THE IMPLEMENTATION OF INCINERATION FOR WASTE REDUCTION

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ABSTRACT

The purpose of this paper is to review the waste generation and management in different parts of the world. In order to create a sustainable society, various environmental issues should be addressed. Waste generation and management has gradually become an alarming environmental problem these years. It is estimated that the current global Municipal Solid Waste (MSW) generation levels are about 1.3 billion tonnes per year (1.2 kg per capita per day) and will be doubled by 2050. Therefore, an integrated solid waste management is needed to reduce the continuous significant increase in waste generation rates. Even though many countries have introduced and implemented the 3Rs strategy and landfill, however, these are only ways to diverse waste, but cannot reduce the huge volume of waste generated. Instead, the advanced thermal treatment technology, incineration, can reduce up to 90% volume of disposed waste prior to dispose at landfills is discussed. Sweden and Tokyo were chosen as case studies, which provide an overview of the municipal solid waste management system. With the condition of escalating amount of wastes generated, it is crucial to build incinerators to relief pressing needs of landfill. Two solutions are proposed to minimize waste generation, including one incineration in one city and several small incinerators in different cities. While taking into consideration of a sustainable model and the perspectives of all stakeholders, building several incinerators at different cities and different sizes would be the best option to reduce waste. Overall, the solution to the global solid waste management should be a holistic approach with the involvement of both government and citizens.

Keywords: Incineration, Municipal Solid Waste, Thermal Treatment, Waste generation

1. Introduction

It is undeniable that waste generation and management has become an alarming environmental issue. Solid waste generation links inextricably to the degree of industrialization and economic development. Urbanization increases with the economic wealth of the countries. As the income of people and standard of living enhances, so does their consumption of goods and services, leading to a corresponding increase in waste generation. Statistics showed that low-income group generates an average of 0.6-1.0 kg/cap/day; middle-income group generates 0.8-1.5 kg/cap/day, whereas the high-income group generates 1.1-4.5 kg/cap/day [1].

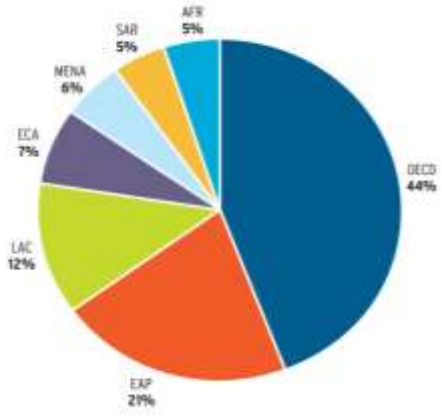

Figure 1: Waste Generation by Region [2]

Based on the latest statistics from *What A Waste Report* published by World Bank (2012), it is estimated that the current global Municipal Solid Waste (MSW) generation levels are about 1.3 billion tonnes per year (1.2 kg per capita per day). By 2050, it is projected that the waste generation will be doubled.

It has shown that OECD countries have the highest percentage (44%) with 32% paper waste; cover almost half of the world's waste generation, whereas Africa and South Asia produce the least waste (5%) with 57% and 50% organic waste respectively.

2. Waste hierarchy

Although many waste collection practices have been implemented in various countries, the amount of waste generation keeps increasing. An integrated solid waste management is needed in order to reduce the continuous significant increase in waste generation rates. Start by the "3Rs" strategy – reduce, reuse and recycle. However, these are only the ways to diverse waste, but cannot reduce the volume. Instead, the advanced technology, incineration, which can reduce up to 90% volume of disposed waste, is introduced.

Figure 2: Waste Hierarchy [3]

3. Incineration

A. Background

Incineration is one of the most widely used technologies for treating municipal solid waste prior to disposal at landfills. It is a thermal treatment technology used to reduce the 90% volume of waste requiring final disposal [4]. Incineration is a combustion process that uses an excess of oxygen to burn the solid wastes [5], while maintaining gas emission levels below current emission standards.

B. Benefits of using incineration to treat waste

(i) Reduction of waste volume

Incineration thermally treats bulky solids or waste while simultaneously reduces their volume by a factor of 10 or more [6]. This can effectively save the land which is used for landfill and greatly improve the ecological environment of the city.

(ii) Harmless treatment of waste

During incineration, the waste undergoes detoxification. This process eliminates hazardous properties of combustible carcinogens, pathologically contaminated materials, toxic organic compounds and biologically active materials [7]. Besides that, incineration destroys gaseous and liquid waste streams, leaving very little residues. The combustion process in incineration also dilutes the concentration of residual and non-destructible radioactive isotopes in low-level radioactive wastes, as well as sterilizes and destroys putrescible matter leading to destruction of pathogenic organisms.

(iii) Recovery of energy (waste-to-energy plant)

When large quantities of waste are incinerated, the heat of combustion or thermal energy generated can be used to produce electricity. The annual electricity production of an incinerator could afford the electricity consumption for large number of families, depending on the capacity of the incinerator.

(iv) Mitigation of environmental impact

Incineration can mitigate environmental impact, especially of organic materials that drain from landfills and of the CO_2"greenhouse gas" generated by waste management. According to an analysis by Harvard School of Public Health in Boston, Massachusetts [8], CO_2 generated by incineration is substantially less than that of the methane and CO_2 generated in landfilling operations. Destruction of waste organic matter in incineration eliminates the problem of biodegradation in landfill that leads to subsidence and gas formation that disrupts cell capping structures.

4. Principle of incineration [9]

The incineration process consists of: tipping area, combustion chamber, boiler and ash residues handling. First, solid waste collection and transfer vehicles proceed into a tipping area. Waste is continuously discharged into refuse feed hoppers. The refuse is metered out into the combustion chamber by gravity. Waste is combusted in the specially designed furnace at high temperature (>850°C) with sufficient supply of air to ensure complete burning and prevent formation of dioxins and carbon monoxide. During combustion, flue gases are heated to 982°C.

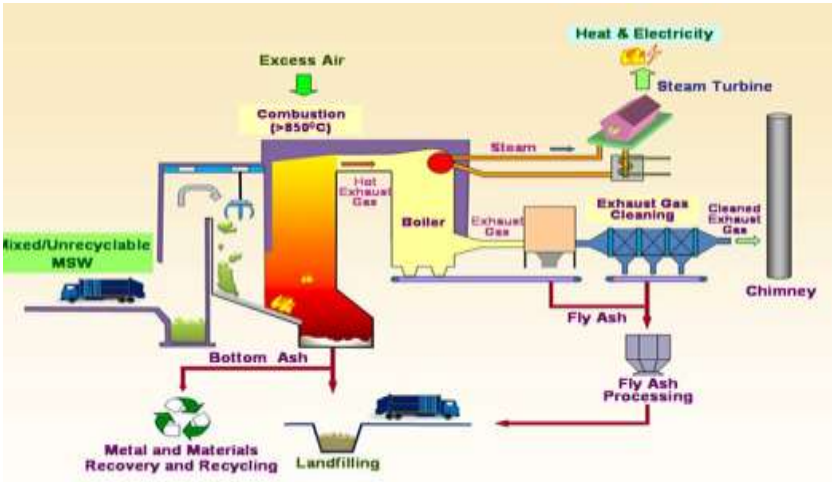

Figure 3: Typical Incineration Flowchart [10]

In the boiler, the contained water is heated to form saturated steam and dry steam. The steam then drives the turbine which is coupled to the electricity generator. The combustion process in the furnace produces bottom ash, and the air-pollution control device produces fly ash and other materials. Fly ash is stabilized and solidified by reagents, then disposed of at dedicated landfill. Mass-burn incineration mostly produces ash residues amounting to 5 – 10% by volume of incoming MSW.

5. Case studies

5.1. Case study I: Sweden

MSW Disposal Rate: 4200 thousand tonnes per year.

Sweden is chosen as a reference due to its worldwide recognition in MSW management strategy in which the UN published a document on how other countries can improve their MSW treatment from the experience of Sweden. In 2001, about 22% of MSW were treated in the landfills. However, the landfill tax, which came into force on 1 January 2000, played a vital role in the diversion of MSW from landfill in favour of recycling and incineration.

Consecutive increases in taxation level in 2002, 2003 and finally in 2006 instigated a continuous increase in material recycling of MSW. The landfill ban on sorted combustible waste in 2002 and the landfill ban on organic waste in 2005 were catalysts for the diversion of MSW from landfills. Almost 49% of waste is treated by incineration; the rest is by recycling [11].

5.2. Case study II: Tokyo

MSW Disposal Rate: 53 million tonnes per year [12] .

Tokyo has the highest number of incinerators worldwide. In 2000, the Government implemented a system of decentralisation of local government services for waste disposal. Waste in Tokyo is collected from street containers, then loaded into carts and taken to the incineration plants for further treatment. Almost 74% of the waste is treated by incineration. The largest incineration plant is Shinkoto, of which it can handle a capacity of 1800 tpd, whereas the smallest one is 200 tpd.

6. Suggestions

With the condition of escalating amount of wastes generated, it is crucial to build an incinerator to relief pressing needs of landfill. Two solutions are proposed to minimize waste generation.

(i) First solution: One Incinerator in one city

One solution to MSW problems is to build a mega-incinerator in every city. It is estimated that the one mega incinerator can cost up to USD 2 billion [13] including the cost for reclamation. For it can process over 3,000 tonnes of waste per day and possesses the least operational complexity, as well as capital and operating costs. It can also recover energy, generate electricity and improve water quality, marine ecology and fishery impacts [14].

(ii) Second Solution: Several small incinerators in different cities (about one-third mega incinerator's capacity)

The goal towards waste reduction and realization of incineration is to build smaller incinerator around one-third of the capacity of mega incinerator in different parts of every country, distributing the amount of wastes that must be transported to and incinerated in the sites. Each incinerator costs roughly USD 260 million [15]. This alternative is worth building consideration as it can offer much simpler transportation plan and waste management system.

Building smaller incinerator requires cheaper capital cost as well as operating cost. It also causes less environmental impact on the areas surrounding the plant and reduces the visual impact, which is more accepted by residents as a "part of city development".

7. Conclusion

While taking into consideration of a sustainable model and the perspectives of all stakeholders, building several incinerators at different cities and different sizes would be the best option to reduce waste.

First, it is estimated that the one mega incinerator costs much more expensive than a small incinerator. Three smaller incinerators can fulfil the capacity of a mega incinerator at the lower capital cost. Moreover, incinerators usually have a life span of 40 years. Assume similar operation costs and electric prices in mega incinerator and smaller incinerators, the smaller incinerators would have higher return on investment because of the lower capital cost. In the long term, smaller incinerators also have economical advantage that they are comparatively easier and cheaper to shut down one of the plants to cope with decreasing demand as more waste will be recycled. It is also more logistically viable because of the decentralized transportation network. Evened out transportation can be designed by heuristic approach so that an optimum cost plan can be achieved by minimizing transportation distance and time.

Second, by achieving a viable business model for the incineration facilities, the government partly addresses the concerns of other stakeholders. Building separate incineration facilities avoids the risk of investing on one big project, thus appeals to tax payers. Decentralized logistic network focuses more on efficiency of management and therefore appeals to lawmakers. In addition,

people will complain the significant visual discomfort and psychological pressure of having huge waste management facilities near their residential areas. It is also possible that some of the residents can find employment in this new industry.

Overall, the solution to the global solid waste management should be a holistic approach with the involvement of both government and citizens.

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