WASTE-TO-ENERGY (WTE): A WAY FROM RENEWABLE ENERGY SOURCES TO SUSTAINABLE CONSTRUCTION WASTE MANAGEMENT

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ABSTRACT

Construction waste generation nowadays becoming a pressing issue in Malaysia with the high numbers of the construction project, which increased rapidly due to 'Malaysia Plan 2020' in the recent years. Although Malaysia Government had introduced few ways in managing the construction waste, still some of it was reportedly either ending up at the open landfill or worsen when it is illegally dumped in the forest or by the roadside. The urgency was need to tackle this issue by providing more alternative method. One of the alternative methods that seen to provide the solution with benefits is Waste-to-Energy (WtE). This technology had been proved by several countries such as China and Europe in reducing the waste-to-landfill problem. A few years back, Malaysia had announced to launch the plant for the WtE but somehow the result from the preliminary study resulted that plant had closed due to the reason of low source of the waste. Therefore, this study intended to explore the probability of construction waste to become one of the sources for the WtE generation. This will lead into solving two problems in future, which were construction waste problem and the low source of waste for the WtE generation.

Keywords: Waste-to-Energy, construction waste, Malaysia, sustainability

1.0 INTRODUCTION

Construction waste generation is becoming a pressing issue in Malaysia (Nagapan et al. 2012; Sin et al. 2013). The numbers of construction project have increased rapidly due to 'Malaysia Plan 2020' in the recent years (Sin et al. 2013). According to the journal in the year 1995, the amount of waste generated in Malaysia is perhaps quite imaginable; the urban area of Asia produced 760,000 tonnes of municipal solid waste, approximately 2.7 million m3 per day. In the year 2025, the estimated figure increase up to 1.8 million tonnes of waste per day, approximately 5.2 million m3 per day (Nitivattananon & Borongan 2007; Huovila et al. 2011; Osmani 2011). There were several researchers resulted that the highest composition of construction waste produced was concrete and aggregate with 65.8%. This list followed by soil and sand (Poon et al. 2013; Ismam & Ismail 2014; Ling 2016).

In Malaysia, most of the waste ends up in open dumping thereby releasing toxic greenhouse gasses into the air and further causing potential health threats to the inhabitants nearby. Issues of illegal dumping have increased rapidly all over the country especially in the year 2001 to 2005 from 3 cases increase to 31 cases as reported by (Zainun et al. 2016; Rahim et al. 2017). This construction waste issue is due to the cost and project location where the contractor also lacks experience and knowledge in handling construction waste management.

In Malaysia, a landfill is the most common method and least expensive, which it gives the harmful impact to the environment. In the year 2001, there were 155 landfills in operation and the number of landfill increase to 176 in the year 2007 (Xiang et al. 2013; Ismail & Manaf 2013; Othman & Chuen Khee 2014). Waste-to-Energy (WtE) generation was implemented as a potential energy variation strategy, especially in Sweden, over past 20 years as a leader in Waste-to-Energy production. The range of net electrical energy that possible to generate is about 500 to 600 kWh of per tonne of waste incinerated. Thus, the incineration of about 2,200 tonnes per day of waste will produce about 50 MW of electrical power. WtE plant able to last well over 30 years with proper maintenance. WtE plant process one million tonnes per year require less than 100,000 m2 of land. In the other hand, landfill over 30 million tonnes of municipal solid waste about 8 years in Greece requires 3,000,000 m2 of land (Michael 2013; Klinghoffer & Castaldi 2013).

A variety of waste sources like urban, agriculture, industrial sectors, vegetable markets, etc., generate huge quantities of solid waste containing a sizeable proportion of biodegradable-organic matter with municipal solid waste (MSW) having largest proportion. Most of the researcher had done a study on the feedstock for the WtE from municipal solid waste. For an example, Nanda et al. 2015 studied both fruit and vegetable wastes together for biogas production. A smilar type of studies was done by Visakh & Thomas 2010; Kple et al. 2016; Miezah et al. 2017 taken market waste (rotten vegetables, fruit skins, potatoes, onion, etc.) and household solid waste respectively intensively used for methane production. However, a very limited study had done in using construction waste as a feedstock for WtE technology. Based on a study done by Reijnders, 2007, it is possible to use construction waste as feedstock as most of the waste are combustible material. Therefore, this study intended to explore the possibility of construction waste to be one of the feedstocks for WtE technology. This paper also will review the progress of WtE implementation in Malaysia.

2.0 IMPLEMENTATION OF WASTE-TO-ENERGY (WtE)

Waste-to-Energy plant uses waste to generate the power or electricity. Once they collect all the waste from the site, then they will do preparation for combustion. By referring to Figure 1, there is a moving grate in the combustion area, which to turn the waste over repeatedly for burning. After the combustion, all the waste will become ash. These consist of two ash which is fly ash and bottom ash. Fly ash will be returned to landfill and bottom ash is non-combustible recyclable matter such as ferrous metal example stainless steel, mild steel and so on coming out of the pre-processing plant would sell to recycling units. On the other hand, the heat makes the steam, which runs a turbine and generator to produce electricity.

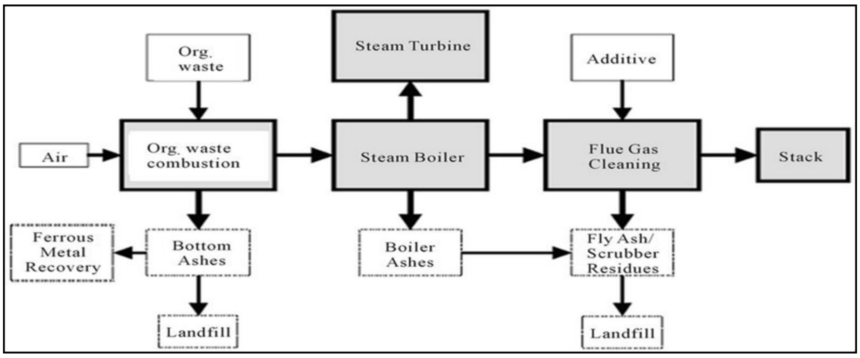

Figure 1: Process of WtE (Klinghoffer & Castaldi 2013)

Countries such as United States, Europe and so on where emerging into powerful economies, at the same time the production of waste also will increase. According to the (Michael 2013), post shows that the latest estimates in United Stated were 89 WtE plants and 431 power plant in Europe. In Asia region, Japan leading the list by having 21 WtE plants, which recorded only in Tokyo. While Singapore recorded 5 WtE plants in operation at this moment. This is to show the positive investment and return from the implementation of the WtE plant towards environment and return an investment.

In Malaysia, various technologies used by considering the properties of waste such as biomass and incinerator. There are four incinerators are still operating located at Pulau Langkawi, Cameron Highland, Pulau Pangkor and Pulau Tioman. Biomass is the most widely used in technology in Malaysia. One of the reason behind the wide usage of biomass energy given its equatorial climate that is ideal for dense tropical forest growth and agricultural vegetation. Whereas in Malaysia, there are 12 plants use biomass as shown below table 1 from the year 1998 to 2017.

Table 1: Biomass Plant in Malaysia (Chuah et al. 2006; Zafar 2015)

Year	Plant	Fuel
2015	Kerteh	Wood
2007	Bentong Biomass Energy Sdn Bhd	Palm Waste, Wood chips
2007	Mensilin Holding Sdn Bhd	Palm Waste
2006	SEO Energy Sdn Bhd, Sabah	Palm Waste
2006	LDEO Energy Sdn Bhd, Sabah	Palm Waste
2005	PGEO Edible Oils Sdn Bhd	Palm Waste
2004	TSH	Palm Waste
2003	Superlatex, Melaka	Palm Waste
2003	IOI Edible oil Sdn Bhd, Sabah	Wood
2002	Kwantas Oil Sdn Bhd, Sabah	Palm Waste
2000	Pofachem, Klang	Palm Waste
1998	LH Kiln Drying & Moulding	Wood

3.0 METHODOLOGY

This study mainly focused on extracting information that can be used as a fundamental research as this technology still new in Malaysia. An observation had done for entire 3 months study duration at two location, which was: (i) construction site of Waste-to-Energy plant at Lukut, Negeri Sembilan and (ii) WtE pilot plant at Kualiti Alam Sdn Bhd, Port Dickson. This observation purposely to view the development and future planning for feedstock compilation area and receiver.

In order to explore the possibility of having the construction waste as a feedstock, an in-depth interview method was implemented. Several of the government and nongovernment bodies involved with waste management were selected. The interview method was chosen because it provides an environment of obtaining clarity and confirmation on details of information/data for the study topic. The questions were developed for each specific focus group. In order to gain details on costing and design specification, the requirement on the field trip of solar energy provider was obtained.

4.0 RESULTS AND FINDINGS

4.1 Waste-to-Energy (WtE) in Malaysia

The Solid Waste Corporation (SWCorp) stated that the Malaysia government were planning to implement a full scale of WtE technology in order to settle the waste issues. This refers to the various type of waste that suitable to be the feedstock for this technology. However, every facility of WtE must plan well in order to be able managing in the future. So, that it will not happen as a previous failure WtE pilot plant, which situated at Semenyih, Selangor. Based on the report provided by SEDA (Sustainable Energy Development Authority), this plant had shut down due to an issue of less supply of feedstock and environmental requirements during the process of combustion and incineration.

For a new project, the government had listed three proposals of the WtE plant which are: (i) Taman Beringin, Kuala Lumpur, (ii) Sungai Udang, Malacca and (iii) Bukit Payung, Johor. All of this plant will follow the emission standard produce by Continuous Emissions Systems (GEMS) and monitor by Department of Environment (DOE).

Kualiti Alam Sdn Bhd had successfully handled and managed a WtE pilot plant, which it operated from 2016 until to date. The Incineration Plant for scheduled waste built to cater for all organic waste that requires thermal treatment to achieve maximum destruction efficiency (figure 2). Scheduled organic waste, including toxic, hazardous, clinical and pathological waste in all forms, solids, sludge, and liquids were treated. A rotary kiln as the primary combustion chamber with a temperature of up to 1000°C and secondary combustion chamber operating at above 1000°C to ensure the highest possible destruction efficiency, followed by heat recovery system and finally an extensive multi-stage flue-gas treatment system (figure 3).

Designed with multiple feed streams, dual combustion chambers, rapid cooling, dry and wet scrubbing systems, the plant was designed to achieve 99.99% destruction and flue-gas removal efficiency. Emissions from this plant meet all Malaysian Environmental standards. Continuous Emissions Systems (GEMS) are monitoring the incineration process in order to ensure the compliance with Department of Environment, Malaysia (DOE) license condition. Fully computerized and equipped with continuous monitoring systems, the Incineration Plant represents the latest standard in rotary kiln incineration technology.

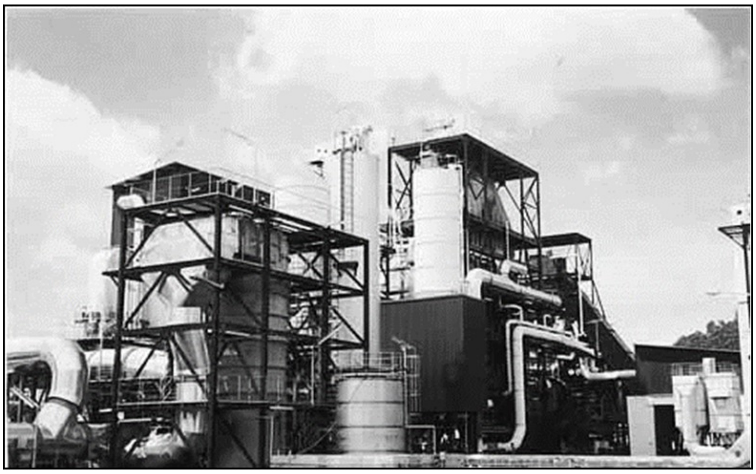

Figure 2: Incineration Plant at Kualiti Alam.

Figure 3: Combustion Chamber at Kualiti Alam.

4.2 Construction waste as feedstock for WtE

Major construction waste that highly produced were concrete, timber, plastic, and metal. The 3R concept which was recycled, reuse and reduce had widely implemented in the construction industry as part of waste management. Most of the construction waste such as metal, copper, and steel were collected and sent for recycling or reuse. This method however only applicable for the type of waste, which has a high second-hand value in the market. There have other wastes such as timber, concrete, and plastic which abundantly left without proper treatment.

Based on the waste management hierarchy (figure 4), before any waste sent for disposal in a secured landfill, there was possibility that some of the waste to be recover to energy.

This is where the function of WtE technology for those waste that not been able for recycle, reuse or reduce.

Figure 4: Hierarchy of Waste Management (Gren 2008).

In order to check the suitability of using the construction waste as a feedstock for WtE, each of the compositions of major construction waste was review. Plastic and timber shown a good composition as a material which able to be combust and turn into energy recovery. These waste were suitable as it easily burns and turns into fly ash in a minute. Furthermore, this type of construction waste not only produced in construction site but also produced in municipal solid waste.

4.3 Limitation for WtE technology

There are, however, several limitations to the development of waste substrates as an immediate energy resource. Foremost, the development of renewable waste substrates as energy resources is the distributed or dispersed nature. Large sources of waste substrates are often located at a distance from potential energy production sites. The collection, transport, and processing of renewable waste also pose a significant challenge to their use in energy production. The costs of this feedstock are directly proportional to the costs of collection and transportation to energy production sites.

With these various points in mind, clearly it needs additional in-depth research to improve the technology itself. It also related with the management on the suitability type of construction waste as a feedstock. The substrate pre-treatment, purification, maintenance and manpower also limited for the WtE technology.

Hence, with scientific and engineering advancements, limitations for WtE technologies can be solved and viewed as a key for the economically viable component to a renewable based economy.

5.0 CONCLUSION

In Malaysia, there are only a few incinerator plants operating but not even one is capable of recovering energy from waste in an economically viable way. An appropriate waste management technology such as WtE in order to attain such goals effectively. One important parameter to increase WtE plants efficiency is waste sorting at sources requires upgrading the level of people's awareness and change their attitude toward the environment. This facility helps in land savings, material recovery, and energy production and reduce the environmental pollutant. Considerable research and development studies are needed to improve the "state of art" in WtE for sustainable development in construction waste management.

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