

Future Development of Waste Management in China According to the 13th Five-Year Plan

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Municipal solid waste (MSW) known as trash or garbage consists of food waste, paper, cardboard, plastics, PET, glass, textiles, metals, wood and leather, nappies, slug, ash, etc. are arising from human and animal activities. The rapid development and urbanization of China have resulted in an increasing volume of MSW. So the problem of MSW management has become a major social problem [8], but on the other hand, because of their intrinsic properties, MSW are often reusable and may be considered a resource for energy recovery. The delivering quantity of household waste averages 179 million tons in China, and the amount of untreated MSW over the years has reached 7 billion tons.

In response, Chinese government is seeking more effective ways of MSW disposal. Compared with other MSW treatment technologies, the waste incineration performs best, and it is a better waste management option [2], The application of large-scale incineration technologies is inevitable as landfill areas would ultimately cease [1]. Thus, the waste-to-energy (WTE) incineration plant becomes a good choice in China, which uses incineration to convert MSW to electricity. It makes use of waste resources and transfers them to electricity to achieve waste reduction, recycling and harmlessness, which can meet the requirements of circular economy with significant economic and environmental benefits.

1. Waste management situation in China

China is a developing country, the deepening of urbanization and steady growth of urban population is leading to a continuing increase of total MSW amount. As shown in Figure 1, in 2015, MSW generation in China surpasses 190 million tonnes per year, and the harmless garbage disposal rate was 94.1 percent, with an annual compound increase of 8.38 percent. The need for MSW management therefore has become paramount. A MSW management includes those measures aimed at reducing the wastes and their adverse effects on the environment [10]. In order to compare and define the advantages and disadvantages of the strategies used on municipal solid waste management systems, various municipal waste management strategies have been investigated.

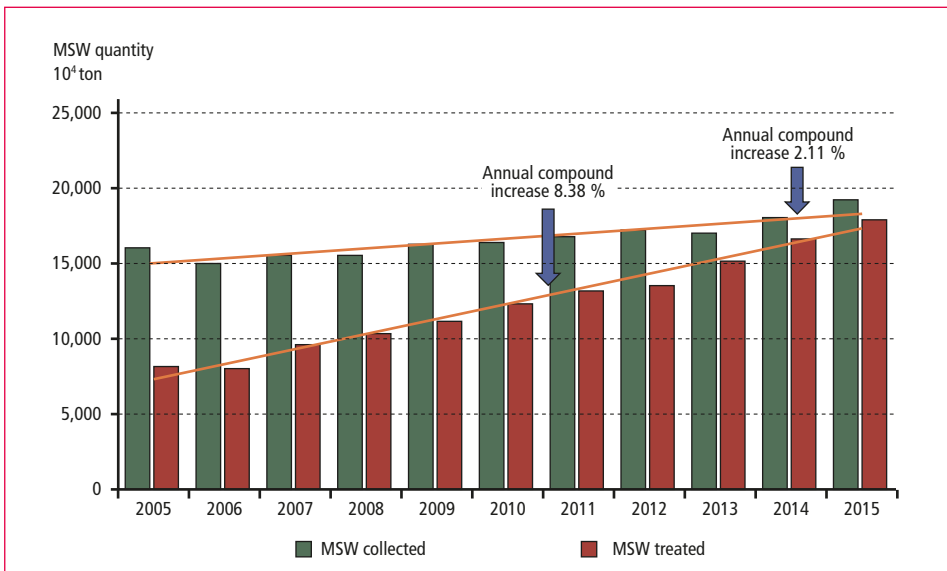


Figure 1: Variation of quantity of MSW between 2005 and 2015

Source: National Bureau of Statistics of China

As can be seen in Table 1, there are three main methods to reduce the volume of the municipal solid waste. In the 11th Five-Year Plan of China, about 80 percent of MSW treatment is landfill, it is a comparatively simple and economic way for municipal solid waste disposal. Moreover, landfilling is the ultimate disposal method waste that cannot be recovered. However, the most problem is that there is no enough room for landfill. With the development of technologies, incineration becomes more popular in China. The number of WTE incineration plants is 244, accounting for about 27.42 percent of the total amount of MSW treatment plants in China. The incineration processing of MSW, used both for volume reduction and energy recovery, is an important element in many integrated waste management systems. The capacity of MSW incineration plants had accounted for 38.82 percent of waste elimination by the end of 12th Five-Year Plan.

Table 1: Three main modes for MSW treatment

Year	Number of MSW disposal facilities				Capacity of MSW treatment plants			
	%				%			
	No.	Landfill	Composting/ Other	Incineration	Capacity 10 ⁴ ton/d	Landfill	Composting/ Other	Incineration
2005	471	75.58	10.19	14.23	25.63	82.35	4.59	12.88
2006	419	77.33	6.21	16.47	25.80	80.07	3.68	15.49
2007	460	79.57	6.09	14.35	27.18	79.17	2.90	16.44
2008	509	79.96	2.75	15.54	31.52	80.36	1.71	16.37
2009	567	78.84	4.76	16.40	35.56	76.83	3.15	20.02
2010	628	79.30	1.75	16.56	38.8	74.74	1.41	21.88
2011	677	80.80	3.10	16.10	40.91	73.38	3.62	23.00
2012	701	77.03	3.28	19.69	44.63	69.67	2.84	27.48
2013	765	75.82	2.48	21.70	49.23	65.57	2.24	32.19
2014	818	73.84	3.18	22.98	53.35	62.86	2.28	34.86
2015	890	69.66	2.92	27.42	57.70	ND	ND	38.82

Source: National Bureau of Statistics of China

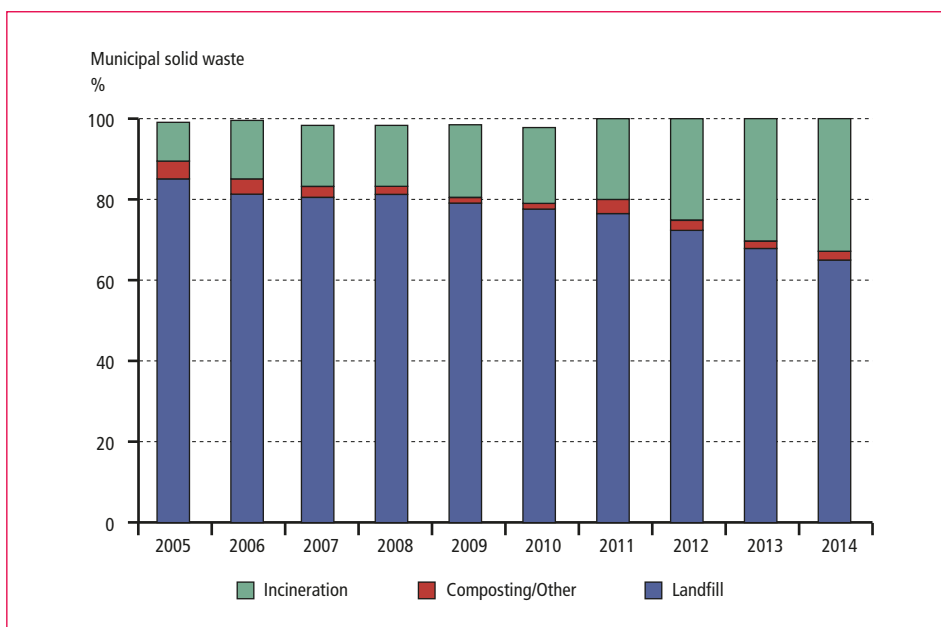


Figure 2: Actual burned amount of MSW in China between 2005 and 2014

Source: National Bureau of Statistics of China

From the perspective of capacity ratio, the incineration target of 12th Five-Year Plan had been finished, which is 35 percent [4].

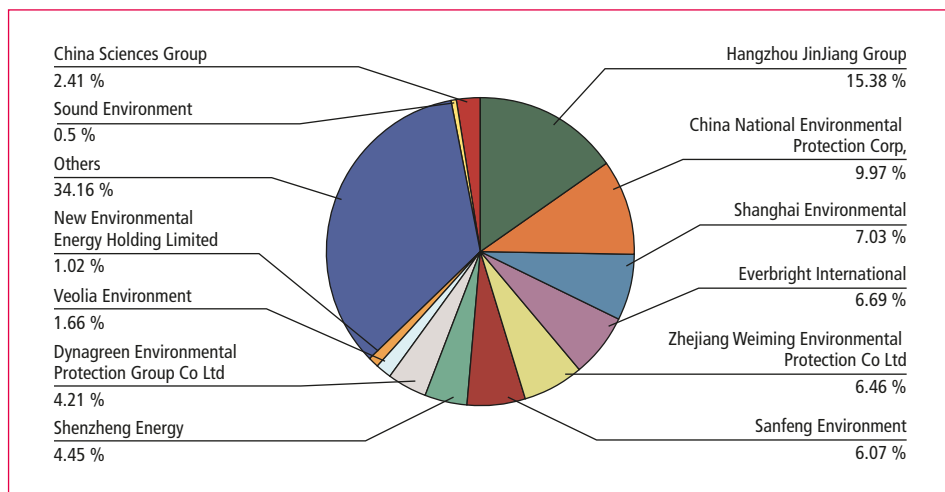


Figure 3: The WTE incineration market share of 12 well-known corporations in China

In China, there are 12 well-known corporations which produce electricity using MSW. The installed power capacities ratio of these companies is shown in Figure 3. As shown in Figure 3, these 12 companies accounted for approximately 76 percent of all the WTE incineration capacity in China. The biggest one is Hangzhou Jinjiang Group, which WTE incineration capacity is 14,688 tonnes per day, accounting for about 15.38 percent of the total capacity of the WTE incineration capacity in China.

2. Future waste management in 13th Five-Year Plan

It is an indisputable fact that China have huge amount of MSW. China has surpassed the United States, becoming the world's largest producer of MSW, accounting for about 70 percent of the total amount of MSW in East Asia. The amount of untreated MSW has accumulated year after year.

2.1. Development trends and opportunities

The development of landfill sites reaching saturation point

Using landfill sites to deal with waste is an old method and it is very common in China. But the sharp growth of the urban population and the waste amount resulted from the urbanization is raising sharp conflicts of landfills and land resources. Many cities have difficulties finding suitable landfill sites. Not only the existing waste landfills have reached saturation point in number but their disposal capacities are close to saturation point due to overuse [6, 7]. Many waste landfill sites have reached their designed capacity in advance. In 13th Five-Year Plan, the number of landfill plants will peak around 2,400, and then later will be reduced slightly, stabilized at about 2,000 to 2,200.

The rapid growing amount of WTE incineration plant

Taking a view of the entire WTE incineration industry, as shown in Table 1, the annual amount of WTE incineration was 81 million tons in 2015. That is to say, the daily disposal would be about 224 thousand tons. At the end of the 13th Five-Year Plan, the WTE incineration capacity will be 467 thousand tonnes per day, accounting for above 50 percent of the total actual treatment of MSW in China. Great market demands for the disposal of MSW will bring this industry an equipment investment of nearly 16.3 USD billion and a stable annual profit. In the 13th Five-Year Plan, WTE plants will face a rapid growth, and the demands for relevant equipment will increase.

Table 2: Prediction of WTE incineration in the 13th Five-Year Plan

Year	Unit	2015	2016	2018	2020
WTE Incineration capacity	10 ⁴ t/d	22.4 (32.0 %)	34.3 (49.0 %)	44.4 (63.4)	46.7 (66.7%)
WTE Incineration Treatment		32.0 % • 80 % (load rate) = 25.6 %	49.0 % • 80 % (load rate) = 39.2 %	63.4 % • 75 % (load rate) = 47.5 %	66.7 % • 75 % (load rate) = 50.2 %

WTE incineration technology will develop rapidly to the central, western and north of China

As shown in Figure 4, the WTE incineration technology will develop steady growth in Jiangsu, Zhejiang, Fujian, Guangdong, Shandong and other east provinces in the 13th Five-Year Plan. But, the rapidly increasing of WTE incineration technology will

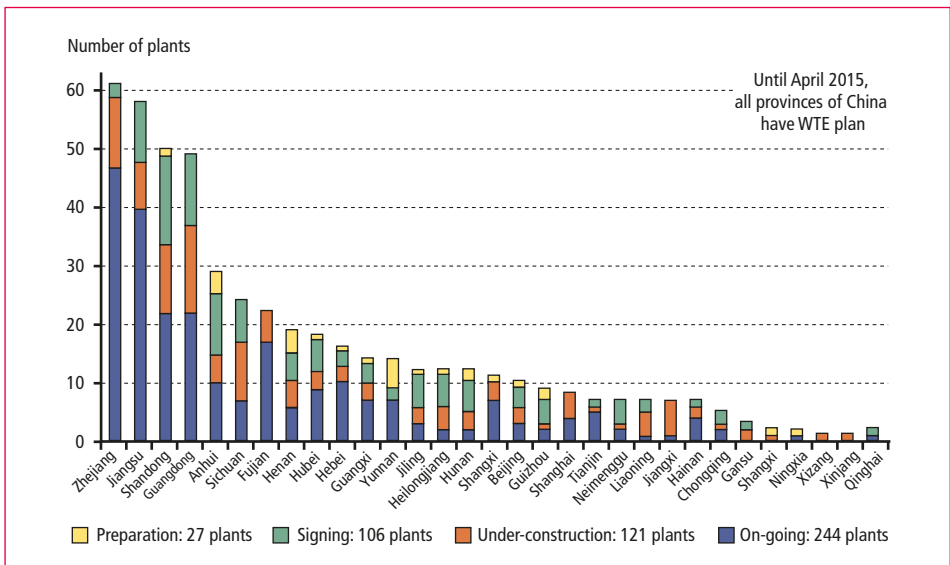


Figure 4: The situation and trend of WTE incineration plants in the provinces of China

be promoted in these inland provinces, just like Hebei, Shanxi, Anhui, Hubei, Hunan, and Sichuan. In these provinces, prefecture-level cities generally promote the waste incineration projects, and also the economic developed county-level city and county.

The circulating fluidized bed incineration technology will develop rapidly

The Circulating Fluidized Bed (CFB) incineration is an energy saving technology proposed by environmental protection department in China. The daily disposal capacity of a single furnace is 500 tons of waste. The advantages include effective prevention of dioxins, stable and reliable operation and higher thermal efficiency of combustion. The main disadvantages are shorter annual operation time, incomplete combustion but mixing with coal, much flue gas dust, frequent equipment maintenance, etc. [5]. CFB burning is domestic technology, it will develop rapidly in the 13th Five-Year Plan, Hangzhou Jinjiang Group, whose WTE incineration market share is biggest in China, given priority to the CFB incinerator.

2.2. Challenges

Besides strong technical advantages, WTE incineration is also faced with some technical challenges, hindering the rapid development of this industry [9]. The compositions of MSW themselves are unstable. The contained waste materials change with the seasons in sorts and quantities. And the high water content and low heat value of the MSW itself result in an unstable generating capacity [3]. The major problem of WTE incineration technologies is the controlling and preventing of some pollutants, especially fly ash. In China, MSW incineration (MSWI) fly ash is classified as hazardous waste owing to its high concentration of leachable heavy metals and the presence of chlorinated organic compounds, such as dioxins and furans. In the 13th Five-Year Plan, above 5 million tones MSWI fly ash will be produced.

WTE incineration industry is faced with dilemma of development in China. On the one hand, it is advocated and supported by the government and enjoys many preferential policies. On the other hand, it is misunderstood and even resisted or rejected by the public.

3. Integrated WTE by sources separation

Because of the city scale, living condition and income, the Average Bio-Waste content of MSW is above 66 percent, which is the average of 38 analysis form 27 cities in China. In Shenyang, a central city in northeast of China, this value is 73.7 percent, which is shown in Figure 5. So China cannot copy the model of source separation from developed countries. From Figure 6, it could be found that: The best way for WTE is to separate bio-waste (BMW) and residual solid waste (RMW). Bio-waste can be used for BMW Anaerobic Digestion to collect energy. The net energy of BMW Anaerobic Digestion can reach up to 504 MJ/t. RMW can be directly used for incineration plant, the net

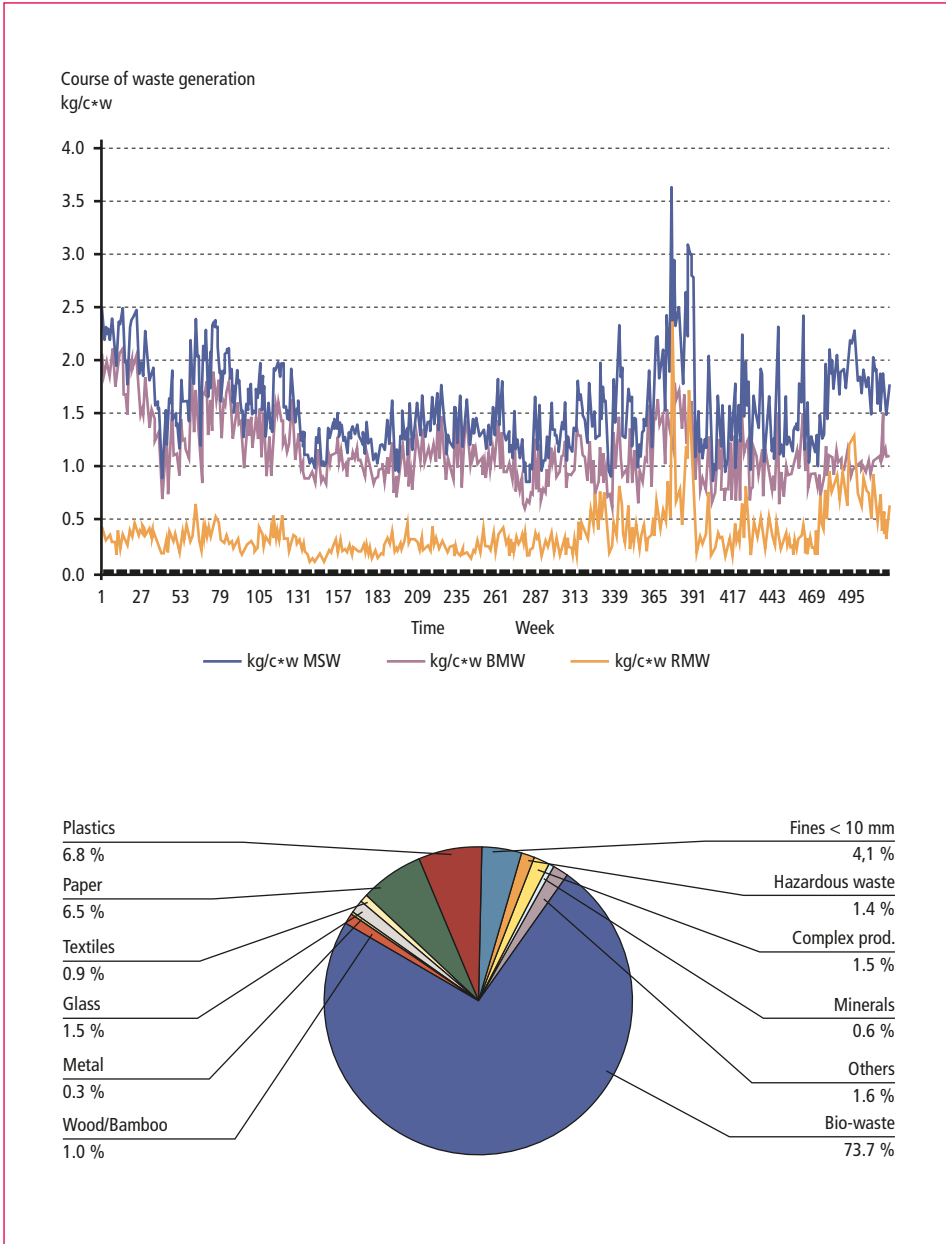


Figure 5: Average composition of MSW in Shenyang (2005 to 2015)

energy of RMW incineration is 1850 to 2,960 MJ/t, and the integrated energy efficiency of integrated WTE by sources separation is 27 to 50 percent, while the WTE incineration is 14 to 25 percent, and the WTE landfill is 3 to 10 percent.

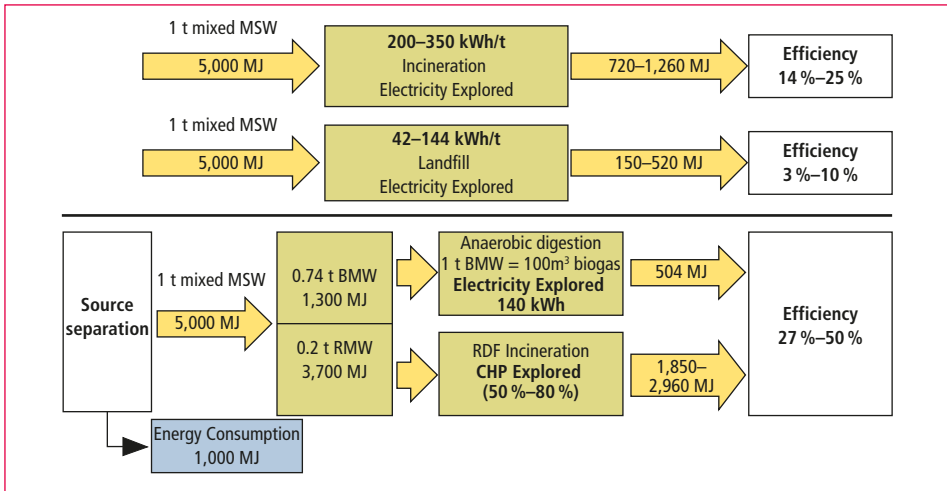


Figure 6: Integrated energy efficiency analysis of some WTE method

4. Conclusion

This review demonstrates that it is fully possible for WTE in China. WTE meets the requirement of renewable energy and circular. The management of MSW can play an important role in WTE. At the end of the 13th Five-Year Plan, the WTE incineration capacity will be 467 thousand tonnes per day, accounting for above 50 percent of the total actual treatment of MSW in China. An effective waste focuses on recycling and separating the collection. Source separation can contribute a lot for integrated WTE and environment protection. The WTE plants collect electrical and thermal from solid waste.

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