Comparative Impacts of Local Waste to Energy vs. Long Distance Disposal of Municipal Waste

Extended Abstract # 08

Prepared by Jack Lauber; Margretta E. Morris; Priscilla Ulloa; Floyd Hasselriis

Jack D. Lauber, PEDEE: Latham NY, Consultant to Columbia University's Earth Engineering Center jlpe37@nycap.rr.com
Margretta E. Morris: EnergyAnswers Corp. 79 North Pearl Street, Albany, NY 12207, mmorris@energyanswers.com
Priscilla Ulloa: M.S. (c) in Earth and Environmental Engineering, The Fu Foundation School of Engineering and Applied Science, Columbia University, New York, pau2102@columbia.edu
Floyd Hasselriis: PEDEE, Forest Hills, NY, BSME, Columbia University, MME, Univ. of Delaware; Member Emeritus, ASME Research Committee on Industrial and Municipal Waste, hasselriis@aol.com

INTRODUCTION

Nationally, approximately 28% of the solid waste generated is recycled. Another 55% is being disposed of at about 1,800 landfills nationwide. By contrast, only 17% of municipal solid waste (MSW) is being converted into energy through the 89 modern waste-to-energy facilities located in the United States. As the cost of energy and transportation fuels continue to rise and landfill space in large urban centers is zoned out, there has been renewed interest in assessing other viable, proven, waste management alternatives that are presently available. This paper compares the environmental impacts, as well as the most obvious economic impacts, of local, state-of-the-art facilities that combust MSW and recover electricity, heat, and metals, with the alternative of diesel truck hauling of MSW to distant landfills, as is presently the case for New York City, Toronto, and most other major urban cities.

In particular, this paper examines the comparative dioxin, particulate matter, and other air emissions of these two disposal scenarios. Different emissions can have a different impact not only on the health of local residents, but the health of our planet as well, due to global warming. In addition to these risks, the conservation of fossil fuels that are used for long-distance trucking and power generation will also be compared.

Landfill Emissions

On March 12, 1996, the US EPA New Source Performance Standards (NSPS) were issued. The main purpose of these standards was to reduce the emission of non-methane organic, compounds (NMOC) from landfills, which are implicated in the formation of atmospheric ozone. It is estimated that solid waste management practices in the U.S. contribute about 10% of total volatile organic compounds (VOC) emissions. It should be noted that the NSPS regulates large landfills (over 2.75 million tons); and requires landfills that emit more than 55 tpy of NMOC to capture and reuse, or destroy these gases.[1] During a landfill's peak production phase, a MSW landfill of 0.5 million tons capacity may produce enough NMOC to exceed the US EPA's Title V Major Source Threshold for VOC and require a permit as a point source of air pollution.[4, 20]

Currently, MSW landfills are estimated to release approximately 14,300 tons/yr of NMOC. Methane and carbon dioxide emissions released into the atmosphere contribute to the greenhouse effect, and the release of VOC cause air-quality issues such as smog and ozone formation. In the gas of a MSW landfill, VOC comprise about 39% of NMOC.[1]

Table 1[2] shows the typical composition of MSW landfill gas, listing typical NMOC. Several of these NMOC are carcinogenic, e.g. benzene, vinyl chloride, tetrachloroethylene, etc. They are present due to illicit disposal of hazardous wastes, such as dry cleaning wastes, or are formed from anaerobic degradation of other chemicals in the landfill, such as the generation of vinyl chloride from chlorinated organic wastes like trichloroethylene or tetrachlorethylene.

Table 1. Composition of typical MSW landfill gas (LFG) showing gross composition and non-methane organic compounds

Chemical	% Dry Volume	NMOC	ppmv
Methane	45 - 60		
Carbon Dioxide	40 - 55	Toluene	35
Nitrogen	2 - 5	Dichloromethane	25
Ammonia	0.1 - 1.0	Ethylbenzene	7
Sulfur Comp	0.01 - 1.0	Acetone	7
Oxygen	0.1 - 1.0	Vinyl Acetate	6
Carbon Monoxide	0 - 0.2	Tetrachloroethelene	5
Hydrogen	0 - 0.2	Vinyl Chloride	4
NMOC	0.01 - 1.0	Methyl Ethyl Ketone	3.1
		Xylenes	2.6
		Dichloroethylene	2.8
		Trichloroethylene	2.1
		Benzene	2.1

When landfill gases are either flared for disposal, or even combusted for energy recovery at the landfill, they are likely to form dioxin/furan emissions. It is known that steel and iron halides in the combustion flare can catalyze dioxin formation. In fact, a 1998 New York State Department of Health report on health effects from MSW landfills reported that women living near the studied landfills, where gas is migrating, have a four-fold increased chance of bladder cancer or leukemia.[3]

Truck Emissions

Most large urban centers transport their waste to a disposal facility outside of their geo-political boundary. Using New York City (NYC) as an example, we find that in 2004, over 3,000,000 tons of MSW from NYC were transported mainly by means of 20-ton long haul travel trailers

(92.4% by truck and 7.6% by train)[10] over long distances to other states such as Pennsylvania (63%), Virginia (34%) and Ohio (2.9%).[11]

Following an intensive campaign to recycle, if NYC were to develop two waste-to-energy facilities to combust 2 million tons of MSW per year, instead of transporting and disposing of this tonnage in Pennsylvania's landfills, it would avoid 26 million truck miles annually.[1, 12] This would avoid emissions of about 16,000 kilograms (32,000 lbs) of truck particulate emissions per year [13, 25]

It is important to note that trucking also generates dioxin emissions due to combustion of the fuel. This can occur with the combustion of any organic material with halogens, e.g. dioxins are formed in diesel engines, where the fuel contains residual chlorine from salt originating in the seawater ballast in oil tankers. A Norwegian study shows that the dioxin emissions could be as high as 8.2 ng TEQ per truck-mile[10], while a U.S. EPA study estimates 0.8 ng TEQ per truck-mile.[15] This difference may be due to the fact that sulfur content of the fuel is higher in the crude oil used by the U.S. Nevertheless, in the U.S, the sulfur content has been decreasing in the last decade so that the dioxin emissions produced by diesel trucking may also increase[14] and approach the higher European values.[19]

Another concern is the emission of polycyclic aromatic hydrocarbons (PAH) from diesel trucks. PAH are the primary reason that the California Air Resources Board (CARB) considered studying diesel emissions. PAH emissions largely contain benzo-a-pyrene (BaP) and several other polycyclic aromatic carcinogens and are a significant fraction of heavy duty diesel truck emissions. PAH emissions were previously identified from diesel trucks transporting MSW in differing states over long distances to landfills. The average emissions of PAH's was about 16 kg/day/state.[4, 20] These emissions are variable, however, and newer trucks generally do have lower emissions. Nonetheless these visible, carcinogenic PAH emissions from diesels can adversely affect the health of residents.

Health Risks

According to the National Academy of Sciences, as many as 15% of the general population suffer from multiple chemical sensitivity (MCS).[5] British environmental medicine specialist Dr. Jean Monro has stated that, "In my clinical practice I have had patients who report cases of onset of MCS from exposure to landfill sites. The syndrome often begins with generalized symptoms such as headaches, migraines, constant fatigue, muscle pain, asthma, and progresses to specific organ dysfunction."[6]

The key NMOC in landfill gas and their health effects from inhalation exposure have been previously well documented[7]. Multiple health risk studies have shown that estimated cancer health risks for exposure to MSW landfill emissions were 41 in a million, compared to estimated cancer health risks for waste-to-energy (WTE) plants of 8 in a million, respectively.[7] Generally lifetime cancer risks in excess of the 10 in a million range are considered unacceptable by health

[1] Avert truck miles = 2 * 125 miles averted * 7000 tons MSW/ day /20 tons / truck*300 days/y = 26,250,000 truck miles

risk professionals. WTE combustion may pose far less health risks than landfill exposure when impacts from diesel truck transportation of MSW are accounted for, as is discussed.

Municipal solid wastes are an inevitable by-product of our society and our economy and must be managed in an environmentally sound and health protective manner. Although few studies have compared and evaluated the health risks of landfills and waste combustion, a recent study, conducted by Pearl Moy[7] for New York City (NYC), points out that disposing of waste via landfills increases health risks 30-fold, compared with using waste-to-energy, which produces several types of energy, e.g. steam, electricity, by combusting MSW. Moy's study concluded that the emissions from diesel truck engines transporting waste to landfills resulted in a ten-fold increase in health risks in the landfill disposal option.

Global Warming Potential

There is much concern about global warming and greenhouse gas emissions. Previous greenhouse gas and global warming concerns have focused on carbon dioxide, CO_2. However, methane, $CH_{4,}$ accounts for about 18% of the greenhouse global warming effect, and is about 21 times more potent in trapping solar heat than $CO_{2.}$[8]

The basic global warming potential of the alternatives of a WTE facility and a Landfill derive from the CO_2 (carbon dioxide) and CH_4 (methane) emissions. The CO_2 emissions of a WTE facility derive from the carbon content of the waste. The CH_4 emissions from a landfill derive from the natural organic compounds in the waste. The WTE facility completes the combustion of organic carbon and hydrogen in about one hour and produces carbon dioxide and water vapor. Anaerobic decomposition of the MSW in landfills produces CO_2 and CH_4, in roughly equal quantities. In regulated landfills an estimated 60% of the generated methane is captured and either used as a fuel in turbine generators or flared. Because of the high greenhouse gas potential of methane, the equivalent carbon emissions of a regulated landfill have been estimated at about 1.3 tons of carbon dioxide higher than in the case of combustion in a WTE facility. Most important, it takes 40 to 60 years to essentially complete the degradation, if ever. What is certain, is that the waste is being stored in the landfill -- essentially indefinitely -- and threatening the environment, especially the local environment, with pollution.

Previous greenhouse gas studies comparing landfilling and combustion of MSW are limited to examinations of the emissions weighted by their relative radiative activity.[9] Computer modeling studies analyzed the atmospheric response to these greenhouse gas emissions for both MSW landfills and combustion systems, assuming 1000 tons/day MSW, a 30-year operating period, and a 70-year post closure period. In this baseline scenario, the time-integrated radiative forcing for a conventional landfill was estimated to be 115 times that of combustion.[9] A different scenario adds active gas collection at the landfill, and energy offset credits for avoided power plant carbon emissions. In this case the landfill has 45 times the radiative forcing potential of WTE combustion.[9]

Considering that gas collection systems for landfill gas generally are about 50-60% efficient[9] and that relatively few MSW landfills have such gas collection/energy generation systems, the global warming potential of landfills is a serious problem. Even the best controlled MSW landfill has about 50 times the global warming potential of a controlled WTE plant.

Waste-to-Energy Emissions

When considering WTE as a waste management strategy, the general public voices the most concern about dioxins.

Table 2, however, documents the average emissions of 95 Waste-to-Energy plants in the United States for each pollutant, including dioxins. As noted, these values are much lower than the U.S. EPA standard values.

Table 2. Comparison of 2001 Emissions from 95 U.S. WTE with U.S. EPA standard [24, 12]

Pollutant	Average Emission	EPA standard[a]	Unit
Dioxin/Furan, TEQ basis	0.05	0.26	ng/dscm
Particulate Matter	4	24	mg/dscm
Sulfur dioxide	6	30	ppmv
Nitrogen Oxides	170	180	ppmv
Hydrogen Chloride	10	25	ppmv
Mercury	0.01	0.08	mg/dscm
Cadmium	0.001	0.020	mg/dscm
Lead	0.02	0.20	mg/dscm
Carbon Monoxide	33	100	ppmv

[a] Data are reported for 7% oxygen, dry basis, and standard temperature and pressure
ng/dscm: nanogram per dry standard cubic meter
mg/dscm: milligram per dry standard cubic meter
ppmv: parts per million dry volume

During the last two decades dioxin emissions have dropped to insignificant levels in WTE facilities. In fact, in the U.S., waste-to-energy has moved from being the major source of dioxins in 1987 - 8,877 TEQ grams (or 63% of total dioxin sources measured), to being a minor source in 2002 (12 grams or 1%) of the total.[16] Moreover, the latest compilation of the WTE emission data (95 units) from U.S. EPA shows that the average dioxin emission is 0.05 ng TEQ/dscm, i.e. 2.50E-7 g TEQ/ton MSW (see Table 2). For instance, the Hempstead and Onondaga waste-to-energy facilities, both of which are mass-burn and located in Long Island NY and Syracuse NY, respectively, and the SEMASS facility, a processed refuse fuel facility, located in Rochester MA have been decreasing their dioxin emissions so that they are lower than the stringent EU dioxin emission limit (European Waste Directive (0.1 ng TEQ per Nm^3). Nowadays, these American facilities have emissions that are less than 1.0 E-6 grams per ton of MSW combusted: Hempstead: 1.0 E-7 TEQ g/ton; Onondaga: 5.2 E-8 TEQ g/ton; and SEMASS: 9.6 E-8 TEQ g/ton. [21, 22, 27]

Figure 1 shows the dramatic reduction of dioxin emissions from all the U.S. WTE plants since 1987, attained by implementing the EPA MACT controls for industrial processes and waste combustion.[23]

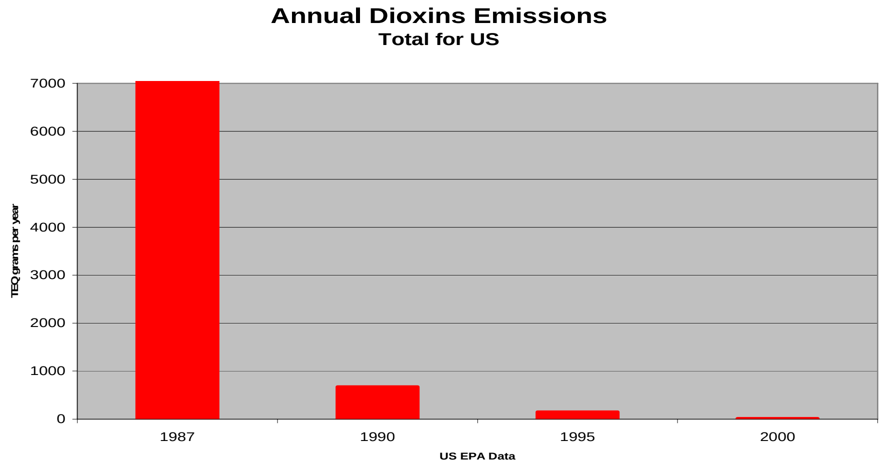

Figure 1. Annual Dioxin Emissions in the United States WTE plants.

Figure 2 compares the emissions permitted by the USEPA and the European Union with the actual emissions reported in compliance tests of a modern WTE facility in New York. The WTE facility emissions were 0.01 ng/dscm Toxic Equivalent TCDD, whereas the standards are 10 times to 30 times higher than the actual emissions.

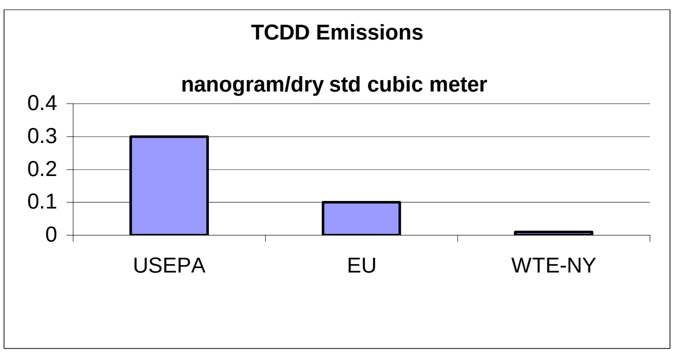

Figure 2. TCDD emissions: EPA and EU Standards
versus WTE facility in New York

The most significant contributor to the dioxin inventory in the U.S. today is the uncontrolled combustion of residential and agricultural waste ("backyard barrel burning") and the residential combustion of wood in stoves. "Backyard barrel burning" constitutes over 50% of the U.S. dioxin emissions. Extensive research has been conducted by the US EPA on this topic and the research concluded that "A family of 4 burning trash in a barrel in their backyard – still a common practice in many rural areas – can potentially put as much dioxin and furan into the air as a well-controlled municipal waste [combustor] serving tens of thousands of households…"[26]

Socio-Economic Impact

A recent study of waste disposal by NYC indicated that the city was paying $126 per ton of waste transported to Pennsylvania.[22] This cost was the total per ton billed for waste transported in containers, after they were filled in New York City, transported, and landfilled out of state.

Landfills only generate revenues derived from the tip fee or sale of captured recyclables. A WTE facility, however, has an additional revenue stream of about $40-50 per ton from the sale of generated electricity (about 550 kWh/ton MSW), in addition to the tip fee and recycling revenues. Additionally, diesel fuel prices are constantly increasing and the estimated diesel fuel cost for trucking 2 million tons of NYC MSW 26 million miles/year in the near future is enormous. Just assuming a heavy duty diesel truck mileage of 5 mpg and the somewhat current fuel costs of $2.50 per gallon, this equates to about $13,000,000 per year, projected to increase. Certainly this is wasteful as well as polluting.

Setting aside the transport and dispose (T&D) factor, however, WTE is ultimately more beneficial than the landfilling of non-recyclable waste. Factors such as the reduction of fossil fuel importation and its use in the City for power production; generation of electricity and heat for use by an adjoining community or industry; recovery of ferrous and non-ferrous metals; production of saleable products from ash residue; and the elimination of several municipal waste transfer stations all add up to a better local environment, more jobs, and more recycling. And, were NYC to construct two appropriately sized WTE facilities, they would require the long-term use of only 30 acres, over a period of 30 years, in contrast to the estimated 1500 acres (excluding the surrounding "buffer" zones), that are required for landfilling two million tons of NYC MSW over the same thirty-year period.

CONCLUSION

We have reviewed the environmental pollution, global warming and diesel transport emission problems related to MSW landfills. NYC and some other urban centers do not have such WTE facilities primarily because of the mistaken belief amongst policy makers and the public that these plants pollute. In fact, WTE facilities are still commonly called incinerators by their detractors in order to invoke memories of those plants of yesteryear that had no pollution control equipment and did not produce energy. Every modern WTE facility in the United States captures the energy value from the waste stream as well as controlling the emissions to a level that is, in many ways, better than the European standard.

Today, there are more than 600 modern, successful WTE facilities operating worldwide, including 89 in the United States, without any significant pollution. They produce much-needed, clean energy, replacing the need to mine and burn coal, oil and natural gas. The combustion residue combined with air pollution control products, yields a material suitable for construction applications e.g. roads, building materials, etc. In this way, WTE should be recognized for what it does well, i.e., converting solid waste into clean, usable energy and recycled by-products.

Also, if we choose to continue to look towards Europe for environmental standards, it must be noted that MSW landfills are now banned in Europe, largely because of global warming concerns. A recent European report[25] documents that European WTE facilities now supply the equivalent of 27 million individuals with electricity (13 million with heat). Furthermore, the EU considers the biodegradable fraction of MSW as biomass and therefore a renewable energy source. A recent German Ministry of the Environment report[17] also indicates negligible dioxin emissions from 66 WTE plants in that nation. In short, it is obvious, and exemplified by the nearly 400 WTE plants in operation in the European nations, that the Europeans remain committed to producing energy from that portion of the waste stream that is not reused, recycled or composted.

It is imperative that, as a nation, we consider and accept producing fuel from our garbage rather than wasting this resource by trucking it to distant landfills that emit greenhouse gases and spoil vast tracts of green fields. In addition, emissions from diesel trucks are far greater than the trace emissions from controlled WTE plants. Public health studies of MSW landfills repeatedly show a multitude of non-methane and chlorinated organic compounds emanating from landfills, which indicates significantly greater health risks from such emissions.

As American citizens, we must learn to conserve our energy resources and not overlook energy recovery and production from renewable sources -- such as garbage -- by burying it in landfills. WTE provides us with the opportunity to lessen our reliance on unstable or hostile nations that can economically hold us hostage due to our sole dependency on fossil fuels for energy production. We simply must replace these fuels with a variety of renewable fuels, including WTE, in order to assure our energy independence.

To conclude, while great strides have been made, and remain to be made in recycling and waste reduction in the United States, the public must be educated that using waste as a fuel to produce energy is yet another form of recycling. Today’s idealists promote "zero waste" as a solution -- and we should reduce, reuse and recycle as much as possible -- but zero waste is a practical impossibility. Rather, “zero disposal” should be our goal, which can then avert the conversion of more and more green fields to landfills, thus making our environment worse and wasting valuable fuels and energy. We must make WTE conversion a priority in order to best protect our environment and conserve our energy resources.

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