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WASTE-TO-ENERGY BIOGENIC CARBON DIOXIDE REDUCTIONS AND USEPA'S GREENHOUSE GAS REPORTING MANDATE – WHAT DOES THE FUTURE HOLD?

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ABSTRACT

On October 30, 2009 the U.S. Environmental Protection Agency (USEPA) promulgated the Mandatory Reporting of Greenhouse Gases (ghg) across virtually every industry sector in the U.S., including Waste-to-Energy (WTE) plants, emitting over 25,000 metric tons of carbon dioxide (CO_2) equivalent emissions per year. In conformance with 40CFR part 98, subpart C stationary fuel combustion sources, WTE plants were required to report 2010 CO_2 emissions by September 30, 2011, and annually thereafter by March 31st. A key element of this process involves the quarterly collection of flue gas samples for characterization of mean biogenic CO_2 content. While this rule is in its infancy, it is clear that the Agency intends to regulate CO_2 emissions, especially the anthropogenic fraction, across all industry sectors. Currently, **ecomaine's** sample results for its municipal waste combustor (MWC) contain, on average, 60% biogenic carbon with the remaining 40% fraction characterized by anthropogenic carbon. As **ecomaine** begins to optimize the removal of organic material through stepped up recycling efforts and the phase-in of large-scale composting operations, it is plausible that the biogenic carbon fraction will diminish over time, leaving a growing fraction of the less desirable anthropogenic carbon. Based on USEPA's 2010 *Municipal Solid Waste in the U.S. – 2009 Facts and Figures* report *(EPA-530R-10-012),* the organic fraction of municipal solid waste is approximately 62.5% by weight before recycling. The successful diversion of even ½ this material away from **ecomaine's** MWC could result in a measurable reduction of biogenic carbon, possibly reversing the biogenic:anthropogenic fraction to 40%:60%. This paper will explore strategies, including Life Cycle Analyses of WTE, recycling, and composting operations that the WTE industry can employ to help frame anthropogenic carbon emissions in a better light and stave off future regulatory sanctions as the climate change debate advances to a new level in the years ahead.

KEYWORDS: Biogenic carbon dioxide (CO_2), anthropogenic CO_2, greenhouse gases (ghg), Waste-to-Energy (WTE), USEPA's ghg rule, ASTM D7459-08, ASTM D6866-06, Recycling and Composting Carbon Credits, WTE Life Cycle Studies.

INTRODUCTION

Waste-to-Energy (WTE) plants emitting over 25,000 metric tons of CO_2 equivalents per year are now required to report their emissions to USEPA each year in early spring (by March 31st) [1]. This mandate was driven, to a large extent, by USEPA's "Endangerment Finding" on December

7, 2009, where the Agency concluded that "…current and projected concentrations of the six key well-mixed greenhouse gases – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) — in the atmosphere threaten the public health and welfare of current and future generations" [2].

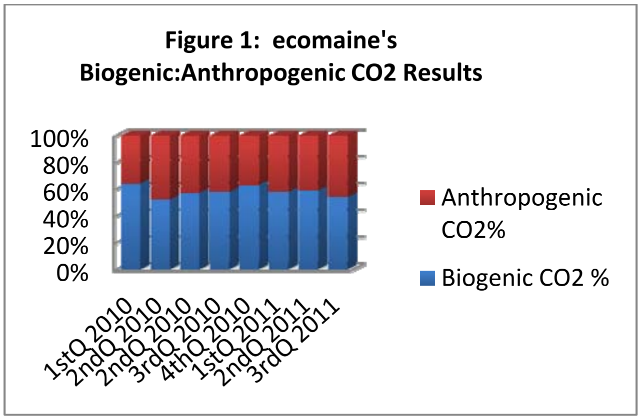
The methodology for reporting ghg to USEPA is via the "e-GGRT" web-based platform, which stands for "electronic greenhouse gas reporting tool" [3]. Currently, e-GGRT requires WTE facilities to report mean annual metric ton average emissions of biogenic, or plant-derived, CO_2, the anthropogenic or petroleum-derived CO_2 fraction, methane, and nitrous oxide.

To distinguish between biogenic and anthropogenic CO_2 in flue gas, WTE's must employ two specific American Society for Testing and Materials (ASTM) Methods: ASTM D7459-08 [4] to assure the proper sample collection methodology and the second, ASTM D6866-08 [5], a specific laboratory analysis that uses radiocarbon (C14) to "fingerprint" the ratio of fossil-based carbon dioxide to carbon-neutral biogenic CO_2. This test compares the quantity of a decaying carbon isotope that remains in a sample to how much the same sample would contain if it were composed completely of recently grown materials (Note: There is currently a single laboratory in the United States, Beta Analytic in Miami, Florida, that can comply with this test method).

While reporting of ghg's under USEPA's rule is on an annual basis and represents a "rolled up average" biogenic and non-biogenic CO_2 fraction, WTE plants must collect a representative biogenic stack sample quarterly [1]. As stipulated in ASTM D7459-08, samples are collected at a constant rate from stationary emission sources. **ecomaine** draws its sample from a flue gas line that services the backup continuous emission monitoring systems (CEMS) equipment. The sample collection rate of the flue gas is 1 liter per minute (1L/min). The ASTM protocol calls for a 24-hour leak-check to confirm the integrity of the tedlar sample bag prior to overnight courier to the lab. Results are often possible within 1 week.

BIOGENIC: NONBIOGENIC SAMPLING RESULTS

At the time of submission of this paper, **ecomaine** (and the rest of the U.S. WTE industry) has collected seven quarter's of biogenic sampling data since the inception of USEPA's ghg rule. **ecomaine's** CO_2 sampling results (Figure 1 below) over this period demonstrate reasonable uniformity among biogenic vs. fossil-based CO_2 percentages, with the biogenic component ranging from 52 – 64%.



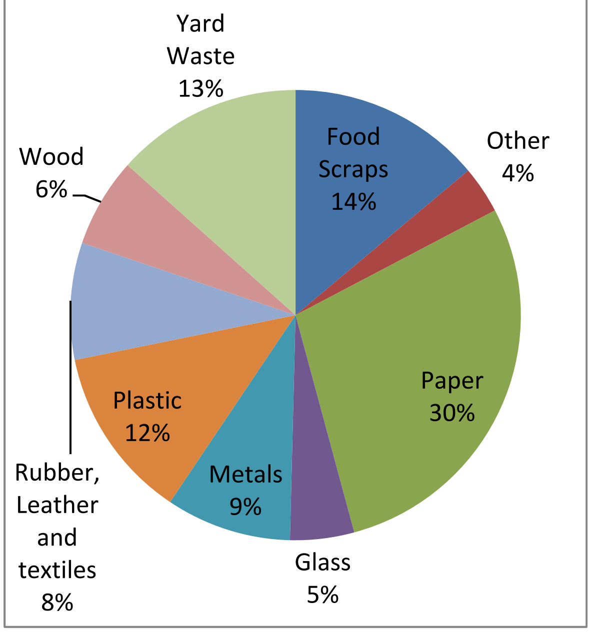
DOING THE RIGHT THING

The State of Maine identified a solid waste management hierarchy in 2007 that articulates Reduce, Reuse, Recycle, Compost, WTE and finally Landfill [6]. **ecomaine** strives for continuous environmental improvement and strongly embraces the Hierarchy by advocating upper tiers as part of its business plan, confirming the compatibility of recycling and WTE [7]. In 2007, **ecomaine** expanded its recycling program by adopting a single-stream processing technology which removed a greater fraction of biogenic fiber from the municipal waste stream. **ecomaine** is currently investigating the feasibility of implementing a municipal composting program, which will also remove a portion of the organic waste from its fuel source at the WTE. As noted in Figure 1, **ecomaine** has been collecting data on the composition of its flue gas in conformance with EPAs ghg mandate. It stands to reason that the current ratio of biogenic:anthropogenic 60%:40% will be altered as more organic waste is removed from the fuel source. How then can a WTE demonstrate that a decline in biogenically-derived CO_2 in flue gas is acceptable yet still strive for outcomes consistent with Maine's solid waste management hierarchy?

THE TREND OF LOWER BIOGENIC CARBON MSW SOURCES

Based on USEPA's most recent characterization (Figure 2 below) of the composition of different source categories that comprise MSW (pre-recycling), during this snapshot in time, it appears that MSW contains approximately 63% by weight of materials contributing to the biogenic fraction [8].

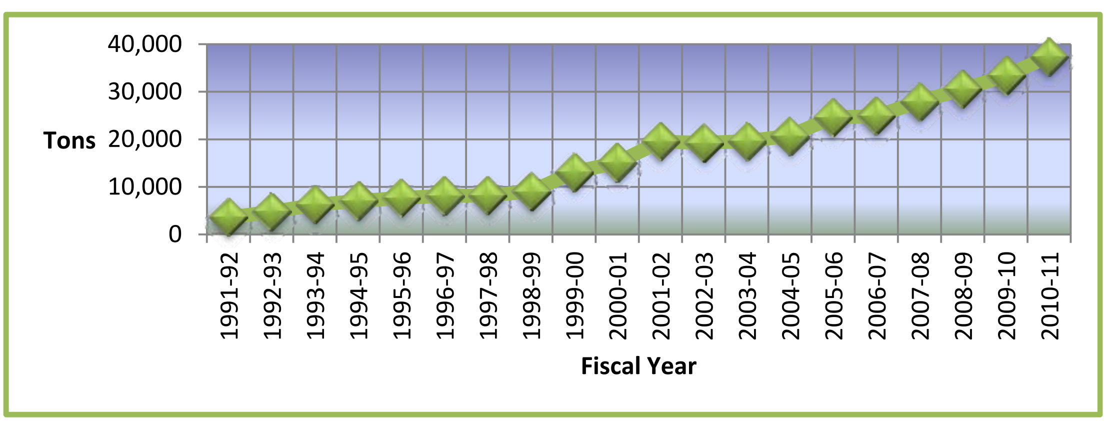
Figure 2: Total MSW Generation (by material), 2010
250 Million Tons (before recycling)
USEPA 2011 [6]



With diversion of some of these materials for re-processing (recycled materials) or re-purposed into soil amendment and energy in the case of composting/digestion, the total available fraction of biogenic carbon will begin to diminish. It is unclear how fast this shift will occur. In **ecomaine's** case, our owner and contract communities have steadily increased recycling tonnages year-over-year as noted in Figure 3 below over the 20-year evaluation period. This increased recycling rate is a function of three factors. The first is increased education outreach by **ecomaine** to communities regarding the ease of single sort recycling (if it is easy, people will do it). Second, each town that recycles a ton of material directly translates to a ton that does not come to the WTE plant. Towns only pay a tipping fee for MSW in-bound to the WTE. With municipal budgets stressed during the economic downturn, this per ton cost savings has been a particular ray of economic hope. Finally, **ecomaine** has prospected for additional communities' recycling material to optimize the tonnage flow through the single sort plant.

From a WTE-plant operational standpoint, the reduction of in-bound biogenic carbon is likely a net benefit, as the organics in MSW often contain high moisture and therefore represent a lower BTU fuel that can contribute to incomplete combustion if not augmented with expensive fossil-based natural gas in **ecomaine's** case. Thus, a paradox is created – removing organics from the municipal waste stream may improve facility operations but their removal may reverse the current biogenic:anthropogenic CO_2 emission ratios. If USEPA elects to treat all anthropogenic CO_2 emissions the same in years to come, and regulate their release, this could become a costly proposition for the WTE industry as a whole.

Figure 3: ecomaine's Fiscal Year Recycling Tonnages



HOW WILL OUR INDUSTRY COPE WITH EVENTUAL ANTHROPOGENIC CO_2 EMISSION REGULATIONS?

As an industry, it is incumbent upon us to take a leadership role in helping to ensure that good science prevails as we collectively make our case. Fortunately, we have some data at our disposal that suggests WTE operations are net *negative* contributors to ghg releases when one takes into account the life cycle of certain aspects of the operation, including:

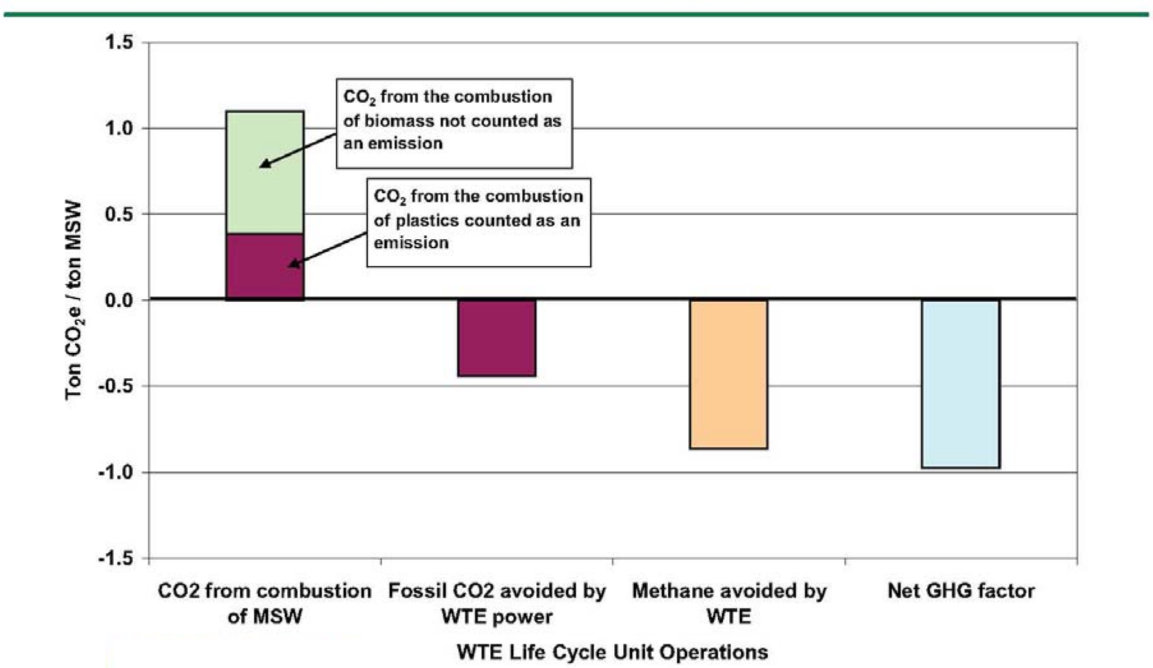
- The electrical and thermal energy produced from combusting MSW was not produced with fossil fuels. Therefore, WTE's help displace the need for using fossil fuels and their associated ghg's.

- Metal (ferrous and non-ferrous) recovered pre-combustion and post-combustion can be recycled into new metal. Metal recycling saves enormous quantities of energy and water and dramatically reduces pollution.

- A ton of MSW combusted is a ton of MSW not entombed in the earth where microbes break it down and release methane gas (among other pollutants). USEPA considers methane to be more than 20-fold more effective compared to CO_2 at trapping heat in the earth's atmosphere and therefore more detrimental to global warming [9].

When all of these factors are taken into account, net CO_2 emissions look like the summary characterization shown below in Figure 4 (courtesy of the Energy Recovery Council):

Figure 4: Life Cycle Evaluation of WTE Operations



Thus, from this example, combusting one ton of MSW actually *saves* the equivalent of 1 ton of CO_2 emissions, based on avoided fossil emissions during power generation and avoided methane production by not landfilling the waste. Nevertheless, as increasing quantities of biogenic carbon are removed from the WTE waste stream, less positive benefit will accrue at the end of a site-specific life cycle analysis (LCA) process. For integrated waste management operations, this is where the concept of being able to accrue non-WTE operation carbon credits will be beneficial. For example, if the complete business entity involved a WTE plant, recycling, and composting operation, LCAs could be completed for each operating unit to arrive at the net benefit in CO_2 emissions reduction. In theory, CO_2 emission debits and credits should be able to be summed together to arrive at a single "facility-specific" positive (bad) or negative (good) result. In this way, anthropogenic CO_2 emissions can be offset by biogenic emission credits accrued as a result of the recycling and composting operation LCA, in the case of the example given.

TOOLS FOR CONDUCTING LCAs AT VARIOUS WASTE MANAGEMENT OPERATIONS

While there are undoubtedly countless commercial software packages and still more specialists available for hire to conduct your site-specific LCA(s), these authors believe in screening analyses and a phased-approach, wherever possible. In that spirit, USEPA has a number of user-friendly web-based tools to help you navigate through this process. General information on the LCA process can be found at http://www.epa.gov/nrmrl/lcaccess/. To actually begin to "crunch the numbers", a model of particular utility is USEPA's Waste Reduction Model (WARM), whose primary focus is to "…help managers and policy-makers understand and compare the life cycle GHG and energy implications of materials management options…"[10]. The program is available for use either as a web-based platform or by downloading an Excel spreadsheet. Tables 1 and 2 below show a truncated screenshot of the input data screen (they are a single table in WARM). For illustration, a few values (aluminum cans, steel cans, and PET) have been populated to show hypothetical before and after results. The left hand portion of the input table addresses current processing rates by commodity type (referred to as the baseline case). Table 2 (the right hand portion of the WARM input table below) offers the user the option of adjusting any input category tonnage (up or down) to see the overall impact on metric tons of carbon dioxide equivalents ($MTCO_2E$) for the alternative case. The model will also prompt you to answer a series of questions relating to where in the nation you are located (factors in regional electricity issues), whether you are comparing to re-manufacturing using virgin material inputs or some recycled content, whether any of the material goes to a landfill and, if so, whether methane is captured and either used for the generation of electricity or flared off. Transportation emissions are also captured by the model, so you will need an estimate of mileage between each of the integrated MSW and composting facilities.

Table 1: WARM Baseline Input Values

Material	Tons Recycled	Tons Combusted	Tons Generated
Aluminum Cans	50.0	15.0	65.0
Steel Cans	100.0	25.0	125.0
PET	4.0	8.0	12.0

Table 2: WARM Alternative Scenario Input Values

Material	Tons Source Reduced	Tons Recycled	Tons Combusted
Aluminum Cans	5.0	55.0	5.0
Steel Cans	-	110.0	15.0
PET	-	6.0	6.0

Finally, when all of the appropriate input categories are complete, you simply click on the “Summary Report” tab to view output results (Table 3 below). In our simple example, the changes made between the baseline and alternative scenarios saved an additional 156 metric tons of CO_2 equivalents. This is a very useful tool for conducting a sensitivity analysis of your facilities to help pinpoint those aspects that might be contributing the most to either ghg generation or effective ghg offsets.

Table 3: WARM Output (Metric Tons of CO_2 Equivalents)

GHG Emissions Analysis -- Summary Report

GHG Emissions Waste Management Analysis for ecomaine
Prepared by: Mark Maritato
Project Period for this Analysis: 12/12/11

GHG Emissions from Baseline Waste Management (M

Commodity	Tons Recycled	Tons Combusted	Total $MTCO_2E$
Aluminum Cans	50.0	15.0	(680)
Steel Cans	100.0	25.0	(218)
PET	4.0	8.0	6

GHG Emissions from Alternative Waste Management Scenario (MTCO2E):

Commodity	Tons Source Reduced	Tons Recycled	Tons Combusted	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$
Aluminum Cans	5.0	55.0	5.0	(827)	(147)
Steel Cans	0.0	110.0	15.0	(221)	(3)
PET	0.0	6.0	6.0	(0)	(6)
					(156)

This is equivalent to:

Removing annual emissions from	28.48	Passenger Vehicles
Conserving	17,651	Gallons of Gasoline
Conserving	64,794	Cylinders of Propane Used for Home Barbeques
Conserving	0.81	Railway Cars of Coal

Beyond using interactive tools like USEPA’s WARM model, by proxy, other previously published LCA industry reports might be useful. One example already presented above was the results for a WTE summarized by the Energy Recovery Council. The limitation with any of these existing analyses is that they may or may not have all of the elements appropriate for your operation (or they may contain too many). Thus, you will have to do some legwork to find one study that comes close to the characteristics of your WTE plant, recycling facility, or composting plant. A comprehensive composting LCA that these authors are aware of was published by C. Morawski in BioCycle in 2008 and titled “Composting – Best Bang for MSW Management Buck” [11]. For recycling, the reader is referred to a McKinsey & Company (2009) study titled “Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve” [12]. Finally, a recent (2011) study commissioned by Wecycle “Screening LCA of E-Waste Recycling” [13] could help to shed some light on how to take credit for positive CO_2 emissions offsets in the event your waste management facility is proactively involved with the recycling of electronic waste.

SUMMARY

It is likely that, at some point in the foreseeable future, non-biogenic WTE CO_2 emissions will be viewed more pessimistically by state and federal regulatory bodies. Because the mass of anthropogenic CO_2 emissions from the typical WTE plant in the U.S. and beyond is not inconsequential, the industry may increasingly be put on the defensive to counter claims that their operations are not net emitters of anthropogenic CO_2 and other greenhouses gases. Efforts to divert an increasing percentage of organic material away from the WTE tipping floor, through positive environmental stewardship programs involving recycling and composting, could exacerbate this issue by resulting in an inverted ratio of perhaps 60% anthropogenic: 40% biogenic CO_2 emissions. The industry will need to rely more on quantitative tools to present site-specific analyses demonstrating favorable CO_2 offsets.

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