

Waste Management Practices in New York City, Hong Kong and Beijing

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Introduction

Solid waste management is a challenge for large urban areas around the world. Removing garbage from residential, institutional and commercial locations in cities is a major logistical and operational task. Waste management is usually a function of local government, and is often a city's largest budget item. Solid waste generation rates are rising fast, particularly in cities experiencing increasing population rates and higher economic activity, putting pressure on municipal governments to deal with rising costs and environmental impacts.

The waste from cities around the world is already enough to fill a line of trash trucks 5,000 kilometers long every day. In 1900, the world had 220 million urban residents that produced 300,000 tons of waste per day; by 2000, those numbers grew to 2.9 billion people generating 3 million tons of solid waste per day. Worldwide, waste rates are expected to triple by 2100, to exceed 11 million tons per day. The global cost of dealing with all that trash is rising too, from \$205 billion a year in 2010 to \$375 billion by 2025, with the sharpest cost increases in developing countries (The World Bank, 2013). Due to this volume of waste material, an increasing amount of waste is recycled, burned for energy, or in the case of food waste, reprocessed as fertilizer.

East Asia is now the world's fastest growing region for waste. Waste generation in Asia's urban areas is expected to soon reach 1.8 million tons per day (World Bank, 2013). In 2004, China surpassed the U.S. as the world's largest waste generator. The Chinese government has developed a number of laws and development plans related to waste management, many of which are discussed in the government's Five Year Plan- the five year social and economic plan for the country, developed periodically by the National People's Congress. Waste management practices in China are governed by the 'Solid Waste Pollution Prevention and Control Law' (2005) and the 'Circular Economy Promotion Law' (2009).

The 12th Five Year Plan states that by 2015 all counties will be able to manage solid waste, with an emphasis on recycling of post-consumer materials. However, China is undergoing an unprecedented increase in waste generation. According to the World Bank, the quantity of municipal solid waste generated in China's cities has increased fivefold between 1980 and 2009, from 85,000 tons to 430,000 tons per day, and is projected to reach 1.6 million tons per day by 2030 (2014). Most waste in China goes to landfills or unregulated waste heaps outside major cities, and as China's landfills are filling up, cities are turning to burning waste to generate electricity at waste-to-energy plants. Overall in China, the number of waste incinerators is projected to increase from 93 in 2009 to 200 in 2015, raising the daily disposal capacity from 55,400 tons to 140,000 tons (World Bank, 2014). However, there is increasing public concern about the environmental performance of these waste incinerators, and their impact on the local environment and communities.

Many cities around the world are implementing innovative measures to deal with waste, and are increasingly incorporating waste management into sustainability plans. Some cities are setting positive examples through aggressive recycling and zero waste programs. Cities are reducing food waste with better storage and transportation. They are implementing construction strategies that increase reuse of materials. Some local policies such as waste disposal fees and other charges are being used to encourage waste reduction. Some cities have banned the use of plastic shopping bags and some are requiring that stores charge for the use of bags.

This case study examines waste management practices in three cities: New York City, Hong Kong and Beijing. We begin by assessing New York City to provide an overview of waste management practices in a large, complex U.S. city. We then focus on Hong Kong, and finally on Beijing, to provide detail on the waste management practices of two major Chinese cities and learn how they are dealing with the growing volume of waste generated by these large cities. In each of the three cases we describe the history of waste management in that locale, the status of waste management today, and discuss the challenges faced in each location. Finally, we compare the practices in these cities, and detail the technical, managerial and political issues that define the waste management system in each place.

New York City

New York City's 8 million residents and millions of businesses, construction projects and non-resident employees generate 14 million tons of waste and recyclables per year (City of New York, 2014). This amount is so vast that waste is handled by two separate systems – one public and one private. The public agency – the New York City Department of Sanitation (DSNY) – serves residential buildings, government agencies and many nonprofit organizations. Private commercial firms do not receive free garbage pick-up by the city government. They must pay private firms to remove their solid waste. The private waste removal system is comprised of a small group of waste removal firms that are regulated by the City's Business Integrity Commission. This Commission licenses waste hauling firms that remove commercial waste. The New York City Department of Sanitation collaborates with the Sims Multi Recycling Recovery Facility (Sims), the Department of Parks and Recreation (DPR), and GreenNYC to manage the city's waste through reduction initiatives in the following areas: waste reduction, recycling, and composting and organic waste diversion. Spending on residential and commercial garbage is about \$2.3 billion of the city's \$75 billion annual budget (Citizens Budget Commission, 2014).

During the twentieth century, the New York City Department of Sanitation relied on a number of landfills for garbage disposal. Then in December 2001, the city's last garbage dump closed. In response, the City Council adopted a twenty-year plan for exporting government-managed waste, relying on a truck-based system and a combination of local, land-based transfer stations that took the city's garbage and disposed it in landfills, recycling facilities and waste-to-energy plants in neighboring states and in places as far away as 750 miles. Once local landfills were filled, and efforts to build local waste-to-energy incinerators were blocked, waste export became the only option for New York City (DSNY, 2006). The City recognized that waste disposal costs would continue to increase as nearby landfills closed and trucks would have to travel to more distant landfills.

Of the 3.8 million tons of solid waste that the New York City Department of Sanitation now collects annually, 14% is recycled, 76% is sent to landfills and 10% is converted to energy at a waste-to-energy facility (Citizens Budget Commission, 2014). The waste that goes to landfills often travels long distances to states like Pennsylvania, Ohio, Virginia and South Carolina. New York is one of the few large U.S. cities

that funds trash collection with general tax revenue – it doesn't charge customers for waste collection.

History of the Problem

New York City has a long and difficult history in solid waste management. Ocean dumping ended in 1935, brought on by a federal lawsuit filed by New Jersey coastal cities (McCrorry, 1998). With plans for new incinerators slowed, first by the Great Depression and then by World War II, the city found itself struggling to meet its waste disposal needs. In 1947, the Fresh Kills Landfill opened in Staten Island, one of the city's five boroughs. Initially, the city's new mayor promised that "raw" garbage would only be landfilled at Fresh Kills for three years – the time it would take to build a large incinerator in every borough. However, by the 1960s, one-third of the city's trash was burned in over 17,000 apartment building incinerators and 22 municipal incinerators. The remaining residential refuse was still sent to Fresh Kills as well as the city's other landfills (Miller, 2000). As environmental awareness grew, public pressure began to mount against incineration and landfilling. Old landfills and incinerators were gradually shut down, with the last municipal incinerator closed in 1992. By the late 1990s, Fresh Kills was the only remaining waste disposal option for the residential and public waste managed by the New York City Department of Sanitation (Earth Institute, 2001).

In 1996, Mayor Rudolph Giuliani and Governor George Pataki announced that Fresh Kills would receive its last ton of garbage no later than January 1, 2002, and the city developed a Fresh Kills Closure Task Force. The principal goal of the task force was to develop a short-term plan for diverting the waste from Fresh Kills up to its full closure in 2001. In order to divert the waste prior to closure, the city entered into a number of three-year interim contracts with private waste haulers. The city's annual bill for collecting and disposing residential trash jumped by nearly 50%, to about \$658 million in 2000 and then to nearly \$1 billion in 2001. While New York City was paying under \$50 per ton for disposal at Fresh Kills, some of the interim contracts were nearly double the price, costing more than \$100 per ton when increased transportation costs were taken into account (Earth Institute, 2001).

The next goal of the task force was to develop a longer-term solution to the waste issue. Under the long-term plan, approved by both the New York City Council and the New York State Department of Environmental Conservation, the city entered into six 20-year contracts with private waste companies. The contracts featured fixed cost increases and, according to the DSNY, no minimum tonnage requirements. Although the plan was ostensibly long-term, it was and is vulnerable to cost escalation and increased regulation from the states that host landfills. Furthermore, the plan doesn't include careful planning for waste transfer processes within the city.

In the summer of 2002, the city began to take some steps to develop elements of a true long-term plan for managing waste. While the overall waste export strategy was still being pursued, then-Mayor Michael Bloomberg announced a plan to develop garbage transfer stations that would compact refuse and ship it by barge for disposal. These stations would be placed in waterfront locations in each of the five New York City boroughs and would replace a system of land-based waste transfer that uses thousands of diesel-fueled trucks daily to haul garbage through city streets to disposal sites in other states. In late 2003, the projected expense of building these transfer stations grew, putting the plan on hold.

Relying on waste export systems leaves the city vulnerable over the long run, as both restrictions on waste disposal and its costs are likely to escalate. Future regulations on new landfills by federal and state environmental protection agencies could increase the cost of new landfills and limit future landfill

capacity. In addition, landfill operators will certainly raise prices over time, and state and municipal governments will likely enact taxes on waste disposal (Thompson, 2004).

Incorporating Sustainability

In 2006, the City Council approved a Comprehensive Solid Waste Management Plan (SWMP), which aimed to establish a cost-effective, reliable and environmentally sound system for managing the City's waste. The cornerstone of the City's recycling efforts is its curbside program, which collects paper, metal, glass and plastic. After the City experienced a number of changes in recycling policies that resulted in public confusion, this plan worked with City Council to set percentage targets for recycling, enhance public education on recycling practices, and establish a city office to provide outreach and education. The City initially aimed to achieve a 25% diversion rate by 2007 (DSNY, 2006). A diversion rate is the percentage of waste that is diverted from landfills to some form of waste treatment or reuse. The plan also aimed to reduce the City's dependence on a truck-based export system, to export in a manner that is cost-effective, environmentally responsible and sensitive to the local communities. It also aimed to simply export less waste. The plan listed a series of initiatives and goals within three areas: recycling, residential waste and commercial waste.

In 2011, solid waste management became incorporated into sustainability planning under PlaNYC, New York City's comprehensive sustainability plan. PlaNYC had a goal of reducing the high amount of greenhouse gasses generated by waste transportation and disposal in landfills. One of the goals under PlaNYC was to divert 75% of solid waste from landfills by 2030. New York City's Solid Waste Management Plan expects to reduce annual greenhouse gas emissions by 34,000 tons while diverting 2,000 tons of waste per day from land-based solid waste transfer stations in Brooklyn and Queens to marine transfer stations (City of New York, 2014). The City opened a Materials and Recovery Facility at the South Brooklyn Marine Terminal which sorts metal, glass and plastic. With the opening of this facility, the New York City Department of Sanitation expanded the curbside recycling program to include all rigid plastics – the first expansion of the program in 20 years.

The Sanitation Department also launched a voluntary residential organics recycling program in parts of Staten Island, Brooklyn and the Bronx, and expanded the school food waste composting pilot to 400 public schools in 2013. This is also part of a pilot anaerobic digestion program, in conjunction with the Newtown Creek wastewater treatment plant. The City added more public recycling bins, to a total of 2,190. It also regularly holds events for residents to safely dispose of textiles and clothing, electronics, and other household hazardous waste. In 2013, the City Council proposed the Commercial Organics Law. Once this law is enacted, it will require large-scale commercial generators of organic waste to have separate collection of their organic streams. They also passed a law to ban the sale of polystyrene foam products beginning July 2015, since this material cannot be recycled. This law was overturned by the courts and continues to be debated.

New York City is pursuing several different strategies to improve waste management, including increasing recycling capture rates; encouraging residents and businesses to divert organic material from landfills; and overcoming permitting obstacles related to waste-to-energy. The 2014 progress report for PlaNYC determined that the goal of reducing waste sent to landfills by 75% was gradually being reached, with 52% diverted in the previous year (City of New York, 2014).

In April 2015, Mayor Bill de Blasio announced the rebranding of PlaNYC to One NYC, a plan for a strong and just city that includes strategies for growth, sustainability, resiliency and equity. Under this plan, the city's goal is zero waste by 2030, such that no waste is sent to landfills. The goals include:

- Expanding the organics program to serve all New Yorkers by the end of 2018.
- Enhancing curbside recycling by offering a single-stream recycling by 2020.
- Reducing the use of plastic bags.
- Giving every New Yorkers the opportunity to recycle and reduce waste.
- Making all schools "Zero Waste Schools."
- Expanding opportunities to recycle textiles and electronic waste.
- Developing an equitable blueprint for a Save-As-You-Throw program to reduce waste.
- Reducing commercial waste disposal by 90% by 2030 (City of New York, 2015).

Other Challenges

Waste transfer in New York City is land-based, expensive and environmentally damaging, though well organized and operated successfully by the Department of Sanitation. The major unsolved management dilemma is the price of long-term disposal and the uncertainty about the availability of waste disposal facilities. Today, the city has contracts with out-of-state landfills and incinerators to accept the city's waste, but the price of disposal continues to rise and the supply of disposal sites is not guaranteed.

The preference for exporting waste is based on a desire to avoid the potential environmental insult of locally treating garbage and on the values that underlie the "Not in My Back Yard" syndrome (NIMBY). The consumption behaviors described show little sign of fundamental change from decade to decade. Though the growth in per capita waste disposal in New York City has begun to slow, mirroring national trends, New Yorkers clearly value the benefits of the throwaway society. The value system that supports this mode of consumption dominates and has kept waste reduction off the political agenda. This is a problem of many modern, developed economies. We will discuss this value system in more detail later, but next we will turn to the city of Hong Kong to look at how it manages waste.

Hong Kong

Like many other developed regions, Hong Kong has seen its waste levels grow as its economy has grown. Since the mid-1980s, Hong Kong's municipal solid waste load has increased by 85%, mirroring the city's rapid economic expansion and population growth over that same period (Blueprint, 2013). Today, Hong Kong is one of the most densely populated urban areas in the world, with an estimated 7.2 million residents and millions of additional visitors each year (Hong Kong Government, 2014). The city generates over 18,000 tons of municipal solid waste per day, around 6 million tons annually (EPD, 2011). The Environmental Protection Department (EPD) oversees all of Hong Kong's waste, and is responsible for facilities management, waste-reduction programming and policy implementation. Waste collection and removal is managed by the Food and Environmental Hygiene Department and by private contractors (Yau, 2010).

The rise in population and commercial activity has created new pressures on the city's landfills and waste management systems. In 2013, the average person in Hong Kong generated 1.33 kg of waste

daily, compared to 0.97 kg in 1991. This indicates that not only are more people throwing away waste, each person is discarding about 30% more. At present, landfills are the primary method of waste disposal in Hong Kong. The city's existing three landfills are expected to reach their design capacity by 2020, or earlier, if waste disposal levels continue to increase at the current rate (EPD Blueprint, 2013). While plans for extending the landfills are underway, Hong Kong's high-density population and lack of space limit the scope of extending landfill capacity.

History of Waste Management in Hong Kong

During most of the twentieth century, Hong Kong relied on a combination of landfills and urban incineration plants to dispose of its municipal solid waste. In the mid-1980s, health and environmental concerns led to the dismantling of solid waste incineration (Yau, 2010). The Environmental Protection Department was created in 1986 to coordinate pollution prevention and control activities in five strategic areas, including waste management. As it became evident that existing disposal sites were inadequate, the Environmental Protection Department published its first waste management policy, the Waste Disposal Plan (WDP), in 1989. The plan called for the development of an extensive network of waste transfer stations and three new, large, rurally located landfill sites to serve expanding disposal needs. At the time, the city operated 13 landfills; these were phased out or closed, then restored and converted for recreational use. The new landfills were established in three corners of Hong Kong – North East New Territories (NENT), South East New Territories (SENT), and West New Territories (WENT) – and began operation in the mid-1990s. It cost nearly HK\$6 billion (roughly \$775 million U.S.) to build these landfills, and the operating cost of all three is around HK\$400 million (roughly \$51.6 million U.S.) per year (EPD, 2014).

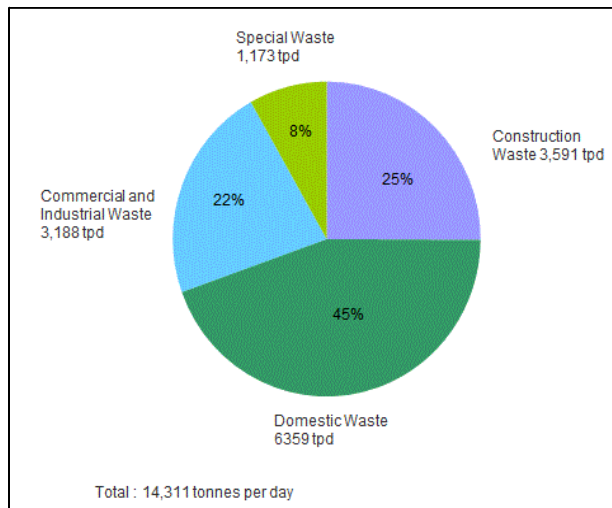
In 1998, Hong Kong published the Waste Reduction Framework Plan (WRFPP), which set out a series of waste reduction initiatives. At this time, around 70% of municipal solid waste was disposed of at landfills, and only around 30% was recovered for recycling (EPD, 2006). The Waste Reduction Plan shifted the emphasis from collection and disposal of waste at landfills to waste prevention and reuse of waste materials. Although there was some progress in the overall waste recovery rate into the early 2000s, Hong Kong's waste levels continued to rise, reaching just under 8 million tons in 2002 (EPD, 2013). In 2005, the Environmental Protection Department published a 10-year waste management strategy called "A Policy Framework for the Management of Municipal Solid Waste in Hong Kong (2005-2014)." In addition to setting out new recycling initiatives, the framework's proposed policy tools included the polluter-pays principle (PPP), through municipal solid waste charging, and various producer responsibility schemes (PRS) (Ross, 2008). In 2008, the Product Eco-responsibility Ordinance was enacted to provide a legal basis for introducing Producer Responsibility Schemes in Hong Kong. The first mandatory producer responsibility scheme was implemented shortly after, the Environmental Levy Scheme on Plastic Shopping Bags, to reduce the use of plastic shopping bags (Yau, 2010).

In 2013, the Environmental Bureau released the "Blueprint for Sustainable Use of Resources 2013-2022," which maps out a comprehensive strategy for waste management over 10 years. Promulgating a "Use Less, Waste Less" tagline, it announced Hong Kong's target to reduce the per capita disposal rate of municipal solid waste by 40% by 2022. To achieve this goal, the blueprint proposes policies and actions in three areas: (1) policies and legislation to drive behavioral changes to reduce waste at source, (2) targeted territory-wide waste reduction campaigns to arouse public awareness and encourage community participation, and (3) enhancement of waste-related infrastructure (Blueprint, 2013). For non-recyclable waste, the Environmental Protection Department is proposing to develop a number of waste treatment facilities, including an integrated waste management facility (IWMF) on an artificial site

near Shek Kwu Chau, a small island south of Lantau (Hong Kong Government, 2015). The key elements of the project comprise a 3,000 ton per day thermal waste-to-energy facility, a mechanical sorting and recycling plant and an environmental education center. The proposal for this facility was approved by the Finance Committee of the Legislative Council in January 2015, and the completion date for phase I will be around 2022-23. The facility will cost an estimated HK\$18 billion (roughly \$2.3 billion U.S.).

Today, waste management is a top priority for the Hong Kong government. Hong Kong’s three remaining landfills are projected to be full by 2020 or earlier, and solid waste loads are rising at a faster pace than the waste reduction efforts. “Even if we increase our recycling rate, there is no way we can deal with the thousands of tons of waste generated by our households, restaurants and construction sites,” stated the Environmental Protection Department in a recent report. Over half of Hong Kong’s solid waste is disposed of at landfills; the three sites accept 14,000 tons of solid waste per day (EPD, 2013). The current operational costs for waste collection, transfer, treatment and landfilling amount to HK\$1.4 billion per year (\$181 million U.S.). The waste is brought to the landfill sites by sea or truck without prior treatment and is directly dumped and covered up with soil. This includes municipal solid waste (domestic, commercial, and industrial waste), construction waste and special waste.

Figure 1. Types of Solid Waste Disposed at Landfills in 2014.



Domestic waste, which is generated from households and public areas, accounts for 45% of total waste disposed at landfills (see figure 1). It is collected by the Environmental Protection Department as a public service and transferred to landfills through a network of refuse transfer stations. Commercial and industrial waste, which are generated from businesses, restaurants, and industries, are collected by private waste collectors, with the exception of some industrial companies who deliver their waste directly to landfills for disposal (EPD, 2013).

Another major source of total waste going into landfills is construction waste. Generated from Hong Kong’s frequent construction and demolition activities, construction waste accounts for 25% of landfill waste. In 2006, the Hong Kong government implemented the Construction Waste Disposal Charging Scheme to provide financial incentives to construction and demolition waste generators to reduce waste and encourage reuse and recycling. It operates under the polluter pays principle, whereby construction waste producers pay appropriate charges for the disposal of their waste. The results have been positive. In 1999, the city sent an average 7,890 tons of construction waste to landfills every day. In 2013, it sent just 6% of its construction waste to landfills, or 3,300 tons per day (Yau, 2010).

Recycling

Waste recycling didn’t reach the top of the policy agenda until the handover of Hong Kong in 1997. Starting in June 1997, the Hong Kong government established a number of waste reduction task forces to pursue waste reduction initiatives in different sectors of the city. At that time, only 8% of total domestic waste disposed in the city was recycled or reused (Yau, 2010). The Environmental Protection Department set out a 10-year recycling implementation program in the 1998 Waste Reduction

Framework Plan (WRFP). To boost the waste-recycling rate, waste separation bins were provided on the ground floor or in designated common areas in public housing to collect waste paper, aluminum cans and plastic bottles (Waste Reduction Committee, 2000). Since provision of recycling facilities in private housing was voluntary, the government lured the developers to provide space for refuse storage and waste recovery in the original building designs by permitting such space to be non-accountable for gross floor area calculation under the Building (Planning) Regulations in 2000.

In 2005, the Environmental Protection Department launched the Program on Source Separation of Domestic Waste under the "Policy Framework for the Management of Municipal Solid Waste in Hong Kong (2005-2014)." The program encouraged private residential property management companies to provide waste separation facilities on each building floor, with the aim to make it more convenient for residents to separate waste at the source. As of 2013, more than 1,700 buildings had joined the program (Woo, 2013). The government also established the Community Recycling Network, which provides collection points for low-valued recyclables, as a way to promote public awareness about recycling and to encourage public participation in waste recovery.

Another recycling initiative is Hong Kong's EcoPark. In early 2001, the government announced it was reserving land for the development of a recycling park (later renamed "EcoPark") in Tuen Mun. The area would be provided at affordable prices for the local recycling industry to use over the long term. In addition, the area would be equipped with infrastructure and a designated pier for transporting materials, to ease the problems caused by over-reliance on exporting local recycling material (Woo, 2013). The EcoPark began operation in 2007, and now leases thirteen lots for the recycling of waste products. Two of these lots are waste recycling centers, which are managed by non-profit organizations for waste plastic and waste electrical and electronic equipment (WEEE) recycling.

Other than the government's initiatives, domestic waste recycling has also been promoted in the private sector. For example, property management companies have launched different reward schemes to motivate residents to recycle (Yau 2010). In 2012, a local organization named HK Recycles was founded as an enterprising recycling service to address the growing demand for recycling services. For as little as HK\$25 (\$3.22 U.S.) a week, HK Recycles provides households with a full recycling collection service. They guarantee that all waste material collected will be recycled. However, the organization only covers 1,000 households over six different districts across Hong Kong (Price, 2015).

Overall, these efforts have been relatively successful. Between 2001 and 2013, the domestic recycling rate grew from 10% to 48% (EPD, 2013). With the imminent threat of landfill closure, the government announced in 2013 that it was aiming to increase Hong Kong's recycling rate to 55% by 2015 (Blueprint, 2013). Hong Kong will likely face challenges in achieving this goal.

Food Waste

One of the largest sources of waste in Hong Kong is food waste. About 40% of the food in the city goes uneaten, creating around 3,500 tons of unwanted food each day, most of which is disposed of in landfills. The amount produced by the hospitality industry alone has doubled in the last 5 years (EPD Food, 2014). Reducing the amount of food waste in landfills has become a central focus of Hong Kong's waste reduction strategy, as disposing of food waste in landfills not only depletes limited landfill space, it creates odor, generates greenhouse gases, and wastes useful organic contents. In urban climates such as Hong Kong, emissions from decomposing food have a serious negative impact on air quality. In

addition to producing wastewater, as food decays in landfills, it releases significant quantities of methane and carbon dioxide (Feeding Hong Kong, 2014).

Currently, there is no ordinance controlling food waste management. There are, however, trial programs and campaigns. In 2009, the Environmental Protection Department launched the Food Waste Recycling Partnership Scheme with commercial and industrial sectors, in order to promote good food waste management practices. To further strengthen the promotion of food waste reduction, the government launched the Food Wise Hong Kong Campaign in 2013, a territory-wide food waste reduction campaign that aims to promote public awareness of food waste problems in Hong Kong (EPD Food, 2014). The EPD is also planning the construction of organic waste treatment facilities for the recycling of food waste, such that food waste will be used for compost and biogas products (EPD Fact Sheet, 2015).

Other Challenges

Hong Kong also faces challenges with public mistrust. While many improvements have been made with recycling, people question whether their efforts in waste separation are helping to increase waste recovery. There has also been significant pushback from the community around the Integrated Waste Management Facility, with opponents of the scheme suggesting it is “motivated by politics rather than logic” (Price, 2013). Furthermore, the landfill expansions have aroused public controversy among residents who worry that the extensions would harm the environment and the residents’ health, despite positive Environmental Impact Assessments (EIAs) on the projects.

Beijing

China’s rapid population growth, urbanization and industrialization have brought with it an enormous increase in the amount of solid waste generated. Beijing, the capital of China, is a huge metropolitan area with a population that reached 21.15 million in 2014 (The Global Times, 2014b). And like Hong Kong and many other large and rapidly growing cities in China, it continues to face waste management issues as waste generation exceeds capacity. Currently, the Beijing Municipal Administration Commission (BMAC) in cooperation with the Beijing Municipal Environmental Protection Bureau (BMEPB) oversees waste management. These agencies are responsible for environmental monitoring at waste disposal sites. The Beijing Municipal Environmental Bureau of Commerce (BMBC) oversees material recovery. In 2006, the Beijing Environment Sanitation Engineering Group Company was contracted to handle the collection and transportation of municipal solid waste; this company collects waste daily from the streets, and transports to transfer stations and disposal areas (Wang & Wang, 2013).

History of Waste Management in Beijing

Prior to 1979, when municipal solid waste (MSW) transportation and disposal was a function of the Ministry of Public Health, Beijing had no regulations regarding waste, and dumping was the norm. Waste was sent to rural outskirts and dumped without any restrictions, and often acted as ground fertilizer. However as the level of plastic, metal and glass increased in the makeup of waste, the waste residue became increasingly non-biodegradable. The quick solution was to build landfills. Beijing’s first landfill was built in 1994 – the Asuwei landfill – at the same time that the Ministry of City Construction took over waste management responsibilities. By the early 2000s, 90% of Beijing’s garbage was sent to landfills and by the end of 2001, a separate department – the Beijing Municipal Administration

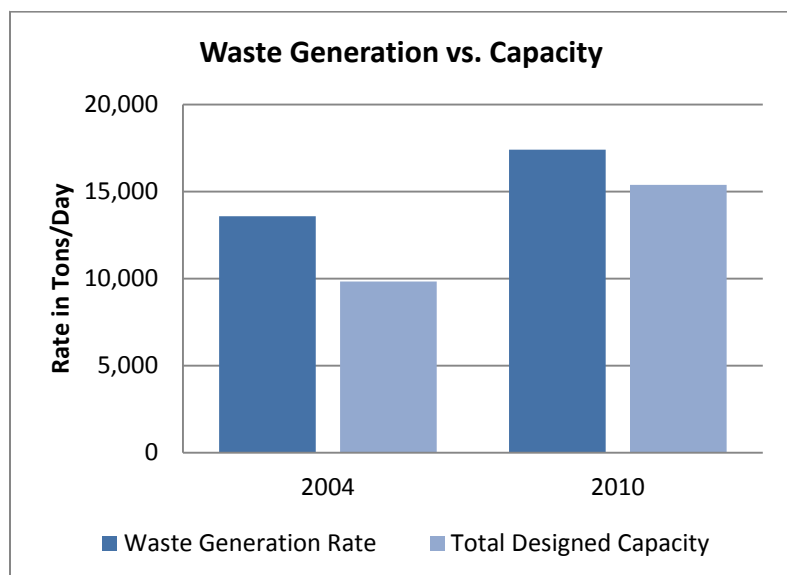
Commission (BMAC) took over waste management responsibilities (Global Times, 2014a). Landfills were considered a good option because of their cost-effectiveness compared to other options and could accommodate large fluctuations in the type of waste; landfills in China are usually supervised by environmental protection departments. However, the government began to see that the growing level of waste would not be supported by landfills, and since 2008 began to place a greater focus on reduction and resource conservation, incineration and to some extent composting as a substitute for sending waste to landfills.

Waste collection in major cities in China is generally carried out in two tiers: in primary collection, waste is transported from households to local collection points, and in secondary collection, waste is stored and then transported to points of treatment and disposal at landfills or incineration sites. However, waste collection services vary largely between Chinese cities, and even within different parts of the city. For example, in Beijing, waste collection services in modern, high-rise apartments function well, while collection systems in poorer suburban areas are much more rudimentary (Zhang et al., 2010). Residential waste is generally placed in garbage bins outside homes, and waste is picked up and transported by truck to a transfer station. Waste is generally collected in a mixed state (organics, inorganics and recyclables all mixed together), because separation of waste is not compulsory. This complicates collection since recyclable material and solid waste are often handled by different entities; the government handles solid waste, but recycled material has more value and is often collected and traded by individuals or private companies. Some residents volunteer to participate in a source-separated collection, or sell their recyclables to buyers who go door-to-door and in turn sell to distribution centers.

In 2006, Beijing spent about \$242.8 million (U.S.) on waste management, and collected and transported 149 million tons of waste, 92.4% of which was sent to landfills (Zhen-shan et al., 2009; Zhang et al., 2010). Transportation is the largest single cost in Beijing’s waste management system, because waste treatment sites are often constructed far from urban areas. One challenge is that it is hard to discern how many landfills exist currently in the city; some sources say there are 15 landfill sites and six full transfer stations in the city, (plus two incinerators and two composting plants) for a total capacity of 15,280 tons per day in 2010 (Wang & Wang, 2013). This doesn’t include any illegal landfill sites – of which there could be hundreds.

Regardless, data shows that waste generation rates exceed the capacity of disposal plants (see figure 2). More recent sources say that existing facilities can process around 21,000 tons every day, according to the Beijing Commission of City Administration and Environment (Jinran, 2015).

Figure 2. Waste generation versus waste capacity in Beijing, in tons per day.



Recycling

Since 1996, Beijing has attempted to practice separation at the source, and promised in the City’s bid for the Olympics to achieve a separation rate of 50% before 2008.

According to the Beijing Municipal Administration Commission, this was achieved by 2007, with 4.7 million people taking part in waste source separation. In 2006, Beijing recycled 1.638 million tons of material, saving \$1.43 million. Much of the recycling sector in Beijing is an informal system of “waste pickers.” By some estimates, there are 300,000 individuals in the city who manually pick up and recycle material, although they are concentrated in only a few areas of the city. These workers go door-to-door to collect plastic bottles, or arrive for collection when called. Many low-income citizens make their living collecting plastic bottles. These informal collectors may be responsible for removing as much as 30% of total waste in the city.

The government has attempted to increase efficiency in separation through targeted pilot programs in some areas, though these attempts have not resulted in large scale program implementation. A trial in 2013 that included 5 million Beijing residents equipped neighborhoods with sets of household trash bins. Over 20,000 volunteers were sent to the neighborhoods to teach and promote recycling practices, however residents often did not follow the regulations. Other recycling innovations have been introduced as well. For example, in 2012, the city introduced a “reverse vending machine” at a select number of subway stations where individuals can insert plastic bottles into a machine, and get subway credits in return. This is managed through a state-owned resources recovery company called Incom, which already processes 50,000 tons of bottles of year (most of which are bought from informal waste pickers) (Watts, 2012). However, the effectiveness of these types of programs – whether focused on outreach and education or on new programs – remains uncertain, especially as many are in their beginning stages and only in select areas in the city.

Incineration

Incineration is increasingly seen as an important solution to the solid waste overflow problem in Beijing and other large cities in China, especially in waste-to-energy plants. There are two fully-functioning incineration plants in Beijing (Wang & Wang, 2013). In 2013, the Lujiashan incineration facility was built in the Mentougou district, a suburb of Beijing. It is expected to process 3,000 tons of garbage each day and produce 360 million kilowatts of electricity each year. The facility cost RMB 2.1 billion to build (roughly \$330 million U.S.), which was funded by the Shougang Group, a large steel corporation, and the Beijing local government. The second incinerator is in Gaoantun, in the Chaoyang district, which can process 1,800 tons of garbage per day. The Beijing government is planning to build more incineration plants; sources say there are anywhere between 4 and 10 incinerators under construction (Global Times, 2014a).

One large technical issue with incineration is that the composition of waste in Beijing is often too wet to be burned. In order to effectively burn wet solid waste, the waste may be mixed with an even greater amount of coal, which leads to greenhouse gas emissions that are harmful to human health and the environment. Larger cities such as Beijing can afford more sophisticated incinerators that have the correct pollution controls – but smaller cities cannot. While there are legal limits on the amount of coal added, this is not effectively regulated, and at times the blend of coal and waste is as much as 70% coal (Ferris, 2012). Emission controls on waste-to-energy plants tend to be more lax than coal-fired power plants, and the fly ash that comes from incineration processes is highly toxic. So while Beijing and other cities in China are reportedly planning for the more incinerators, public opposition has been high, which has delayed many of these sites from being built. According to media reports, at least six new incineration plants postponed construction due to public opposition (Balkan, 2012).

Waste-to-energy in China is classified as renewable energy, so plants receive a feed-in tariff for every kilowatt hour of electricity they generate. However, these waste-to-energy plants often operate under regulations that are much more relaxed than coal-fired power plants. Legally, incinerators can emit nitrous oxide and sulphur dioxide at four to five times the level of power plants (Balkan, 2012). Air-pollution control systems are often too costly to maintain, and wastewater from these plants is not effectively regulated.

Other Challenges

One key obstacle to developing waste management plans is the lack of statistical data on waste generated in Beijing and many other Chinese cities (World Bank, 2014). This data is not collected or isn't made publicly available. Data are inconsistent and not verified; and there is an overall lack of data and research on landfills and incinerators and associated environmental impacts. The complicated and often informal recycling system also makes it difficult to know how much is actually being recycled and by whom. Cities often also face lack of adequate facilities for transport, sorting and recycling; lack of effective regulatory and policy instruments; and lack of public awareness and participation in waste separation activities.

Analysis and Comparison

Having detailed the waste practices in New York City, Hong Kong and Beijing, we will compare the practices in each locality. In consideration of each city's history and population, we will analyze waste as an issue values, politics, science/technology, public policy and management. The table in Appendix A shows a summary comparison of these three cities.

Waste as an Issue of Values

The generation of waste begins with the individual values that shape the consumption patterns responsible for creating tons of residential garbage each day. The types and quantities of waste that individuals generate are influenced by economic development, lifestyle and habitat. The use of large amounts of packaging material in distributing goods reflects a community's collective values. Exporting waste is based on a desire to avoid the potential environmental insult of treating garbage and on the values that underlie the "Not in My Back Yard" syndrome (NIMBY). In New York, this value system has kept waste reduction off the political agenda, but this is not unique to New York City; these consumption patterns currently prevail in all modern, developed economies. Citizens of Hong Kong and Beijing also value the benefits of a "throwaway" society.

There is also a subtle value choice reflected by the public and governing elite's avoidance of the waste issue. Perhaps part of the problem arises from the fact that garbage is physically unpleasant and reminds some of us of our relative wealth in the face of poverty. We discard food and clothing from which the world's poor could derive sustenance. Garbage is also ugly and smells bad. We prefer not to think about garbage or where it will end up. Coupled with this attitude is the historic tendency to keep garbage processing as far away from the middle and upper classes as possible (Bullard, 1992). This coupling of convenience-driven consumption with "waste avoidance" is the value underpinning the solid waste management crisis.

Waste as a Political Issue

The value issues described above have created a political climate that makes it difficult for local decision makers to address solid waste issues. At the core of the solid waste issue are local politics around the siting of waste disposal and treatment facilities. Garbage is inherently undesirable, and it is difficult to identify the benefit of serving as the host site for a community's waste. In some cases "side-payments" or community benefits are needed to assure siting. In New York City, a state park was built on top of a sewage treatment plant in order to gain local acceptance of the facility.

The political antipathy to waste in New York City was evidenced for over two decades by the local politics of waste in Staten Island; the highest priority for most of Staten Island's elected officials during the 1990s was closing Staten Island's Fresh Kills landfill. By the time Fresh Kills closed, all of New York City's residential waste was dumped there. With few exceptions, local politicians have caved to the long-standing aversion toward locating waste facilities in New York City. In the 1980s, with great conflict and enormous political courage, then-Mayor Ed Koch was able to obtain an agreement to site a waste incinerator in each borough. Mayor Koch's incinerator agreement collapsed during the subsequent Dinkins and Giuliani administrations, as each mayor decided that community opposition to siting was too intense to override. The politics of waste, particularly the community politics of siting, has been the principal constraint on policy options for managing the city's waste in New York City.

In Hong Kong, the issue of solid waste management has been low on the political agenda. Waste management concerns never appear as pressing to the wider public as issues such as healthcare and education. Furthermore, as in New York, Hong Kong also faces "NIMBY" when seeking to site waste management facilities. In the past decade, the government proposed the expansion of three strategic landfills as a solution to its growing waste problem. The proposed expansion generated opposition among residents and District Council members, who were worried that larger waste facilities would harm the environment and the residents' health, despite environmental impact assessments proving otherwise. Local residents have also pushed back the development of an incinerator at the Integrated Waste Management Facility (IWMF). Proponents of incineration claim that new technologies have made it cleaner, and that there is no other choice.

In Beijing, the government has placed increased emphasis on incineration as a solution to the growing waste problem, but officials are starting to face the same siting issues, despite a different political environment. Local opposition to the building of incineration plants has grown, and this public opposition has prevented new incineration plants from being built.

Waste as an Issue of Science and Technology

The high population density of any city cannot be possible without a number of technological innovations: an extensive network of mass transit, electricity, the water system, modern sewage removal and treatment, product packaging, food refrigeration, preservatives and, of course, solid waste removal. The technology of waste incineration has advanced dramatically since the 1960s. In New York City, regional or local waste-to-energy plants or other advanced waste treatment technologies, supplied by marine waste transfer stations or by rail transfer, are in all likelihood the most environmentally sound methods of disposing the waste generated by millions of residents and visitors. Similarly, in Hong Kong, building a waste-to-energy facility is seen as a necessary component to manage growing waste loads. The incinerator being built at the Integrated Waste Management Facility will use thermal treatment technology, which will reduce the waste volume into compounded ash. Beijing officials see waste-to-

energy as a solution as well – one that can reduce the volume of waste that would overload landfill space.

Despite the existence of appropriate and effective waste disposal technology, the politics of siting still dominates the issue as experts are not trusted, and the government sometimes lacks credibility with the public. Science has a “solution” to this problem, but politics makes utilizing new technology difficult. For example, an alternative to thermal treatment technology is plasma gasification. While current waste-to-energy technology converts trash into compounded ash, which then is shipped to landfills, plasma gasification converts organic matter into synthetic gas, electricity, and slag and removes toxic waste from the trash. However, it’s an expensive technology to utilize. Many of the newest waste facilities in Japan use this technology. If science could reduce waste plant emissions to zero, and if experts credible to the public and interest groups could confirm the improved technology, scientific fact *might* influence the political dialogue.

Another technical issue is the high proportion of organic waste, which in Beijing must be mixed with coal before being burned, contributing to further pollution problems. For this challenge, the government in Hong Kong is pursuing a technological solution, constructing a network of organic waste treatment facilities (OWTFs) to handle food waste. Food waste is the largest component in organic waste, and these treatment plants will adopt biological technologies, including composting and anaerobic digestion, to turn the waste into energy (Environment Bureau, 2014).

The technology of waste treatment is developing quickly, and it is possible that a proven, clean waste treatment technology might someday be developed that could overcome political opposition to facility siting.

Waste as a Public Policy Design Issue

Until recently in New York City, the use of inexpensive local landfills kept the price of waste disposal low, thus waste disposal did not pose a major fiscal dilemma. Now, however, as costs are rising rapidly, cost benefit calculations are starting to influence the policymaking process. While the cost of disposal has risen dramatically in recent years, alternatives to waste export have not reached New York’s political agenda. However, it is possible that if costs continue to increase, the waste issue could emerge as a public policy priority. If disposal costs, as well as community opposition to receiving New York City waste, continue to rise, waste disposal as a public policy issue may be redefined, thus providing legitimacy to the search for alternatives to waste export.

Another aspect of the solid waste dilemma as a policy issue is its regulatory dimension. Local, state and federal governments in the United States regulate waste disposal. Individuals and apartment building staff must package and sort garbage in specified ways. If it is packaged or sorted incorrectly, fines or non-collection may result. The visibility of the issue and the immediacy of enforcement make the regulatory dimensions of this issue relatively straightforward. Hong Kong’s government has tended to favor voluntary policies over mandatory ones. Some of Hong Kong’s residential buildings have separated waste and recycling bins on each floor, as part of the government’s source separation program, but oversight is left to building managers and participation is entirely voluntary.

Beijing has not forcefully regulated solid waste management. Effective public policy design is made difficult by inaccurate or unavailable data on waste. The definition of ‘municipal waste’ is not consistent between cities in China. Chinese governments tend to endorse incineration plants, and have been

testing different types of policies to incentivize the building of incineration facilities, including tax refunds, prioritized bank loans, subsidies, and feed-in tariffs for electricity sale onto the grid (The World Bank, 2014).

In Hong Kong, waste management public policy involves a complex arrangement of laws, capacity-building tools, economic incentives, and voluntary initiatives. The government uses the internationally-accepted multi-tiered waste management hierarchy to guide its policies. On top is prevention, followed by reuse, recycling, recovery, with disposal at the bottom. Recycling is a key element of public policy surrounding waste, and is the focal point of public education campaigns.

One partial solution to the problem of waste disposal is a policy that encourages waste reduction. One option for New York City, Hong Kong or Beijing might be the use of a fee-for-service system for waste disposal. In such a system, charges are levied for all waste pickups and rates for recycling are significantly lower than for mixed waste. However, while this type of policy design has proven effective in places dominated by single-family homes, many residents in these large cities live in apartment buildings, making it difficult to connect fees to individual behavior (Cornell Waste Management Institute, 2000). Furthermore in Beijing, the informal system of waste pickers might make this type of policy difficult to implement.

Waste as a Management Issue

Removing garbage from residential, institutional and commercial locations in New York City, Hong Kong and Beijing are major logistical and operational tasks. Private firms remove the waste from New York City's commercial establishments, but the city's residences, governments and non-profit organizations produce thousands tons of waste each day – waste that is removed by the City's Department of Sanitation, which must employ thousands of employees to do the work. In Hong Kong, waste removal is a complex system that involves government workers, their contractors, cleansing workers, and those employed by private waste collectors. There are around 400 active private waste collectors, with a portion also involved in waste recycling and reprocessing operations. In Beijing, there are similarly thousands of people who engage in sanitation work – many who are not employed or managed by the local government.

Most of the management tasks of garbage removal do not present major challenges to sanitation managers in New York City. However recycling and waste transfer/final disposal are two tasks that have presented challenges. Due to previous investments in specific types of collection trucks, the Department's collection vehicles must conduct separate trips for recycled paper, glass, plastic and mixed garbage. One of the major operational issues in managing recycling is predicting the rate of recycled goods per household. One of the reasons that recycling costs more than traditional waste disposal in New York City is that collection trucks often return to the garage more empty than full. Since a route costs almost the same to run with full or half-full loads, the collection cost per ton of recycled waste is quite high.

In Hong Kong, the waste management structure is well defined. The Environmental Protection Department (EPD) has three divisions that oversee facilities management, policy and programming, and recycling, and the Food and Environmental Hygiene Department is responsible for day-to-day street collection. Domestic waste is handled primarily by the government, although private waste collectors may be involved, while as in New York, commercial and industrial waste are managed exclusively by private waste collectors. The exact collection routes depend on the waste locations and the provision of

local waste collectors. Alternative routes are not uncommon. For instance, people living in rural areas may bring their domestic waste to nearby public refuse collection points directly without the involvement of private waste collectors.

Waste management in Beijing often involves complicated arrangements, with governing bodies that have overlapping responsibilities, and sometimes leaving gaps in responsibilities. The overall system has both formal and informal elements. The formal system includes employees paid by local government or businesses, who collect and transport waste, while the informal system is much larger in number and includes waste pickers, who make money by the sale of the materials they collect. Waste pickers often collect in unauthorized areas – such as at collection sites, where they disrupt operations, or at landfills, where they face health and safety hazards. Waste pickers then sell recyclable material to recycling factories. Landfills are often not well operated, with over 1,000 unregulated landfills across the city that release toxic pollutants into nearby water and soil; these landfills are difficult and costly to clean up, although officials in Beijing are beginning to try.

Conclusions

It would be difficult to find a more fundamental environmental issue than solid waste disposal. The current crisis of landfill capacity in New York City is less than a decade old – and this issue is even newer in large cities in China. About 70 incinerators are now being built throughout China, adding to the more than 180 that are in operation (The Economist, 2015). Nationally, the government had wanted 35% of urban household waste to be incinerated by the end of 2015, although that goal probably won't be met, largely due to the public opposition to the potential impact of these incineration facilities (The Economist, 2015). In 2014, the Ministry of Environmental Protection used a revised Standard for Pollution Control on the Municipal Solid Waste Incineration, requiring existing incinerators to comply by January 2016 and new incinerators to comply by July 2014 (The World Bank, 2014). However, it is not clear if these rules are being enforced. Tipping fees, which are charges on waste received at a waste processing facility, are often much lower in China compared to prices in the U.S. and Europe. Tipping fees paid by Chinese cities to incineration plants average \$8 per ton compared with \$70-\$100 in the United States (Balkan, 2012).

New York City's solid waste issue is primarily a political issue, not a technical one. Hong Kong's solid waste issue is primarily a political and management one. Beijing's solid waste issue is primarily a public policy and management one. The need to remove waste from households is a simple matter of public health, and all cities are learning how to reduce, collect and manage their wastes more efficiently and effectively.

Appendix A: Waste Management Comparison Chart

	New York City	Hong Kong	Beijing
Population	8.4 million	7.24 million	21.15 million
Area	790 km ²	1,104 km ²	16,800 km ²
Waste Generation Rate	More than 6 million tons per year (OneNYC)	6 million tons per year of solid waste (EPD)	4.13 million tons (in 2006, when the population was 13.33 million) (Zhen-Shan, 2009)
Spending on Waste Management (\$U.S.)	\$2.3 billion annually (2014)	\$1.4 billion annually (2013)	\$242.8 million (2006)
Government Agency Responsible for Waste Management	New York City Department of Sanitation (DSNY)	Environmental Protection Department (EPD); Food and Environmental Hygiene Department	Beijing Municipal Administration Commission (BMAC); Beijing Municipal Environmental Protection Bureau (BMEPB); Beijing Municipal Environmental Bureau of Commerce (BMBC)
Private Partners	The Business Integrity Commission	Not specified	The Beijing Environment Sanitation Engineering Group Company
Year First Landfill was Built	1947	1960	1994
Major Goals	Zero waste by 2030 (OneNYC)	Reduce the per capita disposal rate of municipal solid waste by 40% by 2022 (Blueprint for Sustainable Use of Resources)	Incinerate 30% of municipal solid waste by 2030 (China's Twelfth Five-Year Plan)

Appendix B: Discussion Questions

- What issues do all three cities face with respect to waste management and policy?
- What were the most effective policy options in each of the three cases?
- Is it beneficial to incorporate sustainability principles into waste management operations?
- What is the role of public-private partnerships in waste management?
- What is the role of the public and local communities in waste management?
- How can local government ensure public support for waste policies?
- Are polluter-pays principles viable options in New York City and/or Beijing?
- What can the Beijing government do to improve regulation of incineration plants?
- What recycling mechanisms and/or rules from New York or Hong Kong can be applied in Beijing?
- What are the challenges associated with waste-to-energy facilities? Are these viable options in any of these cities?
- What is the importance of setting measurable goals in waste planning and in collecting accurate data on waste collection, recycling and disposal?

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