social-source hazardous waste collection and disposal system	Departments responsible for the social-source hazardous waste
29	Final disposal of solid waste	Storage and disposal of general industrial solid waste	Storage and disposal volume of general industrial solid waste ★	Municipal Ecological and Environmental Bureau
30			Proportion of the number of storage sites (including tailings depots) that carry out comprehensive improvement of bulk industrial solid waste	Municipal Natural Resources Bureau, Municipal Ecological and Environmental Bureau, Municipal Emergency Management Bureau
31		Agricultural waste disposal	Rate of the centralized, professional and harmless treatment of sick and dead pigs	Municipal Agriculture and Rural Affairs Bureau
32			Collected disposal amount of pesticide packaging waste	Municipal Agriculture and Rural Affairs Bureau, Municipal

				Ecological and Environmental Bureau
33		Collected disposal of construction waste	Amount of collected disposal of construction waste	Municipal Housing and Urban-Rural Development Bureau
34		Domestic solid waste disposal	Landfill amount of domestic waste ★	Municipal Housing and Urban-Rural Development Bureau, Municipal Agriculture and Rural Affairs Bureau
35	Rural sanitary toilet prevalence rate ★		Municipal Agriculture and Rural Affairs Bureau	
36	Coverage of the hazardous waste collection and disposal system		Municipal Housing and Urban-Rural Development Bureau	
37	Completion rate of improving informal waste landfill sites		Municipal Housing and Urban-Rural Development Bureau	
38	Supporting capacity	Institutional system construction	Local regulations or policy documents on construction of “zero-waste cities” ★	Coordinating agency responsible for “zero-waste cities” construction
39			Coordination mechanism for “zero-waste cities” construction	Coordinating agency responsible for “zero-waste cities” construction
40			Incorporate the “zero-waste cities” construction into the official performance appraisal ★	Municipal Party Committee Organization Department, Supervision Department
41	Supporting capacity	Market system construction	Proportion of the investment in solid waste recycling and disposal to the total investments in environmental pollution treatment ★	Municipal Ecological and Environmental Bureau
42			Proportion of solid waste companies which are included in the scope of corporate environmental credit assessment	Municipal Ecological and Environmental Bureau
43			Coverage of environmental pollution liability insurances over hazardous waste operators	Municipal Ecological and Environmental Bureau, Municipal

				Banking and Insurance Regulatory Bureau or Local Financial Regulatory Bureau
44			Balance of green credits for construction of the “zero-waste city” projects	Municipal Banking and Insurance Regulatory Bureau or Local Financial Regulatory Bureau
45			Number of key enterprises which engage in the business of solid waste recycling and disposal ★	Municipal Development and Reform Commission, Municipal Bureau of Commerce, Municipal Industrial and Information Technology Bureau, Municipal Ecological and Environmental Bureau
46			Proportion of industrial added value of the resource recycling industry to regional GDP	Municipal Bureau of Statistics
47		Technology system construction	Demonstration of the technologies of bulk industrial solid waste reduction, recycling, and harmless treatment	Municipal Industrial and Information Technology Bureau, Municipal Development and Reform Commission
48			Demonstration of full-scale utilization of agricultural waste	Municipal Agriculture and Rural Affairs Bureau
49			Demonstration of domestic waste reduction and recycling technologies ★	Municipal Housing and Urban-Rural Development Bureau
50	Support capability	Technology system construction	Demonstration of technologies for comprehensive safe management and control of hazardous waste	Municipal Ecological and Environmental Bureau
51				Demonstration of key technologies, processes, equipment R&D and application of recycling solid waste
52			Regulatory system construction	Building of solid waste supervision capacity

53			Rate of qualified standardized management of hazardous wastes rated in random inspection	Municipal Ecological and Environmental Bureau
54			Number of criminal cases of solid waste environmental pollution that are discovered, disposed, and detected ★	Municipal Public Security Bureau, Municipal Ecological and Environmental Bureau
55			Number of solid waste-related environmental pollution incidents	Municipal Ecological and Environmental Bureau
56			Settlement rate of petitions, complaints and whistle-blows on solid waste	Municipal Ecological and Environmental Bureau
57	Mass feeling of gain	Mass Feeling of Gain	Popularization rate of “zero-waste city” construction publicity, education and training	Third party survey
58			Participation levels of government, public institution ,enterprise and the public in the construction of “zero-waste cities”	Third party survey
59			Satisfaction of the public on effectiveness and construction of a “zero-waste cities” ★	Third party survey

Note: ★ indicates mandatory indicators

* represents departments that can be adjusted by the pilot cities according to their specific conditions

(3) Technology list

On October 29, 2019, the Ministry of Ecology and Environment publicly started to solicit a batch of advanced and applicable technologies from the public for constructing “zero-waste cities”¹⁰. After evaluation and selection, it compiled the *Compilation of Recommended Technologies for Pilot Construction of Zero-waste City* (the first batch), to provide technical support for the pilot cities and regions. On December 2, the evaluation results of the advanced and applicable technologies (the first batch) for pilot construction of the “zero-waste city” were announced on the special column of “zero-

¹⁰ http://gts.mee.gov.cn/gtfwgl/zcfgybzgf/201910/t20191029_739756.shtml

waste” cities on the China Ecological & Environmental Technology Transformation.¹¹

(4) Garbage classification in 46 cities

In recent years, China has increasingly paid importance to the waste classification. At the end of March 2017, the National Development and Reform Commission and the Ministry of Housing and Urban-Rural Development issued the *Implementation Plan for Classification of Domestic Garbage*, which requires mandatory implementation of domestic waste classification in 46 cities across the country, and by the end of 2020, the rate of recycling domestic garbage should reach over 35%. The 46 key cities are Beijing, Tianjin, Shanghai, Chongqing, Shijiazhuang, Handan, Taiyuan, Hohhot, Shenyang, Dalian, Changchun, Harbin, Nanjing, Suzhou, Hangzhou, Ningbo, Hefei, Tongling, Fuzhou, Xiamen, Nanchang, Yichun, Zhengzhou, Jinan, Taian, Qingdao, Wuhan, Yichang, Changsha, Guangzhou, Shenzhen, Nanning, Haikou, Chengdu, Guangyuan, Deyang, Guiyang, Kunming, Lhasa, Shigatse, Xi’an, Xianyang, Lanzhou, Xining, Yinchuan, Urumqi, etc.

At the end of 2017, the Ministry of Housing and Urban-Rural Development issued the *Notice on Accelerating Classification of Domestic Waste in some Key Cities*. It is required that by the end of 2020, the 46 major cities should have generally established a domestic waste classification and treatment system, created a system of laws, regulations, norms and standards, and created a batch of replicable models. Before being sent into incineration and landfill facilities, the recycling rate of total recyclables and putrescible waste in the cities should reach 35% or above. By 2035, the 46 key cities should comprehensively establish a municipal solid waste classification system, and their waste classification should reach international advanced level.

In April 2019, the Ministry of Housing and Urban-Rural Development and other 8 ministries and commissions jointly issued the *Notice on Comprehensively Carrying out Classification of Domestic Waste in Cities at and above the Prefectural Level*. According to the requirements of the document, the progress of domestic waste classification should be made against three crucial timelines: by 2020, the 46 major cities each should essentially have created a domestic waste classification and treatment system. Other prefecture-level cities should have fully realized the classification of domestic garbage in all public institutions, and should have at least one sub-district who should have essentially built a demonstration area for classification of domestic garbage. By 2022, at least one district in each prefectural city should have achieved full coverage

¹¹ http://www.ceett.org.cn/huanbao/wfcity/news_detail.html?id=295

of domestic waste classification, and in other districts, should have at least one sub-district who has essentially built a demonstration area for classification of domestic garbage. By 2025, each city at the prefecture level and above should have essentially built a domestic waste classification and treatment system.

At the local government level, there are also some specific implementation plans. For instance, the Second Meeting of the 15th People's Congress of Shanghai Municipality voted to pass the *Shanghai Municipal Domestic Waste Management Regulations* and officially began to enforce it on July 1, 2019. This regulation has caused broad interests among industry practitioners and the society, and is dubbed as “the strictest garbage classification regulation in history”. At the same time, Shanghai has also formulated the *Shanghai Municipal Action Plan for Construction of a Comprehensive Solid Waste Classification System*. This action plan pays more attention to the whole process, including classified throwing, classified collection, classified transportation, and classified disposal. It is expected that it can help Shanghai build a benchmark city for garbage classification.

On November 15, 2019, the Ministry of Housing and Urban-Rural Development issued the Standard for *Classification Signs of Domestic Garbage*, which will be officially enforced on December 1. This revision mainly adjusted the scope of application, category composition, and graphic symbols of domestic garbage classification signs. Compared with the 2008 version, the scope of application of this standard has been further expanded. The types of domestic waste have been adjusted to four major categories: recyclables, hazardous waste, kitchen waste and other wastes, plus 11 small categories such as paper, plastic, and metal.

As of November 2019, 53.9% of residential communities in 46 key cities of China have realized waste classification. Among which, 14 cities, including Shanghai, Xiamen, Ningbo, and Guangzhou, had more than 70% of domestic waste classification coverage. 30 cities have promulgated local laws, regulations or rules for garbage classification, and 16 cities have included garbage classification in their legislative plans. The central units, the troops stationed in Beijing and the agencies directly under the provincial government have comprehensively promoted waste classification. All provinces and autonomous regions have formulated implementation plans for waste classification. Zhejiang, Fujian, and Guangdong have enacted waste classification local laws and regulations. And 13 provinces including Hebei have started the legislative process. 237

cities at the prefectural level and above have started garbage classification.¹²

3.3 Carrying out two special actions

3.3.1 Continuing to implement waste removal actions

On May 9, 2018, the Ministry of Ecology and Environment officially launched the “Special Action to Strike down Environmental Illegal Actions of Solid Waste”, that is, “Waste Removal Action Plan 2018”. In this operation, the Ministry deployed 150 teams composed of backbone members from all over the country to carry out on-site investigation and verification at 2,796 solid waste storage sites in 11 provinces (cities) along the Yangtze River Economic Belt. The teams identified a total of 1,308 problems. And the problems are primarily involved in the dumping or stacking at will of construction waste, general industrial solid waste, and domestic waste. Beginning on May 10, the Ministry of Ecology and Environment had listed 111 outstanding problems and violations for special supervision and rectification to be completed within 7 days, while referring the remaining 1,197 problems to relevant provincial environmental protection departments. The Ministry has continuously empowered the law enforcement, demonstrating its determination to curb the frequent occurrence of illegal movement and dumping and ensure security of the Yangtze River’s ecosystems and environment.

In 2019, this special action is still an important task for curbing solid waste pollution. Following the “Action 2018”, it continued to carry out the *Special Action Plan on Focusing on Resolutely Curbing Illegal Transferring and Dumping of Solid Waste along the Yangtze River Economic Belt* and the *Notice on Resolutely Curbing Illegal Transferring and Dumping of Solid Waste and Hazardous Waste.*” It established a joint prevention and control mechanism for departments and regions, and continued to advance the investigation and rectification of solid waste in key river basins and regions such as the Yangtze River Economic Belt. It enhanced the application of the results obtained from drone remote sensing surveys of the ecosystems and environment in the mainstreams of the Yangtze River, and promoted to establish a sound environmental protection whistle-blowing rule system, so as to severely crack down on serious illegal acts of solid waste and hazardous waste, and resolutely curb the frequent transfer and dumping of solid waste and hazardous waste.

¹² http://www.gov.cn/xinwen/2019-11/19/content_5453465.htm

3.3.2 Special action to curb waste lead battery pollution

Another special action is to promote the curbing of waste lead battery pollution. The task force takes the curbing of waste lead battery pollution as a key part of the battle against pollution prevention. It printed and distributed the action plan to curb waste lead battery pollution and implemented it. Particularly, it extended and entailed the producer responsibilities, and organized to pilot a system in which the lead battery production enterprises shall carry out collection and cross-region transfer of lead battery.

3.4 Promoting key work in four areas

3.4.1 Effectively strengthening the supervision over solid waste environment

Speed up the construction of local hazardous waste centralized treatment facilities, and continue to improve the capability of centralized hazardous waste treatment. It will promote the joint e-recording over transfer of hazardous wastes throughout the country, and accelerate nationwide operation of the solid waste management information system, striving to improve the IT-based solid waste supervision. It will accelerate revision to the pollution control standards of hazardous waste storage, incineration, and landfill, and further advance the tech R&D in key areas such as curbing hazardous waste risks. It will strengthen the environmental supervision over bulk industrial solid wastes, to eliminate environmental risks that may arise during storage and disposal of the industrial solid wastes. It will promote revision to the pollution control standards on domestic waste incineration and landfill, to continuously strengthen the supervision of domestic waste. In addition, it will toughen up the review over disposal of waste electrical appliances and electronic products and improve the relevant rule systems. Besides, it will promote to formulate a “white pollution” comprehensive treatment plan.

3.4.2 Promoting risk assessment and control of chemical substances

It will put efforts to promote legislation on assessment and control of environmental risk of chemical substances. The task force will strictly implement the registration of environmental management of new chemical substances, and amend the *Measures for Environmental Management of New Chemical Substances*. It will strengthen the capacity building for assessment of environmental and health risk of chemical substances, continue to carry out assessment of environmental and health risk of key chemical substances, and promote to implement control measures for supporting the *List of Chemicals under Prioritized Control (First Batch)*.

3.4.3 Putting efforts to curb heavy metal pollution

The task force will strengthen the control of heavy metal discharge, formulate rules for assessing key heavy metal discharges, and advance implementation of heavy metal discharge reduction projects. It will carry out investigations on all enterprises producing and operating key heavy metals, compile a full list of such enterprises, and update it dynamically, and continue to promote classification of the industries involving heavy metals. In addition, it will promote to implement the *Opinions on Strengthening Pollution Prevention and Control in Heavy Metal Industries*.

3.4.4 Steady promoting to implement international environmental conventions and protocols

Promote to better implement international conventions such as conventions on persistent organic pollutants and mercury in the country. The task force will carry out the national plan to implement the *Stockholm Convention on Persistent Organic Pollutants* (supplementary version), and publish an announcement to phase out persistent organic pollutants such as lindane and supervise its implementation, and carry out a national statistical survey of persistent organic pollutants. In accordance with the relevant requirements of the *Minamata Convention on Mercury*, it will promote to implement the goal of halving the usage amount of mercury for per unit of the product produced based on the chloroethylene monomer production process under the calcium carbide method, conduct a survey of mercury and mercury-compound inventories and closed chlor-alkali facilities, and prepare to submit the first nation biennium report. Meanwhile, it will implement the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal*, and its amendments, and restrict the management over approval of hazardous waste exports.

4. City Practice

4.1 Weihai City: One of the Europe-China Eco Cities Link projects (EC Link)

Weihai is a prefecture in Shandong Province, China. It is located at the eastern end of the Shandong Peninsula and has jurisdiction over Huancui District and Wendeng District, Rongcheng District and Rushan District. In 2018, Weihai has a permanent population of 2.83 million, with an urbanization rate of 67.81%. Weihai City was selected into the “EC-Link Project” in 2015 and started the following works in the solid waste management.

(1) Classification, collection, transportation and treatment of domestic garbage

In terms of domestic garbage classification, from 2016 to 2018, it had made a cumulative investment of more than RMB 20 million in Huancui District for carrying out the pilot project of garbage classification. The pilot coverage reached to 13 communities and 8 neighborhoods, covering 29 primary and secondary schools, all Party and government organs, and 80 government-owned enterprises and institutions. In 2018, the city began to explore intelligent ways of waste classification and installed 30 smart recycling bins. It has facilitated to create a number of pilot units for classification of domestic waste, such as the Taojiakuang Community, the Weigao Shopping Plaza Complex, and the Weihai Branch of the People's Bank of China. In 2019, Huancui District plans to add 15 pilot communities for smart classifications, improve the management of the big data operation platform, further standardize the management chain of collection, transportation and disposal, establish offline point-exchange sites of intelligent classification, and improve the collection and transportation system.

In terms of terminal treatment, Weihai currently takes 2 treatment methods: direct landfill, and landfill after incineration. Among them, the central district of Weihai and Rongcheng and Rushan have adopted the incineration methods. Currently, Wendeng District now adopts the landfill methods, and it is pushing on an incineration project which is expected to be put into use in 2020. During 2016 - 2018, the average daily productions of domestic garbage in Weihai were 2,721 tons per day, 2,773 tons per day, and 3,003 tons per day, respectively, all lower than the city's daily treatment capacity of 3,100 tons per day. The city has achieved 100% harmless treatment. After the incineration project in Wendeng District is put into use, the city's incineration treatment capacity of domestic waste will reach 3,300 tons per day, and the incineration treatment rate will reach 100%, achieving "zero landfill" of primary waste.

The kitchen waste management in Weihai City, including collection, transportation and disposal, is based on the territoriality principle. The sanitation departments in each district are responsible for the management of kitchen waste at source under their jurisdiction. The city has invested more than RMB 7 million to purchase 16 special kitchen waste collection and transportation vehicles which are matched with a 35-person collection and transportation team. It included 2,178 influential major hotels, restaurants, and large shopping malls that are with big kitchen waste generation, big regional distribution, and large influences into a special kitchen waste collection and transportation system, and signed a collection and transportation agreement with aforesaid entities, with a contracting rate of 80%. At present, it collects and transports an average of 80 tons of food waste daily. The kitchen waste generated by each of the

above entities is separately collected and stored and transported by the sanitation departments in each district with closed special vehicles to the processing plants for centralized processing. Weihai Development Investment Co., Ltd. invested RMB 85 million to build a kitchen waste treatment facility with a daily processing capacity of 100 tons. The project decided to adopt a centralized anaerobic digestion process. As of the end of April 2019, the total kitchen waste processed by it was 64,000 tons, with an average daily processing capacity of 80 tons per day.¹³

(2) Treatment of industrial solid waste and hazardous waste

According to the *Information on Curbing Environmental Pollution Caused by Solid Wastes of Weihai City*, in 2017, Weihai City produced 3.196 million tons of industrial solid waste. The main types of industrial solid waste are fly ash, slag, tailings, other wastes, and phosphogypsum.

In 2017, Weihai generated 15,400 tons of industrial hazardous waste. It disposed a total of 2,052.8 tons of medical wastes. The disposal method is first to sterilize with high-temperature steam and then transport to Weihai Municipal Domestic Waste Site for safe disposal. Weihai is generally lack of the capacity for hazardous waste disposal. Currently it has formulated the *Guidelines for Standardized Management of Hazardous Wastes in Weihai City*, which guides hazardous waste producers and operators, as well as district and municipal environmental protection authorities to carry out the management of hazardous wastes. It requires that, in accordance with the territoriality principle, implement a hierarchical supervision model for managing hazardous waste producers and operators in Weihai. It divided such producers or operators into groups to be managed by specific people, and it divided the responsibilities layer by layer to create a long-term supervision mechanism.

Weihai City issued the *Three-year Implementation Plan for the Improvement of the Rural Settlement Environment in Weihai City* at the end of 2018 to promote comprehensive management of rural waste. The plan states that by 2020, the prefecture will fully achieve all villages being planned, domestic waste being collected and disposed, and sanitary latrines be reconstructed in innocuous way across the prefecture; and the treatment rate of domestic sewage to be significantly improved, the villagers' environment and health awareness to be generally enhanced, and the ecological and environmental quality to be significantly improved, and the countryside to present a

¹³ Source: Weihai Municipal Bureau of Housing and Urban-Rural Development

new look of “good economy, good life, and good ecosystems”.¹⁴

4.2 Shenzhen City: Pioneer of solid waste management in China, one of the pilot “zero-waste cities”

Shenzhen City is a special economic zone, a national economic center and an international metropolis in China, and one of a handful of first-tier cities in the country. As of 2018, Shenzhen has a total area of 1,996.85 square kilometers, a resident population of 13,026.6 million, and an urbanization rate of 100%. It is China’s first fully-urbanized city. In the process of urbanization, Shenzhen focuses on implementing the concepts of green, ecology and sustainable development. It is a pioneer of China’s green cities. Among the 11 pilot “zero-waste cities”, it is undoubtedly the most advanced city in terms of solid waste management.

(1) Classification and treatment of domestic garbage

In 2015, Shenzhen took the lead in establishing a large-scale domestic waste shunting treatment system in China, and guided citizens to sort waste by gradually improving its legal system. In recent years, Shenzhen has issued 1 government regulation, 3 local standards, and 7 normative documents in relation to waste classification management, forming a rather complete norm and standard system. In February 2018, it solicited for public comments on its legislative documents, aiming to refine the garbage classification into 13 categories.

As the first city in China that carries out the special project of collection and transportation of large-scale garbage, Shenzhen is also the first in the country in terms of its appointment-based recycling system, in which the garbage collection is scheduled at fixed sites. According to public information, Shenzhen has built 21 large-scale garbage treatment facilities, and the garbage utilization rate exceeds 70%. The volume of large-size waste generated in Shenzhen is about 650 tons per day. In 2017, it handled 529 tons per day, with a recovery rate of 81.4%. The amount of waste fabrics produced in the city is about 12 tons per day. In 2017, the city’s processing and handling capacity of waste fabrics was 9.6 tons per day, and the recovery rate was 80%. It has approximately 3,500 recycling bins that cover the city’s all neighborhoods (urban villages) and that are uniformly filed and are sprayed with the box numbers, complaint hotlines and other supervisory information. For the waste glass, metal, plastic and paper, 5,913 sets of classified collection containers are placed in the 3,478 neighborhoods

¹⁴*Current Situation of Solid Waste Management in “11 + 5” Zero-waste Pilot Areas*

(urban villages) in the city. The classification-based collection system is established at the same time, and a free appointment-based collection service is provided. The city's production volume of waste glass, metal, plastic and paper is about 350 tons per day (mainly glass), and the 2017 processing and handling capacity is 30 tons per day. In addition, due to its unique local cultural characteristics, Shenzhen's large garbage also includes such unique items as flowers and cumquat trees generated before and after festivals. These kinds of waste have also become a special category. For this kind of garbage, special recycling activities are carried out around the Lantern Festival each year. The intact flower pots, soil, and brackets are recovered and reused, and the plants are used as fertilizers, and some are replanted. In 2018, 2.02 million pots of flowers and cumquat trees were recovered, 470,000 flower pots were reused, and about 80,000 plants were replanted.



Figure 4-1 Demonstration Project of domestic Garbage Classification in Meilin Yicun, Shenzhen City

Due to its large population size, the daily production of domestic garbage in Shenzhen reaches as high as more than 20,000 tons. In terms of terminal treatment, Shenzhen currently has 3 landfill sites with a total design capacity of 5,940 tons per day; 6 incineration and power generation facilities with a total designed capacity of 8,625 tons per day. Based on the assumption of 22,227 tons of domestic garbage generated daily, it can see the city's incineration capacity use rate is nearly 40%. Based on the current processing capacity, the city still shows a shortage of processing capabilities for treating garbage. Shenzhen currently has one incineration project under construction that is with a processing capacity of 5,000 tons per day. After completion, the domestic garbage incineration capacity in Shenzhen will be greatly enhanced.

In terms of management of kitchen waste collection and transportation, Shenzhen currently has 8 companies engaged in the business at the mid-processing stage, and in addition, it has built four kitchen waste treatment facilities with a capability of 1,130 tons a day at the terminal treatment stage. According to the calculation based on Shenzhen's population size, it can be estimated that the amount of kitchen waste generated is about 1,482.9 tons per day. And assuming that the kitchen waste treatment capability being 100% used, it can see the kitchen waste treatment rate is about 76%.

(2) Disposal of industrial solid waste and hazardous waste

Shenzhen started early in construction of solid waste treatment facilities. It has a rather mature market mechanism in place. The mass is widely involved in solid waste management; this provides a good cultural environment for construction of "zero-waste city". In 1988, Shenzhen established the country's first industrial hazardous waste treatment station, and built and operated the country's first domestic waste incineration plant. In 1997, Shenzhen was the first in the country to build and put into operation the Xiaping Landfill Site in light of internationally accepted sanitary landfill technologies. In addition, the city was the first to establish a hazardous waste joint-billing management system and a full IT processing system, and was the first to carry out the recycling of construction waste and kitchen waste.

Industrial solid waste

In 2017, Shenzhen's total industrial solid waste generated was 2.0925 million tons (including 955,600 tons of sludge generated by sewage treatment plants, and 1.137 million tons of general industrial solid waste). The harmless treatment rate of industrial solid waste reached 99.78%. Major industrial solid wastes include sludge, incinerator slag, and fly ash.

Hazardous waste

In 2017, Shenzhen operators received and disposed of 385,700 tons of industrial hazardous waste in the city. The harmless treatment rate of hazardous waste reached 97.77%. The hazardous waste in Shenzhen which was transferred to operating companies outside the city for disposal was 154,500 tons. Shenzhen operators received 46,800 tons of hazardous waste from other places outside the city. The large quantities of hazardous wastes include mainly copper-containing wastes, metal-surface treatment wastes, waste acids, incineration residues and slag, and dye and coating wastes. In 2017, the city's medical waste was 141,000 tons, all of which were harmlessly incinerated and disposed.

Construction waste

In 2017, the construction waste generated in Shenzhen was approximately 94.1 million cubic meters (including project spoil and demolition materials). Among them, about 15.24 million cubic meters were land-filled (including landfill at the receiving sites, safety hazards remediation, various ecological restoration and spoil backfilling, etc.); about 3.97 million cubic meters (about 5.96 million tons) were comprehensively utilized; and others were transported to surrounding cities and were mainly used for land reclamation, land consolidation, ecological restoration and other projects.¹⁵

After the concept “zero-waste city” was put forward, Shenzhen issued the nation’s first quota standards and technical standards for governing construction waste discharge. At the same time, Shenzhen also promulgated *Several Measures on Further Strengthening the Management over Construction Waste Disposal in the City*, which adopted 28 measures in 5 aspects, including source reduction, comprehensive utilization, landfill, cross-regional balance, and improvement of management mechanism, to accelerate the realization of Shenzhen’s construction waste re-utilization, discharge reduction, management standardization, and promote sustainable urban development. In addition, it issued and implemented the *Administrative Measures for Demolition of Houses in Shenzhen City*, to promote the comprehensive management of building demolition, comprehensive utilization, and removal and transportation, and to vigorously promote the on-site crushing and disposal of mobile construction waste.

4.3 China-Singapore Tianjin Eco-city: One of the first green ecological demonstration areas in China

The China-Singapore Tianjin Eco-city is a strategic cooperation project between the governments of China and Singapore. This is the second inter-governmental cooperation project between the 2 countries after the project of Suzhou Industrial Park. It is also one of China’s first 8 “green ecological demonstration zones”.

In order to achieving the goals of the Eco-city indicator system: “0.8 kg per capita per day of garbage, 60% of waste recycling rate, and 100% of harmless treatment rate”, the Eco-city adopted advanced technologies and established a whole-process management mode in regards to garbage collection, transportation and disposal, to effectively improve comprehensive efficiency of waste management. The garbage pneumatic conveying system is one of the key techs it applied. The Eco-city’s garbage pneumatic

¹⁵*Current Situation of Solid Waste Management in “11 + 5” Zero-waste Pilot Areas*

conveying system has covered about 5.6 square kilometers in the southern area of the city, covering a construction area of 5.32 million square meters, a pipe network with pipe length of 35,000 meters (The pipes are with a diameter of 500 millimeters), and more than 1,200 sets of dumping outlets. It has a serving population of 80,000 people, with a total designed transport capacity of 87.2 tons per day, and with a total investment of RMB 347 million (See Figure 4-2). The underground pneumatic pipeline network in the central area has a planned length of 46,000 meters and more than 1,600 sets of dumping outlets. The longest suction distance of the pneumatic pipe network is 1,500 meters, and the u-turn semi-axis is 1.8 meters.

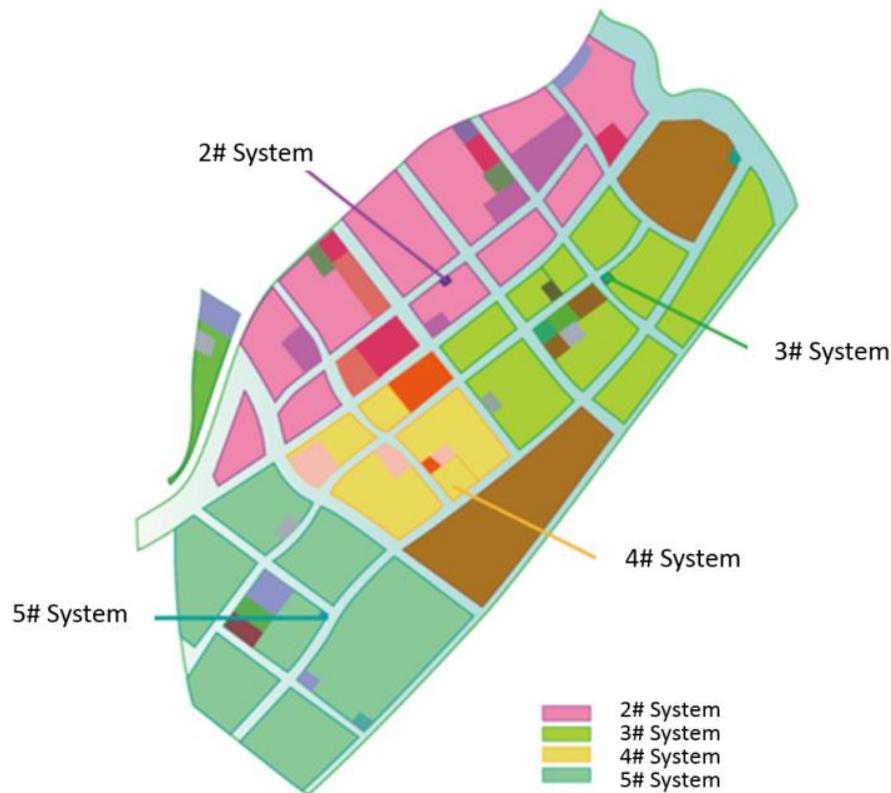


Figure 4-2 Plan of the pneumatic Conveying System for Garbage in the Southern Part of the Eco-city

(1) Construction and operation: government and market co-participation

After preliminary investigations and discussions, the Eco-city has clearly adopted the DBOO (design-build-own-operate) model for creating and operating the waste pneumatic conveying system, and implemented the process of government authorization, company investment, and government subsidies. Specifically, the Eco-city Management Committee signed the *DBOO Framework Agreement for Waste*

Pneumatic Conveying System with reputable enterprises, entrusting them to be responsible for design, construction and operation of the public pipe network and the central collection station; granting them the powers of construction, operation and fee charging; clearly stipulating the project's total investment, payment methods and subsidy schemes, and clarifying specific details such as the operation period and operation mode. The enterprises should raise funds for the construction themselves, and they can own the garbage pneumatic conveying system within an authorized period. After the project started, the government started to subsidize. But the subsidy would decrease with the construction progress, and the total subsidy would not exceed 70% of the construction costs. The selection of the DBOO model not only provides a basis for the construction and operation of the garbage pneumatic conveying system, but also provides a practice for replication and promotion of the "government-led, market-participated" model.

(2) Planning and design: source control and quality assurance

In the Eco-city planning and design stage, the garbage pneumatic conveying system was included into the comprehensive consideration of the total city construction. The city had made ample studies and demonstrations on such difficulties as laying underground pipe network and in construction of collection stations. The research topics mainly include: underground pipes that undertake the task of garbage conveying, most of which are of DN400 mm or DN500mm in diameter, and a large number of manholes along the line that require more underground space along the municipal roads and in residential areas. As pipeline climbing and suction distances are limited, therefore, collection station sites are particularly selective. Unlike the water, gas, heat and other energy pipelines, the waste pipeline system is still new in China and there are no mature cases for reference, especially in terms of its equipment and control systems which are complex and need a very professional team to participate in the whole process of design, civil construction, equipment installation, operation and commissioning. Meanwhile, domestically it has fewer professionals working in this area and most workers lack of experience. All of these, it has raised high requirements on the capabilities and quality of all participating parties to build the garbage pneumatic conveying system. To this end, the Eco-city Management Committee strictly selects all participating parties in the project, requiring that the parties selected should be the best. It requires the design company, equipment supplier, supervision company, construction company, project management company, and construction company to dispatch key technical personnel to the project form an excellent team, to enhance communication and coordination and to ensure the project quality from the very beginning of the project.

(3) Management and maintenance: running smoothly by catering to standards

Standardize operational processes. The garbage pneumatic conveying system is a new process. The city carried out a large amount of investigation and analysis in light of its 2-year operation of the No. 2 pneumatic garbage conveying system in the southern part of the Eco-city, and developed a fairly complete set of standardized operating norms and rules, such as the *System Operation Guide*, the *System Maintenance and Repair Guide*, the *SOP Standardized Operation Guide*, and the *Common Fault Maintenance Guide*, covering all aspects of system operation, maintenance, overhaul, and safe operation, and providing professional guidance for daily management and operations (see Figure 4-3). In addition, the visual management mode of the sites further promotes a harmonious co-working unity among workers, machines, and materials and things, promotes seamless connection to each community for garbage collection, reduces the personnel cost of the property management company, and facilitates residents' lives.

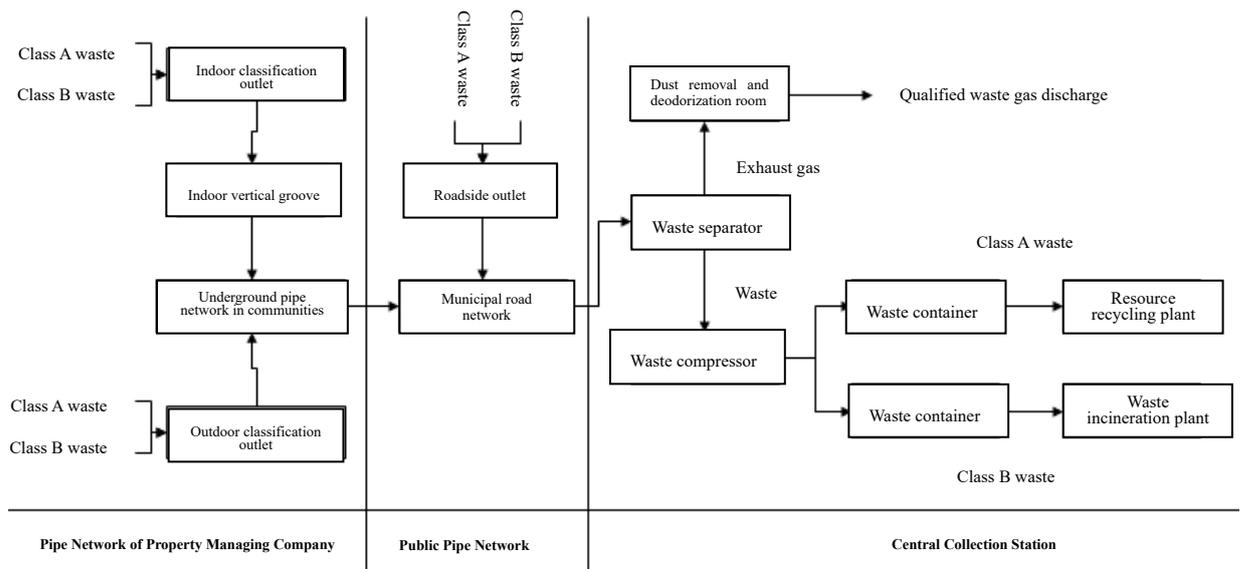


Figure 4-3 Flow Chart of the Pneumatic Conveyance System of the Eco-city

Localize experiences. We see that as a Chinese saying goes, “Stones excavated from other region’s hills can be used to produce beautiful jade”. We learn experiences from others. However, this garbage pneumatic conveying system is not a “full copy” of foreign advanced technologies and experiences. Instead, the city insisted on the principles of introduction, digestion and innovation at the very beginning. It actively studies advanced technology, fully considers the distribution of its urban area, and implements innovation and transformation according to its local conditions. At the same time as it eyed for seeking more component procurement channels, it reduced its

dependence on foreign equipment suppliers and effectively reduced operating costs.¹⁶

5. Future Outlook

5.1 Problems and challenges

China is accelerating its urbanization process. While the amount of solid waste generated in cities is increasing rapidly, the amount of solid waste per capita greatly declines gradually however. The idea of construction of “zero-waste cities” will push China’s solid waste management to an unprecedented level, and it will become one of spotlights and focuses in urban construction in the future for a long time to come. However, at present, the management of municipal solid waste still has the problems of “a slow promotion for classification”, a kitchen waste recycling system that needs to be improved, and a “difficulty to seek sites for landfill project construction in the densely populated” eastern China.

The overall progress in pushing for solid waste classification and collection in China has been slow, which has impacted the collection, transportation and processing. Except for large cities such as Shanghai and the 46 key cities, the overall progress of solid waste classification nationwide has been slow. Insufficient waste classification at source has a-certain-degree impact on the solid waste collection, transportation, and re-utilization. It sure can result in higher costs for subsequent processes of gas collection, leachate treatment, composting, and incineration. At the same time, the construction of supporting facilities for the solid waste classification and collection is relatively lagging behind. The level of harmless treatment of urban solid waste and the level of urban economic development are seriously inconsistent. A nationwide construction and operation system of solid waste classification has not yet been formed. In addition, the effort of publicity and education also needs to be further heated up.

The mechanism of kitchen solid waste re-utilization is yet to be improved. At present, the market of kitchen solid waste treatment is imperfect in terms of charging mechanism and of immature treatment technology, which has hindered the re-utilization of kitchen solid waste. Most projects of the kitchen solid waste treatment plants are still in the process of project establishment stage, and few have been put into operation. In addition, the current approaches of solid waste collection and transportation for restaurants and kitchens which are in the frontal segments of the system cannot be well matched with and serve the terminal recycling and disposal methods which are in the back end of the

¹⁶Source: *China-Singapore Tianjin Eco-city Innovation Demonstration Achievements and Cases*

segment. So, the smooth integration is needed to get it improved.

As the scope that a landfill site needs to occupy a large area of land and the land in the eastern regions of China has already been extensively used, it undesirably results in difficulties in seeking right project sites that is a big problem. A number of simple landfills constructed at the end of the 20th century were closed down successively. The 300 landfills that were put into operation before 2005 are about to cease operations. The land area as large as nearly 7,023hm² is to be remediated in the next few years.¹⁷ The eastern regions in China that are with high population density have virtually no new landfill sites allocated since 2011. Site selection has become increasingly difficult.¹⁸

5.2 Trends and outlook

In the future, comprehensive management of urban solid waste in China can start from three areas: source reduction, classification-based collection, and recycling. Specifically, urban solid waste in the future should be managed from the following three aspects: establishing an entire-cycle solid waste management system based on big data; improving the laws and policies based on the idea of circular economy for comprehensive waste management; and promoting comprehensive management of solid waste.

(1) Establishing an entire-cycle solid waste management system based on big data

At present, the “solid waste information platform” established by environmental protection departments in various parts of China is still focusing its attention on a solid waste management concept that centers mostly on curbing of environmental pollution by solid waste, emphasizing curbing of pollutants in solid waste, while ignoring the role and effect of solid waste transactions and the related solid waste trading market in curbing solid waste pollution of the environment and in improving the capability of solid waste environmental management.¹⁹ In practice, while the kind of solid waste trading platforms is established by market entities, or the construction is under the environmental protection department encouragement with subsidies, such a trading platform practically does not serve the regulatory authorities well in performing their solid waste supervision, and also cannot help to form a systematic solid waste recovery

¹⁷*Environmental Sanitation Engineering: Status, Problems and Development Countermeasures of China's Landfill Sites*

¹⁸*Urbanism and Architecture: Status and Outlook of Municipal Solid Waste Treatment in China*

¹⁹*Applications of IC: Status and Improvement Countermeasures of Solid Waste Management*

and treatment system.

In building futuristic platforms, it may rely on the Internet of Things technology and mobile Internet technology, to conduct real-time management of the whole process of workers, vehicles, objects and things involved in the sanitation management. It may reasonably design and plan a sanitation management mode, to improve the quality of sanitation operations, and reduce sanitation operation costs. And it may use digital assessment to assess effectiveness of solid waste classification management²⁰. All smart services of sanitation departments of a city will be deployed in the smart urban management cloud of the city, to connect to the smart city network, and provide the required services to managers and operators at any time by the means of cloud services. In addition, key information about the source of solid waste and the source of hazardous waste on the platform of intelligent solid waste sanitation management shall be reported to the solid waste information platform for monitoring and management.

(2) Regulations and policies system for comprehensive solid waste management based on the idea of circular economy

As one of the fastest-growing countries, China has an imbalance between its economic development and its construction of a legal framework for managing municipal solid waste. It is urgently needed to formulate a series of special regulations and policies on urban solid waste management. Within the framework of solid waste laws and regulations, it may primarily take the following measures. First, clearly formulate the rules that extend the producer responsibilities. The producers' responsibility should not only extend to the front end, but also to the source end, such as the responsibilities on raw materials and on product waste recycling and treatment. The laws and regulations in our country at this stage are not comprehensive enough in the sense of incomplete producer responsibilities. So it is necessary to increase the scope of producer responsibilities and to enforce the obligations and responsibilities at the source end. Second, strengthen the role of social organizations and the public in implementing the circular economy laws and regulations. With the circular economy legislation, it should specifically list various rights of the public such as their right to know in terms of circular economy. Third, further improve the information disclosure rules. It should establish an obligation on enterprises to disclose their environmental information, including a list of toxic and hazardous substances that they discharge. It should stipulate that the enterprises should report the amount of toxic and hazardous substances discharged by them to the government each year, and the government should be

²⁰Smart energy city development: a story told by urban planners[J]. Cities, 2017

responsible for making it public. This can increase public participation and scrutiny and effectively reduce the discharge of toxic and hazardous substances. Fourth, it should further stipulate in the law the circular-economy labeling system. The Product & Resource Consumption Marking System provided by the *Circular Economy Promotion Law* provides consumers with the necessary information to make it easier for them to know the products or resources. It should improve the circular economy identification capability in the circular economy legal system, to increase the types of circular elements for identification, such as identification of energy conservation, water conservation, waste utilization, and renewable resources.

(3) Promoting comprehensive management of solid waste

Many policies introduced in 2017-2019 will continue to help improve the domestic waste management in the next few years. With the gradual improvement of waste classification, how to better manage solid wastes following up has become a new issue in the new era. After strict classification of waste, it can be expected that it will also bring changes in the waste processing technologies, and it can be expected the resource recycling technologies will no doubt get increasing weight and be highly regarded. And this trend of technical changes will be also consistent with the development of solid waste treatment in the United States and Japan to the later stage. The proportion of waste incineration treatment in the United States stabilized after it reached the peak around 20% in 1995-1998. After 2000, it gradually decreased, while the proportion of recycling began to increase gradually after 2000.

The emerging industry of solid waste cycling, such as recycling of scrapped cars and used batteries, has huge potential in the recycling market. But this industry is also suffered by illegal recycling networks which take a large chunk of business of scrapped car recycling, causing those legal dismantling enterprises unable to make sufficient orders. It is recommended to establish a circular economy industrial park and implement the model of “decentralized recycling and centralized dismantling”; to deploy a shared network of environmental protection facilities to guide the industry in the direction of environmental-friendly dismantling and recycling of waste resources; and to implement the auto producer responsibility system and implement full life cycle management.

In addition, with the rapid advancement of urbanization and the large-scale carrying out of shantytown renovation projects in provinces and cities across the country, the construction waste in China has increased year by year. According to the estimates of China Strategic Alliance of Technological Innovation for Construction Waste Recycling

Industry, in 2017, China produced 2.379 billion tons of construction waste, of which just 11.893 million tons were processed for re-utilization. The re-utilization rate was only about 5%. We see recycling of construction waste is a rigid precondition for urban development. With the frequent introduction of national construction waste treatment policies, the construction waste treatment industry will usher in a new era that is full of opportunities and challenges.²¹

²¹ Source : Solid Waste Disposal and Utilization Committee under the China Association of Environmental Protection Industry



The Europe-China Eco Cities Link (EC-LINK) Project is funded by the European Union In cooperation with the Ministry of Housing and Urban-Rural Development (MoHURD)

Implemented by the Chinese Society for Urban Studies (CSUS) and the European Consortium led by GIZ

中欧低碳生态城市合作项目由欧盟资助与住房和城乡建设部合作
由中国城市科学研究会执行项目管理, 德国国际合作机构等提供技术支持