# A Critical Analysis of Waste to Energy Methods: Waste Incineration and Methane Recovery

As increases in population and development continue across the globe, issues of the management of this refuse have become much more acute. Although reduction, reuse and recycling have helped to curb the amount of waste that enters landfills each year, inevitably some municipal solid wastes (MSW) need to be disposed of in other ways. This paper will critically examine the benefits and consequences of the two main forms of waste to energy recovery; waste incineration and methane recovery. Followed by an examination of the policy implications as they relate to the unique situations decision-making bodies face with respect to their local waste management practices.

## Waste Incineration:

Waste incineration has been a method for dealing with waste sine the 20$^{th}$ century (Denafas and Jager, 2007). While the original motivation for this practice was likely due to the simple fact that combustion reduces the amount of waste one has to deal with, today the energy generated from incineration offers a convincing argument for this type of waste disposal.

Energy recovered from burning wastes falls under the fourth and final 'R'; recovery. From an energy standpoint, incineration is an environmentally friendly alternative to burning fossil fuels; no energy is needed to mine and refine petroleum products for combustion. The energy recovered from incineration in many cases is harvested as steam for heating purposes while many facilities convert it to electricity and sell it to power companies who add it to the grid. (MSW Thermal Treatment in Canada, 2006). This diversifies the energy dependences of a particular area with a renewable and reliable resource; in today's society there is a steady supply of the waste that fuels this process.

The next main benefit of incineration is quite simple; it is an effective way to reduce the volume and weight of waste. Putting waste in a landfill is financially expensive; sanitary landfills are costly both in the short and long term. These facilities need the initial funding for construction as well as the capital for longer-term maintenance and monitoring. On top of this there are the costs associated with lowered land values in the surrounding areas that motivate the strong resentment of these facilities on behalf of locals due to the NIMBY phenomenon. This not only damages the financial situation of the residents in the area but also has the potential to weaken the political capital, elected politicians may have from their citizens. Therefore the financial and political disincentives offer a compelling argument against relying heavily on land filling.

Despite the fact that fire reduces the quantity of waste, remnants will be left over in the form of ash. In 2006, in Canada a quarter of the original input weight prior to incineration was bottom ash, while 4% of the input emits as fly ash (MSW Thermal Treatment in Canada, 2006). Interestingly, these still substantial quantities of ash have some value both practically and financially. Ash goes through vitrification, which ensures the heavy metals are not leachable when they enter a landfill (Themelis, Kim, and Brady, 2002). This means when ash is deposited in landfill it puts less of a strain on the leachate processing systems in a sanitary landfill, saving both money and resources. Ash can also be used in construction and even as a medium to cover landfills due to is inert qualities, high specific gravity and compression rating (Themelis, Kim, and Brady, 2002). With these benefits now made clear a look at some of the negative consequences of incineration is in order.

The most significant negative outcome of incineration is the emissions that result from combustion. This air pollution has both a harmful effect on the local area and on the planets climate. Although there is no scientific consensus on whether or not fine or coarse particle sizes are to blame for the majority of negative impacts on air quality, there are substantial repercussions on local air quality (Buonanno, Ficco and Stabile 2008). These suspended particulates can wreak havoc on the human respiration system as well as being a contributing factor to photochemical smog in urban areas. In addition to the ramifications of particulate emissions, there are the toxic outputs of combusted materials. For example, in 1989 WTE facilities generated 81 tones of mercury in the US (Themelis, Kim, and Brady, 2002). When massive quantities of extremely potent substances, like mercury are released in to the air the health effects on the local population are quite harmful. Consequently, examples such as these clearly illustrate how incineration can be a threat to local human health, but unfortunately incineration has a much larger scale impact on the environment.

Greenhouse gas emissions (GHGs) mainly in the form of $CO_2$ and $N_2O$ are the main contributors to climate change through incineration (Gutierrez, 2005). Although Nitrous oxides are not as prevalent as $CO_2$ emissions they are 300 times more potent than $CO_2$ and have a lifespan up to 150 years (Gutierrez, 2005). Thus reductions in these emissions are important if waste incinerations effects on climate change are to be mitigated. One way to achieve this is to reduce the recyclable content in the waste stream. However, this comes at the cost of reduced efficiency as these items, particularly plastics are high in potential energy. (Liamsanguan, Shabbir and Gheewala, 2008). Other methods at reducing emissions are higher burn temperatures: burn temperatures between 850c and 950c are optimal if all emissions are to be minimized (Gutierrez, 2005). Nonetheless, these measures may indeed mitigate the emissions, but they in no way eliminate them, and in a world where the reduction of all GHG emissions is becoming more of a priority, the arguments against incineration in this area are quite substantial.

**Methane Recovery:**

As waste decomposes through anaerobic processes in landfill, methane is one of the main byproducts. Unfortunately the emission of this gas from our landfills in Canada accounts for 25 % of man-made methane emissions (Canada. Environment Canada, 2009). Methane is also twenty times more effective as a GHG than $CO_2$, so its impacts on climate change should not be underestimated (Themelis, Kim, and Brady, 2002). As a result, capturing methane emitting from landfills and using it for energy not only reduces its contribution to climate change, but also provides an alternative form of energy; methane can be burned as method of heating or electricity generation.

Another benefit of methane recovery is that it is not substantially affected by the removal of plastics that would otherwise dampen energy prospects of incineration facility (Liamsanguan, Shabbir and Gheewala 2008). In other words plastics do not emit much methane and therefore removing them from the waste stream does not significantly impact methane recovery. This trend would also have the added environmental benefits of reducing waste with no significant counter argument to this reduction like that of incineration.

In addition, there is a growing exploration of the possibilities for using recovered methane as an alternative transportation fuel (Muradov and Smith 2008). The use of this gas would be sustainable and very environmentally friendly as it is gathered out of a win-win scenario where emissions are reduced and energy is gained. Even so, such wide scale usage of methane as a transportation fuel is unlikely due to the fact that there are only 41 landfills in Canada that gather methane (Canada. Environment Canada, 2009).

A final and more pragmatic reason to capture methane relates to safety concerns. As methane builds up underground in a landfill it can move through the soil and waste and cause explosions if ignited (Canada. Environment Canada, 2009). Thus capturing methane before it builds up has the added benefit of public safety.

Despite these many arguments for methane recovery there is one big problem with his type of waste management; land use. Relying heavily on landfill even with methane recovery does require vast amounts of space. Indeed the emissions from this waste are harnessed for the good but the aesthetic, financial and environmental costs of such practices remain nonetheless. These costs are further aggravated in areas with less than ideal physical geography for land filling e.g. a mountainous area. Little free space and aesthetic damage to a tourist destination offer other strong arguments for incineration versus landfill; as incineration requires little space and can be implemented in varied terrain.

**Policy Implications and Conclusion:**

The policy implications for municipalities debating waste incineration verses methane recovery as both a waste management practice and a mode of energy recovery vary substantially on each unique situation. There is no universally superior option as their benefits may be more suited to the particular circumstances. For example, in a tropical climate such as Thailand, methane recovery may be a more suitable option since the increased heat and temperatures in that area make the recovery of methane more efficient (Machado, et al. 2009). Incineration in Thailand's case would also be much less ideal due to the higher than average organics content in the waste; there is less energy stored in organics than plastics for example (Liamsanguan, Shabbir and Gheewala 2008). In a case such as Switzerland which incinerates nearly all its waste, burning refuse is a much more logical option (Denafas and Jager 2007). Since Switzerland is a smaller country geographically with mountainous terrain that is not suitable for landfills incineration makes more sense as a waste to energy option.

Ideally composting and recycling are more ideal options in the fist place since the environmental effects are further minimized and in the case of organics, costs are nominal (Pickin, Yuen, and Hennings 2002). Nonetheless, current socioeconomic trends, such as the everyday practices of citizens hinder the actual manifestations of waste reduction (Themelis, Kim, and Brady, 2002). Thus, a policy maker should try to minimize the waste stream as much as possible in a given situation. Followed by a comparison of the feasibility of both types of waste to energy practices given their local circumstance.

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