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Title	The destiny of waste in Hong Kong: either dumping or combusting? Why not both?
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**The Destiny of Waste in Hong Kong:
Either Dumping or Combusting? Why Not Both?**

by

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2015

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1. Introduction

The waste problem in Hong Kong is being very tight and urgent. Hong Kong generates various kinds of solid waste. Majority of them are municipal solid waste come from residential and commercial building, as well as manufacturing industry, while other waste are come from construction solid waste and agricultural waste.

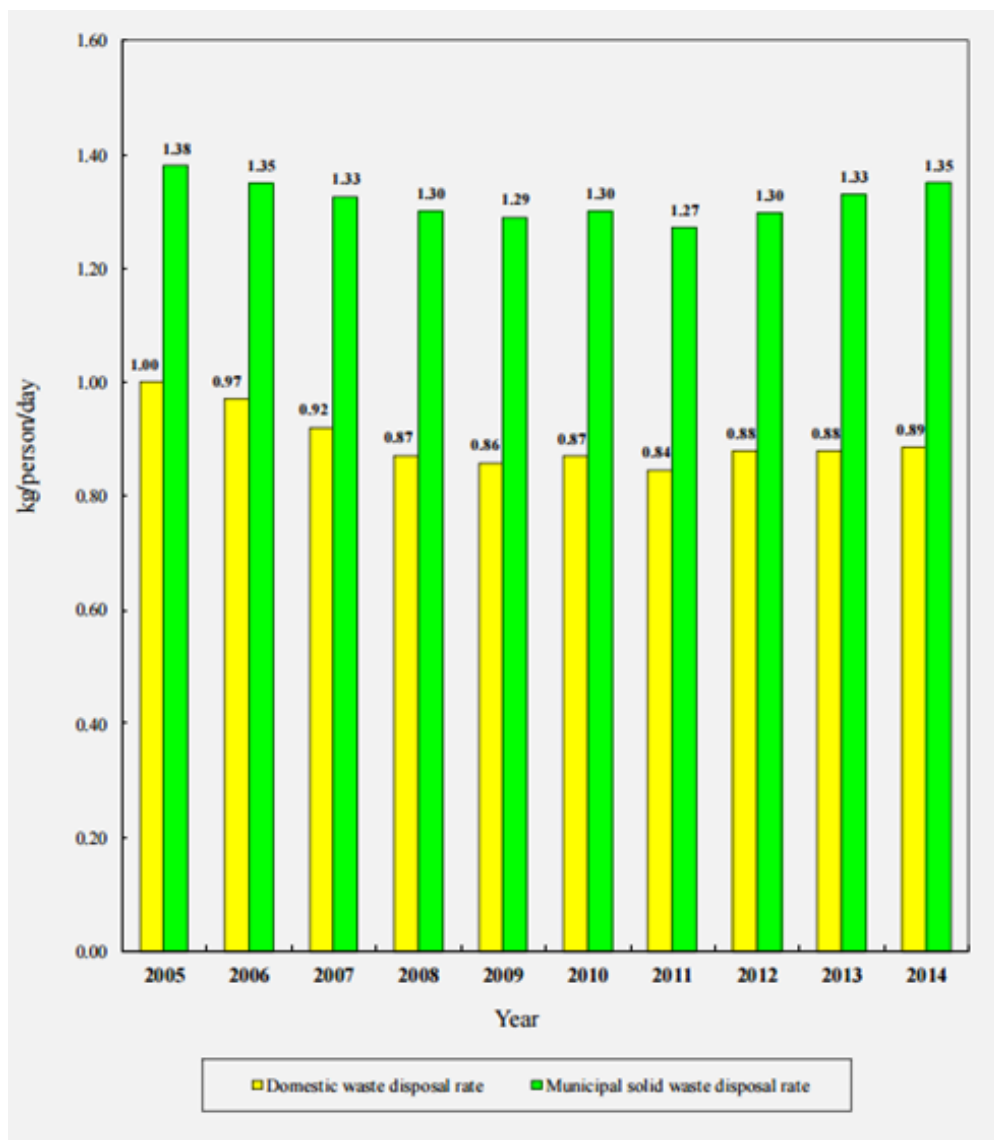
According to the official data, Hong Kong produces around 6,000,000 metric tons of municipal solid waste yearly, which is exceed the amount disposed in the three existing landfills. They are South East New Territories (SENT) Landfill, North East New Territories (NENT) Landfill, and West New Territories (WENT) Landfill. However, the prevailed consuming lifestyle in Hong Kong has aggravated the burden of these three landfills. Moreover, the growth rate of waste is higher than anticipated. If it keeps rising continuously, the existing three landfills will be full gradually in the mid-decade of 2010. Until the year of 2030, Hong Kong will need an extra 400 hectare landfill space in order to deal with the demand of wastes handling.

Facing the overcapacity problem of our three landfills, we are interested in knowing how Hong Kong government should restructure the current waste management system. In order to investigate any other possibilities to change the destiny of the waste in Hong Kong, this report is going to introduce the waste problem in Hong Kong, discuss the sustainability of using landfills and incinerator, and then suggest recommendations in the ways of reducing and dealing with the wastes.

1.1 Current Situation

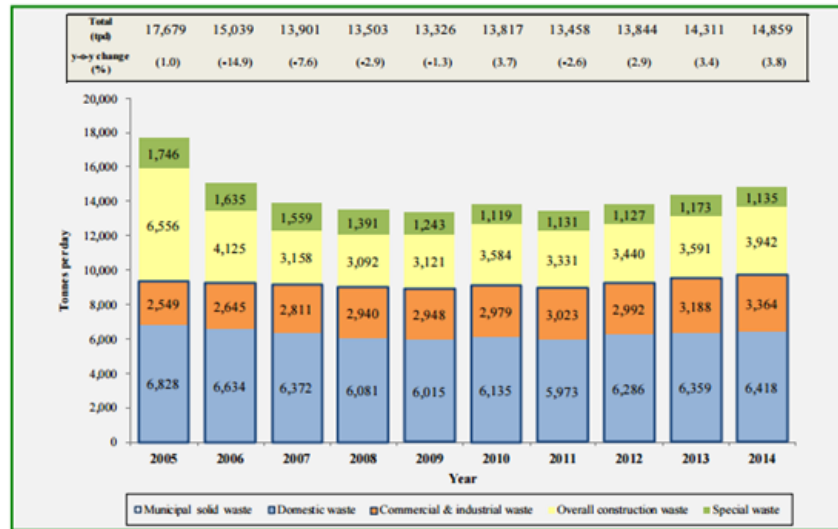
According to the figure 1.1, data indicates that the disposed solid waste at landfills has been increasing during the previous years. The rising disposal rate of municipal solid waste and domestic waste is observed. Starting at the year of 2009, the rate has been increasing steadily even though in small extent. But with the fixed capacity of landfills, rigid supply in addition to increasing demand, the fullness of the three existing landfills is reasonable and foreseeable.

Figure 1.1 Disposal rates of MSW and domestic waste (per capita) year 2005 – 2014



Source: Environmental Protection Department, HKSAR

Figure 1.2 Disposal of total solid waste at landfills from 2005 to 2014-By main waste category



Source: Environmental Protection Department, HKSAR

Figure 1.2 tells us that the disposed solid waste at landfills which tells us the result of increasing disposal rate of MSW and domestic rate - more solid waste is disposed at landfills, which is inevitable. The trend matches with the one of figure 1.1, the rate started to increase steadily from 2009 in small extent in addition to the fixed space supply of landfills.

Figure 1.3 Comparisons Per Capita Daily Generation and Disposal of Waste

	Daily Generation 每日產生量 (kg / person 公斤/人)	Daily Disposal 每日產生量 (kg / person 公斤/人)
Hong Kong 香港	2.44	1.27
Other cities (Due to different waste classifications, the following figures do not include all wastes as defined under Hong Kong's MSW)** 其他城市 (由於廢物分類方法不同，以下數字不包括全部香港都市固體廢物定義之下的廢物)**		
London 倫敦	1.22	0.85
Tokyo 東京	1.01	0.77
Taipei City 台北市	1.00	0.39
Seoul 首爾	0.95	0.32

Source: Environmental Protection Department, HKSAR

Moreover, as referred to figure 1.3, the generation and disposal rates of Hong Kong are comparably high. Our daily generation rate is the double of London's while the daily disposal rate is the highest among all the other observed cities. The above statistics has explicitly shown the warning of facing the increasing saturation rate of landfills in Hong Kong, and therefore solutions should be discussed.

2. Current Waste Management Structure in Hong Kong

From the Environment Bureau's statistic, the MSW that the city created is either recycled or go to the landfill directly (Environmental Protection Department, 2015). Computing from the data, in 2014, 63% of MSW are disposed to landfill, while only 37% are recycled. It means that among the 5,623,000 tonnes of MSW created, 3,534,490 tonnes ended up in one of the landfills.

Currently, there are three operating landfills, which are the West New Territories Landfill (WENT) at Tuen Mun, North East New Territories Landfill (NENT) at Ta Kwu Ling and the South East New Territories Landfill (SENT) at Tseung Kwan O, while 13 of landfills have already closed. Exhibit 3 summarized the detail of the three current operating landfills.

The three landfills are geographically distributed to deal with the development need of different regions and to optimize transportation efficiency. MSW are first collected and centralized at refuse transfer station, and then they are transferred to the corresponding landfill for disposal (Legislative Council Secretariat, 2014). Exhibit 4 shows the location of the three operating landfills and the route of waste disposal at different refuse transfer station (Environment Bureau, 2013).

Through centralized waste management, the government take the central role in handling all the waste that the city produced and maintain environmental hygiene by making sure that waste are handled in a timely and proper manner to support city development.

2.1 Challenges faced by the current waste management system

2.1.1 Growing Population And Waste

The population in Hong Kong had continued to grow from 1991 to 2014. The growing population implies that there is a larger number of consumers in Hong Kong. More consumption occurs, and hence more waste is produced. From the regression shown in exhibit 5, it shows that there is a significant relationship between the volume of MSW disposal and the population. The positive coefficient of the variable (Population) implies that the larger the population, the larger amount of MSW created. We may simplify the equation as: MSW disposed of (1000 tonnes) = 235.65 + 0.45*Population ('000), meaning that if the population increased by 1000, 420 more tonnes of MSW will be generated per year. Applying this simplified equation to the projected population from the Census and Statistics Department, where the projected population are 7,518,900, 7,755,800, and 7,941,500 in mid-2019, mid-2024, and mid-2029 respectively, we can project that the MSW disposed of will be increased to 3,619,155, 3,725,760 and 3,809,325 in year 2019, 2024 and 2029 respectively (the Census and Statistics Department, 2015). What made the situation worse is that the waste will keep on accumulating as it takes time for rubbish to decompose. The current rate of waste generated by Hong Kong citizen is way faster than the decomposition process.

2.1.2 Limited Land In Hong Kong

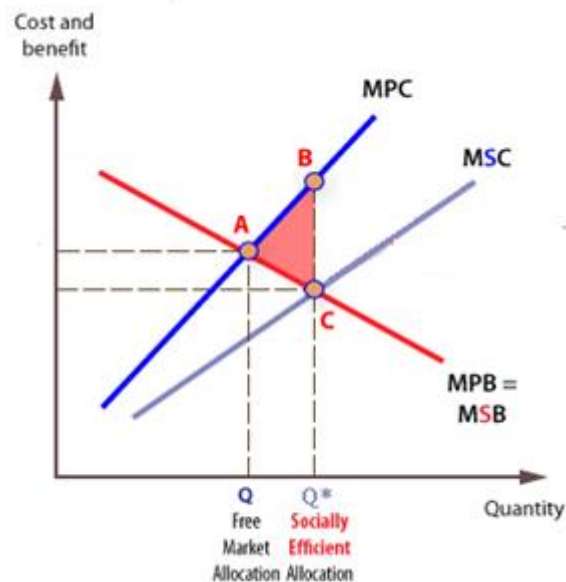
Government statistic estimated that all Hong Kong's landfills will be saturated by 2020. Among them, the SENT will be saturated in 2015. If the government continues its heavy reliance on landfill as the single mean of waste management, it is unavoidable for the government to expend current landfills or even identify new land for constructing a new landfill. However, Hong Kong is renowned for its high population density as well as its sky-high housing price. The supply of land in Hong Kong is very limited. Facing the continued growth in waste, there will be limited landfill space for Hong Kong.

2.1.3 Conflict Between City development and regional development

Waste management is crucial to every city. By allotting specific area for landfills, the Hong Kong government satisfies the need of the city and brings benefit to the whole

community as it address the waste problem of all citizens by providing continuous disposal service. However, to residents living close to the landfills, they incur a higher cost with the existence of the landfill, including bad air quality, odor and dust raised from the operation of landfill.

Figure 2.1 The supply and demand of waste management in Hong Kong



To the community, their demand for landfill is at Q^* , however, most residents are resistant to having waste facilities near their neighborhoods. Similarly, residents' living close to the landfill is also reluctant to expand the size of the landfill as their cost of having a landfill is higher than the rest of the city. As a result, when the government proposed to expand the current landfills, they usually face strong oppose from residents living nearby.

2.1.4 Cost Of Waste Management

There is a cost incurred in operating a landfill. It costed almost \$600 million to construct the existing landfills and \$400 million is incurred every year to operate the landfills. However, the cost of the current waste management system is much more than just the capital and operation cost. There is also cost incurred in transporting the waste from different refuse transfer station to the landfill. According to the chairman of the Waste Disposal Industry Association, After the Tseung Kwan O dumping ground reaches its capacity, waste will have to be redirected to the remaining landfills. Transportation cost will increase. 80 or more garbage truck will be required to

transport the waste across districts every day (Chan, 2013). It may increase cost and add burden to the current waste management system.

2.1.5 Environmental Hazard

During refuse decomposition, landfill gas and leachate are produced. The operating or even closed landfills can create potential hazards and health risks to its surrounding areas. The zoning for landfill doesn't reduce pollution to its socially efficient level but simply moves the pollutant away from residential areas to reduce the exposure to pollution.

What happen to the closed landfills?

Due to the potential hazards, the closed landfills cannot be used as residential area. It requires 30 years for aftercare after the completion of operation. For the purpose of utilizing the closed landfills, the government planned to hold the closed landfill into a green zone or other public recreational facilities. Golf driving ranges, recreational parks and ecological parks are the proposed entertaining facilities. (Legislative Council Secretariat, 2006). By collecting the landfill gas, it can also be used to generate electricity and energy to be used in the site (Environmental Protection Department, 2015).

2.2 Case study – Tseung Kwan O

To better illustrate how a landfill is operated in Hong Kong, we will have a closer look on one of the operating landfill – the SENT established at Tai Chik Sha, Tseung Kwan O.

Background

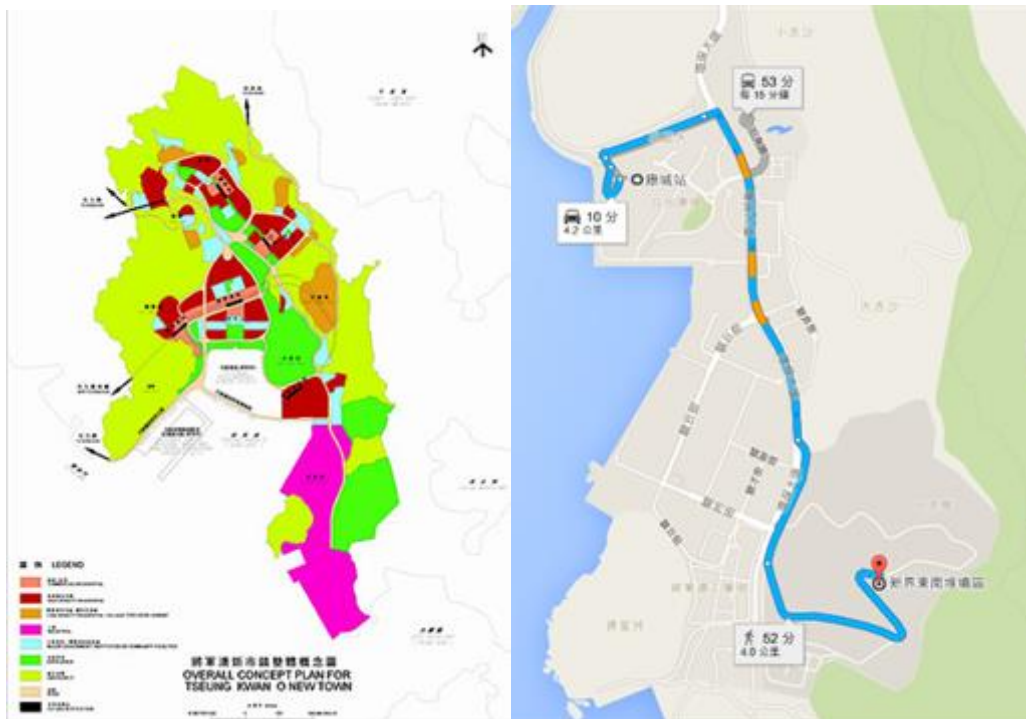
The SENT is one of the important landfill in Hong Kong. It started operating since Sep 1994 and it is expected to reach its capacity in 2015. To deal with the waste problem, the government has request for \$2 billion to fund for the extension of the SENT landfill. After great resistant from environmental group and nearby residents, the government finally gains approval of the fund for landfill extension at Tseung Kwan O in 2014 (Cheung, 2014). We will discuss how the current and proposed

extension of landfill affects the community from the Social, Economic and Environmental aspect.

- **Social Aspect**

Dealing with overriding demand for housing in Hong Kong, the government has develop Tseung Kwan O, located in the outer urban area, as the seventh new town, making it the closest residential area to landfill. As shown in the figure below, it is only a 10-minute drive from the nearest MTR station Lohas to the landfill. The LOHAS Park, the largest single residential estate in the territory is even closer to the landfill, only 800 meters away from it through the Wan Po Road. Placing the landfill so close to the resident causes several problems. First, the odious smell will blow through wind and invaded into households and the entire neighborhood. Secondly, as it is located right next to Wan Po Road, where the trucks pass by every day, it causes congestion, and brings odor problem and noise pollution to the neighborhood. Many residents was astonished knowing that the government has approved the land use to develop a large new town at Tseung Kwan O but at the same time planning for landfill expansion (Guo, 2010).

Figure 2.2 Distance between the SENT landfill and LOHAS Park



Source: Planning Department, 2003

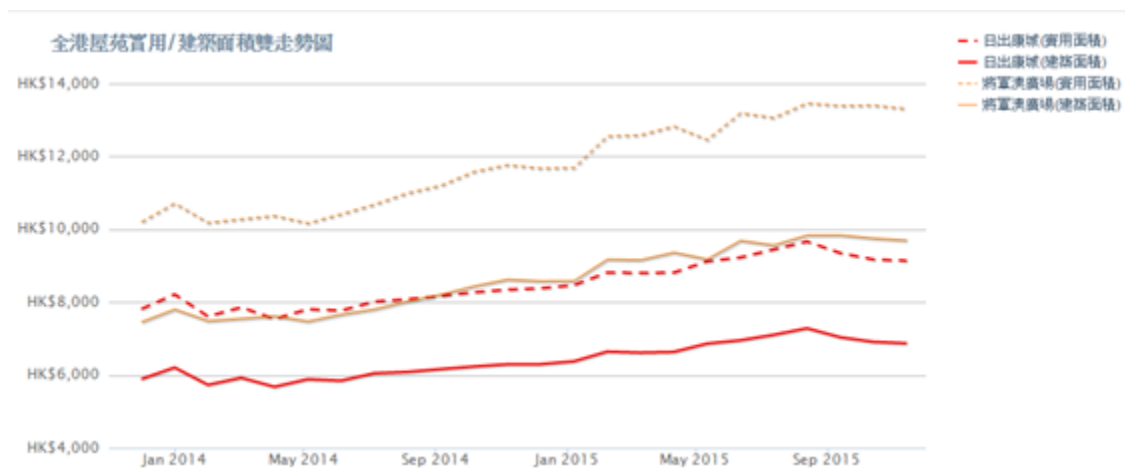
Source: Google map

● Economic Aspect

There are several impacts to the economic aspect. First of all, the original landfill cost \$2,200 million to build and \$216 million per year to operate. The estimated capital cost of the proposed extension will be \$1,993 million (Environment Bureau, 2014). As mentioned in the previous session there will be also other operating cost not directly related to the operation of the landfill, such as transportation cost of transferring rubbish to the site.

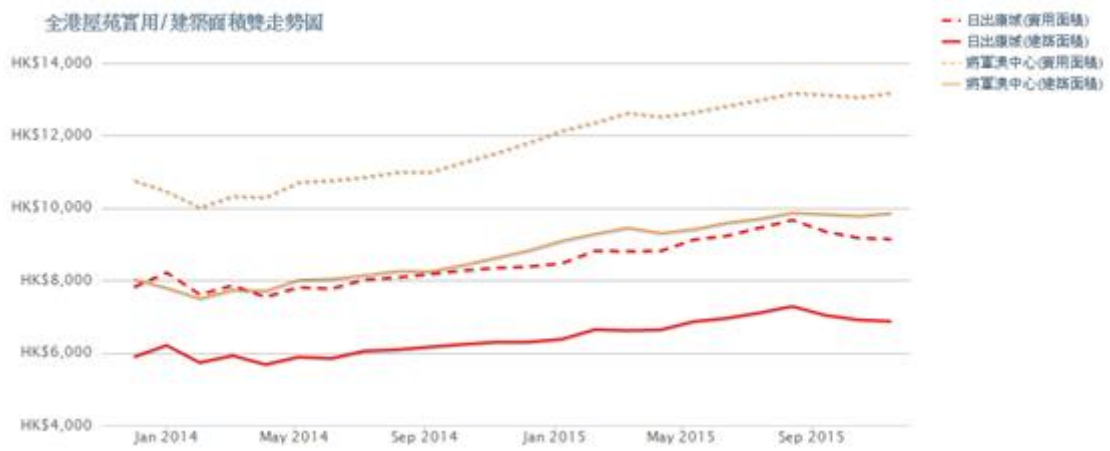
Secondly, there may be potential impact to the housing price of the resident nearby. From the data of Centaline Property, the selling price of LOHAS Park is substantially lower comparing to other residential estate in Tseung Kwan O, around 9 minutes' drive away from the Lohas Park. It costs \$13,179 per saleable area and \$13306 per saleable area to buy a flat in Park Central and Tseung Kwan O Plaza respectively, while it cost only \$9,139 per saleable area for a flat in Lohas Park. Although the price different can be affected by a wide range of factors such as distance and transportation cost to the CBD. However, being near the landfill is a possible cause of the lower housing price as most resident report that they are reluctant to live nearby the landfill.

Figure 2.3 Comparison between the housing price of Lohas Park and Park Central



Source: Centaline Property

Figure 2.4 Comparison between the housing price of Lohas Park and Tseung Kwan O Plaza



(Source: Centaline Property)

Figure 2.5 Distances between Lohas Park and Tseung Kwan O Plaza



Source: Google Map

Figure 2.6 Distances between Lohas Park and Tseung Kwan O Plaza

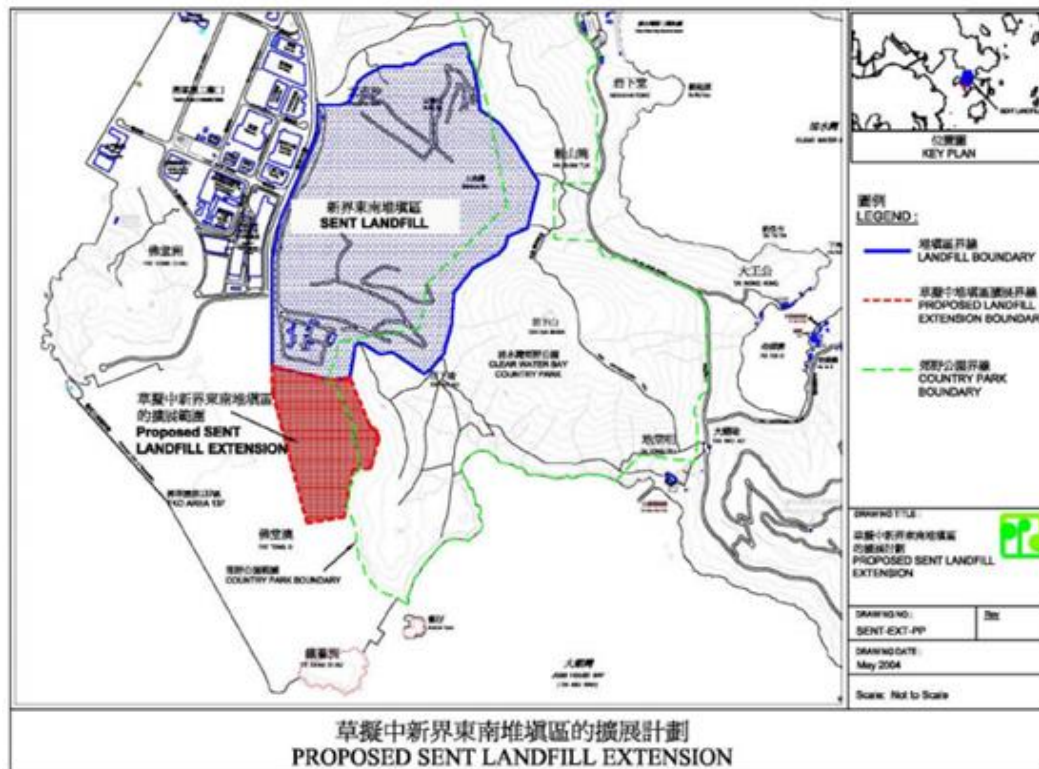


Source: Google Map

- **Environmental Aspect**

Apart from having air quality, noise and water quality impact to the neighborhood, the Landfill extension may also cause potential harm to the ecology. Seeing from the figure below, the Tseung Kwan O landfill is overlapping with the Clearwater Bay Country Park. The extension site include 3 hectare upon the edge of the country park. During the construction of the landfill extension project, trees need to be cut. It is estimated that there are about 10,470 trees within the extended area and 10,415 of them will be removed mainly by felling. The landfill may also interrupt the ecosystem in the country park and cause potential environmental problem (Environmental Protection Department, 2004).

Figure 2.7 The floor plan of the proposed SENT landfill extension



Measures by the government

To address the local concerns, the government has proposed the following plan to ease the problem caused by the landfill. However, it is doubtful whether that measure will be effective in dealing with the existing problem. There are still many challenges faced by the government in managing the SENT landfill as well as the overall waste management system in Hong Kong. The proposed measures are concluded in the table 2.1.

Table 2.1 Actions taken by the government to address local concerns

Social	<ul style="list-style-type: none"> - Restrict the SENT extension to accept waste from construction only - New monitoring team to monitor the site - Road cleansing and vehicle washing
Environmental	<ul style="list-style-type: none"> - Provide woodland planting - New air quality monitoring system

Source: Secretary for the Environment, 2013

3. Alternative Measure: Incinerator

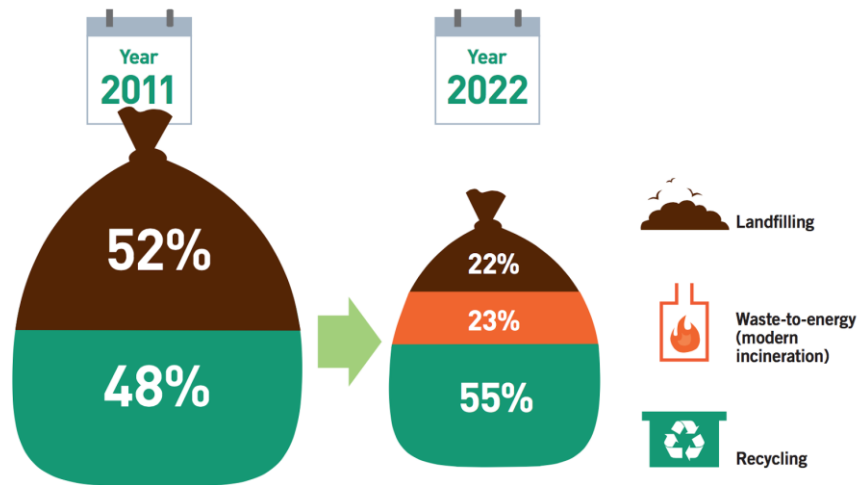
Background

There were once four incinerator plants in Hong Kong during 70s to 80s. They were established in Kennedy Town, Lai Chi Kwok, Mui Wo and Kwai Chung respectively. However, these old incinerators were designed in 60s to 70s, which lacked of proper technology to control the massive contamination and emission of harmful substances such as dioxins during the burning stage of the operation. (J.A.Wallace, 1974) Therefore, these incinerators have stopped operating and been demolished consecutively since 90s.

Facing the urge of landfills saturation, the government has again raised the issue of building an incinerator to cope with the increasing volume of municipal solid waste in Hong Kong. In early 2015, the fund appropriation of HKD\$19.2 billion for the construction of an integrated waste management facility (IWMF), an advanced municipal solid waste (MSW) incinerator on Shek Kwu Chau was accepted by the Finance Committee of the Legislative Council. The Tender Bidding will be held one year after. (Lo, 2015)

In addition, with accordance to the government 10 years plan on waste management (Environment Bureau, 2013), the government aims to adjust Hong Kong waste management structure by increasing the proportion of incineration from 0% in 2011 to 23% in 2022, with cutting half landfilling proportion to 22% and increasing recycling to 55% (Figure 1). This shows that Hong Kong government has made a clear stance and goal to develop and promote incineration to deal with the waste problem in Hong Kong.

Figure 3.1: Target waste structure of Hong Kong in 2022



Source: Environment Bureau, HKSAR

While the decision of constructing an incinerator in Hong Kong has raised controversies among stakeholders, which people concern are the social, economic and mostly the environmental impacts that are likely to be brought to the citizens and the whole city by the incinerator. (Chi-fai, 2014)

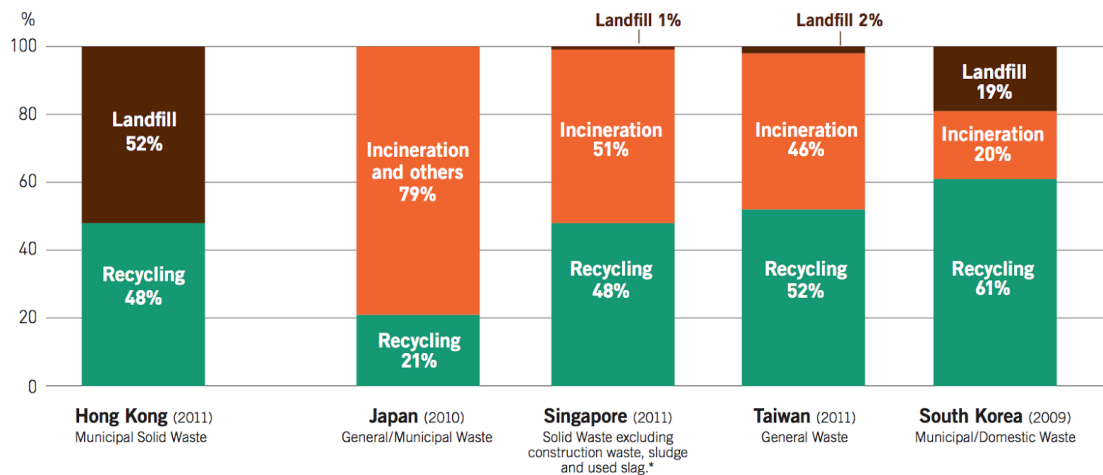
This part of the report therefore focuses on comparing the incineration development in Hong Kong with other cities, evaluating the functions and site selections of the integrated waste management facilities (IWMF) suggested by the Hong Kong government. Nevertheless, this part will analyze the social, economic and environmental impacts that the incinerator might bring forward, with reference to the examples in other countries. Hence, the following part is going to evaluate and estimate the cost-effectiveness of the incinerator.

3.1 Comparison of the incineration development with different cities

The development of incineration in Hong Kong in fact is lagging behind other urban cities in Asia Pacific, such as Japan, Singapore and Taiwan, etc. Figure 3.2 shows that about fifty-fifty of the municipal solid waste are treated by landfill and recycling respectively in Hong Kong, while approximately eighty percent of MSW in Japan handled by incineration and about 50% for Singapore and Taiwan. Comparing to Hong Kong, these three places also have a very small landfill proportion with 0%-2%. While for South Korea, though the incineration and landfill proportion is lower and

higher respectively with approximately 20% for both, the recycling rate is the highest among the 5 places including Hong Kong with over 60%. (Environment Bureau, 2013) This implies that incineration has been widely used in other places while Hong Kong is just ready to start.

Figure 3.2: Comparison of waste management proportion of different countries



* Note: The published Total Solid Waste Recycling rate is 59%. After excluding construction waste, sludge and used slag, the solid waste recycling rate is 48%.

Source: Environment Bureau, HKSAR

3.2 Case Study- The Proposed Integrated Waste Management Facilities

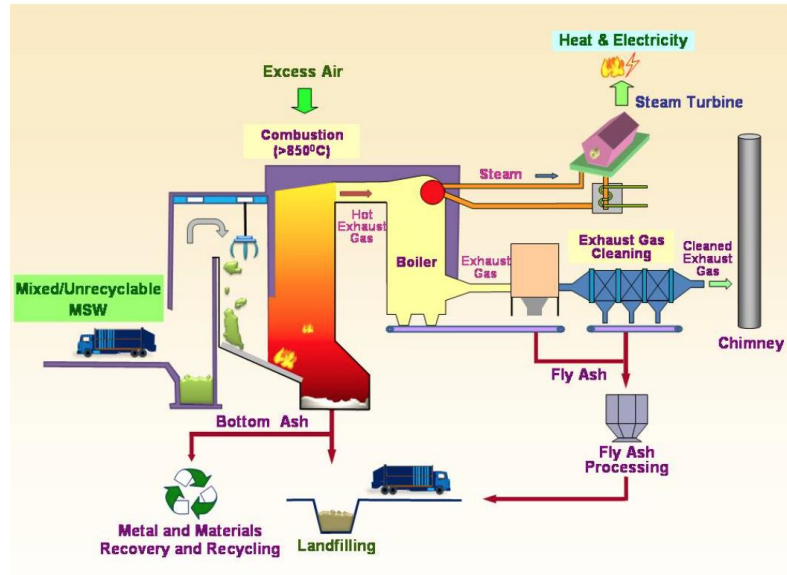
Functions of the Integrated Waste Management Facilities (IWMF)

The IWMF proposed by the Hong Kong government comprises an advanced incinerator plant, mechanical treatment & recycling facilities and ancillary & supporting facilities. The first phase of facilities is expected to operate 24 hours every day to handle 3,000 tonnes MSW per day, which can decrease the capacity of solid waste by 90%. In addition, the organic matters and dioxins will be decomposed at 850°C with 2 second residence time during combustion, which can effectively improve the pollution of harmful substances emission than the four old incinerators. (Legislative Council Secretariat, 2014)

The main feature of IWMF is to turn waste to energy (thermal energy from combustion), which is expected to generate energy for about 480 million kW to cope with energy consumption of the facilities themselves and 100 million households. (Legislative Council Secretariat, 2014) While it is worth noting that incineration is only an intermediate processing stage (see figure 3.3), which the ashes and wastes

generated after combustion still have to be sent to landfills. (Environmental Protection Department, 2015)

Figure 3.3: Typical Incineration Flow Chart



Source: Environmental Protection Department, HKSAR

Site Selection of the IWMF

The IWMF is confirmed to be built at Shek Kwu Chau. It is an island located in the southern part of Lantau Island and accessible by less than 20 minutes ferry from Cheung Chau. (Wikipedia) The government plans to make an artificial island in Shek Kwu Chau with 16 hectares land reclamation for the construction of IWMF.

Figure 3.4: Shek Kwu Chau site for IWMF



While before the site of IWMF has been confirmed to be built on Shek Kwu Chau, Tsang Tsui Ash Lagoons sites in Tuen Mun was also one of the possible location for IWMF (see Figure 3.5).

Figure 3.5: Proposed location of IWMF in Tsang Tsui Ash Lagoons sites in Tuen Mun



Why choosing Shek Kwu Chau but not Tsang Tsui Ash Lagoons sites in Tuen Mun?

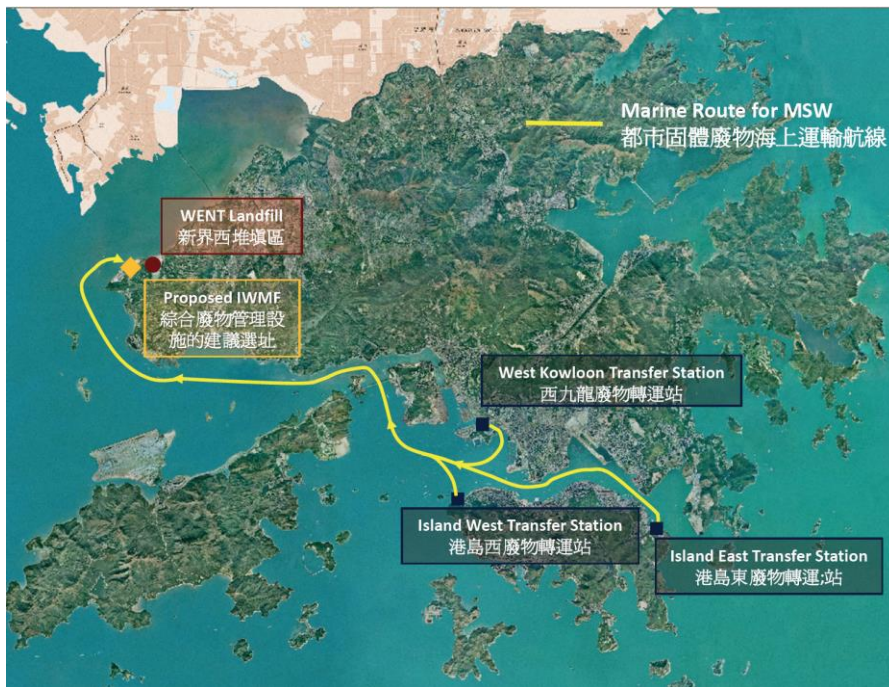
Figure 3.6: Possible sites for IWMF - Tsang Tsui Ash Lagoons VS Shek Kwu Chau



The proposed IWMF with a MSW incinerator is a public service facility, which the site selection must be balanced both economic and environmental issues. (The World Bank, 1999) With accordance to the environmental assessment commenced by the government, a detailed assessment has been done to evaluate the suitability for the two possible IWMF sites in the following to conclude some key pros and cons for choosing Shek Kwu Chau but not Tsang Tsui Ash Lagoon sites in Tuen Mun as the final location of IWMF. (Environmental Protection Department, 2011)

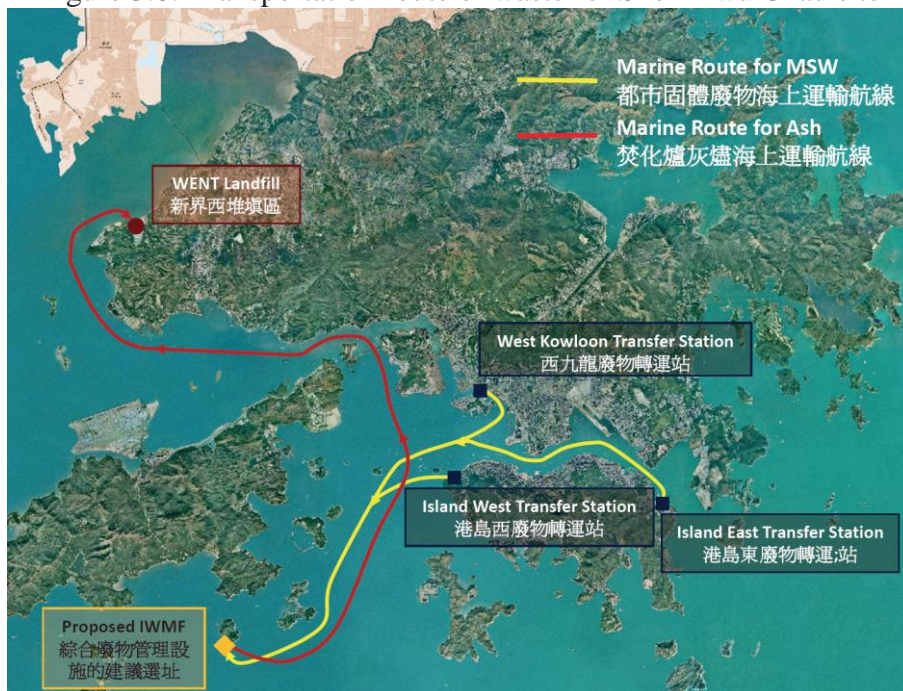
Pros for selecting Shek Kwu Chau	
Reduction of transportation	The total shipping distance for transporting wastes from the three waste treatment centers in Chai Wan, Kennedy Town and Stonecutter Island to Shek Kwu Chau is 66km shorter than that to Tuen Mun, reducing 27% of total shipping distance. (See Figures 3.7 & 3.8)
Less impacts to citizens	The population density around Shek Kwu Chau is lesser. Moreover, the wind direction in Hong Kong is usually from Northeast to Southwest, while it is sea in the Southwest of Shek Kwu Chau, which might make lesser impacts to the citizens.
Less accumulated impacts	Tsang Tsui has already accumulated higher air pollution, as there are a number of emission sources within the 5km, including the Sludge Treatment Facilities, Black Point Power Station, WENT Landfills, etc. (See Figure 3.5) While there is no pollution source within 10km of Shek Kwu Chau, which could alleviate the pollution burden in Tuen Mun.
Encouraging employment and tourism	1,000 additional employments will be created during the construction of the IWMP and 200 during the operation. As there are ships running between Cheung Chau and Shek Kwu Chau, approximately 450 visitors are expected which might encourage economic activities in Lantau Island.
Less influences to Ma Wan	If choosing Tuen Mun as the location of IWMP, there will be three ships every day for transportation from Ma Wan to Tsang Tsui. While for Shek Kwu Chau, there will be only one ship passed from Ma Wan even though the ash generated from the incineration has to be transported to Tuen Mun Landfill. (See Figure 3.7 & 3.8)

Figure 3.7: Transportation route of waste for Tsang Tsui Lagoons site



Source: (Environmental Protection Department)

Figure 3.8: Transportation route of waste for Shek Kwu Chau site



Source: (Environmental Protection Department)

Cons for selecting Shek Kwu Chau	
More expensive	When choosing Shek Kwu Chau, land reclamation for 16 hectares creates additional costs for about few hundred millions which are more expensive than constructing in Tuen Mun.
Increase in cost and environmental impacts for building submarine cables	The energy generated by the combustion of wastes can be transferred through the surrounding power stations and power cables in Tsang Tsui. However, submarine cables have to be built from Shek Kwu Chau to Cheung Sha (Power network in South Lantau), which creates additional costs and time for construction.
Impacts to ecology	With 16 hectares land reclamation, 31 hectares of the ecological environment of the Finless Porpoise will be destroyed permanently. Moreover, the construction and land reclamation also poses threats to the coastal coral and the White-bellied Sea Eagles.
2-year extension for land reclamation	Due to the land reclamation, there will be estimated 2 years longer construction for Shek Kwu Chau site than the Tsang Tsui Lagoons sites in Tuen Mun.

Though the cost and environmental influences are lower for constructing IWMF at Tsang Tsui Lagoons sites in Tuen Mun, considering the higher impacts possibly made to residences in Tuen Mun, the government has determined the decision for selecting Shek Kwu Chau as the finalized IWMF site.

3.3 *Social, economic and environmental impacts of incinerators*

● **Environmental Impacts**

Pollutants Emission

The major negative environmental impact of an incinerator is the emission of harmful substances like dioxin during the combustion of MSW especially when plastics are

burnt. Some studies show that high level of dioxins and heavy metals found in the soil and vegetation in the vicinity of incinerators. (Allsopp, Costner, & Johnston, 2001) However, these studies and research were done in the 90s, that the incinerators using that time are obsolescent now. The advanced incineration facilities widely used among countries are now proven to be more environmental friendly with less greenhouse gas and dioxins emission.

From the study done in 2013 shows that, when comparing the emission of greenhouse gas from landfill and advanced incinerator, the performance of the advanced incineration facility is better with only 19.9kg/tonne of MSW comparing to 111.6kg/tonne of MSW for emitted by landfill (See Table 3.1). The net emission of greenhouse gas of advanced incinerator is 1/6 of that of landfill. (Woon & Lo, 2013)

Table 3.1: Comparison of greenhouse gas emission between landfill and advanced incinerator

Items	Landfill (kg/tonne)	Advanced incinerator (kg/tonne)
Waste Transportation	1.1	1.3
Greenhouse gas emission (Including CO ₂ , Biogas, etc.)	504.3	453.8
CO ₂ emission compensated by power generations (Biogas energy/thermal energy)	-72.4	-435.1
CO ₂ emission of landfill wastes (regardless processed or not)	-321.5	NIL
Net emission	111.6	19.9

Source: (Woon & Lo, 2013)

Apart from greenhouse gas emission, dioxin emission is also found to be low when referring to the case of Japan (See Table 3.2). (Clean Authority of Tokyo 23 cities, 2014)

Table 3.2: Levels of dioxins in exhaust emissions (Japan: Tokyo)

Levels of dioxins in exhaust emissions (FY2013 average value) (ng-TEQ/m³/N)

Facility name	Average level	Facility name	Average level	Facility name	Average level	Facility name	Average level
Hikarigaoka	0.0000025	Sumida	0.0000073	Chuo	0.0000060	Setagaya	0.0000027
Ota	0.000068	Kita	0.0000027	Itabashi	0.0000037	Chubo Ash-Melting Plant	0.000013
Meguro	0.0000085	Shin-koto	0.0000028	Tamagawa	0.0000037	Chubo Pulverization Plant	0.000011
Ariake	0.000013	Minato	0.0000065	Adachi	0.0000054	Nerima · Sugunami	(Construction underway)
Chitose	0.0000020	Toshima	0.0000041	Shinagawa	0.0000080		
Edogawa	0.0000025	Shibuya	0.0000031	Katsushika	0.0000020		

※ The allowed level of dioxins in exhaust emissions is as follows:

For existing facilities	1 ng-TEQ/m ³ /N	For new facilities	0.1 ng-TEQ/m ³ /N
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※ Standard for new facilities: Applies to the Shibuya, Chuo, Itabashi, Tamagawa, Adachi, Shinagawa, Katsushika and Setagaya incineration plants and the Chubo Ash-Melting Plant, all of which went on line after December 2, 1997.

Source: (Clean Authority of Tokyo 23 cities, 2014)

Table 3.2 shows that the average level of dioxins emission among the 21 incineration facilities in Tokyo is about 1 ng-TEQ/m³N and the new facilities will further decrease the level to 0.1 ng-TEQ/m³N. It can be deduced that the pollutants emission level of the IWMF in Shek Kwu Chau will be closed to the above results or even better due to the new technology being used.

Though it can be deduced that both the greenhouse emission and dioxin are lowered with using the advanced incineration facility, the level of harmful substance emission is not zero. In other words, the construction and operation of incinerator still bring impacts to the environment considering the non-zero pollutants emission. More intensive studies and investigation are believed to be done in the future with respect to the operation of Shek Kwu Chau's IWMF started.

● Social Impact

Health Impacts

In the fact that incinerators could deliver different kinds of toxins into the atmosphere after burning the waste, there will be a wide range of health impacts that will probably be brought to the population residing near to the incinerators.

The research paper, which published by the WHO European Centre for Environment and Health in 2014, indicates that hundreds of emitted toxins like dioxins can hurt our immune system. They can be persistently and toxically stored in the entire food chain. (Pollution and health impacts of waste incinerators) The dioxins, as the most toxic

chemical, have been proven to cause cancer on human body as they will store in human fatty organs and tissues over time. These toxic chemicals are also dangerous to the unborn child, in which the toxic substances can be transmitted directly to the fetus through the mother's placenta.

Nevertheless, the heavy metals generated by the incinerator can be stored in human body persistently as well. Our young generation will be affected possibly through different childhood problems like allergies and learning difficulties. Besides, exposed adults will have a relatively higher level of depression and violence as well. (Incinerators and their Health Effects, 2006)

Objection By The Local Residents

Residents from Shek Kwu Chau opposed the implication of incinerator since they have concerns on their health. They criticized the Environmental Protection Department as well as the Town Planning Board for the approval of setting up the incineration at Shek Kwu Chau even with its EIA report was still being questioned. Besides, the residents are also unsatisfied with the failure to fulfill the commitment in stopping the plan by the district board members.

● Economic Impact

Tourism

Indeed, the presence of incinerators will particularly reduce the inflow of tourists in Cheung Chau and southern island respectively, regardless of the tourists from Hong Kong citizens or from foreign visitors. People visit Cheung Chau or southern island because they want to enjoy the beautiful scenery and breathe the fresh air instead of staying at the "concrete jungle" during holiday. Besides, these two tourism plots provide "free" and "natural" entertainments to the visitors such as hiking, swimming, bathing under the sunshine, as well as enjoying the scenery. Shek Kwu Chau, where is located near Cheung Chau and the southern island is a vital island for these tourists. (Plan for Incinerator Island by Shek Kwu Chau environmentally unacceptable, 2011) Yet, the construction of the incinerators causes noise pollution. Besides, there will be serious pollution brought by the incinerator when it comes to the operation. Therefore, the tourism in Cheung Chau or southern part will be hinder.

Income Of The Local Residents

In addition, the former Chairperson of the Hong Kong Fishermen's Association has raised up that Cheung Chau is one of the four major fishing ports in Hong Kong, There is rich of fishery resources along Shek Kwu Chau. However, the reclamation of building an incinerator is not only diffusing the silt of the seabed as well as reducing the resources, but also expanding the restricted area over the sea. And thus, this will greatly affect the fishermen as their income will be lower. (World Green Organization)

3.4 Cost Effectiveness of incinerators

Renewable Energy

Incinerators are prior to generate electricity as renewable energy with less emission of greenhouse gases, compared to traditional power plant. The U.S. Environmental Protection Agency conducted a research, showing that the combustion inside the incinerators functions to create electricity after melting the bio-wastes and other solids.

The behind rationale is that the heat generated by melting waste will create a large amount of steam, which moves the turbines producing energy. This "Waste-Turning to-Energy" process can be improved in the future with several advancements. Plasma gasification is one of the innovations that can turn waste to gas by melting it through extremely high heats. (Pros & Cons of Incinerators).

The most important thing is that, incinerator can effectively reduce the size of solid waste to about ten percent of the original. Therefore, waste incineration is the most useful manner to decrease the size of waste, when compared with the traditional landfill disposal. In this sense, incinerating waste can also lower the volume that accumulated in landfills for the purpose of relieving the landfill saturation. (Incineration of Wastes, 2012)

Though the government needs to spend a high cost in constructing and operating the incinerator, it can have revenue from the incineration plants in the future. The sale of energy is economic for the waste incineration.

The sale of energy can generate an income return of almost eighty to ninety percent of the total costs, representing a cost effective advantage. In the presence of sale, the income return in Europe and North America is averagely forty percent, with waste containing a small calorific value in between 9 and 13 MJ/kg. (World Bank, 1999)

Table 2: Energy Yield and Income from Energy

<i>Heat value</i> \bar{H}_{inf} MJ/kg	<i>CHP</i>			<i>Heat Only</i>		<i>Power Only</i>	
	<i>Power</i> MWh/t	<i>Heat</i> MWh/t	<i>Income</i> US\$/t	<i>Heat</i> MWh/t	<i>Income</i> US\$/t	<i>Power</i> MWh/t	<i>Income</i> US\$/t
6	0.33	1.08	28	1.33	20	0.58	20
7	0.39	1.26	33	1.56	23	0.68	24
8	0.44	1.44	37	1.78	27	0.78	27
9	0.50	1.63	42	2.00	30	0.88	31
10	0.56	1.81	47	2.22	33	0.97	34

Note: CHP 76 percent of yield as heat.

Source: World Bank, 1999

Table 2 shows the energy yield per metric ton of waste burnt in term of heat production, electricity production, and combined heat and power production. Meanwhile, the potential income from sale of energy shown from the graph is indicated as a heat price of US\$15/MWh and a power fee of US\$35/MWh.

4. Recommendation

Currently, the Waste Management in Hong Kong relies 63% in landfilling and the remaining 37% for recycling. The three existing landfills are estimated to be saturated by 2020. Growing population and waste, limited land resources, conflict of land use, cost of waste management, and possible environmental hazard are the challenges faced by the current waste management system. The case study in Tseung Kwan O landfill indicates that operating a landfill cannot be easily for striking a balance between the social, economic, and environmental prospective, in order to achieve the sustainable development.

In order to find any alternatives of current waste management, we have discussed the possibility of incinerator in Hong Kong. The incineration development in Hong Kong is actually lagging behind with other international cities. Even with the possible social, economic and environmental impacts the incinerators brought, the cost-effective of the incinerator would bring much more incentives and advantages to operate an integrated waste management facility in Hong Kong. The case study in IWMF evaluates that the proposed site in Shek Kwu Chau is suitable choice in balancing the social, economic, and environmental impact.

Together with the development of incinerators, there are many other possible approaches to improve the current waste management, thus, for an objective of the policy framework and a better future prospective, a list of policy tools and support measures derived from the waste management hierarchy are recommended in below part.

4.1 Principle of waste management

An integrated solution is needed to solve the Waste Management (MSW) sustainably, but not the only technical end-of-pipe approaches. The waste management hierarchy is one of the famous principle of MSW, which has been guided the policy holders on how to manage MSW since 1975. (United Nations Environmental Program, 2013)

According to figure 4.1, we recommend the government should implement a three-tiered strategy in the waste hierarchy, which are in downward order of preference:

1. Avoidance and minimization;
2. Reuse, recovery and recycling; and
3. Bulk reduction and disposal

Figure 4.1 Waste Management Hierarchies



The three-tiered approach can maintain MSW effectively and sustainably.

The first preference is called avoidance and minimization. Its aims are not only to solve the issue at source, but also to urge individuals to produce less waste as much as could reasonably be expected. In the case that it is not practical to prevent from creating waste, the waste produced ought to be minimized as much as possible.

The second preference is to maximize the reuse, recovery and recycling of suitable recyclable materials. For the purpose of making the work proficiently, robust grouping, collection and distribution systems should be set up accordingly. The market outlets are equally critical for the recycled goods as well. Indeed, the recycling business is important in a "circular economy", whereby recyclable wastes produced in human beings are come back into utilization circle for the consequence of reuse, recovery and recycling. As per the circle of a "circular economy", we can accomplish the proficient utilization of goods, while delivering less waste on the other side.

Once the potential outcomes of waste avoidance, minimization and recycling can be depleted, suitable treatment innovations is used to legitimately lessen the amount of remaining waste. It is a regularly acknowledged sense that the waste ought to be legitimately processed before disposing on landfills to avoid permanent burden. The immediate disposal of untreated waste can create leachate and landfill gas (LFG) outflow.

4.2 Role of Policy Tools and Support Measures

Effective policy tools in the waste hierarchy can help to produce suitable activities, as well as to accomplish the further target of the Policy Implementation. In MSW, the strategy instruments we recommended are intended to achieve the above said three preferences. They are the waste avoidance and minimization, the waste separation and sorting; reuse and recycling, as well as the bulk reduction and treatment. Both legislation and education programs are the support measures for the strategy instruments.

The recommended MSW management strategy involves:

Policy Tools	Waste charging – follow the "polluter-pays" principle to increase the economic incentive on waste reduction
	PRSs – allow mutual responsibility among producers, retailer and consumers for all the economic, social and environmental impacts of a product throughout its lifecycle
	Landfill disposal bans – restrict the waste amount from limited and expensive landfill space
	Use of Incinerator - create another possibility of waste treatment and reduce the reliance on landfills
Support Measures	Public education and Partnership – implement to increase awareness, and foster partnerships between the community and businesses
	Legislation - ensure compliance and punish those who practice environmentally harmful behavior

4.2.1 Waste Charging

The administration of MSW is not costless. Setting up a waste charging is a coordinated way to deal with MSW. Hong Kong people do not need to spend expenses of waste collecting, handling and disposal directly. The burden of MSW is almost \$120 million yearly. Subsequently, no economic incentives for anybody to decrease the amount of waste created, or to involve in the reuse or recycle processes can be found nowadays.

For setting up a clear relationship between consumption and environmental expenses involved, we recommend forcing an immediate fee on every person for the volume of waste created. In this sense, the total cost of MSW can be set unequivocally on individuals who produce wastes in any case. The general residents would support as it

is completely reliable with the "polluter-pays" principle. Other countries show good examples that they demonstrated how waste charges are operating, the waste amounts are diminishing, as well as the rate of avoidance and recycling are increasing.

A consumption-led lifestyle which out-of-design items, whatever new or utilized, is coolly discarded, forces a large liability on the MSW framework. By forcing a fee on MSW, individuals are constrained to reconsider their behaviors on consumption and disposing waste, as well as to turn out to be more aware on the unfriendly environmental outcomes. They are not only be controlled by the amount they spend so as to dispose their waste a choice on purchasing, yet the more significantly, to have influence in decreasing waste, as well as ensuring the well-being in environment.

On the other hand, family units are affected by a strong economic incentive to reducing waste by forcing a fee on MSW. Less amount of waste being created can turn into fewer long-term MSW expenses, as well as reducing usage of landfills and other waste management facilities.

4.2.2 Producer Responsibility (PRs)

A mutual obligation might be forced among produces, retailers and end-users. Every item can bring forward the economic, social and environmental impacts at various phases of its life-cycle. The government must charge the producers and the end-users in charge of the items they create and use. Our policy holder ought to build up a system for presenting PRs on particular goods, with need prone to those that affect disposal of waste, in how they are produced, packaged, consumed.

PRs can maintain the commitment on dealing with specific goods on the producers, and retailers of the items. A well-designed PRS can help to urge producers for producing goods with less generation of waste, or that can be reused. Broadened PRs can show the idea to a mutual obligation among consumers, the industries and the retailers that are involved in the respect of the economic, social and environmental impacts of a product that can bring forward. We need not just the business sectors to reconsider the approaches they produce a good from design to sale, additionally end-users to practice suitable choices on purchasing, reuse and dispose.

PRS is vital in maintaining the local recycling industry in Hong Kong as well. In a "circular economy", waste that being produced by the human beings is come back to the utilization circle. Recycling is not just to reduce the speed of exhaustion on natural resources, but to decrease the pollution in industrial sectors. By building up a local source stream of recyclable goods through PRSs, this creates and maintains the local recycling industry that fulfills the idea of a "circular economy" in the reality.

4.2.3 Landfill Disposal Bans

A long term action is that, landfill disposal bans ought to be actualized to secure our valuable landfills. Waste produced from kitchen and eatery are the biodegradable wastes, which can produce LFG and leachate. LFG is malodorous and potentially combustible and explosive matter, while leachate has the potentials to pollute taint water bodies through penetration or direct release of leachate. The disintegration of biodegradable waste requires a moderate and heterogeneous procedure. It can cause the slope instability problems on the landfills for a long time. Indeed, the aggregate expense of maintaining closed landfill sites to solve their environmentally-related matters adds up to \$62,000 thousand annually. We should therefore retain our valuable landfill space and hold it for inert or unavoidable waste. A restriction on biodegradable waste, should be in the more extended term, permits landfills to last more and makes them to a lesser extent an environmental liability over time.

On the other hand, the landfill disposal bans are reasonable and practical in the aspect of economic. The bans can relieve the burden on landfill capacity, as well as guarantee a steady source of recyclable goods for the recycling business or for the market of second-hand products. They will concentrate on items from the primary waste stream and have a recycling esteem or appropriate treatment outlets. Therefore, the landfill disposal bans fulfills the overall MSW strategy on waste avoidance, reduction, reuse and recycling. They supplement MSW charging and PRSs to guarantee that specific waste types are recycled as well.

4.2.4 Use Of Incinerator

Instead of the traditional landfill disposal, any other advanced treatment technologies to further reduce the volume of waste is necessary. Incinerator is one of the effective and environmental friendly tools that work better than use of landfills. As mentioned in previous section, the net emission of greenhouse gas of advanced incinerator is $\frac{1}{6}$ of that of landfill.

Then again, waste combustion is especially famous worldwide, for example, Japan where land is a rare asset. Denmark and Sweden have been pioneers in utilizing the energy created from incineration for over a century, in localized combined heat and power facilities supporting district heating schemes. Various other European countries depend intensely on incineration for taking care of civil waste, specifically Luxembourg, the Netherlands, Germany and France. Hong Kong, as an international city, ought not to be lagged behind. This is not due to the general utilization of incinerator around the globe, however is to rebuild our existing waste management into more proficient for a future prospective. In this sense, consideration in building more advanced integrated waste management facility should be included in the waste management policy to decrease the reliance on landfilling.

4.2.5 Public Education and Partnership

To implement the strategy instruments effectively, the society's full support is vital. Individuals must figure out the necessary to forgo the old habits and welcome the benefits of the strategy instruments. Offers and promoting effort can increase the awareness, yet the best effects have gotten by a straightforward tool - by reaching out. A sustained, community-wide education and partnership system will role a huge and effective part in strengthening the significance of avoidance, reduction, reuse and recycling.

The government should focus on teenagers beginning at schools. The education sector is important, where our Youngers are nurtured. The responsible behavior and environmentally friendly habits can be built after instilling students' civic awareness and social obligation to think the surrounding world through waste lessening. Therefore, school curriculum plays a critical part in creating environmentally friendly habits. It can be advanced by moral and civic education, environmental education and

also courses, for example, General Learns at the primary school, Social Studies and Liberal Studies, at the secondary school.

Another vital approach is the partnerships with the business group within the MSW management. The well-celebrated WasteWi\$e activity has perceived a huge number of business organizations that actively decrease their amount of waste. Along with the participation of the business group, the government could exhibit to public on how the policy tools can function, as well as present the idea of sustainable MSW administration.

4.2.6 Legislation

Legislative support for the strategy instruments is required. The government should be firm and reasonable, while legislative support on the strategy instruments is imperative. Once legislation is implemented, regulatory measures should be set up to implement MSW charging, PRSs and landfill disposal bans. Monitoring and enforcement will discourage those environmentally harmful practices, for example, "fly-tipping" and ensure that products and materials are appropriately recovered for reuse or recycling.

5. Conclusion

In Hong Kong, the current waste administration depends heavily in landfilling. The prevailed consuming lifestyle of life of Hong Kong residents has intensified the pressure of the current three landfills. For a long term prospective, landfilling is not sustainable in Hong Kong. It forces different negative effects on society, economy, and environment. Nevertheless, the growing population and waste, limited land resources, conflict of land use, cost of waste management, and possible environmental hazard are the challenges we have to face with the current waste management system.

The other regions, for example, Japan, Taipei City and South Korea, have managed sustained efforts in recent years to prevent and decrease waste with incredible achievement. Hong Kong ought not be lagged behind, but needs to catch up with the best-in class cities. Expanding the extent of incineration is one of the approaches to alter our waste management structure. The cost-effective of the incinerator would bring much more incentives and advantages to operate an integrated waste management facility in Hong Kong.

For the objective of the policy framework, we have recommended a list of policy tools and support measures in the report. The recommended approach is according to the three targets of avoidance and minimization; reuse, recovery and recycling; and bulk reduction and disposal. Among each target area is a courses of planned initiatives, each a goal in itself can then lead to the achievement of the target. The driving force of the strategy comes from the policy tools of waste charging, PRSs, landfill disposal bans, and use of incinerator, while public education and partnership, and legislation are the supportive tools.

6. Bibliography

Allsopp, M., Costner, P., & Johnston, P. (2001). *Incineration and Human Health*. Greenpeace Research Laboratories. UK: University of Exeter.

Chan, Y. (2013, May 30). *Lawmakers Halt Tseung Kwan O Landfill Expansion Plan*. Retrieved Nov 30, 2015, HK Magazine Media Ltd: <http://hk-magazine.com/city-living/news/lawmakers-halt-tseung-kwan-o-landfill-expansion-plan>

Cheung, C.-f. (2014, May 22). *Lawmakers finally vote to back HK\$2b Tseung Kwan O landfill extension*. Retrieved Dec 1, 2015, South China Morning Post: <http://www.scmp.com/news/hong-kong/article/1517167/legco-panel-finally-votes-back-hk2b-tseung-kwan-o-landfill-extension>

Chi-fai, C. (2014, April 16). *Lawmakers split over controversial HK\$20b waste landfill and incinerator plans*. Retrieved Nov 30, 2015, from South China Morning Post: <http://www.scmp.com/news/hong-kong/article/1483909/lawmakers-split-over-controversial-hk20-billion-waste-landfill-and>

Clean Authority of Tokyo 23 cities. (2014). *Waste Report 23 2015*. Japan: Clean Authority of Tokyo 23 cities.

Econzine, *Incineration of Waste, 2012*, Retrieved Dec 3, 2015, from: <http://www.hkcleanup.org/en/content/incineration-waste>

Environment Bureau. (2013). *Hong Kong Blueprint For Sustainable Use of Resources 2013-2022*. Hong Kong: HKSAR Environment Bureau.

Environment Bureau. (2013, May). *Hong Kong Blueprint for sustainable use of resources*. Retrieved Nov 30, 2015, <http://www.enb.gov.hk/en/files/WastePlan-E.pdf>

Environment Bureau . (2014, April 16). *164DR – Southeast New Territories landfill extension* . Retrieved Nov 30, 2015, Item for public works subcommittee of finance committee: <http://www.legco.gov.hk/yr13-14/english/fc/pwsc/papers/p14-06e.pdf>

Environmental Protection Department. (n.d.). Integrated Waste Management Facilities. Retrieved Dec 1, 2015, from Environmental Protection Department, The Government of Hong Kong Special Administration Region:

http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_IWMF.html

Environmental Protection Department. (2004, Jun). Project Profile: South-East New Territories Landfill Extension. Retrieved Dec 3, 2015,

<http://www.epd.gov.hk/eia/register/profile/latest/esb119.pdf>

Environmental Protection Department. (2005). A Policy Framework for the Management of Municipal Solid Waste (2005-2014). Retrieved Nov 29, 2015,

<http://www.epd.gov.hk/epd/msw/index.html>

Environmental Protection Department. (2010, Aug 13). Strategic Landfills. Retrieved Nov 28, 2015, Problems & Solutions:

http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/msw_strategic.html

Environmental Protection Department. (2011). IWMF EIA Report. Hong Kong: Engineering Investigation and Environmental Studies.

Environmental Protection Department. (2015, Jul 24). Landfill Restoration and Afteruse - Summary Information. Retrieved Nov 30, 2015, Problems & Solutions:

http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/msw_si_lra.html

Environmental Protection Department. (2015, Oct 6). Advanced Incineration Technology. Retrieved Nov 30, 2015, from Environmental Protection Department, The Government of the Hong Kong Special Administrative Region:

http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_IWMFtech.html

Environmental Protection Department. (2015, November 25). Hong Kong Waste Treatment and Disposal Statistics. Retrieved Nov 30, 2015, Data & Statistics: http://www.epd.gov.hk/epd/english/environmentinhk/waste/data/stat_treat.html

Environmental Protection Department. (2015). Monitoring of Solid Waste in Hong Kong Waste Statistics for 2014. Retrieved Dec 1, 2015, from Environmental Protection Department, The Government of Hong Kong Special Administration Region: <https://www.wastereduction.gov.hk/sites/default/files/msw2014.pdf>

Gov HK. (2015, Oct). What is Municipal Solid Waste? Retrieved from Dec 2, 2015. <http://www.gov.hk/en/residents/environment/waste/msw.htm>

GreenPeace Digital, Pollution and health impacts of waste incinerators, Retrieved Dec2, 2015, from: <http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/3809.PDF>

Guo, J. (2010, Oct 22). It sure doesn't smell like roses. Retrieved Nov 30, 2015, HongKong Focus: http://www.chinadaily.com.cn/hkedition/2010-10/22/content_11443447.htm

Irish Doctors' Environmental Association (IDEA), (2006). "Incinerators and their Health Effects". Retrieved Dec 3, 2015, from: <http://ideaireland.org/library/incinerators-and-their-health-effects/>

J.A.Wallace. (1974). Incineration of Refuse in Hong Kong. National Incinerator Conference (p. 145). The American Society of Mechanical Engineers.

Legislative Council Secretariat. (2006). Landfills in Hong Kong. Retrieved Nov 30, 2015, Research and Library Services Division: <http://www.legco.gov.hk/yr05-06/english/sec/library/0506in37e.pdf>

Legislative Council Secretariat . (2014 , Feb 24). Updated background brief on "Extension of landfills" . Retrieved Nov 29, 2015, Panel on Environmental Affairs : <http://www.legco.gov.hk/yr13-14/english/panels/ea/papers/ea0224cb1-951-3-e.pdf>

Legislative Council Secretariat. (2014). Integrated waste management facilities in Hong Kong. Research Office. Hong Kong: HKSAR Legislative Council Secretariat.

Lo, K. (2015, Nov 27). Court clears way for isle incinerator. Retrieved Nov 30, 2015, from The Standard:

http://www.thestandard.com.hk/news_detail.asp?pp_cat=11&art_id=163650&sid=45650540&con_type=1

Martin Williams, Plan for Incinerator Island by Shek Kwu Chau environmentally unacceptable, (2011), retrieved Dec 3, 2015, from: <http://www.hkoutdoors.com/hk-ecowarriors-online/plan-for-incinerator-island-by-shek-kwu-chau-environmentally-unacceptable.html>

Michelle Allsopp, Pat Costner and Paul Johnston Greenpeace Research Laboratories, University of Exeter, UK., State of Knowledge of the Impacts of Waste Incinerators on Human Health, Retrieved Dec 3, 2015, from: http://www.no-burn.org/downloads/Greenpeace_Incineration_HumanHealth.pdf

Planning Department. (2003, Jan). Planning Principles and Concepts. Retrieved Nov 28, 2015, Publications and Press Releases: http://www.pland.gov.hk/pland_en/press/publication/nt_pamphlet02/tko_html/concept.html

Secretary for the Environment. (2013). Together we tackle the Waste Crisis – Concrete actions to address local concerns. Retrieved Nov 28, 2015, An open letter to Tseung Kwan O residents:

<http://www.enb.gov.hk/sites/default/files/en/node12/landfill.pdf>

Taylor Echolls, Pros and Cons of Incinerators, eHow Contributor, Retrieved Dec 3, 2015, from: http://www.ehow.com/list_6811674_pros-cons-incinerators.html

The Census and Statistics Department. (2015, Sep). Hong Kong Population Projections 2015-2064. Retrieved Nov 28, 2015, Website of the Census and Statistics Department: <http://www.statistics.gov.hk/pub/B1120015062015XXXXB0100.pdf>

The World Bank. (1999). *Municipal Solid Waste Incineration*. Washington, D.C.: The World Bank.

Wikipedia. (n.d.). Shek Kwu Chau. Retrieved Nov 30, 2015, from Wikipedia:
https://en.wikipedia.org/wiki/Shek_Kwu_Chau

Woon, K., & Lo, I. (2013). Greenhouse gas accounting of the proposed landfill extension and advanced incineration facility for municipal solid waste management in Hong Kong. *Science of the total environment* , 458, 499-507.

United Nations Environmental Program, (2013). "Guidelines for National Waste Management Strategies Moving from Challenges to Opportunities".

7. Appendix

Exhibit 1. Quantities of Solid Waste Disposed of at Landfills in 2010-2014

Year	2010	2011	2012	2013	2014
Domestic (1000 tonnes)	2240	2180	2301	2321	2342
Commercial (1000 tonnes)	860	861	827	879	936
Industrial (1000 tonnes)	230	242	268	285	292
Construction (1000 tonnes)	1310	1216	1259	1311	1439
Special (1000 tonnes)	410	413	412	428	414
Total (1000 tonnes)	5050	4912	5067	5223	5423

(Environmental Protection Department, 2015)

Exhibit 2. Quantity of Municipal Solid Waste Disposed of and Recovered in 2010-2014

Year	2010	2011	2012	2013	2014
MSW Disposed of (1000 tonnes)	3327	3283	3396	3485	3570
MSW Recovered (1000 tonnes)	3603	3019	2163	2009	2053
% of MSW Disposed	48%	52%	61%	63%	63%
% of MSW Recovered	52%	48%	39%	37%	37%

Data collected from Environmental Protection Department

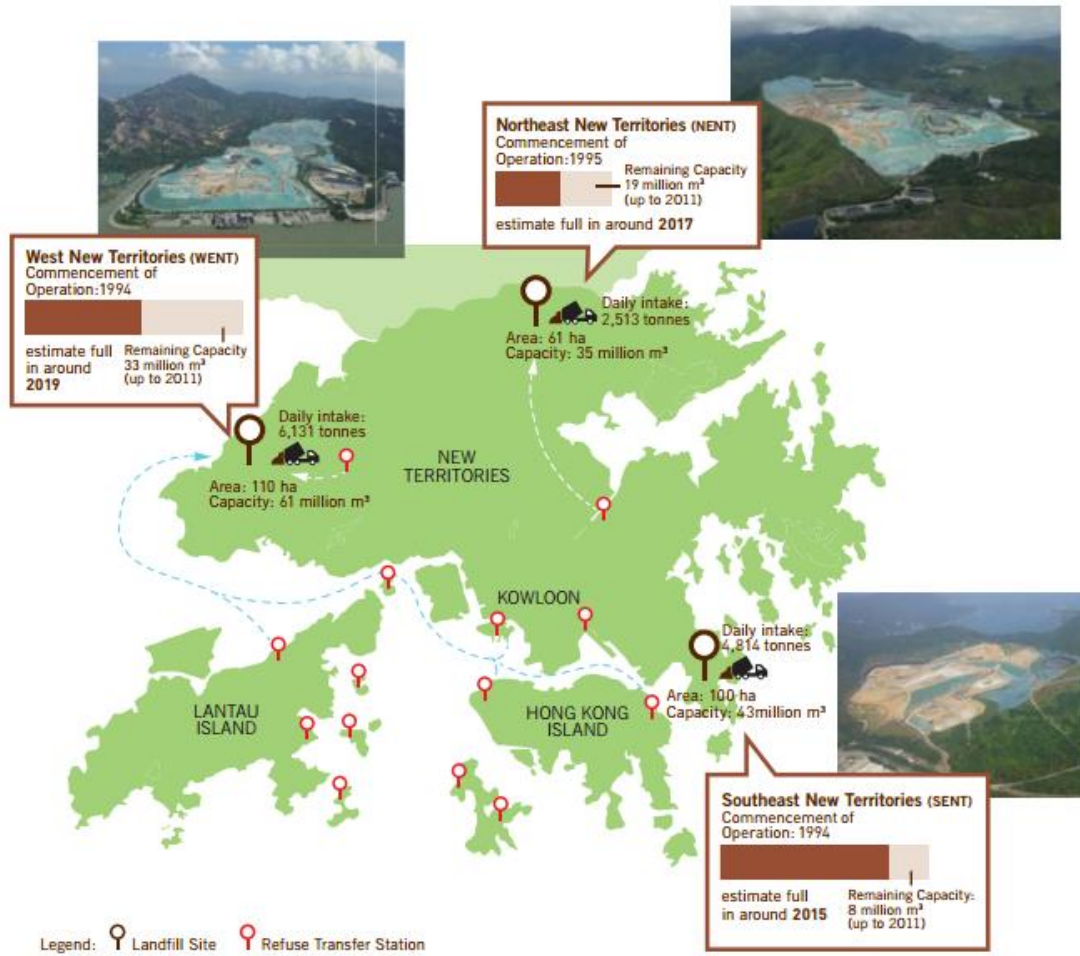
Exhibit 3. Operating landfills in Hong Kong



Landfill	North East New Territories (NENT)	South East New Territories (SENT) Landfill	West New Territories (WENT) Landfill
Location	Ta Kwu Ling, New Territories	Tai Chik Sha, Tseung Kwan O	Nim Wan, Tuen Mun
Commencement of construction	Jul-94	Sep-93	May-93
Commencement of operation	Jun-95	Sep-94	Nov-93
Area	61 ha	100 ha	110 ha
Max. height of filling	240 mPD	135 mPD	170 mPD
Max. depth of waste	140 m	100 m	120 m
Capacity	35 Mm ³	43 Mm ³	61 Mm ³
Current waste intake (tonnes per day)	3000	4,700	6,700
Waste types	Municipal waste, Construction waste, Special waste	Municipal waste, Construction waste, Special waste	Municipal waste, Construction waste
Capital cost (million)	1100	2,200	2,000
Operation cost (million/year)	155	216	260
Aftercare period	30 years after completion of operation	30 years after completion of operation	30 years after completion of operation

(Environmental Protection Department, 2010)

Exhibit 4. The location of the operating landfills and route of disposal



(Environment Bureau, 2013)

Exhibit 5. Data of MSW disposed of and population in Hong Kong in 1991 to 2014

Year	MSW Disposed of (1000 tonnes)	Population ('000)
91	2700	5815
92	2890	5888
93	3090	5998
94	3080	6119
95	2850	6270
96	2970	6467
97	3170	6517
98	3186	6583
99	3383	6638
00	3417	6712
01	3395	6730
02	3439	6726
03	3446	6764
04	3399	6798
05	3423	6838
06	3387	6904
07	3352	6938
08	3302	6964
09	3271	6996
10	3327	7052
11	3283	7112
12	3396	7178
13	3485	7222
14	3570	7267

(Data collected from the Census and Statistics Department & the Environmental Protection Department)

Exhibit 6. Regression of volume of MSW produced on population

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.841472658
R Square	0.708076235
Adjusted R Square	0.694806973
Standard Error	123.2340602
Observations	24

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	810391.2865	810391.2865	53.36214119	2.57947E-07
Residual	22	334105.9393	15186.6336		
Total	23	1144497.226			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	235.6511564	414.6109615	0.568366923	0.575542026	-624.1993503	1095.501663	-624.1993503	1095.501663
Population ('000)	0.45206927	0.061885423	7.304939506	2.57947E-07	0.323726758	0.580411781	0.323726758	0.580411781