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November 15, 2021

Rachel Assink
Department of Ecology
Air Quality Program
P.O. Box 47600
Olympia, WA 98504-7600

RE: City of Spokane Comments on Proposed Revisions to Chapter 173-441 WAC

Dear Ms Assink:

The City of Spokane offers the following specific comments related to the proposed rulemaking and changes to Chapter 173-441 WAC – Reporting of Emissions of Greenhouse Gases, which was filed on October 6, 2021. These proposed rules are as a result of recent legislation adopted in 2021 - entitled the Washington Climate Commitment Act (CCA). One main purpose of the CCA is to mitigate negative impacts on environmental and human health.

The City of Spokane, as part of the Spokane County Solid Waste Management Plan[1], owns and operates the only municipal Waste to Energy Facility (WTE) in the state of Washington. A unique virtual tour of the facility can be viewed on the City of Spokane webpage. The WTE manages and incinerates municipal solid waste for the Spokane Region. Incineration of solid waste provides a dual benefit of not only managing solid waste and avoiding methane production, but also as an ancillary function, generates electricity for the local electric utility[2].

The plant also provides a needed service to law enforcement in the region for controlled substance destruction. Without the option to use the Spokane facility, law enforcement would have to transport controlled substances longer distances and across state lines for destruction. The plant also provides destruction of USDA Regulated Garbage (International Waste) another service that would be difficult for Fairchild Air Force Base, airlines, and other generators of USDA Regulated Garbage to find alternatives.

After review of the proposed draft rules, the City has a number questions and seeks clarification regarding certain sections. These sections, as addressed below, create ambiguity regarding the reporting of greenhouse gas emissions. Accordingly, please clarify the following:

1. Chapter 173-446 WAC is referenced at least 10 times, within the proposed rule. However, this Chapter does not yet exist. As such, it is not possible to properly evaluate the impacts and interrelationships between the proposed rules . In order to avoid ambiguity, misunderstanding,

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[1] RCW 70A.205.010 assigns primary responsibility for solid waste handling (collection and disposal) to local governments. RCW 70A.205.040 requires a coordinated comprehensive solid waste management plan (SWMP) which address final disposal of solid waste. In Spokane County, final disposition is by incineration at the City's WTE.

[2] Recent WUTC decision (UE-210247) found the City's WTE's generation of electricity was ancillary to its primary purpose of managing solid waste and as such was not a 'baseload electric generation' under Chapter 80.80 RCW.

and potentially conflicting provisions, Ecology should consider approaching the rulemaking in a way that allows evaluation of both rules simultaneously and allows comments to be submitted for both.

2. The City's WTE Facility's ancillary function of generating electricity from the incineration of solid waste, appears to fall into the Electric Power Entity category as a first jurisdictional deliverer of electricity. First jurisdictional deliverers of electricity include electric generating facilities. "Electric generating facilities" is not yet defined within the proposed rule. However, based on communications with Ecology, it sounds like Ecology may be considering the WTE facility as an electric generating facility. This conflicts with EPA's reporting rules, where the WTE facility is not considered an electric generating facility. Electric generation is ancillary to the primary purpose of incinerating solid waste pursuant to the Solid Waste Management Plan. None of the Electric Power Entity proposed requirements, are consistent with or identified as being applicable to WTE facility operations. Is there any reason the WTE facility should be considered an Electric Power Entity?

   The WTE facility was constructed to incinerate municipal solid waste. The Washington State Utility Commission (UTC) recently affirmed the City's WTE's generation of electricity as ancillary to the primary purpose of managing solid waste. Including WTE facilities within the Electric Power Entity group feels like an overreach and disparate treatment. This is one example of the difficulty, and perhaps legality, of proposing the Reporting of Emissions of Greenhouse Gases rule before Chapter 173-446 WAC is in place. It is impossible to evaluate whether the WTE Facility should be characterized and included within the Electric Power Entity group and any impacts of inclusion to the City of Spokane.

   Ecology should consider defining electric generating facilities as those facilities that have a primary NAICS code of 2211XX, or otherwise adjust the definitions so that facilities like the waste to energy facility do not get pulled into program elements as complex as Electric Power Entity Reporting unnecessarily.

3. Please provide clarification as to why the production metric in Table 050-1 is not tons of solid waste disposed at the WTE each year? Again, the WTE's primary purpose is and always has always been solid waste disposal and management, including providing special solid waste disposal abilities such as law enforcement's controlled substances destruction and USDA Regulated Garbage disposal in safe secure manner without transporting such wastes long distances to other available facilities. Please clarify why Table 050-1 lists reporting of net electricity production will be required for the WTE .

4. The City is concerned about the parity of the rule regarding the solid waste disposal industry. As a Waste to Energy facility, the City is required to report all biogenic CO2 emissions. However, for landfills (another solid waste disposal tool), biogenic CO2 is only reported if it comes from methane generated in the landfill that is then combusted for purposes other than flaring/destruction.

No biogenic CO2 generated during the decomposition process at landfills is reported because this is not a source category that EPA, and subsequently Ecology, has included in reporting.
No biogenic CO2 generated from flaring landfill gas is reported because this is a category EPA, and subsequently Ecology, has excluded from its Stationary Combustion category.
Biogenic emissions reported by landfills do not represent total biogenic CO2 but potentially only a very small portion of actual biogenic CO2 emissions.

While under the Cap and Invest program there is no compliance obligation for landfill or WTE biogenic CO2 (i.e., for WTE, the emissions are from combustion of biomass), the optics remain - the casual reviewer of Ecology's greenhouse gas reporting program data could easily draw false and inaccurate conclusions when comparing landfills and WTE. WTE disposal of solid waste should be categorized, and emissions reported, consistent with other solid waste disposal options.

In addition, the City is concerned that the Reporting Rule does not allow Waste to Energy to capture avoided greenhouse gas emissions that arise from activities including:

- Transporting less to a landfill (about 75% less),
- Recovering over 9,000 tons of ferrous metals from solid waste annually, avoiding need for using virgin/raw materials,
- Avoiding fossil fuel emissions from electricity generation, etc…

Another important benefit of Waste to Energy is that the technology produces ***an order of magnitude*** more electricity from the same mass of waste than typical landfill gas to energy technologies. While a significant fraction of the energy derived from WTE results from combusting fossil-fuel-derived materials, such as plastics, this in and of itself is a form of greenhouse gas emissions avoidance because it reduces the need for virgin fossil fuels, including reduction of emissions associated with exploration, extraction, processing, and transportation. See the enclosed:

- *Is it Better to Burn or Bury Waste for Clean Electricity Generation* {P. Ozge Kaplan, Joseph Decarolis, and Susan Thorneloe – National Risk Management Research Laboratory, United State Environmental Protection Agency(USEPA), Research Triangle Park, North Carolina and Department of Civil Engineering, North Carolina State University, Raleigh, North Carolina}
- *A Solution to Man-made Methane* {William Brandes, retired branch chief at USEPA's Office of Solid Waste in Washington DC}.

Not accounting for the avoided emissions would be a short-sighted policy decision that does not reflect the legislature's stated intent to reduce greenhouse gas emissions.

5. Proposed changes to WAC 173-441-050(8)(h)(i) add missing data substitution requirements beyond 40 CFR Part 98 as follows (emphasis added):
    (A) If the analytical data capture rate is at least 90 percent for the data year, the person must substitute for each missing value using the best available estimate of the parameter, based on ***all available process data***.
    (B) If the analytical data capture rate is at least 80 percent but not at least 90 percent for the data year, the person must substitute for each missing value with the highest

quality assured value recorded for the parameter during the given data year, as well as the two previous data years.

(C) If the analytical data capture rate is less than 80 percent for the data year, the person must substitute for each missing value with the highest quality assured value recorded for the parameter in ***all records kept***.

(ii) Substitute missing data used for product data by using the best available estimate of the parameter, based on ***all available data***.

The terms "all available data" and "all records kept" raise concerns. Is it anticipated we would have to review data from 1991, if there was data back that far? Most of this data, if it exists, likely will be in a hard copy format, which could make review and evaluation difficult. Please provide clarification as to why a missing data capture of at least 90% seemingly results in more severe substitution than a higher missing data rate of between 80 to 90% and even if missing data capture is less than 80%? A more sensible approach would be as follows:

(A) If the analytical data capture rate is at least 90 percent for the data year, the person must substitute for each missing value using the best available estimate of the parameter, based on ***all available process data for the given data year***.

(B) If the analytical data capture rate is at least 80 percent but not at least 90 percent for the data year, the person must substitute for each missing value with the highest quality assured value recorded for the parameter during the given data year, as well as the two previous data years.

(C) If the analytical data capture rate is less than 80 percent for the data year, the person must substitute for each missing value with the highest quality assured value recorded for the parameter in ***all records kept according to subsection (6) of this section***.

(ii) Substitute missing data used for product data by using the best available estimate of the parameter, based on ***all available data for the given data year***.

Subsection (C) is similar to the California Air Resources Board (CARB) reporting rule, Title 17, CCR, Sections 95100-95163.

6. WAC 173-441-050(3)(j) adds a requirement to describe any direct or indirect affiliation with other reporters. What is meant by affiliation? This term could be interpreted inconsistently. To avoid ambiguity, a definition should be added to the rule, or some clarifying language included.

7. WAC 173-441-050(3)(l) adds a requirement related to self-generated electricity. This term is not defined and creates ambiguity. Review of the CARB Cap & Trade rule has the following definition:

> "Self-Generation of Electricity" means electricity dedicated to serving an electricity user on the same location as the generator. The system may be operated directly by the electricity user or by an entity with a contractual arrangement.

Is this definition appropriate for Ecology's intentions? If so, please add it to the rule?

Furthermore, please provide clarity - would the electricity generated by a facility that is used within the facility to support power generation be considered self-generated electricity, or is “self-generated electricity” electricity that is generated at a facility but used for purposes other than direct support of power generation?

8. The term, “Generation Providing Entity (GPE)”, is used in the proposed rule. This term is another term which is not defined. The CARB reporting rule, Title 17, CCR, Sections 95100-95163 uses the following definition:

   > “Generation Providing Entity (GPE)” or “GPE” means a facility or generating unit operator, full or partial owner, party to a contract for a fixed percentage of net generation from the facility or generating unit, party to a tolling agreement with the owner, or exclusive marketer recognized by ARB that is either the electricity importer or exporter with prevailing rights to claim electricity from the specified source.”

   Terms should be cross referenced to the other applicable legislation to ensure consistency in application and minimize conflicts in the future.

9. The term, “Asset-Controlling Suppliers”, is another term which is used in the proposed rule but not defined. The CARB reporting rule, Title 17, CCR, Sections 95100-95163, uses the following definition:

   > “Asset-controlling supplier” means any entity that owns or operates inter-connected electricity generating facilities or serves as an exclusive marketer for these facilities even though it does not own them and is assigned a supplier-specific identification number and system emission factor by ARB for the wholesale electricity procured from its system and imported into California. Asset controlling suppliers are considered specified sources.

   Shouldn’t a definition of this term be added to the rule?

10. The term, “electricity generation provider” is defined but not used anywhere else in the rule. Is the definition actually needed?

11. While WAC 173-441-050(3)(d)(iv) is not proposed to be changed. It currently reads:

    > Emissions and other data for individual units, processes, activities, and operations as specified in the "data reporting requirements" section of each applicable source category referenced in WAC 173-441-120.

    However, there is ambiguity with the term “data reporting requirements” referring to the “data reporting requirements” from the applicable 40 CFR 98, Subparts for each source category listed in Table 120-1. Better wording would be as follows:

    > Emissions and other data for individual units, processes, activities, and operations as specified in the "data reporting requirements" section of each applicable ***40 CFR Part 98 subpart for source categories*** referenced in WAC 173-441-120**, Table 120-1**.

Ecology may also want to refer to the "data reporting requirements" section in WAC 173-441-120(4)(d) – Data Reporting Requirements, as that subsection contains data reporting requirements as well. In which case, it should read:

> Emissions and other data for individual units, processes, activities, and operations as specified in the "data reporting requirements" section of each applicable ***40 CFR Part 98 subpart for source categories*** referenced in WAC 173-441-120**, Table 120-1 and in WAC 173-441-120(4)(d)**.

12. WAC 173-441-050(3)(e)(iv) currently reads:

    > Emissions and other data for individual units, processes, activities, and operations as specified in the "data reporting requirements" section of each applicable source category referenced in WAC 173-441-122 and 173-441-124.

    For WAC 173-441-122, are the referenced "data reporting requirements" those in section in WAC 173-441-122(4)(d) and (5)(d), as well as any from applicable 40 CFR 98 Subparts? Another area where there are inconsistencies which could create conflict. See comments above.

13. WAC 173-441-050(3(g) uses the phrase "applicable subpart referenced in WAC 173-441-120, 173-441-122, or 173-441-124". Presumably this means a subpart of 40 CFR Part 98, and if so, then the complete reference should be used. Also, if this is the case, there are no subparts referenced in WAC 173-441-124, so Ecology may want to consider deleting this reference to avoid confusion when searching for something that is not there.

The final rule needs to provide clarity and parity as outlined and discussed above. Spokane's WTE Facility has a proven track record; it is an environmentally responsible solution for solid waste management that minimizes greenhouse gases, in addition to numerous other benefits, when compared to more traditional methods, such as landfills (See, _America's Need for Clean, Renewable Energy: - THE CASE FOR WASTE-TO-ENERGY_, attached). The proposed reporting rule and the Cap and Invest program need to acknowledge the science of solid waste management.

Thank you for the opportunity to offer these comments on the proposed rule changes. Please don't hesitate to contact me should you have any questions or would like more information.

Sincerely,

Kelle R Vigeland
Environmental Manager

Enc: _Is it Better to Burn or Bury Waste for Clean Electricity Generation_
A Solution to Man-made Methane
America's Need for Clean, Renewable Energy: - THE CASE FOR WASTE-TO-ENERGY

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Is It Better To Burn or Bury Waste for Clean Electricity Generation?

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The use of municipal solid waste (MSW) to generate electricity through landfill-gas-to-energy (LFGTE) and waste-to-energy (WTE) projects represents roughly 14% of U.S. nonhydro renewable electricity generation. Although various aspects of LFGTE and WTE have been analyzed in the literature, this paper is the first to present a comprehensive set of life-cycle emission factors per unit of electricity generated for these energy recovery options. In addition, sensitivity analysis is conducted on key inputs (e.g., efficiency of the WTE plant, landfill gas management schedules, oxidation rate, and waste composition) to quantify the variability in the resultant life-cycle emissions estimates. While methane from landfills results from the anaerobic breakdown of biogenic materials, the energy derived from WTE results from the combustion of both biogenic and fossil materials. The greenhouse gas emissions for WTE ranges from 0.4 to 1.5 $MTCO_2e/MWh$, whereas the most agressive LFGTE scenerio results in 2.3 $MTCO_2e/MWh$. WTE also produces lower NO_x emissions than LFGTE, whereas SO_x emissions depend on the specific configurations of WTE and LFGTE.

Introduction

In response to increasing public concern over air pollution and climate change, the use of renewable energy for electricity generation has grown steadily over the past few decades. Between 2002 and 2006, U.S. renewable electricity generation—as a percent of total generation—grew an average of 5% annually (*1*), while total electricity supply grew by only 1% on average (*2*). Support mechanisms contributing to the growth of renewables in the United States include corporate partnership programs, investment tax credits, renewable portfolio standards, and green power markets. These mechanisms provide electric utilities, investment firms, corporations, governments, and private citizens with a variety of ways to support renewable energy development. With several competing renewable alternatives, investment and purchasing decisions should be informed, at least in part, by rigorous life-cycle assessment (LCA).

In 2005, a total of 245 million tons of MSW was generated in the United States, with 166 million tons discarded to landfills (*3*). Despite the increase in recycling and composting rates, the quantity of waste disposed to landfills is still significant and expected to increase. How to best manage the discarded portion of the waste remains an important consideration, particularly given the electricity generation options. Although less prominent than solar and wind, the use of municipal solid waste (MSW) to generate electricity represents roughly 14% of U.S. nonhydro renewable electricity generation (*1*). In this paper we compare two options for generating electricity from MSW. One method, referred to as landfill-gas-to-energy (LFGTE), involves the collection of landfill gas (LFG) (50% CH_4 and 50% CO_2), which is generated through the anaerobic decomposition of MSW in landfills. The collected LFG is then combusted in an engine or a turbine to generate electricity. A second method, referred to as waste-to-energy (WTE) involves the direct combustion of MSW, where the resultant steam is used to run a turbine and electric generator.

Clean Air Act (CAA) regulations require capture and control of LFG from large landfills by installing a gas collection system within 5 years of waste placement (*4*). The gas collection system is expanded to newer areas of the landfill as more waste is buried. Not all LFG is collected due to delays in gas collection from initial waste placement and leaks in the header pipes, extraction wells, and cover material. Collected gas can be either flared or utilized for energy recovery. As of 2005, there were 427 landfills out of 1654 municipal landfills in the United States with LFGTE projects for a total capacity of 1260 MW. It is difficult to quantify emissions with a high degree of certainty since emissions result from biological processes that can be difficult to predict, occur over multiple decades, and are distributed over a relatively large area covered by the landfill.

CAA regulations require that all WTE facilities have the latest in air pollution control equipment (*5*). Performance data including annual stack tests and continuous emission monitoring are available for all 87 WTE plants operating in 25 states. Since the early development of this technology, there have been major improvements in stack gas emissions controls for both criteria and metal emissions. The performance data indicate that actual emissions are less than regulatory requirements. Mass burn is the most common and established technology in use, though various MSW combustion technologies are described in ref *6*. All WTE facilities in the United States recover heat from the combustion process to run a steam turbine and electricity generator.

Policy-makers appear hesitant to support new WTE through new incentives and regulation. Of the 30 states that have state-wide renewable portfolio standards, all include landfill gas as an eligible resource, but only 19 include waste-to-energy (*7*). While subjective judgments almost certainly play a role in the preference for LFGTE over WTE, there is a legitimate concern about the renewability of waste-to-energy. While the production of methane in landfills is the result of the anaerobic breakdown of biogenic materials, a significant fraction of the energy derived from WTE results from combusting fossil-fuel-derived materials, such as plastics. Countering this effect, however, is significant methane leakage—ranging from 60% to 85%—from landfills (*8*). Since methane has a global warming potential of 21 times that of CO_2, the CO_2e emissions from LFGTE may be larger than those from WTE despite the difference in biogenic composition.

Although WTE and LFGTE are widely deployed and analyzed in the literature (*9*–*13*), side-by-side comparison of the life-cycle inventory (LCI) emission estimates on a mass

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per unit energy basis is unavailable. LCI-based methods have been used to evaluate and compare solid waste management (SWM) unit operations and systems holistically to quantify either the environmental impacts or energy use associated with SWM options in the broad context of MSW management (*14–16*).

The purpose of this paper is to present a comprehensive set of life-cycle emission factors—per unit of electricity generated—for LFGTE and WTE. In addition, these emission factors are referenced to baseline scenarios without energy recovery to enable comparison of the emissions of LFGTE and WTE to those of other energy sources. While the methodology presented here is applicable to any country, this analysis is based on U.S. waste composition, handling, and disposal, with which the authors are most familiar. In addition, parametric sensitivity analysis is applied to key input parameters to draw robust conclusions regarding the emissions from LFGTE and WTE. The resultant emission factors provide critical data that can inform the development of renewable energy policies as well as purchasing and investment decisions for renewable energy projects in the prevailing marketplace.

Modeling Framework

The LFGTE and WTE emission factors are based on the composition and quantity of MSW discarded in the United States in 2005 (Table S1 of Supporting Information (SI)). We excluded the estimated quantity and composition of recycled and composted waste.

The emission factors are generated using the life-cycle-based process models for WTE (*17*) and LF/LFGTE (*18*) embedded in the municipal solid waste decision support tool (MSW-DST). The MSW-DST was developed through a competed cooperative agreement between EPA's Office of Research and Development and RTI International (*19–22*). The research team included North Carolina State University, which had a major role in the development of the LCI database, process, and cost models as well as the prototype MSW-DST. While a summary is provided here, Table S2 (SI) provides a comprehensive set of references for those interested in particular model details. The MSW-DST includes a number of process models that represent the operation of each SWM unit and all associated processes for collection, sorting, processing, transport, and disposal of waste. In addition, there are process models to account for the emissions associated with the production and consumption of gasoline and electricity. The objective of each process model is to relate the quantity and composition of waste entering a process to the cost and LCI of emissions for that process. The LCI emissions are calculated on the basis of a combination of default LCI data and user-input data to enable the user to model a site-specific system. For example, in the landfill process model, one key exogenous input is the efficiency of the LFG collection system. The functional unit in each process model is 1 ton of MSW set out for collection. The MSW includes the nonhazardous solid waste generated in residential, commercial, institutional, and industrial sectors (*3*).

Each process model can track 32 life-cycle parameters, including energy consumption, CO_2, CO, NO_x, SO_x, total greenhouse gases (CO_2e), particulate matter (PM), CH_4, water pollutants, and solid wastes. CO_2 emissions are represented in two forms: fossil and biogenic. CO_2 released from anthropogenic activities such as burning fossil fuels or fossil-fuel-derived products (e.g., plastics) for electricity generation and transportation are categorized as CO_2-fossil. Likewise, CO_2 released during natural processes such as the decay of paper in landfills is categorized as CO_2-biogenic.

The management of MSW will always result in additional emissions due to collection, transportation, and separation of waste. However, for this analysis, the configuration of the SWM system up through the delivery of the waste to either a landfill or WTE facility is assumed to be same.

TABLE 1. Inputs to the Landfill Process Model

	LFG collection system efficiency [a] (%)	oxidation rate (%)
during venting	0	15
during first year of gas collection	50	15
during second year of gas collection	70	15
during third year and on of gas collection	80	15

[a] We assumed efficiency of the collection system based on the year of the operation and the ranges stated in U.S. EPA's AP-42 (*8*).

Electricity Grids. While LFGTE and WTE provide emissions reductions relative to landfill scenarios without energy recovery, the generation of electricity from these sources also displaces conventional generating units on the electricity grid. The process models in MSW-DST can calculate total electricity generated and apply an offset analysis on the grid mix of fuels specific to each of the North American Electric Reliability Council (NERC) regions, an average national grid mix, or a user-defined grid mix. Because our focus is on the emissions differences between WTE and LFGTE technologies, the emissions factors reported here exclude the displaced grid emissions.

For reference purposes, emission factors for conventional electricity-generating technologies are reported along with the emission factors for WTE and LFGTE (*23*). These emission factors on a per megawatt hour basis include both the operating emissions from power plants with postcombustion air pollution control equipment and precombustion emissions due to extraction, processing, and transportation of fuel. The background LCI data are collected on a unit mass of fuel (*23*); when converted on a per unit of electricity generated basis, the magnitude of resultant emissions depends on the efficiency of the power plant. A sensitivity analysis was conducted on plant efficiencies to provide ranges for emission factors.

Estimating Emission Factors for Landfill Gas-to-Energy. The total LCI emissions from landfills are the summation of the emissions resulting from (1) the site preparation, operation, and postclosure operation of a landfill, (2) the decay of the waste under anaerobic conditions, (3) the equipment utilized during landfill operations and landfill gas management operations, (4) the production of diesel required to operate the vehicles at the site, and (5) the treatment of leachate (*18*). The production of LFG was calculated using a first-order decay equation for a given time horizon of 100 years and the empirical methane yield from each individual waste component (*18, 24*). Other model inputs include the quantity and the composition of waste disposed (Table S1, SI), LFG collection efficiency (Table 1), annual LFG management schedule (Figure 1), oxidation rate (Table 1), emission factors for combustion byproduct from LFG control devices (Table S3, SI), and emission factors for equipment used on site during the site preparation and operation of a landfill. While there are hundreds of inputs to the process models, we have modified and conducted sensitivity analysis on the input parameters that will affect the emission factors most significantly.

The emission factors are calculated under the following scenario assumptions: (1) A regional landfill subject to CAA is considered. (2) A single cell in the regional landfill is modeled. (3) Waste is initially placed in the new cell in year 0. (4) The landfill already has an LFG collection network in place. (5) An internal combustion engine (ICE) is utilized to generate electricity. (6) The offline time that is required for

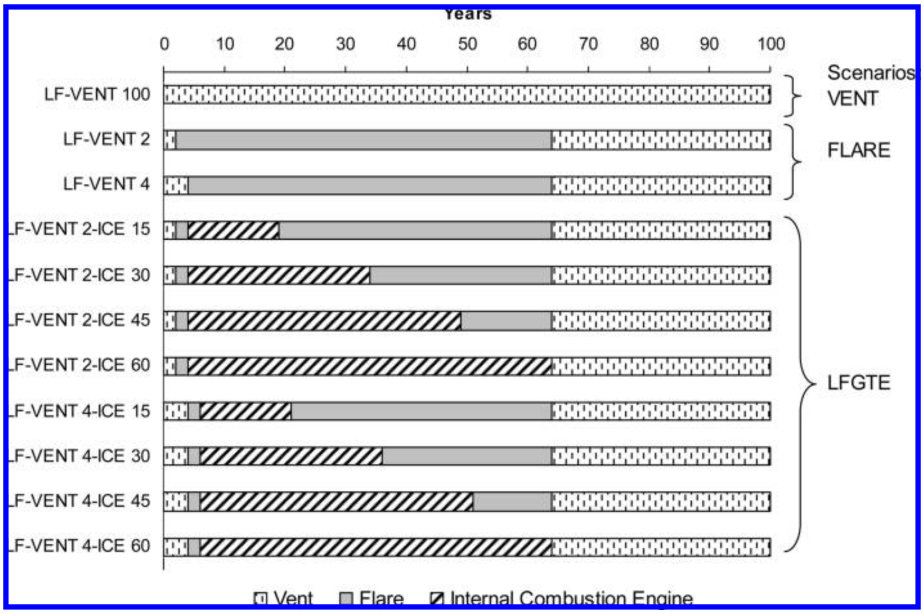

FIGURE 1. Annual landfill gas management schedule assumed for alternative scenarios.

the routine maintenance of the ICE is not considered. (7) The LFG control devices are assumed to have a lifetime of 15 years. (8) The LFG will be collected and controlled until year 65. This assumption is based on a typical landfill with an average operating lifetime of 20 years in which LFG production decreases significantly after about 60 years from initial waste placement. This is based on the use of a first-order decay equation utilizing empirical data from about 50 U.S. LFG collection systems.

The timing of LFG-related operations has significant variation and uncertainty that will influence the total emissions from landfills as well as the emission factors per unit of electricity generated. To capture these uncertainties and variation, several different management schemes were tested. Figure 1 presents the different cases considered for LFGTE projects. Each case differs according to the management timeline of the LFG. For instance, LF-VENT 2-ICE 15 corresponds to no controls on LFG for the first two years, after which the LFG is collected and flared in the third and fourth years. From year 5 until year 19, for a period of 15 years, the LFG is processed through an ICE to generate electricity, after which the collected gas is flared until year 65. Finally from year 65 on, the LFG is released to the atmosphere without controls.

To quantify the emissions benefit from LFGTE and WTE, landfill emissions occurring in the absence of an energy recovery unit can serve as a useful comparison. Thus, three baseline scenarios without electricity generation were defined for comparison to the energy recovery scenarios: LF-VENT 100 (LFG is uncontrolled for the entire lifetime of the LF), LF-VENT 2 (LFG is uncontrolled for the first two years, and then the LFG is collected and flared until year 65), LF-VENT 4 (LFG is uncontrolled for the first four years, and then the LFG is collected and flared until year 65). Since emissions are normalized by the amount of electricity generated (MW h) to obtain the emission rates, an estimate of hypothetical electricity generation for the baseline scenarios must be defined. The average electricity generation from a subset of the energy recovery scenarios is used to calculate the baseline emission rates. For example, emission factors [g/(MW h)] for LF-VENT 2 are based on the average of electricity generated in LF-VENT 2-ICE 15, LF-VENT 2-ICE 30, LF-VENT 2-ICE 45, and LF-VENT 2-ICE 60. Additional sensitivity analysis was conducted on oxidation rates where scenarios were tested for a range of 10−35%.

Estimating Emission Factors for Waste-to-Energy. The total LCI emissions are the summation of the emissions associated with (1) the combustion of waste (i.e., the stack gas (accounting for controls)), (2) the production and use of limestone in the control technologies (i.e., scrubbers), and (3) the disposal of ash in a landfill (*17*).

Emissions associated with the manufacture of equipment such as turbines and boilers for the WTE facility are found to be insignificant (<5% of the overall LCI burdens) and, as a result, were excluded from this analysis (*25*). In addition, WTE facilities have the capability to recover ferrous material from the incoming waste stream and also from bottom ash with up to a 90% recovery rate. The recovered metal displaces the virgin ferrous material used in the manufacturing of steel. The emission offsets from this activity could be significant depending on the amount of ferrous material recovered. Total LCI emissions for WTE were presented without the ferrous offsets; however, sensitivity analysis was conducted to investigate the significance.

In the United States, federal regulations set limits on the maximum allowable concentration of criteria pollutants and some metals from MSW combustors (*5*). The LCI model calculates the controlled stack emissions using either the average concentration values at current WTE facilities based on field data or mass emission limits based on regulatory requirements as upper bound constraints. Two sets of concentration values (Table S4, SI) are used in calculations to report two sets of emission factors for WTE (i.e., WTE-Reg and WTE-Avg). The emission factors for WTE-Reg were based on the regulatory concentration limits (*5*), whereas the emission factors for WTE-Avg were based on the average concentrations at current WTE facilities.

The CO_2 emissions were calculated using basic carbon stoichiometry given the quantity, moisture, and ultimate analysis of individual waste items in the waste stream. The LCI model outputs the total megawatt hour of electricity production and emissions that are generated per unit mass of each waste item. The amount of electricity output is a function of the quantity, energy, and moisture content of the individual waste items in the stream (Table S1, Supporting Information), and the system efficiency. A lifetime of 20 years and a system efficiency of 19% [18000 Btu/(kW h)] were assumed for the WTE scenarios. For each pollutant, the following equation was computed:

$$\mathrm{LCI\_WTE}_i = \sum_j \{(\mathrm{LCI\_Stack}_{ij} + \mathrm{LCI\_Limestone}_{ij} + \mathrm{LCI\_Ash}_{ij}) \times \mathrm{Mass}_j\}/\mathrm{Elec} \quad \text{for all } i \quad (1)$$

where $\mathrm{LCI\_WTE}_i$ is the LCI emission factor for pollutant i [g/(MW h)], $\mathrm{LCI\_Stack}_{ij}$ is the controlled stack gas emissions for pollutant i (g/ton of waste item j), $\mathrm{LCI\_Limestone}_{ij}$ is the allocated emissions of pollutant i from the production and use of limestone in the scrubbers (g/ton of waste item j), $\mathrm{LCI\_Ash}_{ij}$ is the allocated emissions of pollutant i from the disposal of ash (g/ton of waste item j), Mass_j is the amount of each waste item j processed in the facility (ton), and Elec is the total electricity generated from MSW processed in the facility (MW h). In addition, the sensitivity of emission factors to the system efficiency, the fossil and biogenic fractions of MSW, and the remanufacturing offsets from steel recovery was quantified.

Results and Discussion

The LCI emissions resulting from the generation of 1 MW h of electricity through LFGTE and WTE as well as coal, natural gas, oil, and nuclear power (for comparative purposes) were calculated. The sensitivity of emission factors to various inputs was analyzed and is reported. Figures 2−4 summarize the emission factors for total CO_2e, SO_x, and NO_x, respectively.

Landfills are a major source of CH_4 emissions, whereas WTE, coal, natural gas, and oil are major sources of CO_2-fossil emissions (Table S5, SI). The magnitude of CH_4 emissions strongly depends on when the LFG collection system is installed and how long the ICE is used. For example, LF-VENT 2-ICE 60 has the least methane emissions among LFGTE alternatives because the ICE is operated the longest (Table S5, SI). CO_2e emissions from landfills were significantly higher than the emissions for other alternatives because of the relatively high methane emissions (Figure 2, Table S5).

The use of LFG control during operation, closure, and postclosure of the landfill as well as the treatment of leachate contributes to the SO_x emissions from landfills. SO_x emissions from WTE facilities occur during the combustion process and are controlled via wet or dry scrubbers. Overall, the SO_x emissions resulting from the LFGTE and WTE alternatives are approximately 10 times lower than the SO_x emissions resulting from coal- and oil-fired power plants with flue gas controls (Figure 3). The SO_x emissions for WTE ranged from 140 to 730 g/(MW h), and for LFGTE they ranged from 430 to 900 g/(MW h) (Table 2, Table S5). In a coal-fired power plant, average SO_x emissions were 6900 g/(MW h) (Table S6 and S7, SI). Another important observation is that the majority of the SO_x emissions from natural gas are attributed to processing of natural gas rather than the combustion of the natural gas for electricity-generating purposes.

The NO_x emissions for WTE alternatives ranged from 810 to 1800 g/(MW h), and for LFGTE they ranged from 2100 to 3000 g/(MW h) (Figure 4, Table 2, Table S5). In a coal-fired power plant, average NO_x emissions are 3700 g/(MW h) (Tables S6 and S7, Supporting Information). The emission factors for other criteria pollutants were also calculated. Besides CO and HCl emissions, the emission factors for all LFGTE and WTE cases are lower than those for the coal-fired generators (Tables S5−S8, SI).

While we have provided a detailed, side-by-side comparison of life-cycle emissions from LFGTE and WTE, there is an important remaining question about scale: How big an impact can energy recovery from MSW make if all of the discarded MSW (166 million tons/year) is utilized? Hypothetically, if 166 million tons of MSW is discarded in regional landfills, energy recovery on average of ~10 TW h or ~65 (kW h)/ton of MSW of electricity can be generated, whereas a WTE facility can generate on average ~100 TW h or ~600 (kW h)/ton of MSW of electricity with the same amount of MSW (Table 3). WTE can generate an order of magnitude more electricity than LFGTE given the same amount of waste. LFGTE projects would result in significantly lower electricity generation because only the biodegradable portion of the MSW contributes to LFG generation, and there are significant inefficiencies in the gas collection system that affect the quantity and quality of the LFG.

Moreover, if all MSW (excluding the recycled and composted portion) is utilized for electricity generation, the WTE alternative could have a generation capacity of 14000 MW, which could potentially replace ~4.5% of the 313000 MW of current coal-fired generation capacity (*26*).

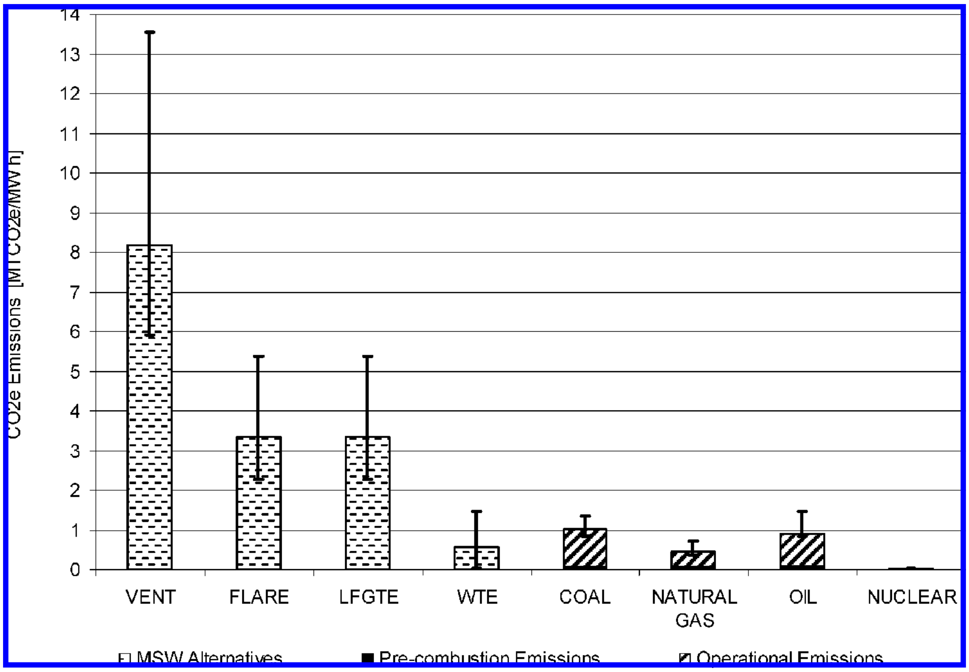

FIGURE 2. Comparison of carbon dioxide equivalents for LFGTE, WTE, and conventional electricity-generating technologies (Tables S5−S8, Supporting Information, include the full data set).

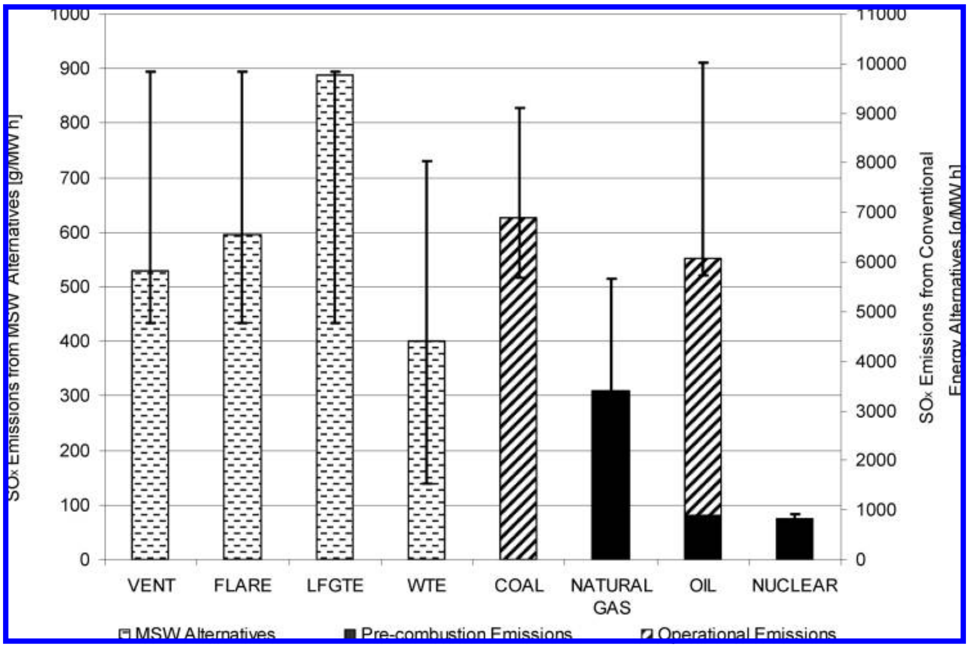

FIGURE 3. Comparison of sulfur oxide emissions for LFGTE, WTE, and conventional electricity-generating technologies (Tables S5−S8, Supporting Information, include the full data set).

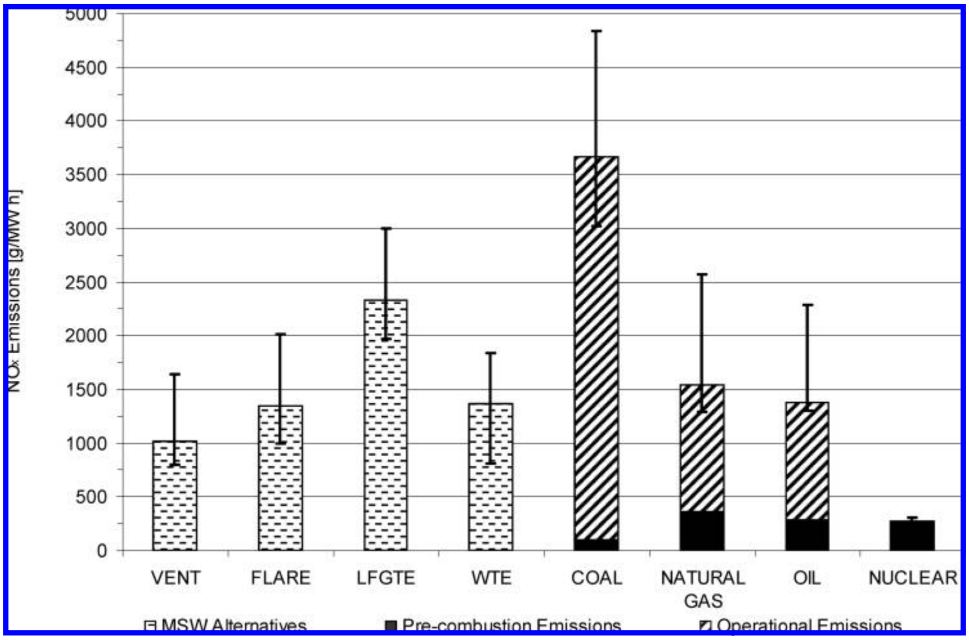

FIGURE 4. Comparison of nitrogen oxide emissions for LFGTE, WTE, and conventional electricity-generating technologies (Tables S5−S8, Supporting Information, include the full data set).

A significant portion of this capacity could be achieved through centralized facilities where waste is transported from greater distances. The transportation of waste could result in additional environmental burdens, and there are clearly limitations in accessing all discarded MSW in the nation. Wanichpongpan studied the LFGTE option for Thailand and found that large centralized landfills with energy recovery performed much better in terms of cost and GHG emissions than small, localized landfills despite the increased burdens associated with transportation (*13*). To quantify these burdens for the United States, emission factors were also calculated for long hauling of the waste via freight or rail. Table S9 (SI) summarizes the emission factors for transporting 1 ton of MSW to a facility by heavy-duty trucks and rail.

Sensitivity analysis was also conducted on key inputs. With incremental improvements, WTE facilities could achieve efficiencies that are closer to those of conventional power plants. Thus, the system efficiency was varied from 15% to 30%, and Table 2 summarizes the resulting LCI emissions. The variation in efficiencies results in a range of 470−930 kW h of electricity/ton of MSW, while with the default heat rate; only 600 (kW h)/ton of MSW can be generated. The efficiency also affects the emission factors; for example, CO_2-fossil emissions vary from 0.36 to 0.71 Mg/(MW h).

The emission savings associated with ferrous recovery decreased the CO_2e emissions of the WTE-Reg case from 0.56 to 0.49 MTCO_2e/(MW h). Significant reductions were observed for CO and PM emissions (Table 2).

TABLE 2. Sensitivity of Emission Factors for WTE to Plant Efficiency, Waste Composition, and Remanufacturing Benefits of Steel Recovery

			Sensitivity on				
	baseline factors		system efficiency	waste composition		steel recovery	
Input Parameters Varied[a]							
heat rate [Btu/(kW h)]	18000	18000	*[11000, 23000]*	18000	18000	18000	18000
efficiency (%)	19	19	*[15, 30]*	19	19	19	19
composition	default	default	default	*all biogenic*	*all fossil*	default	default
stack gas limits	reg	avg	*reg/avg*	reg	reg	*reg*	*avg*
steel recovery	excludes	excludes	excludes	excludes	excludes	*includes*	*includes*
Results: Criteria Pollutants							
CO [g/(MW h)]	790	790	[500,1000]	740	880	−110	−110
NO_x [g/(MW h)]	1300	1500	[810, 1800]	1200	1400	1200	1400
SO_x [g/(MW h)]	578	221	[140, 730]	550	620	450	90
PM [g/(MW h)]	181	60	[38, 230]	180	190	−190	−310
Results: Greenhouse Gases							
CO_2-biogenic [Mg/(MW h)]	0.91	0.91	[0.58, 1.2]	1.5	0.03	0.91	0.91
CO_2-fossil [Mg/(MW h)]	0.56	0.56	[0.36, 0.71]	0.02	1.5	0.49	0.49
CH_4 [Mg/(MW h)]	1.3E−05	1.3E−05	[8.1E−06, 1.6E−05]	1.6E−05	7.9E−06	−5.0E−05	−5.0E−05
CO_2e [$MTCO_2e$/(MW h)]	0.56	0.56	[0.36, 0.71]	0.02	1.45	0.49	0.49
Results: Electricity Generation							
TW h [b]	98	98	[78, 160]	61	37	98	98
(kW h)/ton	590	590	[470, 930]	470	970	590	590
GW [c]	12	12	[9.7, 20]	7.6	4.7	12	12

[a] For each sensitivity analysis scenario, the input parameters in italics were modified and resultant emission factors were calculated and are reported. [b] The values represent the TWh of electricity that could be generated from all MSW disposed into landfills. [c] 1 TWh/8000 h = TW; a capacity factor of approximately 0.91 was utilized.

TABLE 3. Comparison of Total Power Generated

	total electricity generated from 166 million tons of MSW, TW h	total power [a], GW	electricity generated from 1 ton of MSW, (kW h)/ton
waste-to-energy	78−160	9.7−19	470−930
landfill-gas-to-energy	7−14	0.85−1.8	41−84

[a] 1 TW h/8000 h = TW; a capacity factor of approximately 0.91 was utilized.

The composition of MSW also has an effect on the emission factors. One of the controversial aspects of WTE is the fossil-based content of MSW, which contributes to the combustion emissions. The average composition of MSW as discarded by weight was calculated to be 77% biogenic- and 23% fossil-based (Table S1, SI). The sensitivity of emission factors to the biogenic- vs fossil-based waste fraction was also determined. Two compositions (one with 100% biogenic-based waste and another with 100% fossil-based waste) were used to generate the emission factors (Table 2). The CO_2e emissions from WTE increased from 0.56 $MTCO_2e$/(MW h) (WTE-Reg) to 1.5 $MTCO_2e$/(MW h) when the 100% fossil-based composition was used (Table 2, Figure 2). However, the CO_2e emissions from WTE based on 100% fossil-based waste were still lower than the most aggressive LFGTE scenario (i.e., LF-VENT 2-ICE 60) whose CO_2e emissions were 2.3 $MTCO_2e$/(MW h).

The landfill emission factors include the decay of MSW over 100 years, whereas emissions from WTE and conventional electricity-generating technologies are instantaneous. The operation and decomposition of waste in landfills continue even beyond the monitoring phases for an indefinite period of time. Reliably quantifying the landfill gas collection efficiency is difficult due to the ever-changing nature of landfills, number of decades that emissions are generated, and changes over time in landfill design and operation including waste quantity and composition. Landfills are an area source, which makes emissions more difficult to monitor. In a recent release of updated emission factors for landfill gas emissions, data were available for less than 5% of active municipal landfills (*27*). Across the United States, there are major differences in how landfills are designed and operated, which further complicates the development of reliable emission factors. This is why a range of alternative scenarios are evaluated with plausible yet optimistic assumptions for LFG control. For WTE facilities, there is less variability in the design and operation. In addition, the U.S. EPA has data for all the operating WTE facilities as a result of CAA requirements for annual stack testing of pollutants of concern, including dioxin/furan, Cd, Pb, Hg, PM, and HCl. In addition, data are available for SO_2, NO_x, and CO from continuous emissions monitoring. As a result, the quality and availability of data for WTE versus LFGTE results in a greater degree of certainty for estimating emission factors for WTE facilities.

The methane potential of biogenic waste components such as paper, food, and yard waste is measured under optimum anaerobic decay conditions in a laboratory study (*24*), whose other observations reveal that some portion of the carbon in the waste does not biodegrade and thus this quantity gets sequestered in landfills (*28*). However, there is still a debate on how to account for any biogenic "sequestered" carbon. Issues include the choice of appropriate time frame for sequestration and who should be entitled to potential sequestration credits. While important, this analysis does not assign any credits for carbon sequestered in landfills.

Despite increased recycling efforts, U.S. population growth will ensure that the portion of MSW discarded in landfills will remain significant and growing. Discarded MSW is a viable energy source for electricity generation in a carbon-constrained world. One notable difference between LFGTE and WTE is that the latter is capable of producing an order of magnitude more electricity from the same mass of waste. In addition, as demonstrated in this paper, there are significant differences in emissions on a mass per unit energy basis from LFGTE and WTE. On the basis of the assumptions in this paper, WTE appears to be a better option than LFGTE. If the goal is greenhouse gas reduction, then WTE should be considered as an option under U.S. renewable energy policies. In addition, all LFTGE scenarios tested had on the average higher NO_x, SO_x, and PM emissions than WTE. However, HCl emissions from WTE are significantly higher than the LFGTE scenarios.

Supporting Information Available

MSW composition, physical and chemical characteristics of waste items, detailed LCI tables and sensitivity results, and emission factors for long haul of MSW. This material is available free of charge via the Internet at http://pubs.acs.org.

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A Solution to Man-made Methane

Reducing the release of the very potent greenhouse gas methane should be a top priority in the world's fight against climate change. This point was emphasized in a recent Wall Street Journal opinion by Fred Krupp, president of the Environmental Defense Fund. Mr. Krupp argued that reducing releases of anthropogenic methane should be an immediate focus because it would help slow the rate of near-term global warming more quickly than more expensive carbon reduction strategies. There should be no disagreement. In fact, Krupp's point can be strengthened to stress that *any* available reduction of methane will return more immediate benefit than reductions in other greenhouse gases. Leaders at the Glasgow COP26 meeting properly pledged curtailment of methane releases, focusing on regulating emissions from fossil fuel production facilities. Yet one such major source of methane, generated in vast amounts and managed poorly every day, is missing from the Glasgow discussion: garbage.

The world-wide generation of solid waste is huge and growing. The U.S. alone is approaching 300 million tons of garbage annually. Despite long-term efforts to reduce, reuse, and recycle, most of it continues to be landfilled. Once piled high in a landfill, it begins to emit methane in large quantities. Thousands of these sources have been created. Many more are on the way. Most will eventually be abandoned to sit and ooze gases. There is one solution.

Modern waste-to-energy (WTE) facilities exist world-wide. They take waste that contains carbon and convert it to energy while greatly reducing the volume of methane-generating material going to landfills. They produce highly reliable electricity for the grid and work in concert with recycling programs in every locality where they operate. Modeling has shown that for every ton of garbage processed in a WTE plant, about one ton of carbon offset is created via methane reduction, fossil fuel energy replacement, and metals recovery.

Arguments have been made that burning waste for energy to reduce carbon emissions is counter-intuitive; that it is better to work towards attaining zero waste via reduce, reuse, and recycle programs. Yet recycling rates have remained flat since 2010 and recycling markets are not improving. WTE facilities do emit CO2, but that carbon is already in our environment. Better to regain the energy in solid waste than to landfill it. A recent study by Dr. Marco Castaldi of the City College of New York addresses these points in far greater detail than can be covered here.

The answer to massive methane releases may well lie in greater regulation of industrial sources. However, until we recognize the growing impact of methane generation from our own daily consumption and disposal habits, we miss another big opportunity to lower man-made methane generation. Humans put enormous effort into producing products and materials that enhance our lives. Then, we throw much of it away. But why waste this continuously generated resource when, instead, we can significantly reduce landfilling and at the same time recover energy?

As President Biden said at the COP26 summit, "One of the most important things we can do in this decisive decade … is to reduce our methane emissions as quickly as possible."

There should be no disagreement on this.

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City of Tampa, Florida

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ecomaine (Portland, Maine)

Kent County, Michigan

Lancaster County Solid Waste Management Authority (Lancaster, Pennsylvania)

Marion County, Oregon

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York County Solid Waste Authority (York, Pennsylvania)

** In coordination with the U.S. Conference of Mayors/ Municipal Waste Management Association*

LOCAL GOVERNMENT COALITION FOR RENEWABLE ENERGY

America's Need for Clean, Renewable Energy:
THE CASE FOR WASTE-TO-ENERGY

- ► Waste-to-energy (WTE) is one of the most environmentally protective sources of renewable energy.
- ► In fact, the World Economic Forum's report, *Green Investing – Towards a Clean Energy Infrastructure*, recognizes **WTE as one of eight "key renewable energy sectors" and "particularly promising in terms of . . . abatement potential" for carbon emissions**. Attachment ("Att.") 1, p. 27 (for the reader's convenience, many of the sources cited here are reproduced in the Appendix).
- ► Nevertheless, WTE is a largely untapped resource in the United States – only 7% of our municipal solid waste (MSW) is directed to WTE while 69% is landfilled.[1]
- ► But as the former Chief of EPA's Energy Recovery Branch emphasized, "[i]f you want to have an impact on greenhouse gas mitigation, focus on MSW." Att. 2, slide 19 (keynote address, North American Waste-to-Energy Conference, May 18, 2009).

Here are the facts:

WTE HELPS MITIGATE CLIMATE CHANGE – WTE's role in reducing greenhouse gas (GHG) emissions is widely recognized:

- As EPA's solid waste management planning methodology recognizes, WTE reduces GHG emissions in 3 ways by (i) generating electricity and/or steam without having to use fossil fuel sources, (ii) avoiding the potential methane emissions that would result if the same waste was landfilled, and (iii) recovering ferrous and nonferrous metals, which avoids the additional energy consumption that would be required if the same metals were produced from virgin ores. Att. 3, pp. 1711-14; *see also* Att. 4, Part B, Summary and pp. B-23 to B-32.
- In fact, EPA's key model for determining the life-cycle GHG emissions from alternative MSW management methods shows that one ton of GHGs is avoided for every ton of MSW that is directed to WTE rather than landfilled. http://www.epa.gov/epawaste/nonhaz/municipal/wte/airem.htm (scroll to "Greenhouse Gases").
- Consistent with EPA's analysis, the Intergovernmental Panel on Climate Change (IPCC), a leading forum of independent scientific experts on climate change, **emphasizes WTE's dual benefits of (i) offsetting fossil fuel combustion and (ii) avoided landfill methane emissions**. Att. 5, p. 601.
- Similarly, the Kyoto Protocol's Clean Development Mechanism **approves WTE as a source of tradeable GHG emission reduction credits that displaces electricity from fossil fuels and avoids landfill methane emissions**. Att. 6, pp 1-3.

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- In addition, the United Nations' recent (November 2011) report, *Bridging the Emissions Gap*, concludes that waste sector GHG emissions can be reduced 80% if there is significant diversion of currently landfilled waste to WTE. *See* http://www.unep.org/publications/ebooks/bridgingemissionsgap/ (select "Full Report"), pp. 37-38.
- Finally, the former Chief of EPA's Energy Recovery Branch referred to an evolving "best integrated material management strategy" of 45% recycling, 10% landfilling and **45% WTE**. Att. 2, slide 30. But even at the 23% WTE rate the EU15 has achieved (and EU reliance on WTE continues to increase),[2] the additional reduction in CO_2e emissions in the U.S. would be 43.2 million tons, **which is equivalent to removing more than 8 million passenger cars from the nation's roads**.[3]

MODERN WTE FACILITIES – TRUE "GREEN" TECHNOLOGY – In addition to its benefits in reducing GHGs, WTE's status as a very clean and efficient energy source is evident on many other bases:

- Reflecting state and federal requirements for the most advanced emissions control technology, WTE emissions have plummeted since the late 1980's (e.g., annual WTE emissions of dioxin have decreased by a factor of 1,000 to less than 12 grams), Att. 7, p. 1722, and WTE emissions are lower than landfill emissions for 9 of 10 major air pollutants, Att. 4, p. B-30.
- In fact, EPA analysis shows that **WTE yields the best results (compared to landfills) in terms of maximum energy recovery and lowest GHG and criteria pollutant emissions**. Att. 3, pp. 1711-14, 1716-17.
- As a result, USEPA recognizes WTE as a renewable energy source that "produce[s] 2800 megawatts of electricity with **less environmental impact than almost any other source of electricity**."[4]
- EPA's hierarchy for "integrated waste management" **recommends waste combustion with energy recovery over landfilling** (as does the European Union).[5]
- WTE's efficiency and reliability are clear as well:
    - WTE recovers approximately 600 kWh of electricity per ton of waste, which is approximately **10 times the electric energy recoverable from a ton of landfilled waste**. Att. 3, p. 1714; *see also* Att. 4, p. B-29.
    - In addition, WTE is the **paradigm example of "distributed generation"** that serves nearby load without the need for new long-distance transmission lines.
    - WTE is also **base-load generation**, available 24/7 and unaffected by days that are cloudy or calm.
- It should also be noted that **GHG emissions from WTE are primarily of biogenic origin** (approximately two-thirds). Att. 3, p. 1716.
    - These emissions are already part of the natural carbon cycle because the biogenic carbon that comprises paper, food and other biomass in municipal waste is removed from the atmosphere as part of the plant growth-natural carbon cycle.

  - ° The remaining petrochemical-based material (approximately one-third) can also be considered renewable (it's generated year after year), but when relegated to landfilling rather than combustion with energy recovery, the result is the loss of a vast amount of valuable energy – **WTE recovers the energy equivalent of one barrel of oil from each ton of MSW**.

- Not surprisingly, The Nature Conservancy ranks WTE as one of the most environmentally protective alternative energy sources. Att. 8, p. 24; *see also* "*Ask the Conservationist; August 2011: Can Trash Solve Our Energy Problems?*" http://www.nature.org/ourscience/-sciencefeatures/ask-the-conservationist-august-2011.xml

WTE ENCOURAGES RECYCLING – Finally, WTE is also entirely compatible with recycling:

- **WTE communities outperform non-WTE communities in recycling, with recycling rates that are typically at least 5 percentage points above the national average** and in some cases lead the nation in recycling. Att. 9, pp. ii, 8.
- These points are confirmed by a June 2009 national survey that conservatively calculated (i.e., understated) the recycling rate for WTE communities. *Id.*, pp. ii, 6-11.[6]
- Although recycling rates are driven by state recycling policies that apply equally to WTE and non-WTE communities, **WTE communities' recycling rates are generally higher than non-WTE communities in the same state**. *Id.*, p. 11 and Figure 3.
- State laws and policies also discourage diversion of recyclable materials to combustion in a WTE facility:
  - ° For example, an Oregon county using WTE cannot "take any action that would hinder or discourage recycling activities in the county." Ore. Rev. Stat. § 459.153. That statute is focused on WTE-reliant Marion County, which **consistently achieves one of the highest recycling rates in the nation – more than 60.8%**.[7]

RECAP AND CONCLUSIONS

- ► WTE – a significant source of renewable energy that substantially reduces GHG emissions by (a) displacing electric power generation from fossil fuels, (b) avoiding methane emissions from landfill disposal of municipal waste, and (c) facilitating post-combustion recovery and reuse of ferrous and non-ferrous metals.
- ► Clean, baseload energy with very low emissions.
- ► Recovers 10 times the energy (electric power) from a ton of waste in comparison to landfill methane recovery-reuse.
- ► "Distributed" generation, i.e., energy is used where it is generated, which reduces the environmental impact and cost of transporting both waste and energy.
- ► WTE complements recycling programs rather than competing with recycling.
- ► But as is often the case with environmentally preferred alternatives, WTE can cost more (at least on a short-term and intermediate basis) – **Our communities accept the higher cost precisely because the result is better for the environment**.

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[1] *The State of Garbage in America*, http://www.jgpress.com/images/art/1010/bc101016_s.pdf (*BioCycle*, Oct. 2010).

[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/data/sectors/municipal_waste.

[3] The 43.2 million-ton figure noted in the text for reduced landfill CO_2e emissions due to increased WTE usage was calculated based on: (i) data provided in *The State of Garbage in America* (BioCycle, Oct. 2010), *supra* n.1 (Table 2, which shows U.S. landfill disposal of approximately 270 million tons in 2008); and (ii) EPA's factor (cited in the text above) of one ton of landfill CO_2e emissions avoided per ton of WTE-processed MSW. Increasing WTE usage in the U.S. to 23% (from the current 7%) would reduce landfill CO_2e emissions by the previously noted 43.2 million tons, and using EPA data for annual CO_2e emissions per passenger car (4.8 metric tons, or 5.29 tons), *see* http://www.epa.gov/cleanenergy/energy-resources/refs.html#vehicles, a 43.2 million-ton reduction in landfill emissions equals the annual CO_2 emissions of 8,170,000 passenger cars.

[4] *See* http://www.energyrecoverycouncil.org/userfiles/file/epaletter.pdf.

[5] *Municipal Solid Waste in the United States: 2007 Facts and Figures*, p. 11.

[6] The WTE communities' recycling rate omits several recyclables that the national rate includes, and the national rate is a composite that *includes* WTE communities – the more accurate comparison would *exclude* WTE communities in calculating the national rate.

[7] *See 2011 Oregon Material Recovery and Waste Generation Rates Report*, October 2012 (12-LQ-038), Table 1, http://www.deq.state.or.us/lq/pubs/docs/sw/2011MRWGRatesReportTable01.pdf.

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