CENTER FOR A COMPETITIVE WASTE INDUSTRY

Landfill Gas to Energy Compared to Flaring

There is growing understanding that composting is always greatly preferable to landfilling, with or without energy recovery, notwithstanding the industry claim that, since methane emissions are a given, it is better to productively utilize the latent energy to generate electricity.

For it is not true that methane must be generated when managing our organic discards. There are proven commercial alternatives in wide use today for managing our municipal solid wastes (MSW) that do not produce significant volumes of uncontrolled methane(CH_4). Methane does not exist in our discards. In fact, of the several means of managing discards, only one – landfilling – produces major volumes of uncontrolled methane in the process. This happens because, when foods scraps and soiled paper are buried in the ground, oxygen is quickly depleted and, methane gets generated as a byproduct of decomposition by anaerobic bacteria. Methane is an especially powerful greenhouse gas (GHG), between 23 and 103 more potent than carbon dioxide (CO_2), as a function of whether long term or short term concerns are considered. Therefore, if landfilling organic materials were phased out, uncontrolled methane from our discards – and its massive warming impacts – would essentially be eliminated.

Because of this fact (along with the many other debilitating problems with landfills), the European Commission ordered its member nations, with 25 countries and a population of 490 million, to effectively phase out landfilling of organic discards by 2020.

In North America, where national waste policy has been wanting, 124 local governments with an aggregate population of approximately 10 million are now in the process of also diverting organic discards from landfills on their own initiative. Instead, they are composting those organics to produce humus to restore fertility to our depleted soils, which have lost half their foot thick layer of topsoil in the last century, and continue to lose 10,000 pounds per acre each year. This new and growing trend to composting is not only happening in "green", upscale cities such as San Francisco, but also in places such as Toronto, a big city with almost 5 million people, half of whom are new immigrants, and the continent's most successful organics recovery program.

The benefit from addressing climate change at its source, instead of with end-of-pipe measures, can be better appreciated when it is recalled that the methane released from anaerobic decomposition in the ground has *at least* **23 times** the warming potential of CO_2.Thus, viewed from this perspective, there is much greater reduction in GHGs by removing organic discards from landfills. Even Environmental Protection Agency's (EPA) own grossly understated numbers examined below show that ***diverting one metric ton of organics from landfills will avoid <u>ten times</u> as much GHGs as LFGTE***.

With regard to existing landfills some believe that, since the garbage has already been buried and can no longer be processed separately, there it is better to recovery the energy – assuming it were possible to demarcate what section of an open facility consists of existing vs. new wastes, which it is not.

However, the facts described below show that, even when landfill-gas-to-energy (LFGTE) is compared to just flaring, the industry analyses, which focus on the avoided emissions of CO_2 at displaced power plants, provides a fatally incomplete picture. As explained below, the operational changes that are necessary to generate electricity create more uncontrolled methane, with 23 to 103 times that of CO_2, that override any benefits at existing landfills, too.

1. ***The proportion of methane in landfill gas is not a constant.*** The proportion of methane in the landfill gas produced at sites that just flare gas, compared to ones that recover the methane to generate electricity, is not fixed in both at 50%, as the typical studies incorrectly state.[1]

In fact, landfills that are properly operated under the "dry-tomb" principles codified in 40 CFR Part 258 to minimize infiltration of liquids and that maximize gas capture, as intended by 40 CFR Part 60 Subpart WWW, produce gas with such low methane fractions that there is insufficient Btu content to economically generate electricity. Only by deliberating operating a landfill in a way dramatically increases moisture and significantly decreases gas collection efficiency can sufficiently high methane content be produced for making power.

As organic matter decomposes anaerobically in a landfill, gas is generated as a byproduct consisting largely of carbon dioxide and methane, as well as a mix of hazardous air pollutants and other trace compounds. But the actual proportion of methane varies as a function of whether the prerequisites for optimal methanogenesis are present. Along with the absence of oxygen, temperature, pH and microorganisms, the limiting condition is moisture, which needs to be between 40%-70%, depending upon which study is referenced, with the greater weight to the higher end of the range:

> "[I]n many landfills the available moisture is insufficient to allow for the complete conversion of the biodegradable organic constituents in the MSW. The optimum moisture content for the conversion of the biodegradable organic matter in MSW is on the order of 50 to 60 percent. Also in many landfills, the moisture that is present is not uniformly distributed."[2]

Yet average incoming waste has entrained moisture levels of approximately 20%, ranging from 15%-40%[3] (with Arizona and Washington State being obvious outlyers that do not affect the general rule). Also, the very fact of collecting gas can extract part of the moisture as water vapor in excess of infiltration.

Therefore, absent something more – which will become critical later – because there is insufficient moisture in the waste mass for optimal methanogenesis, the CH4 fraction in landfill gas may be 45% or perhaps 35%, when the conditions are not optimal, and 60%, when they are.[4]

2. ***Power engines require high methane levels.*** Ninety-two percent of the landfills that generate electricity do so with reciprocating internal combustion engines (ICE), which are less

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1 EPA, *Frequently Asked Questions About Landfill Gas and How It Affects Public Health, Safety, and the Environment* (October 2006).

2 George Tchobanoglous, *Integrated Solid Waste Management: Engineering Principles and Management Issues* (McGraw-Hill, 1993), at p. 393. Others suggest that optimal range lies between 40% - 70%. Debra Reinhart and Timothy Townsend, *Landfill Bioreactor Design & Operation* (Lewis Publishers, 1998), at p. 140. Still others have done research suggesting full methane conversion does not proceed until moisture levels reaches 60%-70%. G. J. Farquhar, "Gas Production During Refuse Decomposition." 2 *Water, Air and Soil Pollution* 9, at pp. 483-495 (1973). *See, also*, 67 FEDERAL REGISTER 346462 (May 23, 2002).

3 Tchobanogolous, at, pp. 72 to 73.

4 Tchobanogolous, at p. 382. Again, different studies use somewhat different ranges down to 35%.

tolerant for low methane gas than turbines.[5] ICEs need, for example, a minimum methane ratio of 50% to start or propane will be required to do so.[6] Moreover, with ICEs geared to burn natural gas containing 70% to 90% methane levels, there is a further economic incentive for landfill owners to do what it takes to generate more than the minimum methane level to create as high Btu mix as possible.

3. ***LFGTE sites are deliberately managed to increase moisture.*** Therefore, due to these two facts, landfills managed for energy recovery are operated very differently than landfills managed for maximizing gas capture. They typically do one of several things, or a combination of them, to increase moisture –

(i) Turning off gas collection wells on a rotating basis in order to give each field time to recharge moisture removed by the extraction process itself.

(ii) Damping vacuum pressure in wells when imperfections in the cover permit oxygen to be drawn into the waste mass from the surface, along with the landfill gases from the surrounding waste mass. While landfills that just flare gas can accept 5% oxygen infiltration before risking igniting fires, those recovering energy are restricted to as low as 0.1% because methanogenesis depends upon an oxygen starved environment.

(iii) Delaying installation of the final cover in order to encourage infiltration by precipitation, snow melt and runoff.

(iv) Recirculating leachate and regrading the slopes for drainage.

(iv) Adding outside liquids.

These efforts to increase moisture have a further economic attraction for the industry, which accentuate pressure to do so. Those same measures tend to also accelerate decomposition and subsidence, thereby enabling the landfill owner to recover and resell about 20% of the landfill's airspace. When the operator considers which tactics to use to increase moisture – all of whom will degrade collection efficiency – the short term payoff for recovering air space will be a significant consideration, regardless of the fact that capture rates will suffer. For there are no field measurements of uncontrolled landfill gas to provide a check on short term profit motives.

Landfills that invest in equipment to produce energy also tend to focus the distribution of gas collection wells at the center of the landfill where the highest volumes of methane rich gas are concentrated. This provides less collection capacity at the site's periphery.

4. ***Landfills that flare generate lower than normal methane ratios.*** Conversely to the influences on landfills that recover energy, landfills that flare need only focus on maximizing gas capture without running up against cross purposes. Those that do properly manage their landfills will be able to exert more negative pressure than facilities that recover energy. This is because increase vacuum forces tends to draw more oxgen from the surface into the gas wells. The limiting condition for oxygen infiltration by landfills that flare is <5%, which relates to causing combustive conditions). That is 50 times greater than can be tolerated at landfills that recover energy, which is <0.1%, relating to poisoning methanogenesis.

The effect on gas ratios from overdrawing is substantial. Instead of methane ratios of 55%

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5 EPA, Landfill Methane Outreach Program database.

6 Charles Bader, *Landfill Gas Projects: Retail Cost-Deferrals*, MSW Management (Feb. 2004).

or more, methane drops to about 35%, as well as improving capture rates by 5% to 15%.

5. ***Practices that increase moisture decrease collection efficiency.*** By doing one or more of these operational practices at landfills that maximize gas recovery, two critical things happen to the amount of methane generated and released:

(i) The methane fraction of the total volume of landfill gas generated must be increased; and, in order to accomplish that,

(ii) Gas collection efficiency necessarily declines.

This fact is not controversial. The landfill industry has conceded that as much in testimony arguing that the California Air Resources Board ought not judge the industry's overall ability to capture gas by the experience at LFGTE sites:

> "Furthermore, a site with a collection system that is used solely for energy recovery is usually not capable of achieving as high a collection efficiency as compared to one that is compliant with NSPS regulations."[7]
> http://competitivewaste.org/documents/LFGTE-CAIndustryWhitePaper.pdf

6. ***Displaced power generation is cleaner than ICEs.*** The idea that LFGTE displaces dirtier power plants arose in an earlier era, whose salient characteristics no longer exist. Thus, not only does the industry view ignore the dominant issue, which is the fact that energy recovery is associated with more methane releases, but also the benefits they claim do not exist.

(a) Renewable Portfolio Standards. When this contention was developed, the controlling regulatory framework for small independent power producers to sell electricity back to the grid were governed after 1978 by the Public Utility Regulatory Policies Act (PURPA), which for the following 20 years compelled utilities to purchase power produced by qualifying facilities at the utility's avoided cost, which was a multiple of its less favorable wholesale rates that otherwise would govern. Under PURPA, it was the utilities' power plants that were displaced whenever any qualifying facility sold electricity to the utility.[8] However, in 1999, PURPA was repealed.

Today, most LFGTE is generated in the 25 states with Renewable Portfolio Standards (RPS) that require or encourage their utilities to provide some part of the electricity they sell, generally from 5% to 20%, from qualified "renewable" sources of energy.[9] Although, the resources that were consumed in extracting and manufacturing the materials we discard are not, in fact, renewable, LFGTE is qualified in all those states, along with traditional renewables like wind power. However, electricity generated at wind farms typically costs more than from landfill gas. Therefore, the utility will usually first chose LFGTE, the least expensive source to meet their portfolio requirements, and then proceed to move up the cost chain to more expensive sources like wind until its portfolio requirements are met. This suggests that, in RPS states with more supply than demand for renewable power, LFGTE will crowd out portfolio purchases of wind

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7 Solid Waste Industry for Climate Solutions, *Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills* (Jul 2007), at 10.

8 §210 of the Public Utility Regulatory Policy Act of 1978.

9 Lori Bird et al.,*Green Power Marketing in the United States: A Status Report* (20th Ed.)(2007) (prepared for DOE NREL), at p. 19. LMOP Database. Of the 90 LFGTE projects owned by Waste Management in the data base, for example, 77% (on a gas generation-weighted basis) are in RPS states.

power, which produces no pollution, not a dirty fossil fuel utility plant. If portfolio demand exceeds supply, on the other hand, both wind and landfill gas will co-habitat the portfolio to their maximum extent. In that case, dispatching will largely be determined by the normal operation of the ISO described next.

(b) Independent System Operators. Under traditional state regulation of utilities, LFGTE not only displaced utility power plants, it also tended to replace dirtier generating units. However, today more states have changed to an auction system administered by Independent System Operators (ISO) that determines the dispatching order of utility and independent generating units. Under the auction system in which the least expensive bidded generation is used first and the more expensive last, the ISO is more likely to displace the most expensive new combined cycle gas turbines that use expensive natural gas than the old fully depreciated coal units with less expensive fuel. These turbines, however, emit about 790 pounds per MWH, compared to 2,040 lbs./MWH for the dominant ICEs.[10] In most states without RPSs but with auction dispatching, this substantially lower displaced emission rate pertains.

7. ***Hazardous air pollutants from landfills.*** Today, the focus is on global warming, and landfills' responsibility for greenhouse gases. But, at the same time, it ought not be forgotten that more methane with less controls, especially at the periphery closest to neighbors, significantly increases the threats to public health from landfills. For more methane at LFGTE sites mobilizes more of the hazardous volatile compounds, more of which will escape. Otherwise, much of those toxics would tend to be flushed out with the leachate.[11]

Although most attention today has focused on landfills' methane emissions because of their warming impacts, those HAPs include toxic compounds such as "vinyl chloride [that] can adversely affect the central nervous system and have been shown to increase the risk of liver cancer in humans, while benzene is known to cause leukemia in humans [and the] degree of adverse effects to human health from exposures to these HAP can range from mild to severe."[12] Studies suggest that adverse effects have been observed, such as fourfold increases in bladder cancer and leukemia in women living near landfills.[13] Unfortunately, because EPA has not provided adequate funding for epidemiological research, the poorly funded studies to date have not been sufficiently sophisticated to tease out localized impacts from the wider population in order to establish statistical significance.

But, we do know enough to see that LFGTE also tends to add to the toll to public health at the same time as it significantly increases the quantity of greenhouse gases in the atmosphere.

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The attached spread sheet is an analytical tool to model these salient, but until now ignored, factors necessary to determine the true bottom line GHG impacts of energy recovery compared to just flaring in existing landfills.

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10 DOE EIA, *Assumptions to the Annual Energy Outlook* (2006).

11 56 FEDERAL REGISTER 24473 (May 30, 1991); 61 FEDERAL REGISTER 9909 (March 12,1996).

12 68 FEDERAL REGISTER 2229 (January 16, 2003).

13 State of New York Department of Health, *Investigation of Cancer Incidence and Residence Near 38 Landfills With Soil Gas Migration Conditions, New York State, 1980-1989* (1998); Paul Elliot, "Risk of adverse birth outcomes in populations living near landfill sites," 323 *British Medical Journal* 363 (Aug. 2001); 56 FEDERAL REGISTER 24472 (May 3, 1991).

It makes it possible for anyone to substitute alternative input assumptions to see how they affect the result. The takeaway lesson from that interactive process is extremely important.

No matter what assumptions one uses from within the zone of reasonableness, the answer is always the same. In addition to the fact that any of the alternatives to landfilling produce magnitudes less greenhouse gases, even at existing sites where the garbage has already been buried, landfilling here too always releases more GHGs.

Within the range of most uncertainty, the outputs show that existing landfills that generate electricity produce between 19.3% and 39.2% more GHGs than flaring in the long term, and, in the short term, 34.1% to 53.7%. Ironically, for those who believe landfills capture considerably more gas than reflected in those runs on the spreadsheet, the conclusion remains the same. This is the case because, although the total emissions from flaring and energy recovery are reduced, the difference between them, which is what is being measured, is not.

Even in existing landfills, generating electricity always releases more climate-changing gases than simply flaring the gas that escapes.