Center for the study of Sustainable Use of Resources

Advancing the Goals of Sustainable Waste Management

A Comparison of Alternative Solid Waste Management Practices

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Introduction

Representatives of the landfill and waste-to-energy industries (WTE) met in Washington D.C. on January 28 to discuss issues of mutual concern. A summary of the meeting was issued previously by Nick Themelis. One of the action items from our meeting was to provide a table summarizing life-cycle studies on solid waste management. A summary table is provided below.

The table summarizes a limited number of studies in which life-cycle analysis was used to compare the environmental performance of landfills and mass burn WTE facilities. It is recognized that there are many additional studies in which life-cycle analysis is applied to some aspect of the solid waste management system. For example, Weitz et al. (2002) showed reductions in greenhouse emissions between 1974 and 1997 that could be attributed to improved operation of landfills and WTE facilities, as well as to increased recycling.

As expected, the studies are uniform in their finding that WTE is the most effective way in which to reduce greenhouse gas emissions from solid waste management. This is based on the near complete conversion of combustible organics to CO_2 and to the avoided emissions associated with energy recovery. In no case do the studies quantitatively address potential limitations such as the quantity of waste generated in a region. However, this would apply to a relatively small fraction of the total waste in the U.S.

Summary of Life-Cycle Studies Comparing Landfills and Waste-to-Energy

Objective of Study	**Functional Unit**	**Conclusions**	**Citation**
To present a set of life-cycle emission factors per unit of electricity generated for LFGTE and WTE using the MSW-DST (Municipal Solid Waste - Decision Support Tool).	Mass of MSW set out for collection (MSW = nonhazardous solid waste generated in residential, commercial, and institutional, sectors)	When the objective was to compare the per unit electricity generated, WTE was a better option than LFGTE. When comparing emissions, WTE had lower NO_x, SO_x, and PM emissions than LFGTE.	Kaplan, P. O., DeCarolis, J., & Thorneloe, S. (2009). Is it better to burn or bury waste for clean electricity generation? *Environmental Science & Technology*. 2009, 43 (6), 1711–1717
To compare SWM strategies that minimize cost and GHG emissions using the MSW-DST.	Mass of MSW set out for collection	When the objective was to minimize cost, a recyclables drop-off facility was the cheapest SWM alternative. When the objective was to minimize GHG emissions, a WTE facility was shown to be superior.	Solano, E., Dumas, R. D., Harrison, K. W., Ranjithan, S. R., Barlaz, M. A., & Brill, E. D.(2002). Life-cycle-based solid waste management. II Illustrative applications. *Journal of Environmental Engineering*, *128*(10), 93-1005
To compare two strategies for treatment of organic household waste using EASEWASTE (Environmental Assessment of Solid Waste Systems and Technologies): (1) anaerobic digestion of organic household waste, (2) combustion of organic household waste with residual MSW.	Mass of separated organic household waste in Aarhhus, Denmark	The combustion scenario may supply more dwellings with energy for heating and electricity and reduce GHG emissions. However, large energy and resource savings occur with both scenarios. The results show that the combustion of organic waste is marginally better than anaerobic digestion with regards to global warming.	Kirkeby, J. T., Birgisdottir, H., Hansen, T. L., & Christensen, T. H. (2005). Evaluation of environmental impacts from municipal solid waste management in the municipality of Aarhus, Denmark (EASEWASTE). *Waste Management & Research*, *24*, 16-26.
To analyze the validity of six SWM models on three waste treatment scenarios for CO_2 emissions: landfill, combustion, and material recovery facility. The models were ARES, EPIC/CSR (Integrated Solid Waste Management Tool), MSW-DST, IWM2 (Integrated Waste Management 2), ORWARE, and UMBERTO.	Mass of household waste in Dresden, Germany	Five of the six models agreed that the MRF scenario had the lowest CO_2 emissions, followed by either the landfill or incineration scenarios. However, the paper did not differentiate CO_2-fossil and CO_2-biomass, nor did the paper include fugitive CH_4 emissions. The results are, therefore, incomplete and misleading.	Winkler, J. & Bilitewski, B. (2007). Comparative evaluation of life cycle assessment models for solid waste management. *Waste Management*, *27*, 1021-1031.

Objective of Study	Functional Unit	Conclusions	Citation
To evaluate ten SWM options on collection, long haul transportation, recycling (including transfer stations and materials recovery facilities), combustion, and landfilling for GHG, energy consumption, nitrogen oxide emissions, and cost using the MSW-DST.	Mass of MSW	When the objective was to minimize cost, the scenario with 20% recycling and 80% landfilled waste with no gas collection and control was found to be the most cost effective option. When examining impact categories such as acidification, smog, net carbon emissions, and human health a 30% recycle rate with 70% combustion using a WTE facility generating electricity and recovery of metals was the best scenario.	Thorneloe, S. A., Weitz, K., & Jambeck, J. (2007). Application of the US decision support tool for materials and waste management. *Waste Management*, *27*(8), 1006-1020.
To evaluate alternative plans for SWM in the State of Delaware for cost and GHG emissions considering curbside recycling, yard waste composting, and WTE to divert waste from landfills. The MSW-DST model was used.	Mass of MSW set out for collection	Curbside recycling for only a fraction of the population was found to be the most cost effective strategy to achieve a state landfill diversion target. To meet GHG emissions at the minimum cost, using WTE for a fraction of the total waste was the optimal solution.	Kaplan, P. O., Ranjithan, S. R., & Barlaz, M. A. (2009). Use of life-cycle analysis to support solid waste management planning for Delaware. *Environmental Science & Technology*, *43*(5), 1264-1270.
To establish a technique for determining the carbon content of MSW and to use this technique to analyze the GHG impacts of WTE facilities and landfills. The MSW-DST model was used for the LCA.	29 million tons MSW	When the objective was to compare LCA results of WTE and various landfill designs for WTE emissions, WTE was found to mitigate more GHG due to electricity generation.	Bahor, B., Weitz, K., & Szurgot, A. (June 2008). Updated analysis of greenhouse gas emissions and mitigation from municipal solid waste management options using a carbon balance. Paper presented at the 2008 Global Waste Management Symposium, Colorado, September 8-10.
To test the validity of a waste hierarchy by evaluating different scenarios for SWM considering landfilling, combustion with energy recovery, and recycling of newsprint and PET.	Mass of newspaper and PET	When the objective was to compare LCA results of landfilling, combustion, and recycling, landfilling was found to be the least preferred option over a long period of time. As a general rule, the waste hierarchy is valid and should remain recycling, combustion, landfilling.	Moberg, A., Finnveden, G., Johansson, J., & Lind, P. (2005). Life cycle assessment of energy from solid waste- part 2: landfilling compared to other treatment methods. *Journal of Cleaner Production*, *13*, 231-240.

Legend:

LFGTE = landfill gas-to-energy
SWM = solid waste management
GHG = greenhouse gas
PET = polyethylene terephthalate
WTE = waste-to-energy
MSW = municipal solid waste
PM = particulate matter

Additional References Cited

Weitz, K..A, Thorneloe, S.A, Nishtala, S.R., Yarkosky, S., Zannes, M., 2002, The impact of municipal solid waste management on greenhouse gas emissions in the United States, J. Air & Waste Mngmnt. Asscn.. 52(9), p. 1000-11.