August 11, 2011

Clerk of the Board
Air Resources Board
1001 I Street
Sacramento, California 95814

Via Electronic submittal: http://www.arb.ca.gov/lispub/comm/bclist.php

To Whom It May Concern:

Covanta Energy submits these comments on the California Air Resources Board ("CARB") Proposed Regulation to Implement the California Cap-and-Trade ("C&T") Program (released July 27, 2011). Covanta Energy is a national leader in developing, owning and operating facilities that convert municipal solid waste ("MSW") into renewable energy. Energy from waste ("EfW") facilities or waste to energy ("WTE") facilities provide important waste disposal services to municipalities seeking to avoid or minimize use of landfills, while using MSW as a fuel source for generating renewable energy.

Covanta Energy supports the goals of AB 32 and the efforts to reduce GHG in California. Currently, in the proposed 15-Day Language , however, EfW is treated as a carbon source with its GHG impact determined solely by stack emissions, regardless of the benefit of reduced methane emissions realized by keeping waste out of landfills. Without a mechanism to recognize the benefits of EfW, there will be a leakage of GHG emissions to an uncapped sector.

This is a departure, from the ARB Discussion Draft released in July 2010 , where ARB had determined that EfW facilities were excluded from the cap because of the potential economic impacts on the industry and the resultant potential increase in methane emissions resulting from the diversion of waste to landfills, even factoring in the landfill improvements resulting from the early action measures. Staff also noted the consistency with existing cap and trade programs, notably European Union Emissions Trading Scheme (EU-ETS) and the Regional Greenhouse Gas Initiative (RGGI). Further, at the CARB Board meeting in December 2010, the board adopted a resolution which directed staff to "develop a mechanism to satisfy all the risk of emissions leakage and compliance obligations of existing waste-to-energy facilities in the proposed cap and trade program." There is support at the CARB Board to exclude these facilities from the Cap and between now and October, Covanta Energy and its partnering communities of Stanislaus and Long Beach request that the ARB exclude the EfW facilities from the Cap & Trade program.

Internationally, the greenhouse gas ("GHG ") mitigation benefits of EfW are widely recognized by science and climate policy experts. The European Union Emissions Trading Scheme (EU-ETS), the world's largest carbon market, explicitly excludes the 380 EfW facilities in the EU from the existing carbon cap. In fact, the widespread use of EfW, coupled with aggressive recycling programs, has been identified by the European Environmental Agency as the driver of significant reductions in GHG emissions from the waste sector. Additionally, the Nobel Prize winning Intergovernmental Panel on Climate Change ("IPCC") identifies EfW as a key GHG mitigation technology for the waste sector. The World Economic Forum in its 2009 Davos Report, identified EfW as one of 8 technologies likely to make a significant contribution for a future low carbon global energy system. The 2010 Davos Report reiterated their findings but also included a recommendation to follow the European Union's model and increase Energy from Waste by phasing out use of landfills because bury waste in landfill is "increasingly considered environmentally unacceptable".

The California Cap-and-Trade ("C&T") Program disregards the benefits of EfW as a tool to reduce GHG emissions in the waste sector and considers EfW a capped emission source. Conversely, landfills are an uncapped sector. EfW facilities will be required to purchase compliance obligations, but landfills will not, despite landfills being a greater source of emissions per ton of post recycled waste managed. The current draft regulations do not provide a way to evaluate the avoided methane emissions from landfilling that these facilities prevent.

Evaluating Emissions in the Waste Sector

We propose that the Cap-and-Trade ("C&T") Program evaluate the GHG emissions between EfW and landfills. Traditionally, Life Cycle Assessment (LCA) is the recommended method to evaluate the difference in emissions between these two sources. A variety of international organizations involved with GHG management including the IPCC, USEPA's Municipal Solid Waste Decision Support Tool, and the Clean Development Mechanism of the Kyoto Protocol use the LCA. LCA procedures applied to EfW facilities identify four major greenhouse gas related processes:

1. Anthropogenic, or fossil CO_2, GHG emissions from combustion of waste components (plastics, textiles, etc.) made from fossil fuels such as oil;
2. Avoidance of CO_2 from fossil fuel fired power plants on the local grid due to generation of renewable electrical power or steam, by an EfW facility and;
3. Avoidance of landfill methane emissions from waste that would have been landfilled in the absence of the EfW facility.
4. Avoidance of extraction and manufacturing GHG emissions due to ferrous metal recovery and recycling at EfW facilities.

In California's Cap-and-Trade program, however, we recognize that that fossil CO_2 are capped sources, so including them in a calculation to evaluate the emissions between EfW and landfills would be double counting.

We also recognize that any analysis comparing landfills and EfW emissions should include the impact of the ARB Early Action Measures for regulating LFG emissions. These regulations will reduce the fugitive CH_4 emissions associated with landfilling MSW, but there still will be non-zero amounts of CH_4 emitted.

Evaluating EfW GHG Emissions Compared to Landfill Emissions
Covanta has provided the ARB with a conservative calculation, the spreadsheet titled "CA Life Cycle Calcs 3-31-11.xlsx" demonstrating that emissions from the three California EfW facilities are lower than the landfill alternatives. While the calculation is based on some life-cycle principles, it is important to note that it is not a life-cycle calculation. For example and as mentioned above, EfW facilities generate electricity and recover ferrous and non-ferrous metals, the benefits of which would be calculated in a life cycle inventory. However, these benefits have been excluded from this calculation, since they are covered by California's proposed cap and trade program. Only the landfill methane avoided by EfW is calculated since landfills are not a capped sector under the cap and trade program.

In the analysis comparing the emissions of EfW and landfilling, we used existing ARB factors and methodologies to ensure consistency with existing regulations, policies, and information. For example, the input factor for soil oxidization was taken from the ARB Landfill Methane Emissions Estimation Methodology. For collection efficiency, we used ARB's most recent landfill gas study at Palos Verde, to derive an 83% collection efficiency, adjusted to account for soil oxidation.[1] This figure is in excess of the U.S. EPA default, and reflects the increased performance of the Landfill Early Action Measure. It should be noted that the 83% does not account for the emissions that occur before the landfill gas control system is installed and operating at full capacity, nor does it account for emissions after the system is removed. Nationally, under the federal New Source Performance Standards, landfills have two to five years to install gas collection systems after waste is placed in a cell. With the implementation of the landfill early action measure, we conservatively estimated that landfills will have collection systems in place only a year and a half after waste is placed in a cell, and *immediately* attain an 83% collection efficiency. More detail and documentation for these and other model parameters are available in Attachment A.

Unintended Consequences of Capping EfW facilities
California's regulations to reduce and limit greenhouse gas emissions disregard the benefits of EfW as a tool to reduce GHG emissions in the waste sector. The counties and cities that own these facilities will be forced to buy compliance obligations. At a minimum, this will divert funds from municipal programs including recycling, composting and hazardous waste programs. The burden of compliance obligations also means that EfW facilities will be increasingly expensive to operate. Communities will face the difficult decision of either paying higher costs for EfW, or choosing the cheaper route of landfilling with its higher levels of GHG emissions.

[1] The CARB study reported landfill gas collection at 85%; however, this figure is inclusive of the effects of soil oxidation, since the study looked at surface methane concentrations above the landfill. The 83% accounts for a 10% soil oxidation. Higher assumed levels of soil oxidation would require a decreased collection efficiency to attain the 85% total abatement figure presented in the CARB report.

This policy will serve to incentivize the use of landfills and make the better environmental choice, EfW, more expensive.

Conclusion

Inclusion of EfW facilities in the CARB Cap and Trade Program ignores the scientifically recognized GHG benefits of this technology and will ultimately result in more GHG emissions generated in California. Covanta Energy and its community partners support a compliance obligation exemption for the three existing Energy-from-Waste facilities in California. An exemption is consistent with the major cap and trade systems currently in place: energy from waste facilities are not included in either the European Union Emission Trading Scheme or the Regional Greenhouse Gas Initiative (RGGI). Inclusion of these facilities in the cap and trade program will introduce a significant economic burden on these facilities. This additional burden, and the fact that landfills face no compliance obligation under the program, raises a significant risk that waste will be diverted to landfills. Diversion of waste to landfills, as shown in the conservative analysis completed, will result in emissions leakage and higher GHG emissions from the state. Additionally, communities will lose revenues generated from the sale of electricity at these facilities. These are revenues that these communities use to fund their recycling programs.

In support of these recommendations, Covanta is pleased to attach our more detailed comments and supporting information. Thank you for the opportunity to submit comments and please do not hesitate to contact the undersigned if you have any questions.

Sincerely,

Ellie Booth

Ellie Booth
Director of State Government Relations

Attachment A

California Waste to Energy Emissions Calculation and Comparison to Landfill Emissions

Description of Spreadsheet Calculation & References

Introduction

As currently proposed, CARB cap and trade regulations include waste to energy ("WTE") facilities in the cap, but exclude landfills, despite lower GHG emissions for WTE and wide recognition of WTE as a source of GHG mitigation including by U.S. EPA & North Carolina State University scientists,[1] the Intergovernmental Panel on Climate Change ("IPCC"),[2] the World Economic Forum,[3] the European Union,[4,5] the Kyoto Protocol's Clean Development Mechanism,[6] and the Verified Carbon Standard ("VCS").[7] In California, a recent report prepared for the CIWMB (now CalRecycle), outlined a minimum GHG emissions scenario which relied, in part, on expanded WTE.[8] CARB recognized avoided GHG emissions of 1,200 to 1,700 lb CO_2e / MWh, including avoided landfill methane, in its environmental analysis supporting documentation for the RES.[9] On the federal policy level, the House passed Waxman-Markey Bill, and the corresponding Senate bill passed by the Energy & Natural Resources Committee exempted WTE from the carbon cap.[10, 11]

The inclusion of WTE facilities is in direct contrast with both the European Union Emission Trading Scheme ("EU-ETS") and the Regional Greenhouse Gas Initiative (RGGI), both of which exclude WTE facilities from the cap. Thirty-seven WTE facilities are located in the ten RGGI states[12] and over 380 WTE facilities are located in the European Union.[13]

A conservative calculation, provided to CARB in the spreadsheet titled "CA WTE GHG Emissions Calculations.xlsx" demonstrates that GHG emissions from the three California WTE facilities are lower than the landfill alternatives. The inclusion of WTE in a cap subjects WTE to an added economic burden not shared by landfills. This burden results in an economic incentive to landfilling, the waste management alternative with higher GHG emissions.

While the calculation is based on some life-cycle principles, it is important to note that it is not a life-cycle calculation. For example, WTE facilities generate electricity and recover ferrous and non-ferrous metals, the benefits of which would be calculated in a life cycle inventory. However, these benefits have been excluded from this calculation, since they are associated with sectors covered by California's proposed cap and trade program. Only the landfill methane avoided by WTE is calculated since landfills are not a capped sector under the cap and trade program.

The following sections describe the calculations and data sources used in the aforementioned spreadsheet.

Key Default Factors & Inputs

L_o, Methane Generation Potential

The methane generation potential is a constant that represents the total amount of methane a megagram ("Mg") or metric tonne of waste will generate in a landfill through anaerobic digestion. The U.S. EPA uses values between 100 – 170 m^3 CH_4 / Mg MSW.[14] The value of 78.8 m^3 / Mg MSW used in this assessment is an average of the methane generation potential calculated from the 2004 and 2008 California Integrated Waste Management Board (CIWMB) waste characterizations,[15,16] adjusted to exclude most construction & demolition (C&D) debris,[17] medical waste, and sludge. These materials are excluded in the adjustment because the WTE facilities located in the state are not permitted to take these materials. The L_o calculation, which follows the CARB First Order Decay Model Tool and the 2006 IPCC Guidelines, is detailed below, and performed on the spreadsheet tab titled "CA Lo Calc."

First, a weighted degradable waste fraction is developed, excluding those components ineligible for processing at a waste to energy facility:[18]

(1)

Where:

ANDOC%	=	Percent of the waste that is degradable, as carbon
$WIPFRAC_i$	=	Fraction of the i^{th} waste component in waste
$TDOC_i$	=	Total degradable organic fraction of the i^{th} waste component
$DANF_i$	=	Decomposable anaerobic fraction of the i^{th} waste component

Then, the percent of waste that is degradable organic carbon (under anaerobic conditions) is converted to a methane generation potential as follows:[19]

— ———— (2)

Where:

L_o	=	methane generation potential (m^3 CH_4 / Mg MSW)
F	=	fraction of methane in landfill gas, 0.5
—	=	molecular weight ratio of methane to carbon
1,503	=	conversion from Mg methane to m^3 methane at U.S. EPA standard conditions (20°C and 1 atm pressure)

Soil Oxidation Factor

Methane not collected by a landfill gas collection system may be subject to some degree of soil oxidation as it passes through cover soils. Based on a CARB default, 10% of uncollected methane is assumed to be oxidized to CO_2.[20] The 10 percent assumption for soil oxidation is consistent with international and domestic precedents and is used by the CARB Landfill emissions tool[21] and the CARB Local Government Operations Protocol.[22] Use of the 10 percent figure is also required by the US EPA for its GHG Reporting Program.[23] The 10 percent default is used by the U.S. EPA GHG Inventory[24], the Clean Development Mechanism of the Kyoto Protocol[25], the Climate Action Reserve Organic Waste Digestion[26] and Organic Waste Composting Project Protocols[27], and the U.S. EPA Waste Reduction Model (WARM). The Intergovernmental Panel on Climate Change recommends that a value of 10% be used for well-managed landfills to estimate both diffusion through the cap and the escape of methane through cracks / fissures in the cap.[28]

Some research has been published that shows methane oxidation values significantly higher than the 10% default most commonly used; however, these results are preliminary, have not gained wide acceptance, and typically ignore or underestimate the impact of preferential pathways through the soil column. In response to comments advocating for the use of higher soil oxidation figures in the GHG reporting rule, the U.S. EPA responded as follows:

> "We have also reviewed the SWICS protocol for soil oxidation, which provides suggested oxidation factors ranging from 0.22 to 0.55 depending on the soil cover type. We have several concerns with these factors. First, the values were calculated using arithmetic means which appear to be biased high due to a few high oxidation factors; the median values were generally significantly lower than the average values suggested. Second, the recommended values included laboratory test values, which always yielded higher oxidation fractions. The percent of methane oxidized at the landfill surface is highly dependent on the velocity of gas flow. While areas of low flow are expected to have significant oxidation, areas of high flow will have little to no oxidation. Landfill gas will generally flow to the surface in fissures and channels that offer the least resistance to flow. Consequently, a significant portion of the landfill gas is likely to exit the landfill in a limited number of areas under much higher flow rates than other locations. These high volume flows will not have significant oxidation."[29]

Furthermore, in its discussion of the selection of the 10% default for the landfill methane emissions methodology as part of the landfill early action measure, CARB noted that

> "[The default of] 10 percent for [soil] oxidation fraction has been the object of some debate. Staff recognizes that many values can be found for these factors in the literature and that some site specific measurements and local estimates do exist. However, given the current lack of rigorous, scientifically-based measurement data, staff chose to use the default values established by USEPA."[30]

Global Warming Potential

The global warming potential is used to convert methane into carbon dioxide equivalents. The 100-year CH_4 GWP of 21 from the IPCC 2nd Assessment Report is used in the calculation, in accordance with the CARB GHG Reporting Rule. The use of the 2nd Assessment Report is conservative. After two subsequent revisions, the first in 2001, and then in 2007, the IPCC now reports in the 4th Assessment Report that the GWP of methane is 25, a nearly 20% increase from the 1995 2nd Assessment Report value. Furthermore, recent research published in *Science* by a team of Columbia and NASA scientists has found that, when indirect aerosol effects are included, the 100 year GWP for methane is 34, 62% higher than the value reported by IPCC in 1995.[31]

1st Order Decay Rate Constant

The first order decay rate constant determines the rate at which anaerobic degradation is predicted to occur in the model. A k value of 0.02 / year is specified by CARB for areas with annual rainfall of less than 20 inches.[32] Landfill options located near the three energy from waste facilities in California are in areas receiving less than 20 inches per year of rain, on average.

Time from Placement of Waste to Collection of LFG (years)

Federal New Source Performance Standards ("NSPS") require landfill gas collection between two (2) to five (5) years after waste is placed in a cell, depending on specific circumstances. However, the California Early Action measure Methane Emissions from Municipal Solid Waste Landfills has much more stringent requirements.[33] Based on these requirements, a lag time of 1.5 years from waste placement to the installation of landfill gas collection was used.

% Methane in LFG

The percentage of methane in landfill gas is analogous to the fraction of decomposing carbon converted into CH_4. The CARB First Order Decay Model Tool provides a default of 0.5 for this value.[34]

Facility Throughput, Generation & Emissions

Data provided on MSW throughput, net electrical generation, and emissions of carbon dioxide equivalents (CO_2e) are taken from the mandatory GHG reporting submitted to CARB.

Landfill Gas Collection – Inputs

Collection System Efficiency

The current U.S. EPA default collection efficiency is 75%.[35,36] The default CARB First Order Decay Model Tool and the heat input capacity calculation specified by the landfill methane early action measure also use a default efficiency of 75%.[37, 38] However, the landfill methane control early action measure is expected to increase the performance of California landfills in terms of landfill gas collection efficiency.

CARB has estimated that these requirements, which are significantly more stringent than federal NSPS requirements, could be reasonably expected to achieve a collection efficiency of 85%.[39] The figure of 85% is inclusive of the effects of soil oxidation. When the effects of a 10% soil oxidation factor are taken into account, the efficiency attributable to the landfill's collection system is 83%.[40]

To be conservative, a constant efficiency is assumed over the entire collection period. In practice, this is unlikely. The 83% figure is for a well maintained closed and capped landfill. Prior to installation of the final cap, landfill operators use daily and intermediate caps to keep waste covered, which are permeable. Consequently, landfill gas collection systems achieve lower collection efficiencies when these cover materials are in place. Therefore, assuming a constant collection efficiency associated with final cover over the entire period of collection conservatively overestimates actual collection.

Destruction Efficiency

A landfill methane control device destruction efficiency of 99% was assumed, consistent with the requirements of the Landfill Methane Early Action Measure.[41]

# of Years of LFG Collection

The Landfill Methane Early Action Measure requires that gas collection and control systems be in operation for a minimum of 15 years, unless the landfill operator can demonstrate that due to decline methane oxidation rates, the landfill will be unable to operate the gas collection and control system for a 15 year period.[42] For purposes of conservatively estimating the GHG emissions savings by diverting waste from landfills, the model assumed a total collection period of 30 to 45 years, two to three times the regulatory minimum.

Given the importance of this parameter, a sensitivity analysis was performed looking at longer periods of collection. Using the 100-yr global warming potential (GWP) of 21, landfills would need to achieve and maintain a collection efficiency of 83% for 89 years in order to surpass the greenhouse gas emission performance of waste to energy (WTE). However, the GWP of 21 is over fifteen years old, and had been revised twice by the Intergovernmental Panel on Climate Change (IPCC). Based on the most recent available GWP from the IPCC of 25, CA landfills would need to maintain a collection efficiency of 83% for 115 years in order to exceed the greenhouse gas emissions performance of WTE.

Recent research has indicated that the current global warming potential for methane does not accurately reflect methane's impact in the atmosphere. As discussed above, a recent paper by NASA Goddard Institute and Columbia University scientists concluded that a more accurate reflection of methane's impacts in the atmosphere results in a 100-yr GWP of 34.[43] When methane's synergistic effects in the atmosphere are considered, it is either impossible for landfills to outperform WTE, or the period of collection would need to extend for over 200 years.

% of Methane During Collection Period

In order to calculate the methane emissions from a landfill, the percentage of the total methane potential that is generated during the period of active collection must be determined. This is calculated from the solution to the definite integral of the first order decay equation, bounded by the beginning and end of the collection period, in years.

(3)

Where:

- k = 1^{st} order decay constant (/ year)
- t_i = time from first waste placement to installation of collection system (years)
- t_f = time from first waste placement to shutdown / removal of collection system (years)

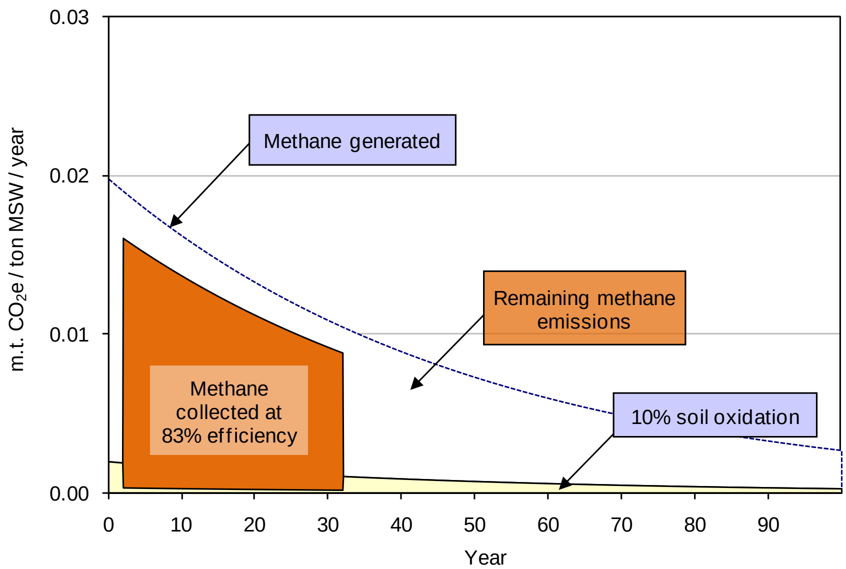
Integrated Lifetime Collection Efficiency

The integrated lifetime collection efficiency is the percentage of the total methane potential (L_o) that is collected over its lifetime in a landfill. This is calculated as the product of the fraction of the methane potential that is generated during the collection period (calculated above) and the efficiency of collection achieved during the collection period.

$$e_{lifetime} = \text{\% of total methane potential} \times \text{collection system efficiency} \quad (4)$$

In this assessment, the integrated efficiency is the overall efficiency achieved by applying an 83% collection efficiency over a period of 30 to 45 years (Figure 1).

Figure 1. Methane Collected During 30 year Collection Period



Landfill Methane Collection & Results

Landfill methane generation, collection, oxidation, and emissions are calculated from the perspective of if the tons of waste processed in the WTE facility were instead sent to a landfill. This provides a useful GHG emissions comparison between WTE and landfilling.

Methane Generated

Methane generated is a hypothetical figure representing the total amount of methane that would have been generated if the MSW processed by the waste to energy facility had been landfilled. This is calculated from the tons of waste processed and the methane generation potential using the following equation:

$$CH_4\ Gen = W \times L_o \times 0.907 / 1{,}503 \quad (5)$$

Where:

CH_4 Gen	=	total mass of CH_4 generated
W	=	total waste throughput of waste-to-energy facility (tons)
L_o	=	methane generation potential (m^3 CH_4 / Mg MSW)
0.907	=	conversion from tons to Mg
1,503	=	conversion from Mg methane to m^3 methane at U.S. EPA standard conditions (20°C and 1 atm pressure)

Methane Collected

Of the methane generated, a substantial amount is collected by the landfill's collection system. This is calculated based on the methane generated, and the integrated collection efficiency described above.

$$CH_4\ Collected = CH_4\ Gen \times e_{lifetime} \quad (6)$$

Oxidizing through Soil Cap

Uncollected methane may pass through the soil cover and/or cap and be oxidized by soil bacteria to CO_2. The mass of methane oxidized is calculated as follows:

$$CH_4\ Oxidized = (CH_4\ Gen - CH_4\ Collected) \times Soil\ Oxidation\ Factor \quad (7)$$

Methane Combusted

Internal combustion engines, flares, and other equipment used to treat collected landfill gas are required to have a destruction efficiency of 99%. The mass of actual methane combusted, or destroyed, is calculated as follows:

$$CH_4 \text{ Combusted} = CH_4 \text{ Collected} \times 0.99 \qquad (8)$$

Methane Emitted

The amount of methane that would have been emitted if the waste were processed in a landfill is calculated as follows:

$$CH_4 \text{ Emitted} = CH_4 \text{ Gen} - CH_4 \text{ Combusted} - CH_4 \text{ Oxidized} \qquad (9)$$

Avoided GHG Emissions

Avoided Landfill Methane (t CO_2e)

The avoided landfill methane represents the emissions which would have occurred if the waste processed by the WTE facility were instead diverted to a landfill and is calculated from the landfill methane emissions multiplied by the methane 100 year global warming potential as follows:

$$\text{Avoided landfill methane} = CH_4 \text{ Emitted} \times CH_4 \text{ GWP} \qquad (10)$$

Net GHG w/ Avoided LFG Only

Avoided landfill methane is subtracted from the total WTE facility's emissions of carbon dioxide equivalents (CO_2e). A negative number indicates that the waste to energy facility has lower GHG emissions than those that would result from sending the same quantity of waste to a landfill. Results of the analysis are presented in Table 1 below.

Table 1. Net GHG Emissions, Accounting for Avoided LFG Emissions Only

	Stanislaus		Commerce		Long Beach (SERRF)	
Years of LFG Collection	30	45	30	45	30	45
2008	-56,036	-31,636	-29,110	-18,623	-127,155	-78,857
2009	-64,626	-38,038	-29,511	-18,997	-151,043	-100,991

[1] Kaplan, P.O, J. DeCarolis, and S. Thorneloe, 2009, Is it better to burn or bury waste for clean electricity generation? *Environ. Sci. Technology* 43 (6) pp1711-1717. Available at: http://pubs.acs.org/doi/abs/10.1021/es802395e

[2] WTE identified as a "key mitigation measure" in IPCC, "Climate Change 2007: Synthesis Report. Contribution of Work Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp. Available at: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

[3] WTE identified as a key technology for a future low carbon energy system in World Economic Forum. *Green Investing: Towards a Clean Energy Infrastructure.* January 2009. Available at: http://www.weforum.org/pdf/climate/Green.pdf

[4] EU policies promoting WTE as part of an integrated waste management strategy have been an overwhelming success, reducing GHG emissions over 72 million metric tonnes per year, see European Environment Agency, *Greenhouse gas emission trends and projections in Europe 2009: Tracking progress towards Kyoto targets* *http://www.eea.europa.eu/publications/eea_report_2009_9*

[5] European Environmental Agency (2008) Better management of municipal waste will reduce greenhouse gas emissions. Available at: http://www.eea.europa.eu/publications/briefing_2008_1/EN_Briefing_01-2008.pdf

[6] Clean Development Mechanism Executive Board: "Approved baseline and monitoring methodology AM0025: Avoided emissions from organic waste through alternative waste treatment processes." Available at: http://www.cdm.unfcc.int/methodologies/DB/3STKBX3UY84WXOQWIO9W7J1B40FMD

[7] Verified Carbon Standard, Lee County Waste to Energy Facility 2007 Capital Expansion Project VCU, *The VCS Project Database,* accessed April 28, 2011. Available at: https://vcsprojectdatabase1.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=290

[8] RTI International (2009) *Life Cycle Assessment and Economic Analysis of Organic Waste Management and Greenhouse Gas Reduction Options*, prepared for California Integrated Waste Management Board. Available at: http://www.calrecycle.ca.gov/climate/Organics/LifeCycle/Reports/default.htm

[9] California Air Resources Board (CARB 2010a) *Proposed Regulation for a California Renewable Electricity Standard, Staff Report: Initial Statement of Reasons, Appendix D: Supporting Documentation for the Environmental Analysis*, Available at: http://www.arb.ca.gov/regact/2010/res2010/res10d.pdf

[10] U.S. House of Representatives, 111th Congress (2009) H.R. 2454 *American Clean Energy and Security Act of 2009*, Available at: http://www.gpo.gov/fdsys/pkg/BILLS-111hr2454eh/pdf/BILLS-111hr2454eh.pdf

[11] Committee on Energy and Natural Resources, U.S. Senate, 111th Congress (2009), *American Clean Energy and Leadership Act of 2009,* Available at: http://www.gpo.gov/fdsys/pkg/CRPT-111srpt48/pdf/CRPT-111srpt48.pdf

[12] Energy Recovery Council, *The 2010 ERC Directory of Waste-to-Energy Plants*, Washington DC. Available at: http://www.WTE.org/userfiles/file/ERC_2010_Directory.pdf

[13] Confederation of European Waste to Energy Plants (CEWEP), *Map of European Waste-to-Energy Plants in 2008*. Accessible at: http://www.cewep.eu/information/data/studies/138.Map_European_Waste-to-Energy_Plants_in_.html

[14] Current U.S. EPA AP-42 uses a mixed MSW Lo of 100 m^3 / Mg, based on data from at 40 landfills. In the latest draft revision to AP-42, the 100 m^3 / Mg value is corrected through a factor of 1.3 to account for uncollected gas in the original study, resulting in an effective Lo of 130 m^3 / Mg. The U.S. EPA Landfill Gas Emission Model ("LandGEM"), uses a default Lo of 100 m^3 / Mg for inventory purposes. U.S. EPA Clean Air Act regulations use 170 m^3 CH_4/Mg MSW as a potential-to-emit value. The USEPA's 2006 solid waste greenhouse gas life cycle report uses a value of 168 m^3 CH_4/Mg MSW (Exhibit 6-3 of U.S. EPA, 2006, *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, 3rd edition, Available at: http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html)

[15] California Air Resources Board (CARB 2010b), Methane Emissions from Municipal Solid Waste Landfills, *California Code of Regulations*, Title 17, Subchapter 10, Article 4, Subarticle 6, §95460 - §95476

[16] Detailed composition from Table 50 of California Integrated Waste Management Board (CIWMB 2009), *California 2008 Statewide Waste Cauterization Study* was adopted to the waste categories contained in CARB (2009).

[17] Lumber, a significant portion of C&D debris is included. This may not accurately reflect the waste stream encountered on the tipping floor of energy from waste facilities, as much of the lumber is likely diverted. However, inclusion of lumber is conservative: when lumber is excluded, calculated methane generation potentials are slightly higher for both 2004 and 2008.

[18] CARB (2010b), Appendix I

[19] Adopted from Volume 5, Chapter 3 of Intergovernmental Panel on Climate Change (IPCC 2006), *2006 IPCC guidelines for national greenhouse gas inventories*, H. S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe, eds., National Greenhouse Gas Inventories Programme, IGES, Japan. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf

[20] California Air Resources Board (CARB 2010c), *California Air Resources Board's Implementation of IPCC's Mathematically Exact First Order Decay Model*, release date June 3, 2010. Available at: http://www.arb.ca.gov/cc/protocols/localgov/pubs/landfill_emissions_tool_v1_2_2010-06-03.xls

[21] *Ibid.*

[22] CARB, California Climate Action Registry, ICLEI – Local Governments for Sustainability, The Climate Registry, 2010, *Local Government Operations Protocol: For the quantification and reporting of greenhouse gas emissions inventories,* Version 1.1, May 2010. Available at: http://www.arb.ca.gov/cc/protocols/localgov/pubs/lgo_protocol_v1_1_2010-05-03.pdf

[23] 40 CFR§98.343(c)(1)

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[40] A collection efficiency of 83% coupled with a soil oxidation rate of 10% gives an overall control efficiency of 85%, as reported in the CARB 2009b report. 83% collection efficiency + 10% soil oxidation x (1 – 83%) = 85%.

[41] CARB(2010b) §95464(b)(2) & (3)

[42] CARB (2010b) §95467

[43] Shindell *et al.* (2009)

California Waste-to-Energy Emissions Calculations

Key Default Factors & Inputs		Source / Notes
Lo, methane generation potential (m^3 CH_4 / t MSW)	78.8	Waste Characterization Study, corrected for no C&D
Soil Oxidation Factor (%)	10%	CARB Default, Landfill CH_4 Emissions Methodology
Global Warming Potential (GWP)	21	CARB GHG Reporting Rule, IPCC SAR (1995)
1st Order Decay Rate Constant, k (/ year)	0.02	CARB Default (<20" precip. / yr)
Time from placement of waste to collection of LFG (years)	1.5	Estimate based on CARB Early Action Measure
% Methane in LFG	50%	

Facility Throughput, Generation & Emissions	Stanislaus	Commerce	Long Beach (SERRF)	
MSW Throughput (tons)	239,644	102,995	474,341	2008 CARB Mandatory GHG Reporting
Net electrical generation (MWh)	119,548	66,223	222,768	
Ferrous Recovery (tons)	4,794	1,201	13,835	Operating Reports
Non-Ferrous Recovery (tons)	0	133	0	Operating Reports
Anthropogenic GHG Emissions (t CO_2e)	81,931	30,186	145,932	2008 CARB Mandatory GHG Reporting

Landfill Gas Collection - Inputs	Stanislaus		Commerce		Long Beach (SERRF)		
Collection system efficiency	83%		83%		83%		CARB Default, Landfill CH_4 Emissions Methodology
Destruction Efficiency	99%		99%		99%		CARB Default, Landfill CH_4 Emissions Methodology
# of Years of LFG Collection	30	45	30	45	30	45	
% of methane during collection period	43.8%	57.6%	43.8%	57.6%	43.8%	57.6%	
Integrated Lifetime Collection Efficiency	36%	48%	36%	48%	36%	48%	

Landfill Methane Collection & Emissions - Results						
Methane generated (t CH_4)	11,395	11,395	4,897	4,897	22,555	22,555
Methane Collected (t CH_4)	4,141	5,447	1,780	2,341	8,197	10,781
Oxidizing through soil cap (t CH_4)	725	595	312	256	1,436	1,177
Methane Combusted (t CH_4)	4,100	5,392	1,762	2,317	8,115	10,673
Methane Emitted (t CH_4)	6,570	5,408	2,824	2,324	13,004	10,704
CO_2 Emissions (t CO_2) - Biogenic	44,605	47,801	19,171	20,544	88,290	94,615

Avoided GHG Emissions (without Displaced Grid Electricity)						
Avoided Landfill Methane (t CO_2e)	-137,967	-113,567	-59,296	-48,809	-273,087	-224,789
LF Methane (t CO_2e / ton MSW)	-0.58	-0.47	-0.58	-0.47	-0.58	-0.47
Net GHG w/ Avoided LFG Only (t CO_2e)	**-56,036**	**-31,636**	**-29,110**	**-18,623**	**-127,155**	**-78,857**

Avoided GHG Emissions (Life Cycle Calc.) *Information Purposes Only*	Stanislaus		Commerce		Long Beach (SERRF)		
Steel recycling GHG emission savings (t CE / ton steel)			0.49				EPA Waste Management GHG Report (2006)
Aluminum recycling GHG emission savings (t CE / ton Al)			3.70				EPA Waste Management GHG Report (2006)
CA Marginal Power (Nat Gas) Emission Rate (lb CO_2/MWh)			830				
GHG Benefit - Ferrous & Non-Ferrous Recycling (t CO_2e)	-8,613		-3,967		-24,857		
Avoided Grid Electricity (t CO_2e)	-45,008		-24,932		-83,868		**Total 30 Year Mitigation**
Net GHG - Life Cycle Calc. (t CO_2e)	**-101,044**	**-76,643**	**-54,042**	**-43,555**	**-211,023**	**-162,725**	**-11 million MT CO2e**

2/16/2010