Food Waste Diversion Greenhouse Gas Analysis: Portland, Oregon

Prepared for

City of Portland
Office of Sustainable Development
Solid Waste and Recycling Division

By

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Abstract

The purpose of this report is to determine the environmental impacts of diverting food waste, generated in Portland and discarded at Columbia Ridge landfill in Arlington, to a composting facility at Three Mile Canyon Farm in Boardman. The findings suggest diverting food waste from landfill would result in:

- no significant change in the carbon dioxide emissions from transportation
- **a remarkable decrease of 0.1 % to 0.4% per year of Multnomah County's total greenhouse gas emissions**

Assumptions

- Each pound of methane gas traps 23 times as much heat as a pound of carbon dioxide[1].
- The Arlington or Columbia Ridge (CR) landfill is 151 miles from the Metro transfer station.
- Three Mile Canyon (TMC) is 159 miles from the Metro transfer station.
- A truck carrying food waste will need to drive an extra 8.75 miles to TMC.

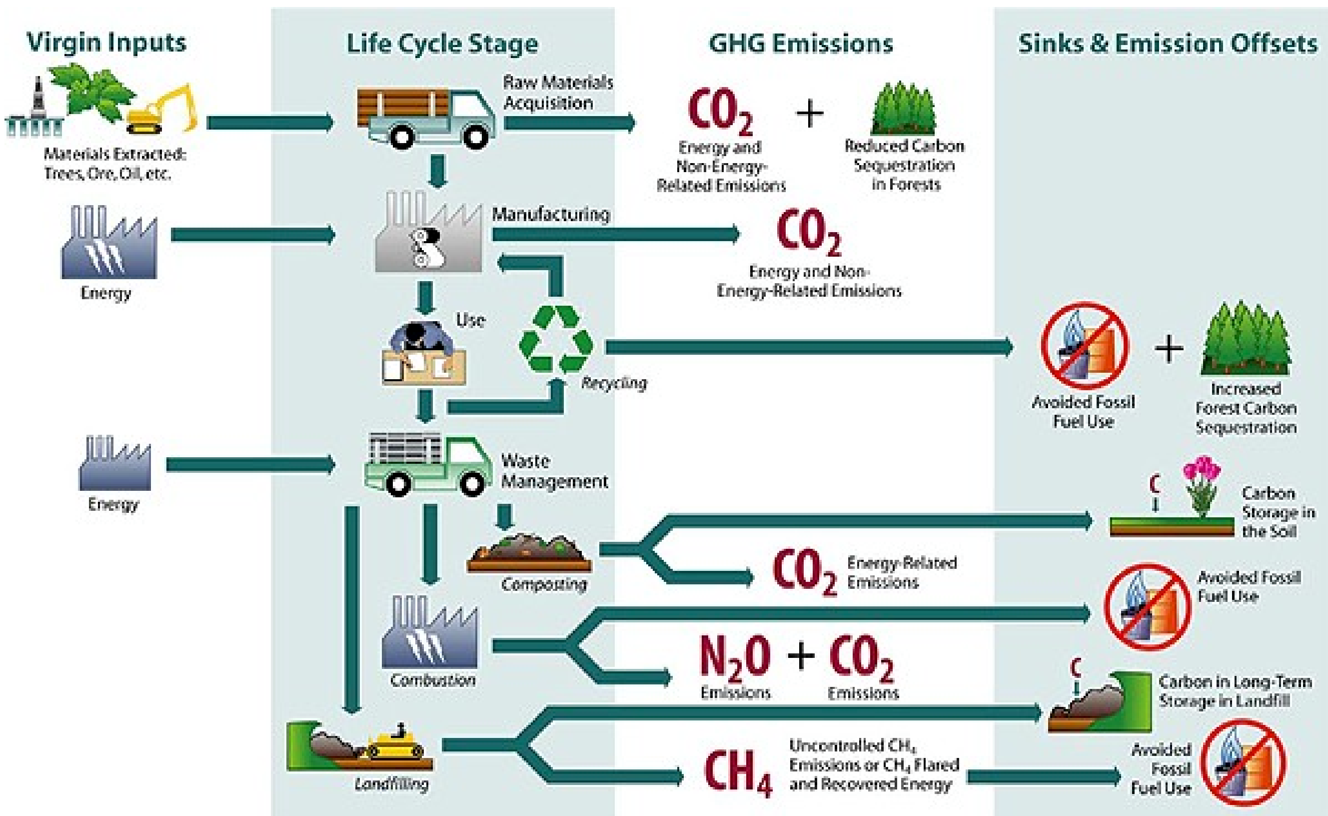
[1] U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001, Final Version*, April 2003.

Food Waste and Greenhouse Gas Generation

The U.S. Environmental Protection Agency (EPA) has performed the most complete national study on climate change emissions and sinks from solid waste management practices[2]. In 2000, the United States generated 232 million tons of municipal solid waste (MSW), indicating an increase of 13% over 1990 generation levels, and a 53% increase over 1980 generation levels[3]. Nationally, food discards represent approximately 11.2% of total MSW. In Portland, approximately 15.6% of the total commercial and residential MSW is comprised of food waste[4].

Virtually every step in the life cycle of MSW produces greenhouse gas (GHG) emissions. GHG emissions such as carbon dioxide (CO_2) and methane are produced during the collection, transfer, disposal, and management of MSW (see EPA diagram below).

Diagram 1. Greenhouse Gas Sources and Sinks Associated with the Material Life Cycle



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[2] U.S. Environmental Protection Agency, *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, June 2002.

[3] U.S. EPA Office of Solid Waste, *Municipal Solid Waste in the United States*: *2000 Facts and Figures*, EPA (2002), p.2.

[4] Metro 2002.

Landfills are the nation's largest emitter of methane, a gas that is 23 times more potent than CO_2 as a GHG. Landfill methane production is due primarily to the anaerobic decomposition of organic matter in municipal solid waste. Certain materials within mixed solid waste, such as food discards and office paper, produce more methane per wet ton than most other MSW materials. For example, one wet ton of food discards produces 16.2% more methane per wet ton than the average wet ton of mixed solid waste. While food waste produces more methane per wet ton decomposing in a landfill scenario, the EPA concludes from available information, interviews with composting experts, and data from the U.S. Department of Agriculture that methane generation (CH_4) from centralized compost piles is essentially zero[5].

After a careful review of current literature, existing empirical data, and consultations with leading compost soil scientists, the EPA estimates that composting food waste diverted from the landfill actually produces a net decrease of 0.82 metric tons of carbon dioxide equivalent (CO_2E) per ton of food waste [6]. This figure again assumes zero net emissions from composting, while landfill methane generation estimates embedded in the calculation reflect a projected national average for landfill methane recovery in 2002. Therefore, according to the EPA, removing food waste from landfill through composting can produce a net decrease in total methane emissions.

Amount of Methane Produced at Columbia Ridge

Methane recovery systems installed at landfills, as well as the emerging technology of bioreactors, present opportunities for energy recovery at landfills. In the case of bioreactors, current research suggests there is the possibility for a net increase in energy generation through recovery[7]. Bioreactors are a technology that may present opportunities for energy generation in the future, but are currently not a reality at Columbia Ridge. Currently, Columbia Ridge has a landfill gas (LFG) recovery system in place that flares methane. During the flare process all energy recovery potential is lost through the burning of methane into an end product (primarily CO_2) where the methane's GHG effect has been mitigated.

Manufacturers of LFG systems claim 70-75% of the methane produced at a landfill can be recovered.

[5] U.S. Environmental Protection Agency, *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, June 2002, section 5.1.1, pg. 66.
[6] U.S. Environmental Protection Agency, *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, June 2002. "Carbon dioxide equivalent," or CO_2E, is a measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents ($MMTCO_2E$)" or "million short tons of carbon dioxide equivalents ($MSTCO_2E$)." The CO_2E for a quantity of gas is derived by multiplying the mass of the gas by the associated GWP. For example, the GWP for methane is 24.5. This means that emissions of one million metric tons of methane make the same contribution to global warming as emissions of 24.5 million metric tons of CO_2.
[7] Morton A. Barlaz, P. Ozge Kaplan, S. Ranji Ranjithan and Robert Rynk. "Evaluating Environmental Impacts of Solid Waste Management Alternatives", Biocycle, October 2003, p. 52-56.

While several cells at Columbia Ridge landfill have the LFG system in place, many other open cells do not, resulting in what appears to be a significantly lower recovery rate at the Arlington site compared to the average rate for recovery systems that EPA assumes in its modeling[8].

Estimates of how much methane is produced by the landfill have increased over the last five years. In a June *1997 Landfill Gas Collection and Control System Design Plan* submitted to DEQ by Columbia Ridge Landfill, it was estimated that 18.5 million cubic meters of methane emissions would be produced in the year 2003. More recently, SCS Engineers, an engineering consulting firm that manages Columbia Ridge for Waste Management (WM), estimated that in 2003 the landfill would release 23.7 million cubic meters of methane [9]. Finally, this researcher was told that when WM recently submitted a report to DEQ for permitting purposes, it estimated that Columbia Ridge would produce 25.5 million cubic meters of methane in 2003[10].

DEQ and EPA rules and regulations for methane recovery systems require computerized readings and reports to monitor the amount of methane being captured. WM recently estimated that 70-75% of the methane produced at the Columbia Ridge landfill is captured[11]. However, data provided for the amount of methane captured in their LFG system suggest a lower capture rate. Figure 1 shows the figures from February-July 2003 for methane recaptured in million cubic feet.

Figure 1.
Amount of methane captured in million cubic feet at the CR landfill facility by month in 2003.

Month	**CH4 captured in million cubic feet**
February	15.8
March	18
April	17
May	17.4
June	16.5
July	17
Ave. per month	**16.95**

Source: WM, 2003 conversation with Phil Kovacs 10/16/03

The monthly average from Figure 1 of 16.95 million cubic feet of methane captured at Columbia Ridge converts to 5,762,040 cubic meters per year, or 5.8 million cubic meters. When compared to the most current estimate of methane production at the landfill (25.5 million cubic meters) it appears that only 22.6% of the total methane is being captured. This is far from the 70-75% methane recovery estimate provided by WM.

[8] U.S. Environmental Protection Agency, *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, June 2002.
[9] Personal communication of Dana Visse with Phil Kovacs, WM, 10/16/03.
[10] ibid.
[11] ibid.

In 2002, DEQ reported that WM collected 450-550 cubic feet per minute of methane from landfill in their recapturing system[12]. When converted to cubic meters and estimated for one year, this figure represents only a 26.2% capture rate when compared to the 25.5 million cubic meters of methane produced[13].

Table 1 shows the total estimated amount of methane produced in 2003 and the amounts recovered under varying recovery rates. These amounts have been converted into equivalent metric tons of CO_2.

Table 1. Methane Production and Recovery at Columbia Ridge Landfill in CO_2E

	Total	75% LFG recovery	26% LFG recovery	22% LFG recovery
Methane (million m^3)	25,500,000	19,125,000	6,700,000	5,800,000
CO_2E (metric tons)	418,856	314,142	110,052	95,269

The DEQ permit for the Columbia Ridge landfill is currently under review. WM has been asked by DEQ to resubmit its permit application due to errors in calculating other aspects of the air quality impacts of the site. Given the low performance of the gas recovery system at the landfill, DEQ is working with WM on a plan to increase the recovery system's effectiveness with the aim of reaching a 70-75% methane capture rate[14].

Measuring Greenhouse Gas Savings from Food Waste Diversion

While the EPA predicts an average decrease of methane emissions when diverting food waste from landfill to compost, it is important to look more specifically at Portland's situation to adequately estimate the likely environmental impacts.

The City of Portland's goal is to divert at least 40%-60% of the 37,000 tons of food waste sent to landfill each year. Metro, the regional government, plans to eventually divert 45,000 tons of food waste each year from the 23-city area in Metro's jurisdiction, of which Portland is the largest by population. Each of these diversion scenarios will be assessed in comparing food waste composting to landfilling.

A model developed by the EPA provides the most credible and site-specific estimate of the net change in methane emissions when diverting food waste from landfill to a composting facility.

[12] Email correspondence from John Straughan of DEQ to Michael Armstrong at City of Portland, Office of Sustainable Development, November 5, 2002.
[13] While the data for recaptured methane come from 2002 and the estimate of methane production is for 2003, together they provide the most favorable estimate of capture rate that can be derived from available data.
[14] Current EPA regulations under the Clean Air Act require many larger landfills to collect and combust LFG. There are several compliance options, including flaring the gas, or installing an LFG use system.

The Waste Reduction Model (WARM) was developed to help solid waste planners and organizations track and voluntarily report GHG emissions reductions from several different waste management practices. The WARM model compares two different waste management strategies -- a baseline generation and management strategy such as landfilling food waste with an alternative management scenario such as composting food waste. The WARM model calculates the probable GHG emissions or sinks in CO_2E that result from a makeup of different variables, including:

- distance to landfill,
- distance to compost facility,
- tons of MSW disposed,
- presence of a gas recovery system at the landfill, and, if there is a gas recovery system, whether it is for flaring or recapturing energy, and
- percentage of efficiency at which the gas recovery system operates.

The GHG emission factors embedded in the WARM model were developed following a life-cycle assessment methodology using estimation techniques developed for national inventories of GHG emissions. EPA's report *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks* describes the methodology in detail[15].

For the Columbia Ridge case, the following variables were used in the WARM model:

Baseline Management Scenario to Landfill from City of Portland

- Distance to landfill = 151 miles
- Food scraps = 14,800 tons/ year at a 40% diversion rate, 22,200 tons/year at a 60% diversion rate, and 45,000 tons/year under Metro goals
- Flare landfill gas recovery system in place
- Landfill gas recovery system estimated at 26%[16] and 75%

Alternative Management Scenario to Compost Facility from City of Portland

- Distance to compost facility = 159 miles
- Food scraps = 14,800 tons/ year at a 40% diversion rate, 22,200 tons/year at a 60% diversion rate, and 45,000 tons/year under Metro goals
- Food scraps sent to compost facility

The results of the WARM model indicate savings in CO_2E at both current and projected landfill gas recovery rates, as shown in Tables 2 and 3. With current operations at the landfill, diverting the food waste to compost would save roughly between 14,500 and 44,000 tons CO_2E. Even with the landfill gas recovery system at Columbia Ridge operating at the desired 75% capture rate, there are significant savings in CO_2E by composting the food scraps.

[15] Report: EPA 530-R-02-006. Free copies are available at http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf or call EPA's RCRA hotline at (800) 424-9346.

[16] This figure is rounded from the estimate of capture rate discussed in footnote 13.

Table 2. GHG Savings from Composting Food Waste: 26% LFG Capture Efficiency		
Portland Diversion Rate	GHG Savings*	Net Decrease Mult. Co. emissions**
40%	14,493	0.14%
60%	21,638	0.22%
Metro Goal of 45,000 tons	44,167	0.44%
* in metric tons of carbon dioxide equivalent		
**Multnomah County currently emits 10 million metric tons of carbon dioxide equivalent		

Table 3. GHG Savings from Composting Food Waste: 75% LFG Capture Efficiency		
Portland Diversion Rate	GHG Savings*	Net Decrease Mult. Co. emissions**
40%	6,514	0.07%
60%	9,771	0.10%
Metro Goal of 45,000 tons	19,805	0.20%
* in metric tons of carbon dioxide equivalent		
**Multnomah County currently emits 10 million metric tons of carbon dioxide equivalent		

GHG Considerations of Transporting Food Waste to Compost Facility

Each day, roughly 70 to 80 full trailers of MSW travel one-way from the Metro transfer station to Arlington, five days a week. The seven-axle tractor-trailers carry 48 tons gross weight. The maximum tonnage payload allowable (not counting the tractor) is 32 tons. Metro reports an average of 30.5 tons per payload. Each truck gets roughly 5 to 5.5 gallons per mile[17]. Approximately 22.4 pounds of CO_2 are emitted per gallon of diesel gas consumed[18].

Jennifer Erickson at Metro's Solid Waste and Recycling division stated that the type of truck planned for the transfer of food waste is yet to be determined and will depend on decisions made by the company contracted to haul the material. However, she estimates they will likely use a smaller five-axle tractor trailer, estimated at 40 tons gross weight with an allowable 26 ton payload. Metro estimates in the beginning of the food waste program that five trucks a week will travel to Three Mile Canyon carrying 26 tons each, for a total of roughly 130 tons per week. Eventually, Metro hopes to divert 45,000 tons of food waste per year. To account for the likely increase in diversion over time, it is appropriate to compare the difference between one truck that heads to landfill against one truck that heads to the compost facility.

[17] Personal communication of Dana Visse with Jennifer Erickson, Metro, 10/23/03.
[18] *Emissions Factors, Global Warming Potentials, Unit Conversions, Emissions, and Related Facts*. Compiled by ICF Consulting, 1999.

A truck carrying food waste is estimated to receive a slightly better fuel efficiency of 6 miles per gallon due to its lighter gross weight and payload size. If one truck carries 26 tons of food waste to a compost facility, this is roughly equivalent to 85% (at 30.5 tons) of a typical MSW truck headed to Columbia Ridge. For calculation purposes for every food waste truck driven to Columbia Ridge landfill, roughly 1/0.85 a truck heads to Three Mile Canyon.

Scenario 1: Transporting Food Waste to Columbia Ridge Landfill
1 truck x 2(151 miles) x 22.4 lbs. CO_2/gallon x 1/5.5 mpg x 1 metric ton/2205 lbs. = 0.56 metric tons of CO_2 emitted per truck/ per roundtrip

Scenario 2: Transporting Food Waste to Three Mile Canyon Compost Facility
1 truck x 2(159 miles) x 22.4lbs. CO_2/gallon x 1/6 mpg x 1 metric ton/2205 lbs. = 0.54/ 0.85 (to account for smaller capacity of food waste trucks) = 0.64 metric tons of CO_2 emitted per truck/ per roundtrip

Carbon Dioxide from 1 Truck to Landfill – Carbon Dioxide from 1 Truck to Compost = - (0.08 CO_2)

Transportation GHG Emissions Findings
For every truck headed to the compost facility, there is a net *increase* in carbon dioxide by .08 CO_2 based on transportation emissions. Diverting 40% of Portland's food waste will require 570 trips to the composting facility each year, resulting in a net increase in CO_2 emissions by 46 metric tons per year. This figure is dwarfed by the estimated greenhouse gas *savings* of approximately 6,500- 14,500[19] metric tons achieved when diverting the food waste from the landfill. Moreover, this figure does not take into account the potential for back haul, whereby, for every truck of food waste delivered to Three Mile Canyon a full truck of compost could return to Portland. Currently, Three Mile Canyon sends trucks to Portland each week full of finished compost generated by their yard debris composting operation. Alternatively, for every truck of food waste delivered to Columbia Ridge, an empty truck returns to Portland.

In considering the management choice of diverting food waste from landfill to a compost facility, the impact in transporting food waste to the compost facility therefore does not have a significant impact on the overall greenhouse gas benefits.

If Metro achieves its goal of diverting 45,000 tons of food waste, there would be a net increase in CO_2 emissions of just 138 metric tons attributable to transportation changes, as compared to a potential savings of approximately 44,000 tons CO_2E from diverting that amount of food waste from landfill.

[19] 6,500 metric tons saved with landfill gas recovery efficiency at 26%, 14,500 metric tons saved with landfill gas recovery efficiency at 75%. See Tables 5 and 6.

Discussion of Findings

Diverting food waste from landfill to a composting scenario produces significant changes in the overall production of greenhouse gases. Multnomah County currently generates 10 million metric tons of CO_2E per year. Given current estimates of methane production and capture at Columbia Ridge, CO_2E savings from diversion to composting correspond to a 0.1-0.4 percent annual decrease in local greenhouse gas emissions. Even with significant improvement in methane capture at the landfill, local greenhouse gas emissions would decrease by approximately 0.1-0.2 percent. While this reduction seems small, it represents a significant accomplishment, particularly given the upward trend in total GHG production occurring nationally and globally.

Table 4 shows the estimated reduction in GHG from food waste composting relative to the amount of LFG produced and recovered at Columbia Ridge. Diverting food waste for composting saves a significant amount of CO_2E when compared to the reduction in GHG emissions from the gas recovery system currently operating at the Columbia Ridge landfill. Composting would save the equivalent of 14-40% of the total methane currently recovered at the landfill. If the higher LFG recovery rate of 75% is achieved, savings from composting would equal 2-6% of the methane recovered. Depending on the level of methane recovery, composting food waste saves an amount equal to a minimum of 2% and as much as 11% of the total methane produced.

Table 4.
GHG Savings from Compost vs. LFG Recovery and Production

	Compost savings as % of current LFG recovery (26%)	Resulting savings as % of total methane produced	Compost savings as % of projected LFG recovery (75%)	Resulting savings as % of total methane produced
40% diversion	14%	3%	2%	2%
60% diversion	20%	5%	3%	2%
Metro goal: 45,000 tons	40%	11%	6%	5%

Conclusion

The WARM model shows that, with current operations at the Columbia Ridge landfill, diverting 40-60% of Portland's food waste will reduce greenhouse gas emissions by approximately 14,500 CO_2E to 21,600 metric tons CO_2E each year. If the goal set by Metro of diverting 45,000 tons of food waste is met, roughly 44,000 metric tons CO_2E would be saved.

The level of landfill gas recovery affects the potential savings of CO_2E. As the methane recovery rate improves in the future, as is expected with DEQ oversight of the site's permit, the benefits of diverting food for composting still exist but at reduced levels. Tables 5 and 6 summarize the reduction in GHG under current and projected gas recovery rates and show the equivalent savings in:

- Taking cars off the road each year[20]
- The amount of GHG produced by vehicle miles driven each year
- The CO_2 absorption benefit provided by trees each year[21]

Table 5.
Annual GHG Reduction at Current Estimated LFG Efficiency (26%)

	GHG's saved (metric tons)	Cars off road per year	Vehicle miles reduced per year	Equivalent trees planted per year
40% diversion rate	14,493	2,663	31,957,065	2,458,236
60% diversion rate	21,638	3,976	47,711,790	3,670,138
Metro goal: 45,000 tons	44,167	8,116	97,388,235	7,491,403

Table 6.
Annual GHG Reduction at Projected LFG Efficiency (75%)

	GHG's saved (metric tons)	Cars off road per year	Vehicle miles reduced per year	Equivalent trees planted per year
40% diversion rate	6,514	1,197	14,363,370	1,104,875
60% diversion rate	9,771	1,795	21,545,055	1,657,312
Metro goal: 45,000 tons	19,805	3,639	43,670,025	3,359,233

[20] 1 lb. of carbon dioxide is produced per one mile traveled. On average cars drive roughly 12,000 miles per year.
[21] Trees absorb approximately 13 pounds of carbon dioxide per year according to the American Forest and Paper Association, US Forests; Facts and Figures 1995. This estimate changes depending upon the age and type of the tree, and its surrounding climate. According to a 1993 figure from the Trust for Public Land, a single mature tree can absorb carbon dioxide at a rate of 48 lbs./year and release enough oxygen back into the atmosphere to support 2 human being, http://www.coloradotrees.org/benefits.htm.