An Evaluation of the Assumptions Underlying Environmental Assessments of Montgomery County's Resource Recovery Facility

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About the Fellow

Katy Koon is a Master of Public Policy candidate at the University of Chicago Harris School. She earned her B.A. in English from Clemson University in 2017 and spent the following year working as a program facilitator for public high school students interested in advanced STEM subjects. Additionally, she assisted in a research project seeking to tell a more accurate and inclusive history of her undergraduate institution. Before beginning graduate school, Katy interned at a nonprofit based in Anchorage, where she worked on a publication to help facilitate discussions in rural Alaskan villages about clean energy and lower electricity costs. At Harris, her interests center on energy and environmental policy.

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EXECUTIVE SUMMARY

Background

The County Executive has expressed an intention to close the Resource Recovery Facility (RRF), also known as the Dickerson incinerator, at the end of its current service agreement. Two tools, the United States Environmental Protection Agency's **Waste Reduction Model (WARM)** and Sound Resource Management's **Measuring Environmental Benefits Calculator (MEBCalc)**, can help local governments decide among alternative municipal solid waste management scenarios. Understanding the assumptions underlying these modeling software options clarifies the differences between each tool's recommendations. The key assumptions evaluated in this report are as follows:

- How does each tool consider biogenic emissions in its carbon accounting methodology?
- What is a reasonable estimate for the energy offsets created by waste-to-energy (WTE) facilities?
- At what rate of methane capture would a landfill's greenhouse gas (GHG) emissions breakeven with the emissions from a WTE facility, and would this rate be reasonable to assume?
- Over how long of a time horizon should GHG emissions from WTE and landfilling be considered?
- Do the levels of pollutants emitted from the RRF and allowed by the facility's current permit regulations pose a threat to human and environmental health?

Main Findings

1. **Improved diversion** through increased recycling and composting could change the County's need for WTE or landfilling.
2. The models' differing assumptions (i.e. the decision not to consider **biogenic emissions**) create biases towards preferred scenarios.
3. Assumptions of a **100-year time horizon** and a **local landfill gas capture rate of 75%** are reasonable.
4. Based on available data, it cannot be concluded that **emissions from the RRF contain levels of dangerous pollutants that threaten human and environmental health**. Levels of metals, dioxins and furans, and other pollutants are below regulatory standards.
5. Models can offer estimates from a general perspective, but **currently available data is not sufficient to use them to conclude on a waste management strategy for the County.**

INTRODUCTION

Definitions

Important definitions to introduce at the beginning of this report are biogenic waste and emissions, methane capture, life cycle assessment, and carbon accounting. Biogenic waste refers to refuse that is comprised of organic materials, like food waste, wood, paper, and yard trimmings. Biogenic emissions, then, refer to carbon released into the atmosphere through the decomposition or combustion of biogenic materials. Methane capture describes the capability of a landfill to catch methane, a greenhouse gas (GHG) more harmful than carbon dioxide, and store these emissions before they are released into the atmosphere. Additionally, methane captured by landfills can be used to produce energy. The term life cycle assessment refers to a methodology used to quantify and interpret various materials' impacts, from the time they are sourced through their disposal and eventual decomposition. Life cycle assessments can rely on different assumptions and consider timeframes of varying lengths, which can lead to discrepancies in interpretations. Most commonly, the research cited in this report considers a timeframe of 100 years. Carbon accounting describes the methods used to measure the amounts of GHGs released into the atmosphere. The way carbon is accounted for relies on assumptions like whether to include biogenic emissions in the count of total emissions. Later sections of this report will evaluate assumptions like those mentioned in the definitions of these key terms.

BIOGENIC WASTE & EMISSIONS

Waste comprised of organic materials, like food scraps, paper, wood, yard trimmings. Emissions from these materials are released through decomposition or combustion.

METHANE CAPTURE

The capability of a landfill to catch methane, a GHG more harmful than carbon dioxide, and store these emissions before they are released into the atmosphere.

LIFECYCLE ASSESSMENT

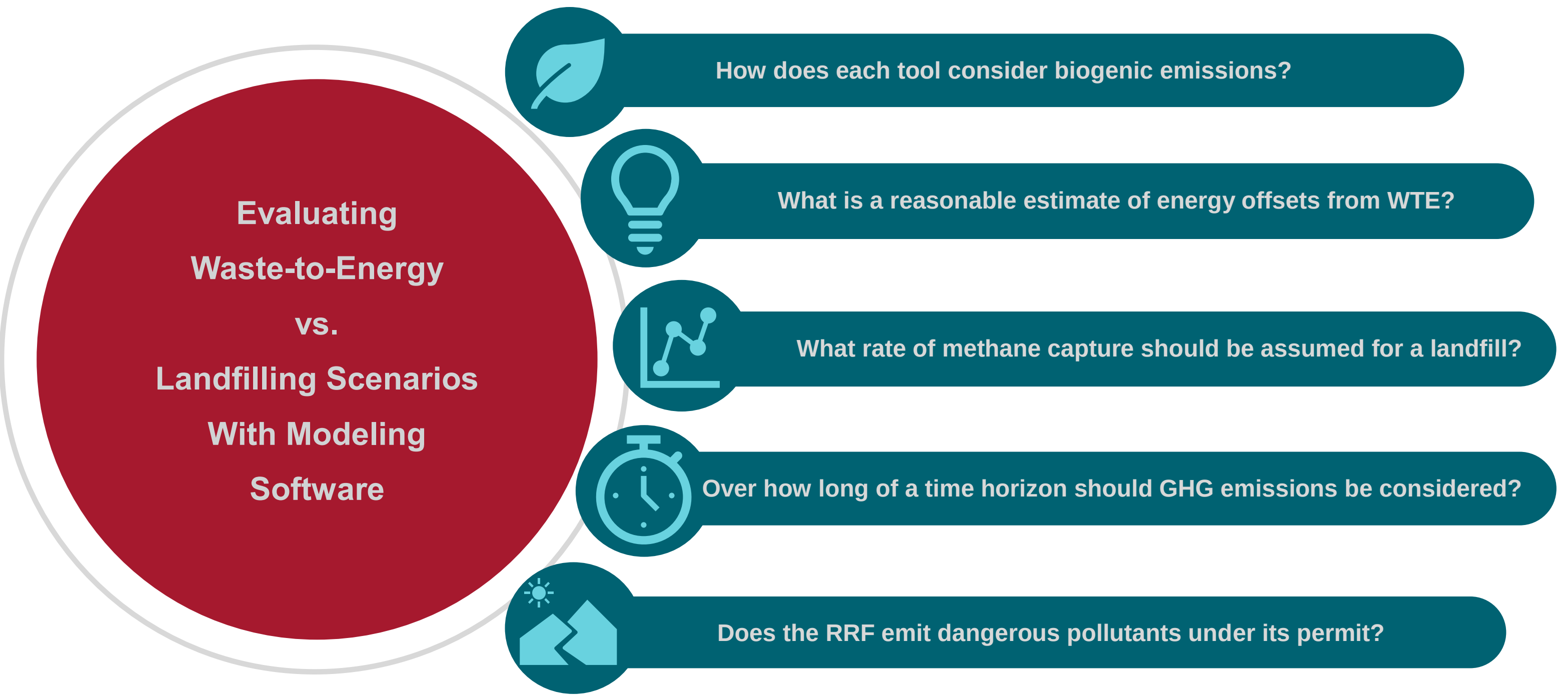
A methodology used to quantify and interpret various materials' impacts, from the time they were sourced through their disposal and eventual decomposition.

CARBON ACCOUNTING

The methods used to measure the amounts of GHG emissions released into the atmosphere.

Key Research Questions

How do assumptions concerning biogenic carbon emissions, landfill methane capture rates, time horizons, and energy offsets for waste-to-energy (WTE) processes affect the modeling tools used to assess the environmental impacts of waste management practices? Why might two different modeling techniques yield different recommendations? Where do the assumptions differ, and what assumptions are most reasonable to make? Ultimately, what course of action should the County take to best manage its municipal solid waste?



This report aims to investigate the assumptions underlying the two models presented during the June 10, 2019, Aiming for Zero Waste Task Force meeting: the United States Environmental Protection Agency's (EPA) Waste Reduction Model (WARM) and Sound Resource Management's Measuring Environmental Benefits Calculator (MEBCalc). Each tool is a software that compares municipal solid waste systems and their environmental impacts across various categories. The purpose of WARM and MEBCalc is to help local governments make decisions about how to manage solid waste in a cost-effective manner while also minimizing negative environmental impacts. The methods of solid waste management that WARM considers include reduction of materials in the waste stream, recycling, WTE combustion, landfilling, anaerobic digestion (a process that breaks biogenic waste down using bacteria), and composting.[1] The waste management strategies that MEBCalc considers include recycling, source reduction, composting, anaerobic digestion, landfilling with methane capture and using the gas to generate electricity with internal combustion engines, landfilling with methane capture and flaring the gas, WTE combustion, and industrial boilers using solid waste as fuel instead of coal or natural gas. MEBCalc uses emissions data from the EPA in its calculations.[2] WARM and MEBCalc each offer estimates of environmental impacts, but they measure these impacts differently and therefore may come to different conclusions depending on their underlying assumptions. In addition to the energy and environmental impacts that WARM considers, MEBCalc compares waste management strategies across categories including human and ecosystem health impacts. One key difference between WARM and MEBCalc is that WARM is a free and publicly available tool, whereas MEBCalc is proprietary software. The goals of this research were to assess the methodology of the two tools, highlight where assumptions differed, explain differing rationales, and offer an evaluation of the models' assumptions.

Background

Montgomery County's solid waste management system currently relies on four facilities: the Materials Recovery Facility (MRF), the Shady Grove Processing Facility and Transfer Station, the Resource Recovery Facility (RRF), and the Yard Trim Composting Facility.[3] The County's trash and recycling is collected, dumped, and processed at these facilities. The RRF, also known as the incinerator, has drawn community and political attention as the magnitude and severity of the facility's polluting and GHG-emitting characteristics have been up for debate. The County Executive, Marc Elrich, has announced his intention to close the RRF by the end of its current service agreement term but has also expressed that he does not intend to increase the volume of waste the County sends to landfill.

The RRF is operated by Covanta Montgomery, for the Northeast Maryland Waste Disposal Authority on behalf of the County. It can process up to 1,800 tons of solid waste daily, but on average the facility processes 1,500 tons per day. Using this waste as fuel, the RRF can

[1] "U.S. EPA Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model," U.S. EPA, last modified June 2019, https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_background.pdf.
[2] "Measuring Environmental Benefits Calculator," Sound Resource Management, accessed on July 21, 2019, http://zerowaste.com/mebcalc/.
[3] "Aiming For Zero Waste, Task 8: Review of Existing Processing Facilities," Department of Environmental Protection, Montgomery County, MD, accessed on July 14, 2019, https://www.montgomerycountymd.gov/SWS/Resources/Files/master-plan/Task-%208-Summary-Report-Review-of-Existing-Processing-Facilities.pdf.

generate up to 63 megawatts (MW) of electricity per day.[4] The facility uses three waterwall furnaces with reverse-reciprocating grates to incinerate solid waste and steam-producing boilers to power an electricity-generating turbine.[5] Emissions from the combustion process are treated using emissions control technology, including boilers that minimize dioxin production and combust volatile organic compounds, selective non-catalytic reduction systems that treat nitrogen oxides with ammonia and urea, an air pollution control system that adds activated carbon to flue gas to absorb mercury and dioxins, a scrubber that uses lime slurry to neutralize acid gases, and a baghouse to remove particulate matter.[6] A review of the facility by HDR consultants found that two of three scrubbers, several baghouse ducting systems, and bottom ash handling systems were in need of maintenance or repair, but otherwise they observed that the facility was overall in good condition.[7] The facility operates under state permitting requirements, and it successfully maintains operations below these permitting requirements. The residual ash from the combustion process is packed onto train cars and taken to a landfill in Brunswick, Virginia, where it is beneficially reused as landfill cover.[8]

The controversy surrounding the RRF among local community groups is based on fears of damaging pollutants released through the combustion process that could harm human health. Additionally, the fires at the incinerator, most recently the ten-day fire in December 2016, have raised concerns about the safety of the RRF and its emissions. Further, Maryland's policy of designating WTE as a tier 1 renewable energy source incentivizes the use of incinerators which, by extension, encourages a steady, continuous waste stream to serve as fuel and, critics argue, disincentivizes the development of renewable energy technologies that utilize actual renewable resources, like wind and solar. Because incinerators use the waste stream as fuel, critics believe they undercut community recycling efforts. The State of Maryland debated but ultimately did not remove WTE facilities' designation as an option for renewable energy in the April 2019 Clean Energy Act, so Montgomery County receives approximately $1.5 million annually in renewable energy credits from the state for the RRF.[9]

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[4] "Building a Greener Future: Projects and Services," Northeast Maryland Waste Disposal Authority, accessed on July 21, 2019, https://www.nmwda.org/montgomery-county/.
[5] "Covanta Montgomery," Covanta, accessed on July 21, 2019, https://www.covanta.com/Our-Facilities/Covanta-Montgomery.
[6] "Emissions Information," Covanta, accessed on July 21, 2019, https://www.covanta.com/Sustainability/Environmental-Overview/Emissions-Information.
[7] DEP, Montgomery County, MD, "Aiming For Zero Waste, Task 8: Review of Existing Processing Facilities."
[8] NMWDA, "Building a Greener Future."
[9] Adam Ortiz, "Trash into Treasure: How the D.C. Region Manages Waste," interview by Sasha-Ann Simons, *The Kojo Nnamdi Show*, WAMU 88.5, July 11, 2019, audio, 12:35, https://thekojonnamdishow.org/shows/2019-07-11/trash-into-treasure-how-the-d-c-region-manages-waste.

SUMMARY OF ASSUMPTIONS UNDERLYING EVALUATIONS OF SOLID WASTE MANAGEMENT STRATEGIES

Overview

Essentially, proponents of WTE argue that waste incineration reduces GHG emissions as compared to alternative landfilling scenarios because each ton of garbage processed through a WTE facility prevents a ton of carbon dioxide equivalent from being released into the atmosphere by trash decomposition in a landfill. Additionally, proponents note that WTE facilities recover metals from waste and that the electricity generated through incineration offsets carbon emissions from electricity that would have otherwise been generated by a coal plant.[10] The EPA and Intergovernmental Panel on Climate Change (IPCC) view WTE as a preferable alternative to landfilling in their waste management hierarchies and as a viable method for reducing GHG emissions. WTE appears to be a net negative emitter of GHGs when comparing WTE emissions to landfills without methane capture and when assuming biogenic emissions should not be counted. By counting avoided methane emissions, WTE looks like a more preferable alternative. However, in practice, an alternative landfilling scenario would have some level of gas capture. According to the EPA's carbon accounting methods, WTE reduces GHG emissions by one ton per ton of waste processed.[11]

The assumptions underlying critics' position are that the RRF's permitting requirements are not adequate and that incinerators remain a leading source of pollutants, like dioxins, particulate matter, mercury, and lead, all materials with serious implications for human health. According to critics' carbon accounting, WTE facilities emit more GHG emissions than coal plants. When accounting for all GHG emissions per MWh coming out of a WTE facility's stack, the amount of emissions is higher than a coal plant. From this perspective, biogenic emissions are counted the same as fossil emissions.

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[10] Matt Kasper, "Energy from Waste Can Help Curb Greenhouse Gas Emissions," Center for American Progress, published on April 17, 2013, ps://www.americanprogress.org/issues/green/reports/2013/04/17/60712/energy-from-waste-can-help-curb-greenhouse-gas-emissions/.

[11] "Is Energy-from-Waste Worse Than Coal?", Covanta, accessed on July 21, 2019, https://www.covanta.com/-/media/Covanta/Documents/Solutions/Is-EfW-Worse-Than-Coal.pdf.

MEBCalc models impacts across the categories of climate change, human health (respiratory, toxic chemicals, carcinogens), eutrophication, acidification, eco-toxicity, ozone depletion, and smog formation. Additionally, MEBCalc estimates a "Monetized Environmental Score," which attributes dollar values to the environmental impacts of different waste management systems. MEBCalc's inclusion of energy impacts is comparatively limited, as is the number of materials included in its calculations.[12] On the other hand, WARM focuses on GHG, energy, and economic impacts, neglecting the more numerous and specific categories calculated by MEBCalc. WARM provides results in terms of total change in GHG emissions, offers energy generation reports, and calculates economic impacts of waste management strategies, yielding estimates of changes in labor hours, wages, and tax revenues from an alternative waste management scenario, based on data from the EPA's 2016 Recycling Economic Information.[13]

Counting Biogenic Emissions

There are several key questions to answer about differences in assumptions between the two models. WARM uses a carbon accounting method that does count methane emissions from landfills but fails to count biogenic emissions from the combustion of organic materials. WARM considers the carbon flow through landfills in three ways: methane, which is counted as a GHG emission; carbon dioxide, which is not counted as a GHG emission because it is from biogenic sources; and sequestered carbon, which is counted as an offset because although it comes from biogenic sources it will not be released into the atmosphere under anaerobic landfilling conditions, whereas it would be through natural aerobic conditions. The EPA estimates that landfills offset approximately 7.5% of landfill methane emissions through stored carbon.[14] The carbon accounting method used by the WARM tool is the internationally accepted standard according to IPCC guidance. The rationale behind this method is that the carbon in biogenic waste was originally sequestered from the atmosphere through the process of photosynthesis and its return to the atmosphere would occur naturally through the materials' decomposition. Therefore, biogenic emissions are actually net neutral when using this carbon accounting, and previously sequestered carbon stored in landfills counts negatively towards the overall

[12] Jeffrey Morris, "Life Cycle Analysis for Disposal of MSW Landfill with Energy Recovery vs. Incineration with Energy Recovery," PowerPoint Presentation, Aiming for Zero Waste Task Force Meeting, June 10, 2019, https://www.montgomerycountymd.gov/SWS/Resources/Files/master-plan/life-cycle-msw.pdf.
[13] Nathan Wittstruck, "Waste Reduction Model by US EPA," PowerPoint Presentation, Aiming for Zero Waste Task Force Meeting, June 10, 2019, https://www.montgomerycountymd.gov/SWS/Resources/Files/master-plan/waste-reduction-model-epa.pdf.
[14] "Landfill Carbon Storage in WARM," U.S. EPA, last modified October 27, 2010, https://www.epa.gov/sites/production/files/2016-03/documents/landfill-carbon-storage-in-warm10-28-10.pdf.

measure of GHG emissions.[15] For WARM, the GHG emissions of concern are exclusively anthropogenic (originating from human activity).

Alternatively, the primary argument for counting carbon from biogenic waste in the GHG emissions of WTE plants is that carbon emissions affect the atmosphere whether they originate from biogenic waste or not. To explain the approach to carbon accounting used in the MEBCalc tool, an article in the model's documentation asserts, "The atmosphere reacts identically to emission of a carbon compound, regardless of whether it is fossil or biogenic."[16] Landfills with anaerobic conditions (that is, that maintain waste in conditions without oxygen) act as carbon sinks; the sequestered carbon that is stored in paper, cardboard, wood products, and yard refuse remains there without decomposing and being released as methane.[17] As mentioned previously, WARM counts this stored, previously sequestered carbon as an offset in its total of GHG emissions of landfills. MEBCalc, on the other hand, does not count avoided emissions from biogenic waste stored in landfills in its calculation of total GHG emissions. The argument for MEBCalc's method is that counting stored biogenic carbon as an offset would be "double-counting" in favor of landfills.[18] MEBCalc counts biogenic and fossil emissions released from WTE processes and landfilling without subtracting offsets from stored biogenic carbon in landfills to compare more similar measures of total GHG emissions.

Deciding whether to include biogenic emissions in carbon accounting matters because a large share of Montgomery County's waste stream is comprised of organics. Based on the SCS Engineers' 2017 Montgomery County Waste Composition Study, 40.7% of the County's waste was organics, 2.7% was yard waste, 7.0% was wood, and 22.4% was paper.[19] Because the County's waste stream is so heavily made up of biogenic materials, the decision not to count GHG emissions associated with them yields a significantly different measurement of the RRF's emissions as compared to a measurement that does account for biogenic emissions.

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[15] U.S. EPA, ""U.S. EPA Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model."
[16] Jeffrey Morris, "Recycle, Bury, or Burn Wood Waste Biomass?" *Journal of Industrial Ecology* 21, no. 4 (2016): 847, DOI: 10.1111/jiec.12469.
[17] Jeffrey Morris, "Bury or Burn North American MSW? LCAs Provide Answers for Climate Impacts & Carbon Neutral Power Potential," *Environmental Science and Technology* 44, no. 20 (2010): 7944-7945, DOI: 10.1021/es100529f.
[18] Jeffrey Morris, phone call to author, August 5, 2019.
[19] SCS Engineers, "2017 Waste Characterization Study Summary of Results," Montgomery County DEP, published on January 29, 2018, https://www.montgomerycountymd.gov/SWS/Resources/Files/studies/waste-composition-study-2017.pdf.

Energy Offsets

Assumptions concerning what level of energy offsets to expect from WTE processes are important in determining what waste management strategy works best for the County. An energy offset refers to reduced GHG emissions that make up for emissions from another source. Energy offsets from WTE plants are estimated at 0.9 megagrams of carbon dioxide equivalent per megagram of solid waste. In other words, for each megagram of solid waste processed, nearly one megagram of carbon dioxide equivalent is compensated for. This number relies on assumptions of recycling, a 100-year time horizon of avoided landfill methane emissions, and avoided emissions from grid electricity generation and was arrived at by Covanta.[20] An article cited in MEBCalc's documentation estimates an offset of 0.68 megagrams of carbon dioxide equivalent per megagram of waste. The offsets from ferrous recycling through WTE are an additional 0.05 megagrams of carbon dioxide equivalent per megagram of waste.[21] This estimation may be understating the offsets because it assumes energy displaced from natural gas, not coal. Also, emissions released through WTE processes depend on the composition of the waste stream, so precise calculations would vary depending on the particular site. Opponents of the RRF argue that the electricity generated through WTE processes is not actually displacing coal as much as it is displacing investment in renewables like wind and solar, considering the tier 1 renewable status that WTE maintains.

The articles documenting MEBCalc's underlying assumptions find that recycling materials from the waste streams of homes and businesses is less energy-intensive and more environmentally friendly than the energy offsets produced by either WTE incineration or electricity generation using landfills. In other words, these articles suggest that the energy saved by using recycled materials instead of virgin materials is the opportunity cost of using recyclable materials as fuel to generate electricity, even after taking into account the emissions produced by collection trucks, the processing of materials, and the transportation of recycled materials. The energy recovered from WTE or from gas capture at a landfill does not offset the energy it would take to use virgin materials as opposed to recycled materials.[22]

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[20] Michael Van Brunt and Brian Bahor, "Potential for Energy-From-Waste Carbon Offsets in North America," *Proceedings of the 18th Annual North American Waste-to-Energy Conference*, May 11-13, 2010, https://pdfs.semanticscholar.org/b33c/8f9a32e8f80dba57c0563f1ab1b1b01c6504.pdf.
[21] Morris, "Bury or Burn North American MSW?" 7946.
[22] Jeffrey Morris, "Comparative LCAs for Curbside Recycling Versus Either Landfilling or Incineration with Energy Recovery," *International Journal of Life Cycle Assessment* 10, no. 4 (2005): 273, DOI: 10.1065/lca2004.09.180.10.

Methane Capture

Each model also relies on assumptions concerning the level of methane capture in landfilling scenarios. For MEBCalc, the assumed level of methane capture for regional landfills is 75%. According to articles cited in the MEBCalc presentation, crossover rates modeling the level of gas capture needed for landfilling scenarios to breakeven with WTE facilities range from 50% to 70%, so at a capture rate of 75%, a landfill would emit fewer GHGs than WTE combustion, according to MEBCalc's methods of calculation.[23] WARM considers different rates of methane capture depending on characteristics of the landfill and environmental conditions surrounding the landfill. In a waste management scenario where landfilling with gas capture is selected, WARM calculates results for landfills with rates categorized as typical, worst-case, aggressive, and California regulatory collections.[24] Both WARM and MEBCalc use the Landfill Gas Emissions Model (LandGEM) to calculate landfill emissions, although this model's assumptions are also being reevaluated and questioned in the current literature.

The assumption of 75% methane capture can be considered reasonable for the Montgomery County region as the number was arrived at through a survey of King and Queen County Landfill, Middle Peninsula Landfill, and Charles City Landfill, all of which are located in Virginia and experience similar environmental conditions as Montgomery County.[25]

Lifecycle Assessment Time Horizon

Another critical assumption that both WARM and MEBCalc rely on is that landfill and WTE emissions are considered within timeframes of 100 years. The MEBCalc tool considers a time horizon for emissions of 100 years and offers a module for considering emissions over 20 years. Its developer acknowledges, "Global warming impact assessment results are very sensitive to the choice of a time horizon."[26] Ultimately, the model ignores emissions after 100 years. Although landfills last beyond this time horizon whereas WTE plants immediately reduce the weight and volume of waste, the 100-year timeframe is used because this is the amount of time over which landfilled materials decompose and release varying levels of methane into the atmosphere.[27] The most methane is released within a 20-year timeframe. Carbon accounting

[23] Morris, "Bury or Burn North American MSW?" 7944.
[24] "WARM User Guide," U.S. EPA, last modified May 2019, https://www.epa.gov/sites/production/files/2019-06/documents/warm-users-guide_v15_may2019.pdf.
[25] Morris, "Life Cycle Analysis for Disposal of MSW Landfill with Energy Recovery vs. Incineration with Energy Recovery.
[26] Sound Resource Management, "Measuring Environmental Benefits Calculator."
[27] Morris, "Life Cycle Analysis for Disposal of MSW Landfill with Energy Recovery vs. Incineration with Energy Recovery."

that counts biogenic emissions as carbon neutral considers 100 years the amount of time it would take for new plant growth to sequester the carbon released by the biogenic waste, despite the fact that it may take many years longer.[28] While other timeframe assumptions are plausible, the 100-year timeframe is used by both models and is the standard practice.

Pollutants from WTE Processes

The final assumption considered in this report concerns the levels of pollutants produced by WTE waste management strategies and whether these emissions pose a threat unaccounted for in the facilities' permits. WTE facilities generally and the RRF specifically are accused of emitting more dangerous pollutants than landfills, such as dioxins, mercury, nitrous oxides, etc. Groups opposing WTE facilities argue that these emissions present dangerous health and environmental risks. However, the RRF operates under permitting requirements meant to mitigate these risks and protect human and environmental health. The RRF meets its permitting requirements, but it is useful to examine them.

The County's RRF adheres to requirements laid out in the Maryland Department of the Environment (MDE) Permit #24-031-01718 and to federal standards.[29] The specifics of the RRF's permitting requirements are detailed in the following table, taken from the Montgomery County Department of Environmental Protection's RRF Emissions Data webpage.

Parameter	MDE Permit Requirements	Federal Standards (40 CFR 60)
Opacity	No visible emissions other than water in an uncombined form	10% (6-minute average)
Carbon monoxide (CO)	200 ppmv @ 7% O_2, dry (1-hour average) 50 ppmv @ 7% O_2, dry (24-hour average)	100 ppmv @ 7% O_2, dry (4-hour average
Hydrogen chloride (HCl)*	25 ppmv @ 7% O_2, dry (3-hour average) **or** >= 95% removal efficiency	29 ppmv @ 7% O_2, dry **or** >= 95% removal efficiency
Sulfur dioxide (SO_2)	30 ppmv @ 7% O_2, dry (3-hour average) **or** >= 85% removal efficiency	29 ppmv @ 7% O_2, dry (24-hour geometric average) **or** >= 75% removal efficiency
Nitrogen oxides (NOx)	180 ppmv @ 7% O_2, dry (24-hour average)	180 ppmv @ 7% O_2, dry (24-hour average)

[28] Morris, "Bury or Burn North American MSW?" 7944.
[29] "Emissions Data - Resource Recovery Facility," Montgomery County DEP, accessed on July 21, 2019, https://www.montgomerycountymd.gov/sws/facilities/rrf/cem.html.

Other pollutants emitted by the RRF have not been found to be threatening to human and environmental health in the quantities existing in incinerator emissions. Incinerators do emit particulate matter, carcinogens, and dioxins but at levels far below regulatory standards and at rates lower than other polluting sectors. Emissions from cars and exposure to dioxins in food constitute a greater risk than exposure from ambient air. Modern incinerators equipped with air pollution control technologies produce far less harmful pollution than early incinerators did. They are "likely to have only a very small effect on health," although there is acknowledged difficulty in precisely studying the effects of pollutants in ambient air.[30]

A 2012 inventory of all dioxin emissions in the United States found that "emissions of the WTE industry have been reduced to 0.54% of all controlled sources and 0.09% of both controlled and non-controlled sources." Dioxin emissions have been reduced 95% since 1987 from regulated sources, like WTE facilities. However, they have increased from unregulated sources, like landfill and forest fires.[31]

Montgomery County has conducted ambient air monitoring to assess the risks of the RRF's emissions. The most recent report assessing emissions' effects on human health was conducted in 2014, and it collects data on the potential short and long-term effects of metals, inorganics, dioxins and furans, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and formaldehyde. The assessment concludes that under a variety of scenarios through which Montgomery County residents could be exposed to the pollutants emitted from the RRF, none yield levels of pollutants that would be threatening.[32] Additionally, a 2016 report monitoring ambient air in the County found no evidence of RRF emissions impacting levels of metals, particulate matter, or dioxins and furans. Data for this study was collected from sampling sites in Lucketts and Beallsville.[33]

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[30] "The Impact on Health of Emissions to Air from Municipal Waste Incinerators," Health Protection Agency, published on September 2009, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/384592/The_impact_on_health_emissions_to_air_from_municipal_waste_incinerators.pdf.
[31] Henri Dwyer and Nickolas Themelis, "Inventory of U.S. 2012 dioxin emissions to atmosphere," *Waste Management,* (2015): 5, DOI: 10.1016/j.wasman.2015.08.009.
[32] "RRF Health Risk Assessment Update Montgomery County Resource Recovery Facility (RRF)," TRC, published on November 2014, https://www.montgomerycountymd.gov/SWS/Resources/Files/rrf/hra2014-executive-summary.pdf.
[33] "Fourth Operational Phase Ambient Air Monitoring Program, Winter 2013-2014 and 2014-2015," TRC, published on June 2016, https://www.montgomerycountymd.gov/SWS/Resources/Files/rrf/ambient-air-report-1606/Ambient-Air-Report-1606.pdf.

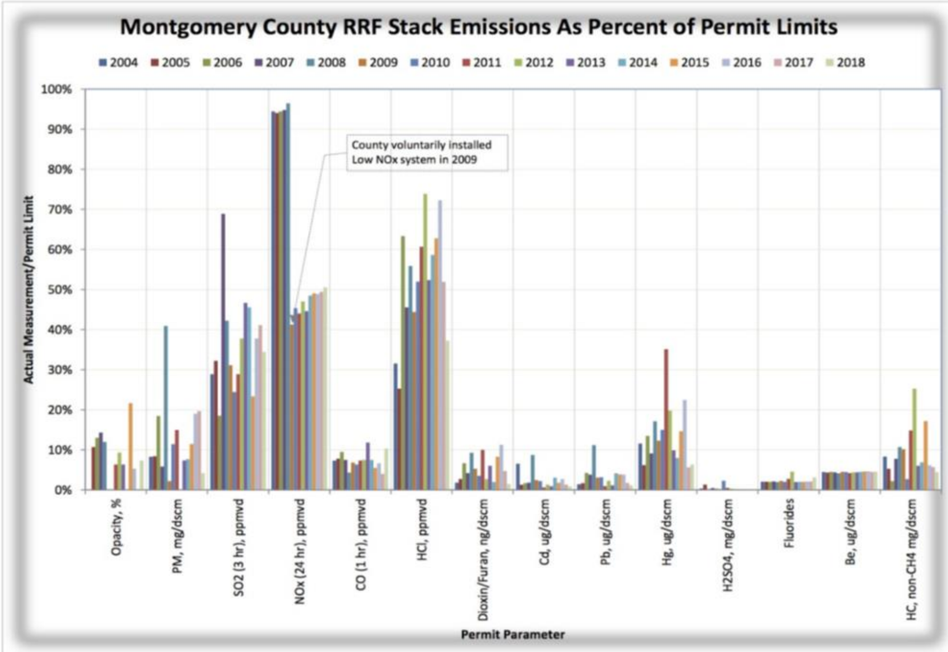

Image Credit: Montgomery County Department of Environmental Protection

As far as the two modeling software examined in this report are concerned, only MEBCalc considers the potential human and ecosystem health impacts of emitted pollutants besides carbon dioxide and its equivalents. MEBCalc calculates monetized scores for human health impacts based on the costs of mortality and morbidity due to particulate matter emissions estimated by the EPA, health costs of mercury emissions reductions and benefits of mercury controls estimated by the National Academy of Sciences, and health costs of benzene emissions estimated by Eastern Research Group.[34] The WARM tool does not consider human or ecosystem health in its calculations. Unlike MEBCalc, the economic calculations that WARM performs does not include estimates of these costs.

[34] Jeffrey Morris, "User Inputs for MEBCalc Ver 6-1," Excel Spreadsheet.

ASSESSMENT OF MODELS

Between landfilling scenarios with methane capture and WTE, MEBCalc shows landfilling with methane capture to be preferable. MEBCalc finds that the energy offsets created by improved recycling are orders of magnitude larger than the offsets yielded through WTE. Removing recyclable materials from the waste stream that is currently fueling the RRF as well as increasing composting to handle the large quantities of biogenic wastes sent to the facility are two critical steps towards reducing the environmental impacts of the County's solid waste management. The MEBCalc tool's calculations of various waste management strategies' impacts on human and ecosystem health are also worth considering alongside its estimates of GHG emissions.

WARM favors combustion as a waste management practice over landfilling but also finds significantly better reductions in GHG emissions through source reduction and recycling. Additionally, WARM data can be particularly useful in determining what materials should be prioritized for recycling because they result in high GHG emissions in combustion. WARM is capable of handling a greater variety of material types than MEBCalc. The tool also estimates economy-wide effects of increased recycling in terms of labor hours, wages, and tax revenues.[35]

Both methods agree on the efficacy and preferability of increased diversion of materials from the waste stream. WARM and MEBCalc show improved recycling and composting as key to Montgomery County's solid waste solution. Importantly, the two tools' recommendations for the County will need to be considered in the context of the County's ongoing diversion initiatives. As the composition of the County's waste stream changes, the conclusions reached by MEBCalc and WARM may be modified.

[35] Wittstruck, "Waste Reduction Model by US EPA."

MAIN FINDINGS

- Improved diversion through increased recycling and composting could change the County’s need for WTE and landfilling.
- The models’ differing assumptions, like the decision whether or not to consider biogenic emissions, create biases towards preferred scenarios.
- Assumptions of a 100-year time horizon and a local landfill gas capture rate of 75% are reasonable to make.
- Based on available data, it cannot be concluded that emissions from the RRF contain levels of dangerous pollutants that threaten human and environmental health. Levels of metals, dioxins and furans, and other pollutants are below regulatory standards.
- The two models can offer estimates from a general perspective, but currently available data is not sufficient to use them to conclude on a waste management strategy for the County at this time.
- The County should reevaluate the issue of alternative waste management strategies in the context of its current diversion goals. An altered waste stream in the future could change the results calculated by the modeling tools.

REFERENCES

Covanta. “Covanta Montgomery.” Accessed on July 21, 2019. https://www.covanta.com/Our-Facilities/Covanta-Montgomery.

Covanta. “Emissions Information.” Accessed on July 21, 2019. https://www.covanta.com/Sustainability/Environmental-Overview/Emissions-Information.

Covanta. “Is Energy-from-Waste Worse Than Coal?” Accessed on July 21, 2019. https://www.covanta.com/-/media/Covanta/Documents/Solutions/Is-EfW-Worse-Than-Coal.pdf.

Department of Environmental Protection, Montgomery County, MD. “Aiming For Zero Waste, Task 8: Review of Existing Processing Facilities.” Accessed on July 14, 2019. https://www.montgomerycountymd.gov/SWS/Resources/Files/master-plan/Task-%208-Summary-Report-Review-of-Existing-Processing-Facilities.pdf.

DEP, Montgomery County. “Emissions Data - Resource Recovery Facility.” Accessed on July 21, 2019. https://www.montgomerycountymd.gov/sws/facilities/rrf/cem.html.

Dwyer, Henri and Nickolas Themelis. “Inventory of U.S. 2012 dioxin emissions to atmosphere.” *Waste Management,* (2015): 5. DOI: 10.1016/j.wasman.2015.08.009.

Health Protection Agency. “The Impact on Health of Emissions to Air from Municipal Waste Incinerators.” Published September 2009. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/384592/The_impact_on_health_emissions_to_air_from_municipal_waste_incinerators.pdf.

Kasper, Matt. “Energy from Waste Can Help Curb Greenhouse Gas Emissions.” Center for American Progress. Published on April 17, 2013. ps://www.americanprogress.org/issues/green/reports/2013/04/17/60712/energy-from-waste-can-help-curb-greenhouse-gas-emissions/.

Morris, Jeffrey. “Bury or burn North American MSW? LCAs provide answers for climate impacts & carbon neutral power potential.” *Environmental Science & Technology* 44, no. 20 (2010): 7944-7949.

Morris, Jeffrey. “Comparative LCAs for curbside recycling versus either landfilling or incineration with energy recovery.” *International Journal of Life Cycle Assessment* 10, no. 4 (2005): 273-284.

Morris, Jeffrey. “Life Cycle Analysis for Disposal of MSW Landfill with Energy Recovery vs. Incineration with Energy Recovery,” PowerPoint Presentation. Aiming for Zero Waste Task Force Meeting, June 10, 2019. https://www.montgomerycountymd.gov/SWS/Resources/Files/master-plan/life-cycle-msw.pdf.

Morris, Jeffrey. “Recycle, bury, or burn wood waste biomass? LCA answer depends on carbon accounting, emissions controls, displaced fuels, and impact costs.” *Journal of Industrial Ecology* 21, no. 4 (2017): 844-856.

Morris, Jeffrey. “Recycling versus incineration: An energy conservation analysis.” *Journal of Hazardous Materials* 47, 1-3 Special Issue on Energy-from-Waste (1996): 277-293.

Northeast Maryland Waste Disposal Authority. “Building a Greener Future: Projects and Services.” Accessed on July 21, 2019. https://www.nmwda.org/montgomery-county/.

Ortiz, Adam. “Trash into Treasure: How the D.C. Region Manages Waste.” Interview by Sasha-Ann Simons. *The Kojo Nnamdi Show*, WAMU 88.5, July 11, 2019. Audio, 12:35. https://thekojonnamdishow.org/shows/2019-07-11/trash-into-treasure-how-the-d-c-region-manages-waste.

SCS Engineers. “2017 Waste Characterization Study Summary of Results.” Montgomery County DEP. Published on January 29, 2018. https://www.montgomerycountymd.gov/SWS/Resources/Files/studies/waste-composition-study-2017.pdf.

Sound Resource Management. “Measuring Environmental Benefits Calculator.” Accessed on July 21, 2019. http://zerowaste.com/mebcalc/.

TRC. “Fourth Operational Phase Ambient Air Monitoring Program, Winter 2013-2014 and 2014-2015.” Published June 2016. https://www.montgomerycountymd.gov/SWS/Resources/Files/rrf/ambient-air-report-1606/Ambient-Air-Report-1606.pdf.

TRC. “RRF Health Risk Assessment Update Montgomery County Resource Recovery Facility (RRF).” Published November 2014. https://www.montgomerycountymd.gov/SWS/Resources/Files/rrf/hra2014-executive-summary.pdf.

U.S. EPA. “Landfill Carbon Storage in WARM.” Last modified October 27, 2010. https://www.epa.gov/sites/production/files/2016-03/documents/landfill-carbon-storage-in-warm10-28-10.pdf.

U.S. EPA. “U.S. EPA Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model.” Last modified June 2019. https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_background.pdf.

U.S. EPA. “WARM User Guide.” Last modified May 2019. https://www.epa.gov/sites/production/files/2019-06/documents/warm-users-guide_v15_may2019.pdf

Van Brunt, Michael and Brian Bahor. “Potential for Energy-From-Waste Carbon Offsets in North America.” *Proceedings of the 18th Annual North American Waste-to-Energy Conference*, May 11-13, 2010. https://pdfs.semanticscholar.org/b33c/8f9a32e8f80dba57c0563f1ab1b1b01c6504.pdf.

Wang, X., Padgett, J. M., De la Cruz, F. B., Barlaz, M. B. “Wood biodegradation in laboratory-scale landfills.” *Environmental Science & Technology* 45 (2011): 6864-6871.

Wittstruck, Nathan. “Waste Reduction Model by US EPA.” PowerPoint Presentation. Aiming for Zero Waste Task Force Meeting, June 10, 2019. https://www.montgomerycountymd.gov/SWS/Resources/Files/master-plan/waste-reduction-model-epa.pdf.