February 7, 2008

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Re: Proposed R.C.S.A 22a-174-31 and R.C.S.A 22a-174-31a
Control of Carbon Dioxide Emissions/Carbon Budget Trading Program

Dear Mr. Sheehan,

On behalf of Covanta Energy Corporation (Covanta), I offer the following comments on the Department's proposed R.C.S.A 22a-174-31 and 31a, Control of Carbon Dioxide Emissions and Greenhouse Gas Emission Offset Projects (the proposal). Covanta is an internationally-recognized owner and operator of Energy-from-Waste (EfW) facilities, which convert municipal solid waste (MSW) into energy. Our company owns and/or operates over 30 EfW facilities in the U.S., including four in Connecticut (Hartford, Bristol, Wallingford and Preston).

Modern EfW is a proven, reliable, environmentally safe waste management option for managing MSW that remains after recycling. EfW is subject to stringent regulations for municipal waste combustors and has a successful compliance record on a national and international basis. EfW provides sustainable development including a variety of parameters that are of value to Connecticut. As an example, EfW generates more electrical power per ton of MSW of any MSW management option, it provides the most greenhouse mitigation, reduces land impacts (reduces the volume of MSW by about 90%), reduces potential of long-term groundwater contamination, promotes recovery of metals and is complementary to recycle programs. EfW is a preferred MSW management option according to the USEPA and European Union waste management hierarchy. The European Union's Landfill Directive requires reduced landfilling of biodegradable waste to prevent global warming and other adverse impacts to human health and the environment. Both Annex I and non-Annex I countries of the Kyoto Protocol recognize that EfW reduces GHG emissions and have mechanisms in place to use these reductions. In summary – EfW has is a demonstrated MSW management option that has a successful national and international track record however the proposed rule does not recognize these accomplishments.

With respect to the proposal, and specifically Section 22a-174-31a, EfW technology should be considered an eligible source for greenhouse gas offsets. The proposal acknowledges that landfills emit man-made methane emissions but it then rewards these same landfills with GHG offsets without creating an enforceable standard. If the reduction of methane emissions is the basis of being an offset project, it is inconsistent and indefensible to exclude EfW as a source of GHG offsets. Landfills are always a net source of greenhouse gases including methane, regardless of the collection systems used. EfW, on the other hand, has virtually no methane emissions and provides net GHG reductions and should be recognized as such in the final Program.

Covanta believes that additional opportunities for GHG offsets are needed and appropriate in order to provide additional compliance flexibility, program cost control and, most importantly, greenhouse gas emission reductions. EfW should be part of that additional opportunity. The proposal restricts the use of allowances from offset projects to only 3.3 percent under normal circumstances and up to 10 percent if regular allowance prices rise above a certain level. Moreover, as stipulated in the proposal, offset allowances can be used for 10 percent of the requirements only when allowance prices have risen to $10 per ton. If an offset project can be verified and quantified, it will result in a reduction of GHG, which is the entire point of the program. It is unnecessary to restrict their use to such a relatively small proportion of the total.

The following comments are provided in the context of the relevant proposed subparts.

22a-174-31(a)(42): Definition of "Eligible Biomass": The proposed definition is:

> "Eligible biomass includes sustainably harvested woody and herbaceous fuel sources that are available on a renewable or recurring basis (excluding old-growth timber), including dedicated energy crops and trees, agricultural food and feed crop residues, aquatic plants, unadulterated wood and wood residues, animal waste, other clean organic waste not mixed with other sold wastes, biogas, and other neat liquid biofuels derived from such fuel sources. Sustainably harvested shall be determined by the Department."

The proposed definition does not recognize the ability of existing facilities that convert conventional biomass to electrical power and will exclude demonstrated technologies that can reduce GHG emissions. We propose the following definition of "biomass" as a substitute:

> "Biomass means non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms, including products, byproducts, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material"

22a-174-31(a)(69): Definition of "Renewable Energy": The proposed definition is

> " Renewable energy means electricity generated from eligible biomass, wind, solar, thermal, photovoltaic, geothermal, hydroelectric facilities certified by the

> Low Impact Hydropower Institute, wave and tidal action, and fuel cells powered by renewable fuels."

This definition is not consistent with Connecticut General Statute 16-1 and Section 16-245-1 Definitions of the Connecticut Regulations that adopt these definitions. The existing definition of renewable energy as defined by Statute is:

> (26) "Class I renewable energy source" means (A) energy derived from solar power, wind power, a fuel cell, methane gas from landfills, ocean thermal power, wave or tidal power, low emission advanced renewable energy conversion technologies, a run-of-the-river hydropower facility provided such facility has a generating capacity of not more than five megawatts, does not cause an appreciable change in the river flow, and began operation after July 1, 2003, or a sustainable biomass facility with an average emission rate of equal to or less than .075 pounds of nitrogen oxides per million BTU of heat input for the previous calendar quarter, except that energy derived from a sustainable biomass facility with a capacity of less than five hundred kilowatts that began construction before July 1, 2003, may be considered a Class I renewable energy source, or (B) any electrical generation, including distributed generation, generated from a Class I renewable energy source;
>
> (27) "Class II renewable energy source" means energy derived from a trash-to-energy facility, a biomass facility that began operation before July 1, 1998, provided the average emission rate for such facility is equal to or less than .2 pounds of nitrogen oxides per million BTU of heat input for the previous calendar quarter, or a run-of-the-river hydropower facility provided such facility has a generating capacity of not more than five megawatts, does not cause an appreciable change in the riverflow, and began operation prior to July 1, 2003;

The proposed regulation does not consider or explain this inconsistency that will certainly create confusion amongst affected parties.

The proposed remedy is to change the definition of renewable to include the full scope of Class I and II sources as defined by Statute.

<u>22a-174-31(a) – Definitions and Abbreviations:</u> Add a new term "Life Cycle Assessment"

Calculation procedures that do not recognize the full range of energy and environmental impacts of a process can lead to an erroneous conclusion. A life cycle assessment that considers long-term impacts is considered to be a more valuable tool for making a decision on current methods to manage greenhouse gas emissions and is recommended by the Intergovernmental Panel on Climate Change (IPCC) and others. It is therefore requested that the following definition be included in the rule:

> "'Life Cycle Assessment' (LCA) is an analytical tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle."

<u>22a-174-31(a) or 22a-174-31(a)(a): Definitions.</u> Add a new term "Methane"
A clear definition of methane is needed. The Draft Generic Environmental Impact Statement for the proposed promulgation of 6 NYCRR Part 242 cites the Fourth Assessment by the Intergovernmental Panel on Climate Change as a technical resource. This IPCC report specifically comments on the impact of anthropogenic emissions including CO2 and CH4 with CH4 emissions being the second largest contributor to radiative forcing. The DEP has decided not to address CH4 as a GHG emission but is providing CO2 offsets for reducing CH4. This contradiction needs to be considered and reconciled in the State's GHG inventory including all landfills, including those subject to 40 CFR Part 60 Subpart WWW. The ability of a major source to be considered as a source of CO2 offsets without consideration of their fugitive (ie, unabated) emissions is ignored by the proposed regulation. This inequity is not explained and is inconsistent with virtually every international GHG inventory. The USEPA has a certified test method (OTM 10) for determining CH4 emissions from area sources such as landfills yet it is not being included as a means to quantify the actual emissions for this category. We propose the following definition:

> "Methane is a greenhouse gas generated by a variety of anthropogenic operations and is a greenhouse gas according to the Intergovernmental Panel on Climate Change."

<u>22a-174-31a(c)(2) and 22a-174-31a(d):</u>
These sections identify "Landfill methane capture and destruction" as an eligible offset project. This criterion should be amended to recognize and apply the requirements that offset allowances must be real, additional, verifiable, enforceable and permanent. The anaerobic environment in a landfill is a man-made environment that promotes the anaerobic decomposition of biodegradable waste over a proximate 100-year period to yield methane, a potent GHG. Methane collected by a landfill gas collection system and converted to CO2 should be considered as carbon neutral whereas methane that is not collected is an emission to the environment that has a positive value. The only scenario where a landfill gas system warrants GHG credits is when landfill gas is used to generate electricity and the avoided fossil fuel CO2 is greater than the methane released to the environment, all on a lifecycle basis. A landfill gas collection system that captures a fraction of the methane some of the time is not real, verifiable, quantifiable, enforceable and permanent when considering the following:

> Real – the statement does not recognize that there is methane released to the environment before, during and after operation of the landfill gas system and that all of this methane is man-made. The reduction or "offset" is not Real unless the CO2 offset from the generation of electricity is greater than the methane released to the environment.

Quantifiable, Verifiable and Permanent – the proposed statement only addresses the fraction of landfill gas collected. The proposed condition does not recognize that there are other fugitive emissions during all phases of a landfills operation including those when no landfill gas is being collected, and that subsequent conditions do not require measurement of such despite the availability of certified EPA test methods (OTM-10). Verification of the "net reduction" or "offset" is not required by the proposed language, therefore the landfills performance is never demonstrated. As a result, the permanent nature of the so-called offset is also never demonstrated.

Enforceable – this standard is not met due to the absence of any enforceable mechanism that includes quantifiable measurements. This statement includes the absence of any requirement for testing fugitive methane emissions during all phases of landfill operation.

Section 22a-174-31a(c)(2) and 22a-174-31a(d) should therefore be amended as follows:

"Landfill methane capture and destruction *on a lifecycle basis that recognizes all of the operating phases of the landfill*"

22a-174-31a(d): The Department clearly understand the benefit of reducing or avoiding methane emissions, which are significantly more potent as greenhouse gas emissions than carbon dioxide. The basis for proposed 242-10.5(a) "Landfill methane capture and destruction" is that collection and destruction of a fraction of methane generated from MSW is an effective GHG mitigation method. If this methane reduction strategy is acceptable, then a technology such as a modern EfW facility should also be included due to its inherent avoidance of 100% of the methane that would be generated from any amount of MSW. Modern EfW facilities are internationally recognized as a viable process for reducing greenhouse gas emissions. Annex I countries are using solid waste management in general and EfW specifically as a mechanism to reduce GHG emissions. In fact, the European Union is using these reductions to demonstrate progress towards meeting their respective Kyoto Protocol targets. Non-Annex I countries are using approved Clean Development Mechanism (CDM) protocols (AM0025 ver.10 methodology) to generate CO2 credits from EfW. The USEPA has co-developed the Municipal Sold Waste Decision Support Tool, a lifecycle analysis protocol that determines the GHG emission characteristics of different MSW disposal options and is a valid technique for estimating the quantity of GHG reduced by EfW when compared to various landfill options.

A simplified methodology based upon the CDM protocol and USEPA MSW-DST is provided as Attachment 1. These calculation procedures are proposed as being appropriate for quantifying greenhouse gas reductions from EFW. Covanta proposes that the DEP identify EfW as an offset project with the attached procedures to document energy-from-waste as a valid offset category.

In light of these facts, a new “Offset project type” should be included at 22a-174-31a(c)(2):

> “Energy-from-waste facilities subject to regulatory requirements at 40 CFR Part 60 Subpart Cb, Eb, AAAA or BBBB that recovery energy from the combustion of municipal solid waste.”

<u>22a-174-31a(d)(2) - “Emissions baseline determination”:</u> This condition for determining the baseline emissions from a landfill gas capture process is proposed as:

> The emissions baseline shall represent the potential fugitive emissions of CH4 (in tons of CO2e), as represented by the CH4 collected and metered for thermal destruction as part of the offset project, and calculated in accordance with this paragraph….”[formula provided].

Covanta has 3 general issues with this proposed condition:

1. Methane from landfills is a man-made pollutant generated due to the burial of organic matter in an oxygen starved environment. Methane does not exist when the waste is buried. It is formed from an artificial environment and all of the methane on a lifecycle basis should be considered in the baseline.
2. Air regulations for the protection of human health and the environment should apply to all of the methane, not only the fraction “collected and metered”.
3. This entire condition fails to regulate CH4 from landfills that do not install a landfill gas collection system.

Item 1 raises the question of why a landfill, or any other generator for that matter, should receive an offset for controlling a pollutant that they created. The concept of rewarding a generator for collecting a fraction of a pollutant is precedent setting.

Item 2 raises a question about the language that awards an offset for the “CH4 collected and metered”. The general equation does not recognize that there are fugitive emissions lost to the environment during all phases of a landfill including the phase when a landfill gas collection system is in operation collecting a fraction of the landfill gas. Why would the landfill get credit for collecting some of the methane part of the time and not be penalized for emitting this same greenhouse gas pollutant during all other phases including the amount not captured when it is operating. As an analogy, this would be similar to awarding NOx emission reduction credits to an emission source, and then imposing no standards whatsoever on the facility’s continuing NOx emissions.

Item 3 raises the general concept of equal application of a regulation to control greenhouse gases. If all landfills are known sources of methane – why aren’t they listed as such and required to implement the best possible control of such.

Based upon this reasoning, this section should be modified as follows:

> “The emissions baseline shall represent the potential fugitive emissions of CH4 (in tons of CO2e), as represented by *total* of *1)* the CH4 collected and metered for thermal destruction as part of the offset project, *2) the CH4 not collected during the*

> *CH4 collection period as quantified by EPA OTM-10, and 3) the CH4 not collected before implementation of the CH4 collection system and after the collection system operation has been terminated*, and calculated in accordance with 22a-174-31a(d)(2)."

Naturally the corresponding equation in 22a-174-31a(d)(2) would need to be re-done to enable an accurate CH4 mass balance.

In addition, the value of the "oxidation factor" (OX) in the formula should be changed. The proposal cites a value of 0.10, stating that it represents "…the estimated portion of collected CH4 that would have eventually oxidized if not collected…". However, the presumed oxidation of CH4 across a landfill cover is not a sound technical statement. For example, how does methane become exposed to soil when there is an impermeable cover? And where are the enforceable management requirements for this soil cover and where are the requirement to measure this parameter on a continuous or semi-continuous basis. The absence of credible facts and enforcement requirements contradicts the requirement that offset allowance are real, additional, verifiable, enforceable and permanent.

From a practical perspective, a landfill gas collection system is most effective after the cell is covered. This same covering that is designed to prevent in-leakage of water, also prevents the escape of landfill gas. As a consequence, gas that escapes is not through soil where oxidation may occur but through the path of least resistance such as a tear in the cover, a penetration through the cover or a leak around a gas recovery well casing.

From a regulatory perspective:
Real – there is no demonstration that oxidation ever occurred.
Verifiable – again, there is no evidence to support this assumption and there is no requirement to generate this information.
Enforceable – again, there is not a requirement to prove this value so it is not an enforceable condition.
Permanent – same argument as above.

Therefore, the description of OX should be changed as follows:

> OX – Oxidation factor (~~0.10~~) *(0.00)* representing estimated portion of collected CH4 that would have eventually oxidized if not collected: and,
>
> An oxidation factor can be applied if the generator implements a demonstration project that identifies an initial factor and landfill management practices that will ensure that this factor is maintained on a continuous basis. In order to assure that this variable is being maintained in practice, repeat field testing on a quarterly basis is required in addition to landfill operating practices to assure integrity of the landfill cap. If field testing does not prove that the requisite oxidation factor is being achieved, the offset calculation will be adjusted accordingly.

<u>22a-174-31a(d)(3) : Calculating emission reductions.</u> This standard states that:

> "Emissions reductions shall be determined based on potential fugitive CH4 emissions that would have occurred at the landfill if metered CH4 collected from the landfill for thermal destruction as part of the offset project was not collected and destroyed."

The issues raised with respect to 242-10.5(a)(3) also apply to this condition. Therefore, this condition should be changed as follows:

> "Emissions reductions shall be determined based on the *difference between total* potential fugitive CH4 emissions that would have occurred at the landfill *and the amount* ~~if~~ *of* metered CH4 collected from the landfill for thermal destruction as part of the offset project ~~was not collected and destroyed~~. *The total potential fugitive emission CH4 factor shall include1) the CH4 not collected during the CH4 collection period as quantified by EPA OTM-10, and 2) the CH4 not collected before implementation of the CH4 collection system and after the collection system operation has been terminated*"

As with 22a-174-31a(d)(2)_, the value of OX in the accompanying formula should also be changed to zero, in the absence of field testing.

In addition, the value of Cef (Combustion efficiency of methane control technology) in the formula should be modified. The proposal identifies this value as 0.98. The assumption that CH4 destruction is a constant value is not a sound technical statement and the absence of any requirement to ever measure this parameter, on a continuous or semi-continuous basis, is contrary to the requirement that offset allowance must be real, additional, verifiable, enforceable and permanent.

From a practical perspective, methane control technology is not a continuous process whether it is a flare or engine. There are well documented variations in the fuel quality, startup, shutdown and malfunction conditions and the inherent limitations of the technology device itself. Internal combustion engines are well known to operate with a combustion efficiency less than 98 %.

From a regulatory perspective, the assumption contradicts required parameters for an offset including:
Real – there is no demonstration that reduction ever occurred wjen considering fugitive emissions
Verifiable – again, there is no requirement to generate this information that validates that a reduction occurred
Enforceable – again, there is not requirement to prove this value and the protocol is not proposing and enforceable limit that would have compliance obligations. .
Permanent – same argument as above.

Therefore, the following change is suggested:

> Cef = Combustion efficiency of methane control technology (~~0.98~~) (*0.00*). and,

A combustion efficiency factor can be applied if the generator implements a demonstration project that identifies an initial factor and landfill management practices that will ensure that this factor is maintained on a continuous basis. In order to assure that this variable is being maintained in practice, repeat field testing on a quarterly basis is required in addition to continuous monitoring of carbon monoxide and other landfill operating practices to assure integrity of the methane control system. If field testing does not prove that the requisite oxidation factor is being achieved, the offset calculation will be adjusted accordingly.

22a-174-31a(d)(4) – Monitoring and verification requirements: This subpart establishes standards for monitoring, recording and sampling the captured landfill gas in a landfill gas offset project. Covanta reviewed the proposed condition in the context of the requirement that an offset allowance must be real, additional, verifiable, enforceable and permanent. Prior comments have addressed the general problem with not measuring or considering methane emissions to the environment before, during and after the landfill gas system has been operational. An additional issue raised in the proposal is reliance on "manufacturers' recommendations" for compliance with a state regulation. Specific points are:

Verifiable – instrumentation and certification procedures are required to affirmatively demonstrate the performance of any system. Manufacturers' recommendations will vary from manufacturer to manufacturer and do not necessarily equate to verifiable.

Enforceable – unless there is some form of state-enforceable compliance mechanism in a facilities permit, this provision by itself does not achieve the verifiable metric. This statement applies equally to methane capture values, the performance of the methane destruction device and oxidation values. We also strongly suggest that the true fugitive losses should be measured by EPA OTM-10.

The subpart should be modified as follows:

Offset projects shall employ a landfill gas collection system that provides continuous metering and data computation of landfill gas volumetric flow rate and CH4 concentration *destroyed by the methane management device*. Annual monitoring and verification reports shall include monthly volumetric flow rate and CH4 concentration data, including documentation that the CH4 ~~was~~ actually supplied to the combustion source *was destroyed*. Monitoring and verification is also subject to the following requirements.

i. The project sponsor shall submit a monitoring and verification plan as part of the consistency application that includes a quality assurance and quality control program associated with equipment *and instrumentation* used to determine landfill gas volumetric flow and CH4 composition. The monitoring and verification plan shall also include provisions for ensuring that measuring and monitoring equipment is maintained, operated and calibrated based on ~~manufacturing recommendations~~ *performance standards approved* *by the State with all calibration being performed by independent third party firm*, as well as provisions for the retention of maintenance records for audit purposes. The monitoring and verification plan shall be *implemented and all results* certified by an independent verifier accredited pursuant to 242-10.6.

ii. The project sponsor shall annually verify landfill gas CH4 composition through landfill gas sampling and independent laboratory analysis using applicable U.S. Environmental Protection Agency laboratory test methods.

Statement of Purpose
The proposed Statement of Purpose is "To adopt a new regulation to implement the provisions of the Regional Greenhouse Gas Initiative (RGGI) necessary to provide for the creation and use of carbon dioxide offset credits through five specific activities: landfill methane capture and destruction; avoided sulfur hexafluoride emissions; sequestration due to afforestation; end-use energy efficiency; and avoided methane."

The following text is proposed an alternative with the basis in fact being prior comments in this letter.

"To adopt a new regulation to implement the provisions of the Regional Greenhouse Gas Initiative (RGGI) necessary to provide for the creation and use of carbon dioxide offset credits through five specific activities: landfill methane capture and destruction; avoided sulfur hexafluoride emissions; sequestration due to afforestation; end-use energy efficiency; and avoided methane *and renewable energy as defined by Connecticut General Statute 16-1*."

Thank you for this opportunity to comment. If you have any questions, please contact me at 973-882-7236.

Sincerely,

Brian Bahor, QEP
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Attachment 1

Greenhouse Gas Emission Credits –
A Simplified Protocol for Energy-from-Waste Projects

The United Nations Framework Convention on Climate Change, Climate Development Mechanism (CDM) allows credits for greenhouse gas (GHG) emission reductions that result from waste management projects such as energy-from-waste (EfW). CDM has issued a protocol[1] for quantifying these emission reductions. The protocol includes consideration of three major life cycle GHG emission components when calculating eligible credits: 1) EfW-related GHG emissions; 2) avoided landfill methane emissions; and, 3) avoided energy generation CO2 emissions. Please note that the CDM protocol and this simplified version does not include factors that recognize the GHG mitigation associated with eth recovery of ferrous and nonferrous metals at EfW facilities. These factors can be added on a site specific basis.

EPA's Municipal Solid Waste Decision Support Tool (MSW DST)[2] is another life cycle GHG emission protocol used to evaluate waste management projects like EfW. The approach is similar to that in the CDM, including the same three major GHG emission components, among others.

The calculations involved in the CDM and MSW DST are straightforward when organized according to the three major life cycle components that quantitatively reflect how a n EfW project reduces GHG emissions. The CDM protocol can be represented by a concise, simple set of equations and calculations, as presented below.

Simplified Protocol Summary

The basic protocol equation is expressed in terms of MTCO2E/year, as follows:

Emission Reduction = Baseline Emissions – EfW Project Emissions

Baseline Emissions:

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[1] CDM's approved baseline and monitoring methodology AM0025 (Version 10), "Avoided emissions from organic waste through alternative waste treatment processes" is the basic protocol applicable to EfW (termed "incineration" in the CDM documents). AM0025 references two other methodological tools – Annex 10 (Version 2) "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", and Annex 12 (Version 1) "Tool to calculate the emission factor for an electricity system". Another document, ACM0001 (Version 7), "Consolidated baseline and monitoring methodology for landfill gas project activities", is used when the baseline landfilling condition involves methane capture and destruction. These four documents make up the CDM protocol for calculating net GHG emissions from an EfW project.

[2] The MSW DST was developed through a cooperative agreement between the U.S. EPA's Office of Research and Development and RTI's Center for Environmental Analysis to assist communities and other waste planners in conducting cost and environmental modeling of MSW management systems.

Baseline emissions are those that would exist in the absence of the EfW project and consist of the methane emissions from landfilling waste and CO_2 emissions from generating electricity.

1. Landfill Methane Emissions:

Landfill methane is generated by anaerobic decomposition of waste. Annual emissions can be predicted using a first order decay model. However, the total methane generation attributable to waste landfilled in a given year can be more simply represented as follows:

Methane generation = Lo x MSW x GWP x 6.8E-4

where: Methane Generation is in MTCO2E/year
Lo = methane generation potential (m3 CH4/Mg MSW)
MSW = annual MSW landfilling rate (Mg MSW/year)
GWP = 25 MTCO2E/MTCH4, the Global Warming Potential for methane[3]
6.8E-4 is the conversion of m3 CH4 to MTCH4

Not all methane generated is emitted. Landfills can collect landfill gas (LFG) and destroy methane emissions using flares or other combustion equipment. LFG collection efficiency varies depending on the type and timing of controls and ranges from 20 to 75% on a lifetime basis, i.e. considering all phases of landfill development. Methane destruction efficiencies for the collected LFG depend on equipment performance but are on the order of $95\text{-}99^{+}\%$. Uncollected methane can be partially oxidized by microorganisms in soils through which uncollected LFG may permeate. A typical assumed value for soil oxidation is 10%. However, since soil oxidation varies and may be less at modern capped landfills where fugitive gases have little contact with soils, the default value should be zero in the absence of site-specific, verified information. Considering both LFG collection/destruction and soil oxidation,

$$\text{Landfill methane emissions} = \text{Methane generation} \times ((1 - E_{LFG\ coll} \times E_{destruct}) - (1 - E_{LFG\ coll}) \times E_{soil\ ox})$$

where: Methane emissions are in MTCO2E/year
$E_{LFG\ coll}$ = LFG collection efficiency as a fraction
$E_{destruct}$ = Methane destruction efficiency as a fraction
$E_{soil\ ox}$ = Methane soil oxidation efficiency as a fraction

2. Electrical Generation CO2 Emissions

CO2 emissions are generated by the combustion of fossil fuels. Electrical generation displaced by EfW excludes existing "must run" facilities such as nuclear, hydroelectric, solar, wind, and low cost biomass. Baseline CO2 emissions therefore normally include only fossil-fired facilities - natural gas, fuel oil, and coal.

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[3] 2007 IPCC Fourth Assessment Report, 100-year time horizon. Methane GWP for 20-year time horizon is 72.

Fossil CO2 emission factors are estimated as follows for each type of fossil fuel displaced:

$$CO2\ EF = EF_{fuel} / E_{gen} \times 3.6$$

where: CO2 EF is the CO2 emission factor in MTCO2E/MWh
EF_{fuel} = emission factor for fossil fuel (MTCO2E/GJ)
E_{gen} = efficiency of the baseline electrical generation as a fraction
3.6 is the equivalent GJ energy in a MWh of electricity

Baseline CO2 emissions are calculated as the sum of each type of fossil fuel avoided by the EfW project.

$$\text{Electrical generation CO2 emissions} = CO2\ EF_{nat\ gas} \times Elec_{nat\ gas} + CO2\ EF_{oil} \times Elec_{oil} + CO2\ EF_{coal} \times Elec_{coal}$$

where: Electrical generation CO2 emissions are in MTCO2E/year
$CO2\ EF_{nat\ gas}$ = CO2 emission factor for natural gas (MTCO2E/MWh)
$CO2\ EF_{oil}$ = CO2 emission factor for oil (MTCO2E/MWh)
$CO2\ EF_{coal}$ = CO2 emission factor for coal (MTCO2E/MWh)
$Elec_{nat\ gas}$ = Displaced electricity from natural gas (MWh/year)
$Elec_{oil}$ = Displaced electricity from oil (MWh/year)
$Elec_{coal}$ = Displaced electricity from coal (MWh/year)

In the event that the EfW project is redirecting MSW that would otherwise be sent to a landfill that has energy recovery, the displaced electricity values should be adjusted downward by the amount of landfill energy that will no longer be recovered.

3. Total Baseline Emissions

Total baseline emissions, expressed as MTCO2E/year, are the sum of landfill methane emissions and electrical generation CO2 emissions, as calculated above

Baseline emissions = Landfill methane emissions + Electrical generation CO2 emissions

EfW Project Emissions

EfW-related GHG emissions include CO2, CH4, and N2O emissions from MSW combustion, and CO2 from combustion of auxiliary fossil fuel. For modern EfW technology, CH4, N2O, and auxiliary fuel CO2 emissions are very small compared to MSW CO2 emissions.

CO2 emissions from MSW combustion are of both biogenic and fossil origin. Only the fossil CO2 is counted as a GHG emission, calculated as follows:

$$\text{EfW Project Emissions} = MSW \times C_{MSW} \times F_{bio} \times E_{comb} \times 44/12$$

where: MSW = annual EfW MSW throughput rate (Mg MSW/year)
C_{MSW} = MSW carbon content as a fraction
F_{bio} = Fraction of total carbon that is of biogenic origin
E_{comb} = Carbon combustion efficiency as a fraction
44/12 = conversion of MTCE to MTCO2E

For MSW, carbon content normally ranges from 28-32% wet weight, biogenic carbon fraction is typically about 65%, and carbon combustion efficiency is about 99%. As an alternative to the above equation, EfW project fossil CO2 emissions can be directly measured using EPA and ASME methods.