CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Municipal solid waste (MSW), or more commonly known as solid waste are generated daily from the industrial sector, agricultural sector, and generally discarded by the society. The rapid population growth, as well as trend in urbanisation and socioeconomic demands are increasing in parallel to the generation of solid waste. The problem of waste management is becoming a withstanding concern to the global citizen. In the light of this situation, this research proposes an elegant solution to contain the situation, as well as providing an alternative green energy which has the potential to replace the depleting natural resources. By converting these wastes into syngas or synthesis gas; we might be able to replace natural gas for industrial, and everyday energy applied by the masses. For instance, syngas may be burned directly in gas engines, used to produce methanol and hydrogen, or converted via the Fischer-Tropsch process into synthetic liquid fuel (Laurence and Ashenafi, 2012).

Syngas is created by the process of gasification. Gasification is heating-up of solid or liquid carbonaceous material with some gasifying agent to produce a gaseous fuel (Ahmed and Gupta, 2009). Carbonaceous fuels such as coals and biomass commonly use in gasification to produce syngas. The heating value of the gases produced is generally low to medium. Combustion is excluded because the product flue gas has no residual heating value from complete combustion of the fuel. Meanwhile, partial oxidation of fuel or fuel-rich combustion, and hydrogenation are included. The oxidant or gasifying agent in partial oxidation process could be steam, carbon dioxide, air or oxygen, or some
mixture of two or more gasifying agents. The oxidant is chosen according to the desired chemical composition of the syngas and efficiency (Ahmed and Gupta, 2009). The high-temperature process refines corrosive ash elements such as chloride and potassium, allowing clean syngas production ready to be used.

Even though conventional gasification is a clean energy technology, it also has some disadvantages. Plasma gasification can compensate for these weaknesses as it is operated under atmospheric pressure and requires a short time to elevate to a higher temperature than conventional gasifier using external electric energy. Conventional gasification technologies maintain the high temperature required for the gasification through partial oxidation of fuels. Plasma gasification technology, however, achieves a gasification reaction temperature by using a high-temperature plasma flame generated using external electric energy (Yoon and Lee, 2011). Plasma gasification technology is commonly referred to as “true gasification” or “pure gasification” because it leads to a pure gasification reaction with a rare occurrence of combustion (Mountouris et al., 2008). Using this technology promotes chemical reactions due to the generation of active particles, including radicals and ions to reduce reaction times (Kanilo et al., 2003).

With the growth of palm oil production in Malaysia, the amount of residues generated will also increase. The oil palm industry is currently producing the largest amount of biomass in Malaysia with 85.5% out of more than 70 million tonnes (Shuit et al., 2009). The type of biomass produced from oil palm industry includes empty fruit bunches (EFB), oil palm fiber (OPF), oil palm shell (OPS), wet shell, palm kernel, fronds and trunks. Due to the huge amount of biomass generated yearly, Malaysia has the potential to utilize the biomass efficiently and effectively to other value added products. Plasma gasification will be able to convert these oil palm biomass to syngas that can be useful in the energy sector. This clearly shows the potential of oil palm biomass as one of the major sources of energy in Malaysia. Its renewable nature makes it even a more important energy source.
1.2 Problem Statement

Solid waste management is often fragmented, and lacks coherence for countries and cities across the globe. Even present, the system has been often negligent to basic environmental preservation and have serious environmental risks. The inconsistent standards, and lack of any scientific basis to the designs of such solid waste management led to general environmental degradation, and contributes directly to climate change. Gasification of biomass char would offer an opportunity for conversion of biomass wastes into value-added products in an environmentally friendly process. The greenhouse gas, CO\textsubscript{2} will be reduced to fuel gas, CO. In Malaysia about 50 million tons of Palm Oil Mill Effluents (POME) and about 40 million tons of Oil Palm Biomass are generated from the palm oil industries every year. The current management practice poses significant environmental problems as much of the waste is disposed by biomass burning of end product emit greenhouse gas into the atmosphere and leave high organic content on the grounds (Alam and Ainuddin, 2007). These wastes, when not treated properly as such will lead to grave consequences to the population and the environment.

Gasification is a clean energy technology that generates syngas consisting of hydrogen and carbon monoxide through the partial oxidation of a fuel source (Yoon and Lee, 2011). However, the conventional gasification process had many arising problems. It operates at high pressure and requires a long time to heat up during startup. Bartels et al. (2010) reviewed 8 types of conventional gasification with different gasifier design. The gasification pressure range was between 70 to 120 bar which is very high pressure. Stassen and Knoef (1995) compared between operation parameters of fixed bed gasifiers and list out the startup time for gasifier between 10 to 60 minutes. In microwave heating systems, rapid and selective material heating can be achieved in only a few minutes with instantaneous start-up and close-down of the processes (Kasin, 2006). In conventional gasification, heat is transferred from the surface towards the center of the material by convection, conduction, or radiation, so the heat transfer is inconsistent. As for microwave plasma gasification, the electromagnetic energy is converted to thermal energy inside the material thus provides a selective and higher heating rate (Fernández et al., 2011; Domínguez et al., 2008).

Microwave plasma gasification is ideal for high temperature heterogenous gas-solid reactions. Microwave absorbers are used to absorb the microwave energy and