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Development of Waste-to-Energy Plant in Kuala Lumpur

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The increasing of waste generation and its accumulation is alarming due to its potential negative effect on the well-being of the society and the integrity of environment sustainability. Waste generation in Kuala Lumpur is about 2,500 t/ d and is expected to increase to about 4,000 t/ d in 2020. The waste is sent to Bukit Tagar Sanitary Landfill via Taman Beringin Transfer Station. The transfer station is overloaded with the design capacity of only 1,700 t/ d. The government of Malaysia has decided to construct a 1,200 t/d waste-to-energy (WtE) plant at Taman Beringin, which is adjacent to the transfer station. As the location is highly populated, the project might raise the concerns from nearby residents. This paper describes the project facilitating activities that have been conducted for the development of WtE plant in KL. The studies include technology selection, site assessment and soil investigation, public safety and health assessment, power system study and waste characteristics. The results of the studies are necessary for the decision making and approval by government agencies such as Department of Environment and local authority, as well as the design of WtE.

1. Introduction

Kuala Lumpur (KL) is the capital city of Malaysia with an estimated population of 1.79 million. Municipal solid waste (MSW) generation in KL is about 2,500 t/ d, equivalent to the generation rate of 1.4 kg/ d per capita. The MSW generation has doubled as compared to the 1,300 t/ d in 2003. Back in 1979 until 2005, MSW from KL was disposed at the Taman Beringin non-sanitary landfill, which is located within the city of KL. The landfill operation was ceased in 2005. A new sanitary landfill for KL at Bukit Tagar was located about 80 km away. Waste from the KL city was sent to the Bukit Tagar Sanitary Landfill via a transfer station located at Taman Beringin. Waste management in KL is facing a problem due to overloading of receiving waste at the transfer station. The transfer station was built with a design capacity of 1,700 t/d but currently, the transfer station is receiving 2,500 t/d MSW.

To cope with the continuous growth of MSW generation and to solve the MSW management problem in KL, the Government of Malaysia planned to construct a 1,200 t/d waste-to-energy (WtE) plant adjacent to the existing transfer station. This is the first large scale WtE project in Malaysia and there are no other similar plants in the region except Singapore.

One of the major concerns of the proposed WtE plant is the project location which is surrounded by highly populated areas. There is rising public concern about the project. To address the issue, efforts have been taken to ensure that the project is technically and environmentally sound. This paper provides an overview of the activities conducted to facilitate the development of WtE plant in KL. These activities include technology selection, site assessment and soil investigation, public safety and health assessment, power system study and waste characterisation.

2. WtE Facilitating Activities: Technology Selection

Stoker, fluidised bed and rotary kiln are the three proven technologies for WtE plant, as shown in Figure 1, Figure 2, and Figure 3. Stoker type (or grate type) is a well-established technology in commercially treating municipal solid waste (MSW). Fluidised bed system is more commonly used in treating homogeneous waste such as sludge. Rotary kiln is primarily used to treat hazardous and clinical waste but less for MSW. Table 1 shows the evaluation of the three technologies based on the criteria of proven operational success, reliability, scalability and waste pre-processing requirement. Arup Consulting Engineers (2008) further concluded that the capital and operation cost for rotary kiln in treating waste is relatively higher. The main issues of treating MSW with rotary kiln are the erosion of refractory materials, plastics deposition on internal refractory lining surface, clinkering effect and solidification of slag at colder part of kiln. Based on the analysis, Stoker type technology shows the most proven track record for large scale unit. Advisor Council on the Environment of Hong Kong (2009) also made similar recommendation for Hong Kong's first integrated waste management facility.

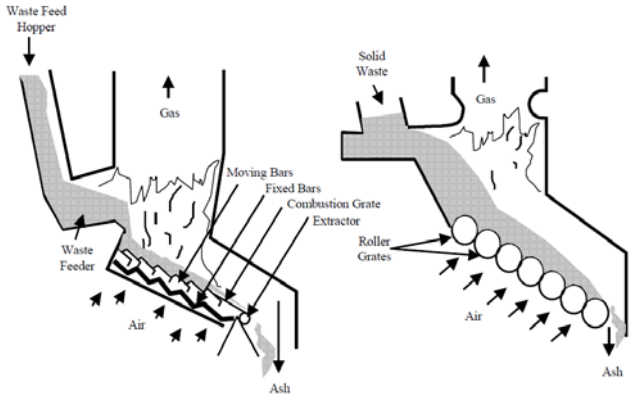

Figure 1: Illustrations of stoker

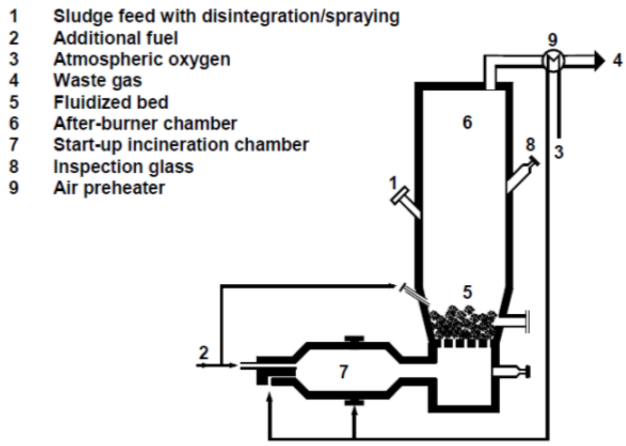

Figure 2: Illustrations of fluidised bed

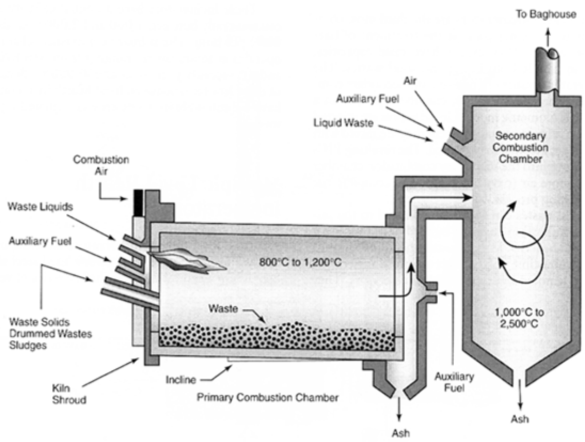

Figure 3: Illustrations of rotary kiln

Table 1: Comparison of Different WtE Technology based on the Track Record, Scalability and Feed Requirement

	Stoker	Fluidised Bed	Rotary Kiln
Track Record	- 900 plants worldwide treating MSW (ACE, 2009) - Principal technology in Japan (Nickolas 2008) - 60 % plants in China (Nelles et al., 2011)	< 10 % plant in Europe (Stantec, 2011)	7 % plant in China (Nelles et. al, 2011)
Scalability	-Some of the large scale unit: - Brescia (Italy) 1,000 t/d, - Moerdijk (Netherlands) 920 t/d, - Honolulu (USA) 1,000 t/d, Tuas - South (Singapore) 500 t/d (plant capacity: 3,000 t/d)	Typical unit capacity: 60 t/d Largest plant: Madorito plant – 300 tpd per unit (Nikolas, 2008)	Typical unit capacity: 100 – 300 t/d (ACE, 2009; Nelles et. al, 2011)
Feed requirement	Can treat various size and composition of unprocessed MSW	Required pre-processing: - Sorting - Removal of metals - Shredding < 50 mm	-

3. Site Location Evaluation

Taman Beringin is gazetted for solid waste management in KL. There are two site options for constructing the 1,200 t/d WtE plant, namely site option A and B at both sides of the transfer station, respectively. Site option A is located on top of the existing closed landfill and east to the transfer station; while site option B is located at the existing bulky waste management site which is the west to the transfer station.
Figure 4 shows the site option A and B at Taman Beringin.

Figure 4: Proposed WtE site option A and B at Taman Beringin, Kuala Lumpur

Site survey, soil investigation, fieldwork and case studies were conducted to evaluate and recommend the suitable site of option A and B. In term of land area, it is estimated that stoker technology has a foot print of 0.2 hectare/t of MSW (Reference on Tuas WtE Plant). It is estimated that, the 1,200 t/d KL WtE required about 3 hectares of land. Both site option A and B fulfill the land size criteria.

Shinkoto plant in Japan and Mapo plant in Korea are similar to site option A because both plants were built on top of closed landfill. These two case studies were reviewed. Constructing WtE plant on Site A involves high cost of site preparation due to the requirement to remove about 8 Mt of accumulated waste underneath the closed landfill. The cost involves the mining and transporting of excavated old waste as well as the disposal cost. The ground improvement i.e. filling back the soil and piling work will incur additional cost on top of waste treatment of the old waste.

Emission of landfill gas (containing methane gas) from the closed landfill also poses high explosion risk in an enclosed structure i.e. WtE plant. To ensure operational safety and security, High Density Polyethhylene (HDPE) membrane is required to be installed under the building to prevent seepage of the gas into the building. Landfill gas collection pipeline should be installed to channel out the accumulated gas while landfill gas detector should be installed in the building to monitor the level of methane gas at the workplace.

Site option B consists of local council's plant nursery and bulky waste transfer station facility. Both facilities can be removed. There is a pond with about 2 m deep within site option B. The pond can be reclaimed. The proposed site can be accessed by Middle Ring Road 2. Compared to site option A, site option B is more feasible.

4. Preliminary Site Assessment (Penilaian Awal Tapak)

Preliminary Site Assessment or known as Penilaian Awal Tapak (PAT) in Malaysian Language is an application to be submitted to DOE for evaluating the suitability and compatibility of the proposed site for a new project. As the proposed WtE site is located close to the surrounding residential area, DOE requested to present the analysis of air dispersion modelling for air pollutants emission from the proposed WtE plant as well as the quantitative risk assessment during the submission of PAT. Air dispersion modelling was conducted using commercial software AERMOD which is recognised by US EPA. Figure 5 shows the result contour for hydrogen chloride (HCl) as the signature air pollutant from WtE plant.

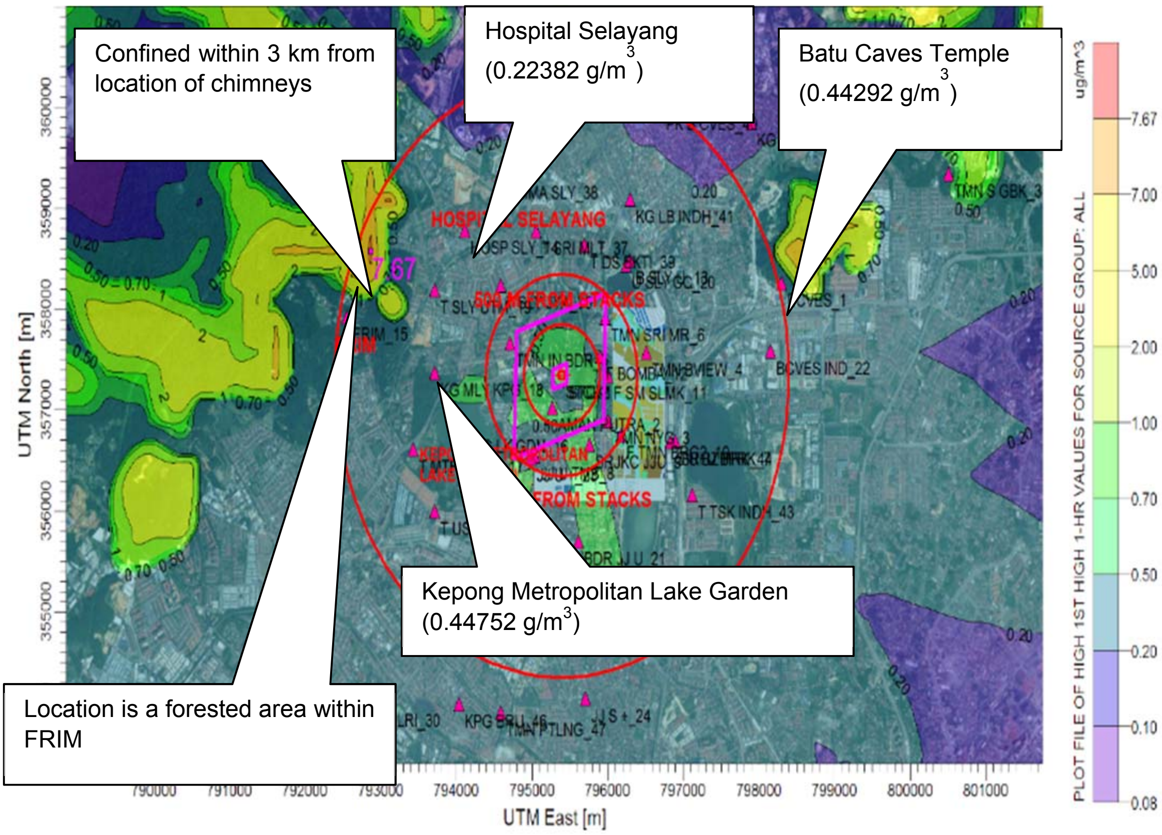

Figure 5: Locations of occurrence of highest GLC (shown for 1-HR HCl)

The result of modelling shows that the highest ground level concentration (GLC) of 1 h average HCl (7.67 ug/m^3) is located at the Forest Research Institute Malaysia (FRIM), which is about 4 km northeast from the proposed site, while the GLC of 1 h average HCl surrounding the proposed site is remained at a low concentration of less than 1.0 ug/m^3. As Malaysia does not have the ambient HCl limit standard, Alberta's Ambient Air Quality Objectives and Guidelines (AAAQOG, Canada) is referred and compared. The result of GLC is lower than the limit (75 ug/m^3) of AAAQOG.
Quantitative risk assessment was conducted to predict the potential fire risk to the surrounding sensitive receptor. It should be noted that the possibility of fire occurrence at the MSW storage pit is low due to the high moisture content of the waste. In the case that the pit catches fire, the result indicates that the fire is only localised within the boundary of the site.
With the result of the scientific study and the experience of plants that located in highly populated urban such as Hikarigaoka plant, Edogawa plant, Clean Plaza Fujimi plant and Megura plant in Japan as well as Spittelau plant in Austria, DOE has no objection on the proposed project site. Nevertheless, Detailed Environmental Impact Assessment (EIA) needs to be conducted to evaluate further of the impact of the WtE on the environment and public health.

4.1 Soil Investigation

KL lies on limestone bedrock with the karstic features e.g. steeply inclined bedrock, cavities, floaters. Soil instigation is required to determine the soil structure underneath of the proposed site. Result shows that the limestone is encountered at the depth of approximately 6 to 8 m below the ground surface, while at Eastern of the site is about 25 m.

4.2 Power System Study

The proposed WtE plant will generate about 30 MW electricity. A power system study (PSS) was conducted. The study identified the interconnection location at Pencawang Masuk Utama (PMU) Batu Caves. The distance between PMU Batu Caves and the proposed site is about 4 km.

4.3 Waste Characteristics

MSW is used as the raw material to feed into WtE plant and generate electricity. The MSW characteristics data especially the thermo-chemical properties are essential for designing the plant. The study team has kept track the data since year 2000. In year 2001, waste sampling was conducted monthly for a year, while in 2014, the sampling waste carried out monthly from June to December. The sampling was repeated again in 2016.Figure 6 shows the comparison of chemical composition and moisture content (MC) between the MSW in 2001 and 2014.

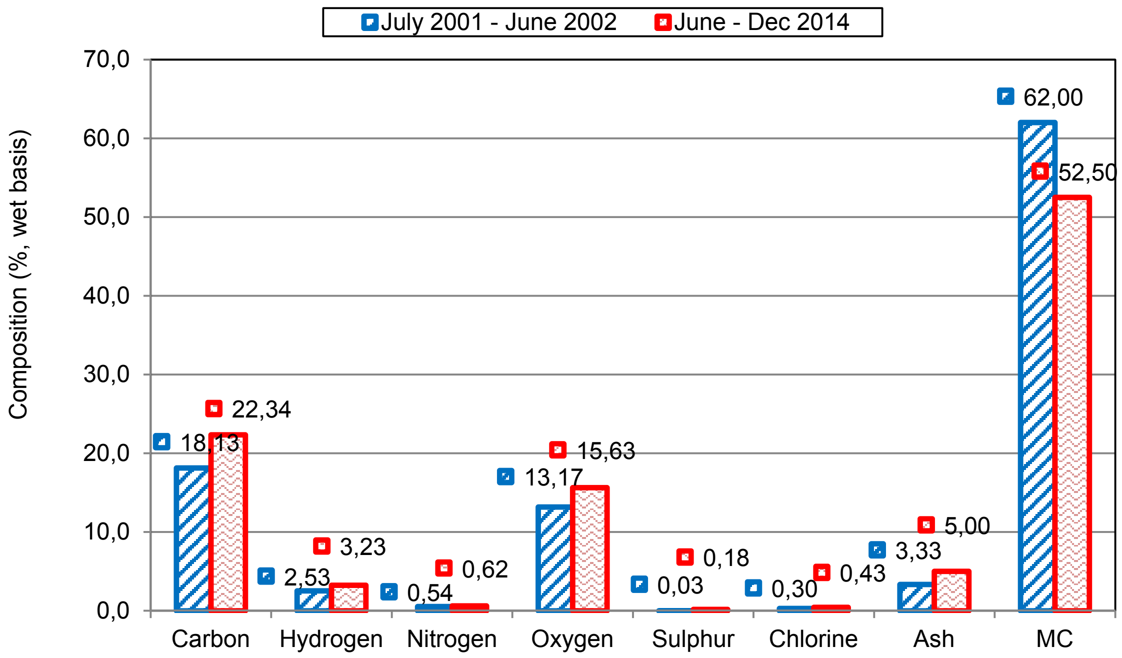

Figure 6: Comparison of chemical composition and moisture content of MSW of year 2001 and 2014

The moisture content is reduced significantly from 62 % to 52 %. The reduced moisture content affects the content of chemical compositions and calorific value. As a result, the net calorific value (CV, wet basis) increases from 6.7 MJ/kg to 8.2 MJ/kg from year 2001 to 2014. The reported CV is higher than the minimum annual average CV i.e. 7 MJ/kg (World Bank, 1999).

5. Conclusion

The MSW problem in KL is critical due to the continuously increasing generation and the overloaded of existing facilities. Following the continuous development of the nation, energy security issues will also derive due to increasing demand. The WtE concept through the incineration technology of MSW offers win-win solution in combating waste production and energy security. The disposal premise is 80 km far from the city. Government of Malaysia decided to construct a 1,200 t/d WtE plant in KL. Project facilitating activities have been carried out for stakeholders to make decision and develop the project. With the completion of the facilitating ground works, it is expected that the WtE plant can be started to construct by 2017.

Acknowledgments

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