Hi Derek,

I had a few questions and comments to the protocol. So I thought it might be best to provide them in an email, so here they are.

1. On Page 4, to determine additionality, the requirement is that the landfill gas be combusted beyond that resulting from the existing collection and combustion system and that the project be either designed to be entirely separate or must be monitored separately from the existing system. My question is how are bioreactors handled in this scenario? Typically, a basic LFG system (or business as usual) would entail the collection system and control device (typically a flare). However, a bioreactor requires more capital in order to enhance decomposition for purposes of possibly generating a higher quality gas for energy production (i.e. liquid injection, additional gas collectors, increased monitoring, etc.). Could the protocol accommodate this potential LFG collection and control as "additional?"

2. On Page 8, I was confused by the statement "For a GHG reduction project at a landfill that is currently collecting and combusting landfill gas (e.g. to address lateral migration of landfill gases), the components of the physical boundary must be considered separately from any existing equipment used for collection and combustion." Not sure what is meant by this.

3. On Page 9, Figure 1, the project boundary includes upgrading the landfill gas to NG pipeline quality but that isn't necessarily combusting or controlling the landfill gas methane. Would the project have to report these methane as emissions although they will be controlled outside of the project boundary?

4. On Page 9, the last paragraph states that this protocol does not account for carbon dioxide reductions associated with displacing grid-delivered electricity. Capturing and using methane to produce electricity for the grid would be defined as a complimentary and separate GHG reduction project. What are you plans for who will get credit for these avoided emissions? Although earlier on Page 3, it mentions that ownership of GHG reductions should be established by clear and explicit title, how you set up this complimentary protocol will determine who will be able to claim reductions.

5. There appears that Table 1, Item 4 is inconsistent with Figure 1. Methane from NG in Table 1 is part of the project boundary but is not reflected in Figure 1.

6. On Page 14, Equation 1 uses a multiplier of 0.90 applied to the total annual methane emissions destroyed by the project system. If CH4DestPR is an actual measured amount of LFG collected and destroyed, then the oxidation multiplier should not apply. The multiplier should be applied to actual emissions (generation - collection), not to collection.

7. On Page 19, Form 1, Item 13, do you mean waste "accepted"? Landfills don't typically "generate" waste, they accept and dispose of it.

8. Page 20, Form 2, Items 1 through 3 - what is the purpose for collecting this data? If you choose to keep this list, you may want to consider broadening the input since many landfills don't just have one type of liner and areas with a cap or daily cover changes daily.

9. Page 20, Form 1, can a developer choose to use the regional/national data from the CIWMB or must they perform their own waste characterization studies?

10. Page 20, Form 3, Item 1.iii: would it be possible to just include the as-built plan of a system instead of written description of the number and depths of wells? A written description might prompt more questions if the landfill configuration is not understood.

Sincerely,
Stephanie

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Landfill
Project Reporting Protocol

Collecting and combusting methane from landfills

DRAFT

November, 2007

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The California Climate Action Registry

Landfill Project Reporting Protocol

Collecting and combusting methane from landfills

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I. Introduction

The California Climate Action Registry's (Registry) Landfill Greenhouse Gas Project Reporting Protocol – for collecting and combusting methane in landfills – provides guidance to account for and report greenhouse gas (GHG) emissions reductions associated with installing a gas collection system at a landfill.

Established by the California Legislature in 2000 as a non-profit, public/private partnership, the Registry runs a voluntary GHG registry. Its purpose is to promote and facilitate the measurement, monitoring and reduction of GHG emissions. Participants in the program account for and certify their GHG emissions according to the Registry's protocols.

Project developers that install landfill gas capture and combustion technologies use this document to register GHG reductions with the Registry. It provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Registry. Additionally, all project reports receive annual, independent verification by California Air Resources Board - and Registry-approved certifiers. Guidance for verifiers to certify reductions is provided in the corresponding Landfill Project Certification Protocol.

This project protocol facilitates the creation of GHG emissions reductions determined in a complete, consistent, transparent, accurate, and conservative manner, while incorporating relevant sources.[1]

Document organization

The Registry's landfill project protocol has the following sections:

- The GHG Reduction Project
- Project Eligibility
- The Project Boundary
- GHG Reductions Calculation Methods
- Project Monitoring
- Reporting Parameters

Project developers that follow the guidance in this protocol and register GHG reductions with the Registry must comply with all local, state, and federal municipal solid waste (MSW), air and water quality regulations.

To register GHG reductions with the Registry, project developers are not required to take an annual entity-level GHG inventory of their MSW operations.

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[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG accounting principles.

II. The GHG Reduction Project

Most municipal solid waste in the United States is deposited in landfills, where bacteria decompose the organic material. A product of both the bacterial decomposition and oxidation of solid waste is landfill gas, which is composed of methane (CH_4) and carbon dioxide (CO_2) in approximately equal concentrations, as well as smaller amounts of non-methane volatile organic compounds (NMVOC), nitrogen (N_2), oxygen (O_2) and other trace gases. If not collected and combusted, over time, this landfill gas is released to the atmosphere. In the United States, landfills are the largest source of anthropogenic emissions of CH_4, accounting for 25 percent of total CH_4 emissions.[2]

Project definition

For the purpose of this protocol, the GHG reduction project is the installation of a landfill gas control system for capturing and combusting methane gas that commences operation on or after January 1, 2001. Captured landfill gas could be combusted on-site, transported for off-site use (e.g., through gas distribution or transmission pipeline), or used to power vehicles. Regardless of how project developers take advantage of the captured landfill gas, the ultimate fate of the methane must be combustion.

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The landfill gas collection and combustion systems typically consist of wells, pipes, blowers, caps and other technologies that enable or enhance the collection landfill gas and convey it to a combustion technology. At some landfills, a flare will be the only device where landfill gas is destroyed. For projects that utilize energy or process heat technologies to combust landfill gas, such as turbines, reciprocating engines, boilers, heaters, or kilns, these devices will be where landfill gas is combusted. Direct use arrangements which entail the piping of landfill gas to be combusted by an industrial end user at an off-site location are also an eligible approach to combustion of the landfill gas.[3] Most projects that produce energy or process heat also include a flare in their design to combust gas during periods when the gas utilization project is down for repair or maintenance.

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In addition to reducing methane, the installation of a landfill gas collection and combustion system could impact anthropogenic carbon dioxide emissions (from the consumption of electricity and fossil fuels) associated with the installation and operation of the gas collection system. The effect could either increase or decrease these GHG emissions, depending on the project's particular circumstance. These system-related effects are secondary to the primary effect of the project (reducing methane emissions). Section IV, The Project Boundary, delineates the scope of the accounting framework.

[2] U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, EPA-430-R-07-002 (April 2007).

[3] For direct use agreements, between the project developer and the end user of the landfill gas (i.e. an industrial client purchasing the landfill gas from the project developer), a mechanism should be built into the agreement language to assure that the GHG offset credits will not be double counted.

The project developer

Project developers could be landfill owners/operators and/or owners of the landfill gas rights. However, they could also include other entities, such as third-party aggregators. Ownership of the GHG reductions should be established by clear and explicit title.

Additional GHG reduction activities in the solid waste sector

The Registry recognizes that project developers could implement a variety of GHG reduction activities associated with the collection, transportation, sorting, recycling and disposal of solid waste. Installing technology to capture and combust methane from landfills is but one of many GHG emissions reduction projects that could occur within the solid waste sector.

However, at this time, GHG reduction activities not associated with installing a landfill gas collection and combustion system do not meet this protocol's definition of the GHG reduction project. Furthermore, producing power for the electricity grid (and thus displacing fossil-fueled power plant GHG emissions) is a complementary and separate GHG project activity to destroying methane gas from landfills, and not included within this protocol's accounting framework. (Will this be a separate protocol or under the Power/Utility Reporting Protocol?)

The Registry anticipates that separate project protocols may be developed in the future to facilitate reduction opportunities in the solid waste sector, including waste reduction & recycling and conversion technologies.

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III. Eligibility Rules

Project developers using this protocol satisfy the following eligibility rules to register reductions with the Registry. The criteria only apply to projects that meet the definition of a GHG reduction project.

Eligibility Rule I:	Additionality	⟶ ⟶	*Meet performance standard* *Exceed regulatory requirements*
Eligibility Rule II:	Location	⟶	*U.S. landfill*
Eligibility Rule III:	Project Start Date	⟶	*January 1, 2001*

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Additionality

The Registry strives to support only projects that yield surplus GHG reductions, which are additional to what might otherwise have occurred. That is, the reductions are above and beyond business-as-usual – the baseline case.

Project developers satisfy the "additionality" eligibility rule by passing two tests:

1. The Performance Standard Test, and
2. The Regulatory Test

The Performance Standard Test. Project developers pass the Performance Standard Test by meeting a program-wide performance threshold – i.e., a standard of performance applicable to all landfill projects, established on an ex-ante basis. The performance threshold represents "better than business-as-usual." If the project meets the threshold, then it exceeds what would happen under the business-as-usual scenario and generates surplus/additional GHG reductions.

For this protocol, the Registry uses a technology-specific threshold; sometimes also referred to as a practice-based threshold, where it serves as "best-practice standard" for managing landfill gas fugitive emissions. By installing a landfill gas collection and combustion system at a landfill that is not required to do so by regulations, a project developer passes the Performance Standard Test.

The first determinant of additionality is whether there is already collection and combustion of landfill gas at the proposed project site. There are two possible scenarios under which the practice-based performance threshold is applied:

1. If the landfill is not currently collecting and combusting any landfill gas, the project is considered additional.

2. If the landfill is currently required to collect and combust landfill gas, two conditions must be met for the project to be considered additional. First, only the landfill gas combusted beyond that resulting from the existing collection and combustion system is considered additional (i.e., those reductions resulting from the implementation of the GHG reduction project).[5] Second, the GHG project must either be designed to be entirely separate from the existing collection system or must be monitored separately from the existing system. These conditions will ensure that the reductions resulting from the GHG project can be accounted for separately from current collection and combustion.

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The Registry defined this Performance Standard based upon an evaluation of landfill practices in the United States. A summary of the performance standard analysis is provided in Appendix A.

The Registry will periodically re-evaluate the appropriateness of the Performance Standard Threshold by updating the market penetration analysis in appendix A. The Registry recognizes the importance of developing waste diversion and recycling incentive programs or protocols to assist in GHG reduction efforts. If sufficient waste diversion and recycling incentive programs or protocols have not become operational and demonstrated effectiveness by 2013 this protocol

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[5] Landfills which are currently collecting and combusting landfill gas to comply with NSPS & EG regulations are not eligible to account for GHG reductions associated with the early installation of gas control systems during landfill expansion.

will be temporarily out of service until such programs or protocols become operational. The Registry will consult with interested stakeholders in this decision process. (Does this mean that project developers won't be granted credits from 2013 to an unspecified time? This only gives the financials 5 years to work out (2008 to 2013). Won't this affect the crediting period?)

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All projects that pass this test are eligible to register reductions with the Registry for the lifetime of the project-crediting period, even if the Performance Standard Test changes during mid-period. As stated in Section VII, Reporting Parameters, the project-crediting period is seven years with the potential for a second five year period (second five year period is contingent upon satisfaction of the additionality eligibility criteria) if the collection and combustion system is installed and operational before any regulation requiring the system to be installed is adopted. See Section VII, Reporting Parameters for the allowable project-crediting period for the case in which a federal or state rulemaking process has begun for a regulation specific to greenhouse gas emission reductions from landfills, and the GHG reduction project is within the jurisdiction of the regulation in development. (See my comments in the Crediting Period section.)

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The Regulatory Test. The Registry subjects all greenhouse gas reduction projects to a regulatory test to ensure that the emission reductions achieved would not have occurred in the absence of the project due to federal, state or local regulations.[6]

Federal Regulations. There are several EPA regulations for MSW landfills that have a bearing on the eligibility of methane collection and combustion projects as voluntary GHG reduction projects. These regulations include:

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• New Source Performance Standards (NSPS) for Municipal Solid Waste Landfills, codified in 40 CFR 60 subpart WWW – Targets landfills that commenced construction or made modifications after May 1991.

• Emission Guidelines (EG) for Municipal Solid Waste Landfills, codified in 40 CFR 60 subpart Cc. – Targets existing landfills that commenced construction before May 30, 1991, but accepted waste after November 8, 1987.

• The National Emission Standards for Hazardous Air Pollutants (NESHAP), codified in 40 CFR 63 subpart AAAA – Regulates new and existing landfills.

These regulations require control of non-methane organic compounds (NMOC) from landfills according to certain size and emission thresholds. In most cases, activities to reduce NMOC will also lead to a reduction in CH_4 emissions, as gas collection and combustion is a common NMOC management technique employed at regulated landfills.

Landfills with a design capacity of at least 2.5 million megagrams and 2.5 million cubic meters of MSW are subject to the NSPS, EG and the NESHAP. Landfills above the design capacity size cutoff must calculate their annual NMOC emissions using equations or procedures in the rules. If a landfill is required to control NMOC emissions due to reaching the 50 megagrams per year threshold of calculated NMOC emissions, the landfill is not eligible to host a GHG

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[6] Federal, State and local regulations information sourced from the U.S. EPA Climate Leader's *Draft Offset Protocol – Landfill Methane Collection and Combustion*. October 2006.

emission reduction project under this protocol. In addition, once an existing project meets or exceeds the 50 megagrams per year of calculated NMOC emissions, they will no longer be eligible to register reductions with the Registry, irrespective of the project-crediting period.

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Landfills smaller than 2.5 million megagrams or 2.5 million cubic meters of waste, and those landfills not defined as MSW landfills, such as landfills that contain only construction and demolition material or industrial waste, are not usually subject to NSPS, EG or NESHAP.

State and Local Regulations, Ordinances and Permitting Requirements. All states are required by the Clean Air Act (CAA) and Subtitle D of the Resource Conservation and Control Act (RCRA subtitle D) to promulgate rules for landfills. It is also possible that some landfills that exceed applicable emission thresholds will require site-specific permits requiring controls under the New Source Review (NSR) or Prevention of Significant Deterioration (PSD) permitting program authorized by the CAA and implemented by states. These state-level rules generally follow federal guidelines, however, the state rules can be more stringent or require the installation of a gas collection and combustion system, or the destruction of volatile organic compounds (VOC), NMOC, or CH_4 earlier, or at smaller facilities, than the federal regulations would require.

On June 21, 2007, the California Air Resources Board (ARB) approved a Landfill Methane Capture Strategy as a discrete early action measure. Accordingly, ARB staff, in collaboration with California Integrated Waste Management Board (CIWMB) staff, is developing a control measure to provide enhanced control of methane emissions from MSW landfills. The control measure will reduce methane emissions from landfills by requiring gas collection and control systems where these systems are not currently required and will establish statewide performance standards to maximize methane capture efficiencies.[7]

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In recent years the inclusion of air quality, water quality and even GHG emissions control measures in permitting requirements (CEQA, NEPA, etc.) is becoming more prevalent. State and local governments may also regulate landfills by putting in place nuisance laws or requiring solid waste facilities smaller than the facilities regulated by the CAA or RCRA Subtitle D to control landfill gas. Other regulations or ordinances may require minimal gas collection to prevent lateral migration of the landfill gas to neighboring properties. Collection and combustion activities at landfills regulated under NSPS, EG, NESHAP, CAA, RCRA Subtitle D and other state and local regulations, ordinances or permitting requirements are not eligible as GHG reduction projects.[8]

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The Registry acknowledges that water quality regulations do not always dictate the installation of a landfill gas collection system as the only compliance mechanism to manage VOC water contamination, but that the installation of a landfill gas collection system is commonly the most

[7] California Air Resources Board, Landfill Methane Control Measure web page http://www.arb.ca.gov/cc/ccea/landfills/landfills.htm

[8] The Registry acknowledges that the third party verifier will need to exercise some discretion when reviewing permits that require the installation of a landfill gas control system or any portion there of. Permits tend to include strong language, such as "must" or "shall" install a landfill gas control system, even in the case that a landfill chooses to voluntarily install a landfill gas control system but is required to obtain a permit to do so.

effective and least demanding compliance mechanism available. Therefore, the installation of a landfill gas collection and combustion system to comply with water quality regulations does not automatically qualify as a GHG reduction project under this protocol. These projects must also meet the eligibility requirements discussed below.

Some water quality, explosive gas mitigation and local nuisance regulations and ordinances allow for passive landfill gas control systems which collect and vent landfill gas to the atmosphere, but are not required to treat or combust the vented gasses. Project activities that add a combustion device to a landfill that is only required to implement a passive landfill gas control system pass the Regulatory Test.

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Some water quality, explosive gas mitigation and local nuisance regulations and ordinances call for the installation of landfill gas collection systems. Once the landfill gas is collected and vented, the landfill then can become subject to air quality regulations requiring the landfill to control NMOC emissions. The air quality regulations may allow for flexibility to treat the landfill gas for NMOCs using combustion devices or carbon adsorption (for the latter the methane would be vented to atmosphere). Even in the regulatory situation where carbon adsorption is a compliance option, oftentimes the installation of a landfill gas combustion device will clearly be the most preferred compliance mechanism. In the situation where flexibility is allowed for regulatory compliance to control NMOCs and the clear compliance mechanism is the installation of a combustion device, the landfill gas control system in question does not pass the Regulatory Test.[9,10]

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For the case in which a landfill is required to treat landfill gas for NMOCs in order to comply with a regulation, ordinance or permitting condition, but combustion of the landfill gas is not the only compliance mechanism available to the landfill operator, the Registry has developed an NMOC emissions threshold whereby the eligibility of a project can be determined. If the total mass flow of NMOC for the landfill gas control system is less than 600 pounds NMOC per month, then the landfill gas control system is eligible as a GHG reduction project under this protocol. If the total mass flow of NMOC for the landfill gas control system is greater than 600 pounds NMOC per month, then the landfill gas control system is *not* eligible as a GHG reduction project under this protocol. A summary of the development of the NMOC emissions threshold is provided in Appendix B.

In the rare case where the project developer can demonstrate that a GHG emission reduction project should be considered eligible even though the total mass flow of NMOC is greater than 600 pounds NMOC per month, the project developer can submit a written request for variance to the Registry, including sufficient documentation to substantiate the case. In such cases the Registry would consult with interested stakeholders in the decision process.

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Project developers pass the Regulatory Test by demonstrating:

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[9] The Registry will provide guidance to Registry Approved third party verifiers to assist in the assessment of additionality in situations where regulations or ordinances allow for flexibility regarding compliance mechanisms.

[10] The Registry is currently accepting data to assist in the development of a threshold (pounds NMOC/hr) whereby verifiers could assess the NMOC/VOC concentration and LFG flow rate that renders carbon adsorption technology less viable than the installation of a flare for regulatory compliance purposes.

- there are no federal, state or regional regulations or permitting requirements (as well as local agency ordinances/rulings) requiring the installation of a landfill gas collection and combustion system at the project location, and
- if adding a combustion device to a passive landfill gas control system - the regulation, ordinance or permitting condition that requires the landfill gas control system does not require any treatment of the vented landfill gas, or
- a landfill gas control system is installed to treat landfill gas for NMOCs in order to comply with a regulation, ordinance or permitting condition, but combustion of the landfill gas is not the only compliance mechanism available to the landfill operator and the total mass flow of NMOC for the landfill gas control system is less than 600 pounds NMOC per month.

All projects that pass the Regulatory Test are eligible to register reductions with the Registry for the lifetime of the project-crediting period, even if a regulatory agency with authority over a landfill operation adopts a new rule obligating the installation of a landfill gas control system during mid-period. With respect to NSPS, EG and NESHAP regulations, once an existing projects meets or exceeds the 50 megagrams per year threshold of calculated NMOC emissions, they will no longer be eligible to register reductions with the Registry, irrespective of the project-crediting period.

Additionally, project developers pass the Registry's Regulatory Test by demonstrating that the project meets Federal, State and local air and water quality regulations. In some cases the installation of landfill gas combustion devices may cause co-pollutant emissions such as NOx and Carbon Monoxide. Therefore, while controlling GHG emissions, an offset project has the potential to be worsening local air quality. In the case that a landfill gas collection project triggers the need for criteria pollutant offsets, the project operator needs to demonstrate that appropriate emissions offsetting measures have been followed. Projects that are in a state of non-compliance with air or water quality regulations are not eligible to register GHG reductions with the Registry.[11]

The regulatory additionality test must be applied at the beginning of each project-crediting period.

Location

All projects located at landfill operations in the U.S. are eligible to register reductions with the Registry. The scope of the analysis of landfill practices that formed the basis of the Performance Standard covered landfill operations in the U.S. Therefore, the Registry will treat GHG reductions from all U.S.-based projects that follow the guidance in this protocol equally.

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[11] If a project verifier finds that a GHG reduction project is in a state of recurrent non-compliance or non-compliance that is the result of negligence or intent, then GHG reduction credits from the period of non-compliance will be deemed void. Non-compliance solely due to administrative and reporting issues or "acts of nature" (also referred to as "acts of god") will not effect GHG reduction crediting. Once the project developer verifies regulatory compliance, GHG reductions associated with the proportion of the crediting period for which the project developer was in compliance will be considered valid.

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Comment [C1]: NSPS/EG refers to NMOCs however the proposed new reg applies to methane. You may want to keep the statement general. Referring to just NMOCs may be confusing.

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The Registry anticipates that this protocol could be applicable internationally. The calculation procedure is consistent with international practices and, considering its rigor, the Performance Standard could apply to regions outside of the U.S. However, at this time, reductions from international projects are not eligible to be registered with the Registry.

Project start date

California Senate Bill 1771 (Sher) created the Registry in September of 2000 to serve as a platform to record and register GHG reduction activities, among other things. This sent a signal to GHG-emitting entities, including landfill operators, that project activities could receive recognition for their carbon value. The establishment of the Registry to support GHG reduction activities is the basis for the project start date criterion.

All GHG reduction projects that install a landfill gas collection and combustion system are eligible to register reductions with the Registry if the system started operating on or after January 1, 2001. Projects that began operating before January 1, 2001 are not eligible to register reductions according to this protocol. For the Registry's purpose, the commencement of operation means a constructed system that is capturing and combusting methane gas from the landfill operation.

IV. The Project Boundary

The project boundary delineates the GHG sources and gasses assessed by project developers to determine the net change in emissions associated with installing a landfill gas collection and combustion system.

Physical Boundary. The physical boundary for the project includes sources from the operation of the landfill gas collection system to the combustion of the landfill gas.

For a GHG reduction project at a landfill that is currently collecting and combusting landfill gas (e.g., to address lateral migration of landfill gases), the components of the physical boundary must be considered separately from any existing equipment used for collection and combustion.

Carbon dioxide emissions associated with the generation and combustion of landfill gas are considered biogenic emissions[13] (as opposed to anthropogenic) and will not be included in the

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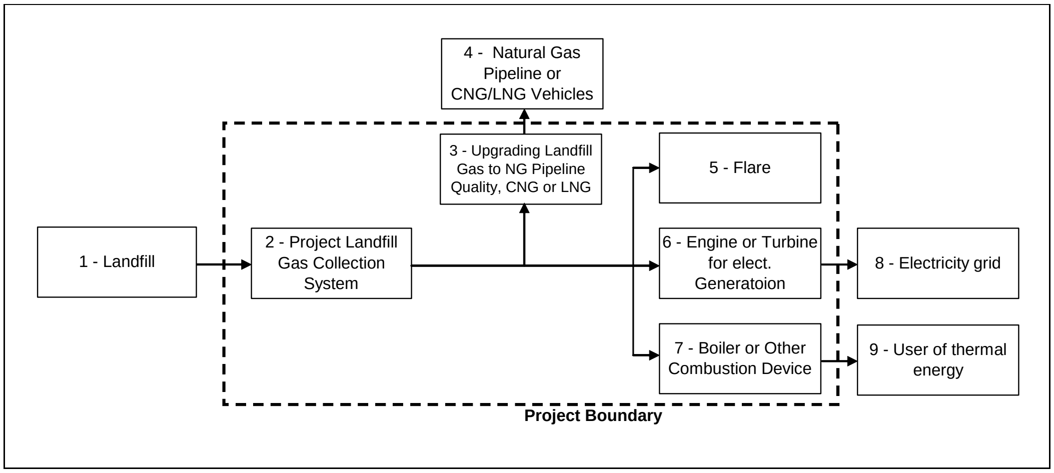
[13] The rationale is that carbon dioxide emitted during combustion represents the carbon dioxide that would have been emitted during natural decomposition of the solid waste. Emissions from the landfill gas control system do not yield a net increase in atmospheric carbon dioxide because they are theoretically equivalent to the carbon dioxide absorbed during plant growth.

GHG reduction calculation. This is consistent with the Intergovernmental Panel on Climate Change's (IPCC) guidelines for captured landfill gas.[14]

Figure 1 provides a general illustration of the project boundary; it encompasses the full landfill gas collection and combustion system. Table 1 (on page 9) identifies the main GHG sources associated with the source categories and specifies the gasses included in the calculation procedure.

Figure 1: Landfill GHG source categories and the project boundary



Temporal Boundary. Landfill gas projects using this protocol will report emissions reductions to the Registry based on an annual accounting cycle (calendar year). The regulatory additionality test should be applied to the landfill gas project at the beginning of eachproject-crediting period.

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Leakage. Leakage is an increase in greenhouse gas emissions or decrease in sequestration caused by the project but not accounted for within the project boundary. The underlying concept is that a particular project can produce offsetting effects outside of the physical boundary that fully or partially negate the benefits of the project. Although there are other forms of leakage, for this performance standard, leakage is limited to activity shifting – the displacement of activities and their associated GHG emissions outside of the project boundary.

Landfill methane collection and combustion projects are not expected to result in leakage of greenhouse gases outside the project boundary.

This protocol does not account for carbon dioxide reductions associated with displacing grid-delivered electricity. This is classified as an indirect emissions reduction activity because the change in GHGs occurs from sources owned and controlled by the power producer, even though

[14] *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; p.5.10, ftnt

the project developer produces the renewable electricity that displaces the fossil-based electricity. Capturing and using methane to produce electricity for the grid would be defined as a complimentary and separate GHG reduction project.

Table 1 relates GHG source categories to sources and gasses, and indicates inclusion in the calculation methodology.

Table 1: Landfill source categories, GHG sources, associated gases, and coverage in the landfill project boundary

GHG Source Category	GHG Source	Gas	Included in Project Boundary	Comment
1. Landfill	• Fugitive emissions from landfill surface	CO_2	No	*Biogenic emissions are excluded.**
		CH_4	No	*Emissions would have occurred absent the project. ***
2. Landfill Gas Collection System	• Well heads and collection headers	CH_4	No	*Emissions would have occurred absent the project.***
	• Emissions resulting from fossil fuel derived energy used by compressors, blowers, and/or gathering system	CO_2	Yes	*All Co2 emissions (direct and indirect) due to fossil fuel combustion are included.*
		CH_4	No	*Excluded, as this emission source is assumed to be very small.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.*
	• Fugitive emissions from conduit to combustion device	CH_4	No	*Emissions would have occurred absent the project.***
3. Upgrading Landfill Gas to NG Pipeline Quality	• Emissions resulting from fossil fuel derived energy used to upgrade the quality of and transport the gas to the NG pipeline	CO_2	Yes	*All Co2 emissions (direct and indirect) due to fossil fuel combustion are included.*
		CH_4	No	*Excluded, as this emission source is assumed to be very small.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.*
4. Natural Gas pipeline or CNG/LNG	• Emissions from compressors and other equipment associated with transporting the natural gas through the pipeline.	CO_2	No	*Excluded, as this emission source is assumed to be very small.*
		CH_4	Yes	*Based on efficiency of end-user combustion, as well as processing, transmissions, and distribution losses. ****
		N_2O	No	*Excluded, as this emission source is assumed to be very small.*
5. Flare	• Emissions resulting from the combustion of landfill gas in flare.	CO_2	No	*Biogenic emissions are excluded.**
		CH_4	Yes	*Based on combustion efficiency of flare.*

GHG Source Category	GHG Source	Gas	Included in Project Boundary	Comment
		N_2O	No	*Excluded, as this emission source is assumed to be very small.*
	• Emissions resulting from the combustion of fossil fuel in flare.	CO_2	Yes	*All Co2 emissions due to fossil fuel combustion are included.*
		CH_4	No	*Excluded, as this emission source is assumed to be very small.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.*
6. Engine or Turbine for Electricity Generation	• Emissions resulting from the combustion of landfill gas in engine or turbine.	CO_2	No	*Biogenic emissions are excluded.**
		CH_4	Yes	*Based on combustion efficiency of engine or turbine*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.*
	• Emissions resulting from the combustion of fossil fuel in engine or turbine	CO_2	Yes	*All Co2 emissions due to fossil fuel combustion are included.*
		CH_4	No	*Excluded, as this emission source is assumed to be very small.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.*
7. Boiler or Other Combustion Device	• Emissions resulting from the combustion of landfill gas in boiler or other combustion device.	CO_2	No	*Biogenic emissions are excluded.**
		CH_4	Yes	*Based on combustion efficiency of boiler device.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small*
	• Emissions resulting from the combustion of fossil fuel in boiler or other combustion device.	CO_2	Yes	*All Co2 emissions due to fossil fuel combustion are included.*
		CH_4	No	*Excluded, as this emission source is assumed to be very small*
		N_2O	No	*Excluded, as this emission source is assumed to be very small*
8. Electricity Grid	• Displacement of GHG emissions from fossil fuel combustion from electricity generated using landfill gas	CO_2	No	*This Protocol does not cover displacement of GHG emissions from Landfill Gas to Energy Projects.*
		CH_4	No	
		N_2O	No	
9. Electricity Grid	• Displacement of GHG emissions from fossil fuel combustion from thermal energy generated using landfill gas	CO_2	No	*This Protocol does not cover displacement of GHG emissions from Landfill Gas to Thermal Energy Projects.*
		CH_4	No	
		N_2O	No	

***** Carbon dioxide emissions from the combustion of landfill gas are considered biogenic emissions (as opposed to anthropogenic) and will not be included in the GHG reduction calculation.

****** Methane emissions that escape from the cap, or from leaking valves or seals do not need to be included within the project boundary because these methane emissions would have occurred absent the project

*** The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas combustion of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH4/PJ, which is 0.8%. These leakage estimates are additive. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations.[15]

V. GHG Reductions Calculation Methods

The Registry's GHG reduction calculation method is derived from the Kyoto Protocol's Clean Development Mechanism (ACM0001 V.6 and AM0053 V.1), the EPA's Climate Leaders Program (Draft Landfill Offset Protocol, October 2006), the GE AES Greenhouse Gas Services Landfill Gas Methodology V.1, and the RGGI Model Rule (January 5, 2007).

Total GHG reductions are registered on an annual basis, thus projects will have yearly project (actual) emissions reductions.

To support project developers and facilitate consistent and complete emissions reporting, the Registry's on-line reporting tool (CARROT) will incorporate the equations in this protocol.[16] Until the landfill project component of CARROT becomes operational the Registry will provide spreadsheet-based calculation tools.

Models that estimate biological and physical processes, such as the biological decomposition of solid waste in landfills and the migration of the landfill gas to the atmosphere are still becoming increasingly available. Process models typically rely on a series of input data that research has shown to be important drivers of the biological and geochemical process. In terms of GHG emissions models, process models identify the mathematical relationships between inputs, basic conditions, and GHG emissions. The procedure for modeling landfills can be quite complex and subject to many different interpretations of how to address site-specific landfill gas generation factors and how to apply models effectively to landfills. At this time, no widely accepted method exists for determining the total amount of uncontrolled landfill gas emissions to the atmosphere from landfills.

Baseline emissions

Traditional baseline emission calculations are not required for this protocol for the quantification of methane reductions. In the baseline scenario all uncontrolled methane emissions are

[15] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007)
[16] For more information on CARROT, see the Registry's website, www.climateregistry.org

considered to be released to the atmosphere except for the 10% which is oxidized by bacteria in the soil.[17]

For landfills where the current collection and combustion system is only installed at a portion of the landfill in order to comply with local regulations, ordinances or permitting requirements, the assumption is also made that any methane beyond that currently being collected would be emitted to the atmosphere (minus the 10% oxidized). Only the landfill gas combusted beyond that resulting from the existing collection and combustion system is considered additional (i.e., those reductions resulting from the implementation of the GHG reduction project). The GHG project must either be designed to be entirely separate from the existing collection system or must be monitored separately from the existing system. These conditions will ensure that the reductions resulting from the GHG project can be accounted for separately from current collection and combustion.

This protocol also accounts for the difference in electricity consumption between the baseline scenario and the project.

Project emissions reductions

Project emissions reductions are actual GHG emissions reductions that occur within the project boundary after the installation of the landfill gas control system. Project emissions reductions are calculated on an annual, *ex-post* basis.

As shown in Equation 1, project GHG emissions reductions equal:

- the total amount of uncontrolled methane collected from the landfill and combusted by the project landfill gas control system, minus
- the portion of methane oxidized in the baseline scenario, minus
- carbon dioxide emissions from fossil fuel consumption, minus
- indirect carbon dioxide emissions from the use of electricity from the grid, if applicable.

[17] A small portion of the methane generated in landfills (around 10%) is naturally oxidized to carbon dioxide by methanotrophic bacteria in the cover soils of managed landfills.

Equation 1: Project GHG emissions reductions

$$ER_y = [(CH_4\,Dest_{PR}) * 21 * 0.90] - FFCO_2 - ELCO_2$$

Where,

ER_y	=	total annual project GHG emissions reductions (tCO_2e/yr)
$CH_4\,Dest_{PR}$	=	total annual methane emissions destroyed by the project landfill gas collection and combustion system (tCH_4/yr) – see Equation 2
21	=	Global Warming Potential factor of methane to carbon dioxide equivalent[18]
0.90	=	Factor for the oxidation of methane by soil bacteria

$$FFCO_2 = \Sigma FF_{PR} * EF_{FF}$$

Where,

$FFCO_2$	=	total annual carbon dioxide emissions from the combustion of fossil fuel (tCO_2/yr)
FF_{PR}	=	total annual fossil fuel consumed by the project landfill gas collection and combustion system, by fuel type (volume fossil fuel/yr)
EF_{FF}	=	fuel specific emission factor (kg CO_2/volume fossil fuel) Registry General Reporting Protocol Appendix C.3 and C.5[19]

$$ELCO_2 = EL_{PR} * EF_{EL}$$

Where,

$ELCO_2$	=	total annual indirect carbon dioxide emissions from the consumption of electricity from the grid (tCO_2/yr)
EL_{PR}	=	total annual electricity consumed by the project landfill gas collection and combustion system(MWh)
EF_{EL}	=	carbon emission factor for electricity used (kg CO_2/MWh)[20]

[18] IPCC Second Assessment Report: Climate Change 1996

[19] California Climate Action Registry. General Reporting Protocol V. 2.2, Appendix C, tables C.3 and C.5

[20] Utility specific emission factors for Registry member utilities are available in the Public Reports section of the CARROT database (see Reference Documents section of the Public Report for a link to the PUP reporting form) - http://www.climateregistry.org/CARROT/public/reports.aspx. If a utility specific emission factor is not available, use the EPA eGRID subregion emission factor available in the Registry's General Reporting Protocol (GRP) V. 2.2, Appendix C, tables C.1 (also see GRP Figure III.6.1)

Equation 2: Total annual methane emissions destroyed

$$CH_4\,Dest_{PR} = CH_4\,Dest_{flare} + CH_4\,Dest_{electricity} + CH_4\,Dest_{thermal} + CH_4\,Dest_{pipeline}$$

Where,

$CH_4\,Dest_{flare}$	=	the quantity of methane destroyed by flaring (tCH_4/yr)
$CH_4\,Dest_{electricity}$	=	the quantity of methane destroyed by generation of electricity (tCH_4/yr)
$CH_4\,Dest_{thermal}$	=	the quantity of methane destroyed for the generation of thermal energy (tCH_4/yr)
$CH_4\,Dest_{pipeline}$	=	the quantity of methane destroyed by upgrading landfill gas to natural gas pipeline quality and injecting it into the pipeline for combustion by end users (tCH_4/yr)

$$CH_4\,Dest_{flare} = LFG_{flare} * w_{CH4} * D_{CH4} * DE$$

Where,

LFG_{flare}	=	total annual quantity of landfill gas fed to the flare(s) (ft^3)
w_{CH4}	=	the average methane fraction of the landfill gas as measured ($ft^3\ CH_4 / ft^3$ LFG)
D_{CH4}	=	density of methane ($tCH_4 / ft^3\ CH_4$)[21]
DE	=	default methane destruction efficiency for flare[22,23] = 0.995

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$$CH_4\,Dest_{electricity} = LFG_{electricity} * w_{CH4} * D_{CH4} * DE$$

Where,

$LFG_{electricity}$	=	total annual quantity of landfill gas fed to the electricity generator(s) (ft^3)
DE	=	default methane destruction efficiency for electricity generation[21,22] using Lean Burn IC engines = 0.936, Rich Burn IC Engines = 0.995, Large Gas turbine = 0.995, Microturbine = 0.995

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$$CH_4\,Dest_{thermal} = LFG_{thermal} * w_{CH4} * D_{CH4} * DE$$

Where,

$LFG_{thermal}$	=	total annual quantity of landfill gas fed to the boiler(s) (ft^3)
DE	=	default methane destruction efficiency for boiler[21] = 0.98

[21] Density of landfill gas should be calculated based on the metered temperature and pressure of the gas.

[22] If available, the official source test destruction efficiency shall be used in Equation 2 in place of the default destruction efficiency. Otherwise, project developers have the option to use a State or local agency accredited source test service provider to test the actual destruction efficiency of each of the combustion devices used in the project case.

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[23] The default destruction efficiencies for this source are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data is made available to the Registry.

$$CH_4\ Dest_{pipeline} = LFG_{upgrade} * w_{CH4\ upgrade} * D_{CH4\ upgrade} * DE$$

Where,

$LFG_{upgrade}$	=	total annual quantity of upgraded landfill gas injected into the natural gas transmission and distribution system or converted to CNG or LNG for use in vehicles (ft^3)
$w_{CH4\ upgrade}$	=	the average methane fraction of the upgraded landfill gas as measured ($m^3\ CH_4 / m^3\ LFG$)
$D_{CH4\ upgrade}$	=	density of methane in upgraded landfill gas ($tCH_4 / ft^3\ CH_4$)
DE	=	Methane destruction efficiency for upgraded landfill gas injected into the natural gas transmission and distribution system = 0.98 (see footnote to Table 1 for description). Destruction efficiency for use in CNG and LNG vehicles = 0.95?????

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VI. Project Monitoring

Project developers are responsible for monitoring the performance of the project and operating the landfill gas collection and combustion system in a manner consistent with the manufacturer's recommendations for each component of the system. According to this protocol, methane emissions from landfill gas capture and control systems are monitored with measurement equipment that directly meter

- the continuous rate of landfill gas flow, temperature, pressure and methane concentration[24] prior to delivery to combustion device, and
- the continuous rate of landfill gas to each combustion device, and
- the continuous rate of landfill gas flow, temperature, pressure and methane concentration prior to injection into the natural gas transmission and distribution system.

Often the direct measurement instrument also uses a data recorder to store and document the landfill gas flow and methane concentration data and can be tailored to provide the amount of methane (m^3) collected from the landfill on a daily basis.

The measurement equipment is sensitive for gas quality (humidity, particulate, etc.), so a strong QA/QC procedure for the calibration of this equipment is needed. Monitoring instruments shall be calibrated at least once per year and maintained as specified by the manufacturer. The hourly operational activity of the landfill gas collection system and the combustion devices should be

[24] Methane fraction of the landfill gas to be measured on a wet basis. No separate monitoring of temperature and pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.

monitored and documented to ensure actual landfill gas destruction. GHG reductions will not be accounted for during periods which the combustion device was not operated.

For qualifying projects that became operational between January 1, 2001 and January 1, 2008, the use of monthly temperature, pressure and methane concentration measurements is acceptable under this protocol.

Project developers have the option to use a State or local agency accredited source test service provider to test the actual methane destruction efficiency of each of the combustion devices used in the project case.

Provisions for monitoring variables to calculate baseline and project emissions are provided in the table below (adapted from ACM0001, V.6). Project developers are required to retain all documentation of project activity for a minimum of two years post project verification.

Table 2. Data to be collected and used to monitor emissions from the project activity

ID number	Data variable	Data unit	calculated (c) measured (m) estimated (e)	Recording frequency	Comment
1. LFG_{total}	Total amount of landfill gas captured	ft^3	m	Continuously	Measured by a flow meter. Data to be aggregated monthly and yearly.
2. LFG_{flare}	Amount of landfill gas flared	ft^3	m	Continuously	Measured by a flow meter. Data to be aggregated monthly and yearly for each flare.
3. $LFG_{electricity}$	Amount of landfill gas combusted in power plant	ft^3	m	Continuously	Measured by a flow meter. Data to be aggregated monthly and yearly for each power plant.
4. $LFG_{thermal}$	Amount of landfill gas combusted in boiler	ft^3	m	Continuously	Measured by a flow meter. Data to be aggregated monthly and yearly for each boiler.
5. $LFG_{upgrade}$	Amount of upgraded landfill gas delivered to NG Transmission and Distribution System of CNG/LNG vehicled	ft^3	m	Continuously	Measured by a flow meter. Data to be aggregated monthly and yearly.
6. w_{CH4}	Methane fraction in the landfill gas	ft^3 CH4 / ft^3 LFG	m	Continuously	Measured by continuous gas analyzer. Methane fraction of the landfill gas to be measured on wet basis. Measured to determine the density of methane DCH4.
7. T	Temperature of the landfill gas	°C	m	Continuously	Measured to determine the density of methane DCH4. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature

ID number	Data variable	Data unit	calculated (c) measured (m) estimated (e)	Recording frequency	Comment
					and pressure, expressing LFG volumes in normalized cubic meters.
8. P	Pressure of the landfill gas	atm	m	Continuously	Measured to determine the density of methane DCH4. No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.
9. EL_{PR}	Total amount of electricity required to meet project requirement	MWh	m	Monthly	Obtained from either onsite metering of utility purchase records. Required to determine CO2 emissions from use of electricity to operate the project activity.
10. EF_{EL}	Carbon emission factor of electricity	Kg CO2/MWh	c	Annually	Utility specific emission factors for Registry member utilities are available in the Public Reports section of the CARROT database. Utility specific not available use the EPA eGRID subregion emission factor from the California Climate Action Registry's General Reporting Protocol (GRP) V. 2.2, Appendix C, tables C.1 (also see GRP Figure III.6.1)
11. FF_{PR}	Total amount of fossil fuel required to meet project requirement	scf or Gallons	c	Monthly	Calculated from monthly record of fossil fuel purchased and consumed. Required to determine CO2 emissions from use of fossil fuels to operate the project activity.
12. Regulations	Regulatory requirements relating to landfill gas projects	n/a	n/a	At the renewal of accounting cycle.	The information is used for the application of the regulatory additionality test. The project developer shall document all Federal, State and local regulations, ordinances and permit requirements (and compliance status for each) that apply to the landfill hosting the GHG reduction project.
13.	Operation of the landfill gas collection system	Hours	m	Daily	This is monitored to ensure methane destruction is claimed for methane used in the combustion devices.
14.	Operation of the energy plant	Hours	m	Daily	This is monitored to ensure methane destruction is claimed for methane used in electricity plant when it is operational.
15.	Operation of the boiler	Hours	m	Daily	This is monitored to ensure methane destruction is claimed for methane used in boiler when it is operational.
16.	Operation of the flare	Hours	m	Daily	This is monitored to ensure methane destruction is claimed for methane used in flare when it is operational.
17. DE	Optional: Source	%	m	Annually	Project developers have the option to

ID number	Data variable	Data unit	calculated (c) measured (m) estimated (e)	Recording frequency	Comment
	test data for combustion device methane destruction efficiency	destruction efficiency			use a State or local agency accredited source test service provider to test the actual methane destruction efficiency of each of the combustion devices used in the project case. If using source test data for destruction efficiencies in Equation 2, all source test documentation shall be provided to the verifier.

VII. Reporting Parameters

This section provides guidance on reporting rules and procedures. A priority of the Registry is to facilitate consistent and transparent information disclosure among project developers. All direct methane and carbon dioxide should be reported within the project boundary. Project developers submit annual project reports through the Registry's on-line reporting tool – CARROT.[25]

Pre-registration reporting forms

Project developers provide the following information to the Registry before registering reductions associated with installing a landfill gas collection and combustion system.[26]

Form 1: General Landfill Information

1. Date of data collection:
2. Form completed by (name):
3. Name of Landfill:
4. Address (including county) :
5. Owner of Landfill and owner contact information:
6. Type of landfill (sanitary, controlled, or open dump):
7. Landfill size – designed area for waste placement (acre or hectare):
8. Waste in place (cubic meters or tons):
9. Designed landfill capacity (cubic meters or tonnes):
10. Year landfill opened:
11. Year landfill closed or estimated date of closure:
12. Approximation of percent municipal / industrial / inert wastes:
13. Quantity of waste accepted and disposed of annually at landfill (cubic meters or tonnes):
14. Description of any regulatory framework for landfill methane capture and control (include an estimate of the date which the landfill will be required to control NMOC emissions per NSPS/EG regulations and the type of testing that justifies the estimate):
15. Description of local and state air and water quality, explosive gas, or other regulations pertinent to the project:

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Comment [C2]: What is meant by "generated"? This protocol focuses on what goes into the landfill, or disposed of.

Comment [C3]: Just current year or historically? Or are you asking for the permitted acceptance rate or average annual? These numbers are very dynamic. First determine what you will use the information for and then decide what to ask for.

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[25] Until the Registry's CARROT tool is updated to accept GHG reductions data submitted according to this protocol, spreadsheet-based tools will be provided to project developers.

[26] The pre-registration reporting forms are sourced from the Methane to Markets Partnership Landfills Subcommittee. *2007 Methane To Markets Partnership Expo, Preliminary Assessment For Landfill Methane Partnership Opportunities.*

16. **Waste Characteristics Table**

Waste Types	**Estimated Percent of Waste Stream**
Food Waste	
Garden and park waste	
Wood	
Paper and textiles	
Plastics	
Concrete	
Metal	
Other Inert waste	

Comment [C4]: Why is this necessary? Most landfills don't perform site specific waste characterization data. Could they use the CIWMB's statewide data as a default?

Form 2: Landfill Operations Data

1. Daily Cover? (Yes/No)
2. Landfill Site Capped? (Yes/No)
3. Landfill Lined? (Yes/No)
   - Type of liner (soil, clay, plastic)?
4. Waste Compaction? (Yes/No)
5. Average annual rainfall at the landfill (cm):
6. Average annual temperature (^{0}C):
7. Describe filling process (i.e., large area shallow lifts, small areas deeper lifts)
8. Note waste pickers or recycling activities:

Comment [C5]: How do you intend to use this data? How does this fit in with landfill gas control and combustion absent of requiring landfill gas generation estimates?

Form 3: Landfillgas control system information

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1. Type of Landfill gas collection and control system in place, if any (e.g., flare, energy recovery etc.):
   i. If Landfill gas collection system is in place, is the system actively collecting or passively venting gas?
   ii. If flare or energy project is in place, what is the landfill gas flow rate (in scfm) and methane content?
   iii. What is the number and average depth of vertical or horizontal wells?
   iv. Name of system designer, address, and other contact information
2. When was the system installed and operational?

Comment [C6]: May want to consider requesting the as-built drawings of the system. The average is not useful information.

Form 4: Landfill gas utilization information

1. Landfill gas utilization (*e.g.*, flared, generation of electricity, use on-site as a boiler or furnace fuel, or sale to a third party)
2. When was the system installed and operational?
3. If designed to generate electricity,
   a. Type of engine-generator set (*e.g.*, internal combustion engine, micro turbine or fuel cell with the name of the manufacturer, model, power output rating

(kW or MJ) for biogas, and nominal voltage
b. Component integration (factory or owner)
c. Origin of equipment controller (manufacturer integrated, third party off-the-shelf, or third party custom)
d. System installer
e. Pretreatment of landfill gas (*e.g.*, none, condensate trap, dryer, hydrogen sulfide removal, *etc.* with the names of manufacturers, models, *etc.*)
f. Exhaust gas emission control (*e.g.*, none, catalytic converter, *etc.*)
g. If interconnected with an electric utility
   - Name of the utility
   - Type of utility contract (e.g., sell all/buy all, surplus sale, or net metering)
h. If engine-generator set waste heat utilization
   - Heat source (e.g., cooling system or exhaust gas or both) and heat recovery capacity (Btu or kJ/hr)
   - Waste heat utilization (*e.g.*, water heating, space heating, *etc.*)

4. If designed to use on-site as a boiler or furnace fuel, a description of the boiler or furnace including manufacturer, model, and rated capacity (Btu or kJ/hr)
5. If designed for landfill gas sale to a third party, a description of the methods of processing, transport, and end use

Reporting cycle

For the purposes of this protocol, project developers report GHG reductions associated with installing a landfill gas collection and combustion system that occurred the preceding year. In keeping with the reporting rules of the Registry's General Reporting Protocol, the reporting deadline for project developers is August 31 the year following the reduction year, and the certification deadline is December 31.[27]

Project crediting period

Project developers are eligible to register GHG reductions with the Registry according to this protocol for a crediting period of seven years with the potential for a second five year period (second five year period is contingent upon satisfaction of the additionality eligibility criteria) if the collection and combustion system is installed and operational before any new regulation requiring the system to be installed is adopted.[28] The first reduction year commences after the landfill gas collection and combustion system becomes operational. A system is operating if it is capturing and combusting methane gas from the landfill.

If a federal or state rulemaking process has begun for a regulation specific to greenhouse gas emission reductions from landfills and a new landfill gas collection and combustion system is installed and becomes operational within the jurisdiction of the regulation in development before the regulation is passed, then the GHG reduction project is eligible for a crediting period up to and including two years after the effective regulation becomes enforceable, but no longer than

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[27] General Reporting Protocol, IV.14.7. http://www.climateregistry.org/PROTOCOLS/GRCP/

[28] When a landfill becomes subject to NSPS/EG regulations it is no longer an eligible project host for a GHG reduction project under this protocol.

seven years (is this to account for the crediting period? What if the regulation becomes enforceable 3 years into the crediting period? Would they have 4 remaining years or just 2? Why is the seven years pertinent? What situation would create this 7 year situation?). This crediting period applies to all landfill operations within the jurisdiction of the regulation in development, regardless of whether or not the landfill operation hosting the GHG reduction project is ultimately subject to the final regulation. (Why apply it to landfills that are not subject to the final regulation?)

(This is California specific and only applies to the situation at hand with the Landfill Methane Capture Regulations. How will this be applied nationally and how will it be interpreted after the proposed ARB regulation becomes enforceable? Since the specifics and the fate of the new regulation are still unknown, it appears premature to put this language in the protocol. Early action should be rewarded for those wishing to install a system before the regulation, regardless of the timing of any proposed regulation. And if economics is to be considered, most of the landfills that may be subject to the new regulation are older, smaller, closed landfills who for the most part, have no funding for a new system (similar to the dairies). To allow them the benefit of credits to put in a system before it's required will help them make the educated decision (financially speaking) to put one in that will ultimately be good for the environment. In this case, they should be allowed the entire crediting period, but maybe not the extension. It may help with the decision to put it in sooner rather than later. The benefits should be considered. And if the intent of the crediting period it to provide some financial protection for the developer for what is a good environmental benefit, then that spirit should be maintained.)

Previous section states the following: "All projects that pass the Regulatory Test are eligible to register reductions with the Registry for the lifetime of the project-crediting period, even if a regulatory agency with authority over a landfill operation adopts a new rule obligating the installation of a landfill gas control system during mid-period." Why not just be consistent with this language given the information above?

Non-California Climate Action Registry reporting

The Registry requests that project developers only register reductions from GHG reduction projects with one registry. However, under a voluntary system, enforcement authority is limited. Therefore, if a project developer participates in this program it is their responsibility to transparently disclose the registration of all emissions reductions associated with the project activity that occur outside of the Registry. If the Registry determines that duplicative emissions reductions registration has occurred, all duplicate reductions reported with the Registry will be made void.

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California Climate Action Registry, General Reporting Protocol Version 2.2, March 2007

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U.S. Department of Energy 1605(b) Technical Guidelines for Voluntary Reporting of Greenhouse Gas Program

U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004, EPA-430-R-07-002 (April 2007).

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World Resource Institute and World Business Counsel for Sustainable Development, Greenhouse Gas Protocol for Project Accounting (November 2005).

Appendix A

Development of the Performance Standard Threshold

Development of the Performance Standard Threshold

The primary data source for the performance standard threshold is the database of nearly 2,400 landfills in the United States developed and maintained by the EPA's Landfill Methane Outreach Program (LMOP)[29]. As landfill gas collection and combustion projects at regulated landfills do not pass the Registry's Regulatory Test, they are not eligible as greenhouse gas offset projects. Therefore, detailed data on these landfills need not be included in this analysis.

Landfill summary information is provided in Tables 1 and 2 with a focus on those landfills not currently subject to the New Source Performance Standards and Emission Guidelines for existing sources (NSPS/EG) promulgated in March 1996.

The results of this analysis reveal that of the 1866 landfills in the U.S., an estimated 697 are subject to NSPS/EG, and 1169 are not subject to NSPS/EG (not required to combust landfill gas under federal regulations). Of the non-NSPS/EG landfills, 261 (22.33%) currently have gas collection and combustion projects, of which 166 (14.20%) are flare only, 67 (5.73%) are electricity projects, and 28 (2.40%) are gas projects.

Focusing on the non-NSPS/EG landfill operations, the Registry has developed an estimated range for market penetration of voluntary landfill gas collection and control projects at non-regulated landfills. As the LMOP database does not contain information on state and local regulations, ordinances or permitting requirements that may affect landfill operations, it is necessary to make assumptions regarding additional regulatory influence on landfill operations. To estimate an upper bound for market penetration, it is assumed that all 261 non-NSPS/EG landfills with gas collection and control (see Table 2) are *not* required to collect and control gas. Under this assumption 261 out of 1169 landfills have implemented voluntary landfill gas projects, equating to a market penetration of 22.3%. To construct a lower bound, it is assumed that all 166 non-NSPS/EG landfills with flares (see Table 2) are required by state and local regulations, ordinances or permitting requirements to have the flare(s) installed. This assumption is based on the observation that there is generally no incentive for a landfill to install a flare absent requirements imposed by regulations, ordinances or permitting requirements. Therefore it is likely that many non-NSPS/EG landfills with flares are required by state or local regulations, ordinances or permitting requirements to combust landfill gas. By assuming all 166 non-NSPS/EG landfills with flares are required to combust landfill gas, a lower bound for market penetration can be estimated. Under this assumption, 95 out of 1003 non- regulated landfills have implemented voluntary landfill gas projects, a market penetration of 9.4%.

[29] LMOP is a voluntary partnership program that was created to reduce methane emissions from landfills by encouraging the use of landfill gas for energy. LMOP tracks whether or not specific landfills are required to reduce landfill gas emissions under the New Source Performance Standards and Emission Guidelines for Municipal Solid Waste Landfills (NSPS/EG). Because LMOP is not a regulatory program, it cannot make an official EPA designation regarding any landfill's NSPS/EG status. Information relating to NSPS/EG was obtained by voluntary submittal and is subject to change over time. Therefore, LMOP can not guarantee the validity of this information.

Table 1 Summary of Information on US Landfills (NSPS/EG and Non-NSPS/EG)

	# Landfills	%Landfills	# w/Gas Collection and Control	% w/ Gas Collection and Control
NSPS/EG	697	37.35	697	100
Non-NSPS/EG	1169	62.65	261	22.33
Total	1866	100	958	51.34

Table 2 Summary of Non-NSPS/EG Landfills

Non-NSPS/EG Landfills	**Number of Landfills**	**Percent of Landfills**
Flares	166	14.20
Electricity	67	5.73
Gas Projects	28	2.40
Subtotal	**261**	**22.33**
No Gas Recovery and Combustion	908	77.67
Total	1169	100
Estimated Market Penetration of Gas Collection and Control Projects into non-regulated landfills	**9.4% - 22.3%**	

Appendix B

Development of the NMOC Emissions Threshold

Development of the NMOC Emissions Threshold

Purpose:
For the specific case in which a landfill gas control system is required to treat landfill gas for NMOCs in order to comply with a regulation, ordinance, or permitting condition, but combustion of the landfill gas is not the only compliance mechanism available to the landfill operator, the Registry has developed an NMOC emissions threshold whereby the eligibility of a project can be determined. If the total mass flow of NMOC for the landfill gas control system is less than or equal to the threshold (measured in pounds NMOC per month), then the landfill gas control system is eligible as a GHG reduction project under this protocol. If the total mass flow of NMOC for the landfill gas control system is greater than the threshold, then the landfill gas control system is *not* eligible as a GHG reduction project under this protocol.[30]

Data:
The primary data source for the threshold analysis is a series of capital cost and monthly operating cost estimates supplied to the Registry by a major carbon adsorption service provider.[31] Secondary sources were obtained from literature made available through the website of CARBTROL Corporation[32], another carbon adsorption service provider. Flare installation cost information was gathered from various workgroup members.

Summary:
The analysis below reveals an estimated NMOC mass flow threshold of **600 lbs NMOC/month**. This analysis was performed assuming an average flare system cost[33] of $350,000 and a carbon adsorption system operational period of 5 years. Both carbon adsorption systems and flare systems have an operational life in excess of 10 years. The upfront costs for a flare system are relatively high (approximately $350,000), but once a flare is installed and operational the annual maintenance costs are relatively low. In contrast the installation costs for a carbon adsorption system are relatively low ($5,000 to $25,000), but the system maintenance cost is relatively high. The analysis shows that the installation of a flare system for NMOC control is more cost effective than carbon adsorption if the measured landfill gas flow rate (CFM) and NMOC concentration (ppmV) result in a total mass flow of 600lbs of NMOC/month or greater. Above this level, costs of carbon adsorption systems, particularly the monthly carbon replacement costs, become cost prohibitive relative to flare systems.

Methodology:

[30] In the rare case where the project developer can demonstrate that a project should be considered eligible even though the total mass flow of NMOC is greater than the threshold, the project developer can submit a written request for variance to the Registry, including sufficient documentation to substantiate the case. In such cases the Registry would consult with interested stakeholders in the decision process.
[31] Due to proprietary confidentiality, the service provider will remain anonymous.
[32] Shepard, Austin. "Activated Carbon Adsorption For Treatment of VOC Emissions" CARBTROL Corporation, 2001. http://www.carbtrol.com/voc.pdf
[33] Inclusive of all necessary components needed for a fully permitted and operational flare system.

In order to carry out this analysis, we required reliable cost information for carbon adsorption relative to NMOC concentration[34] and flow rate. To do this, 6 hypothetical scenarios were created (scenario's 1-6 of Table 1) and submitted to the technical sales department of a well known carbon vendor, who then supplied cost estimates for each case. Additionally, a 7th scenario (scenario 0 in table 1) was estimated by The Registry in order to get a low-end estimate of total costs for a low concentration and low gas flow scenario. This estimated scenario was developed using carbon cost and installation cost information referenced from additional literature[35]. The total cost[36] of carbon adsorption was then calculated for each scenario over an operational period of 5 years. After converting the gas flow rate and concentration of NMOCs into a mass flow (lbs of NMOC per month), NMOC Mass Flow vs. Total Cost was plotted (figure 1).

From observation, it appeared that the Total Cost function was linear, thus a linear curve was fit to the data *(Total cost = 580.76 * NMOC (lbs/month)*)[37]. From this equation, we were able to solve for an upper threshold NMOC Mass Flow value given a Total Cost upper limit (equivalent to the estimated cost of a flare system) of $350,000. The result (*350,000 / 580.76 = 602.66*) was rounded to **600 lbs NMOC/month.** This threshold represents the NMOC mass flow at which carbon adsorption becomes a non-viable compliance mechanism when compared to combustion with a flare.

Table 1: Scenarios and calculations

Years of operation:	*5*					
Scenario	Concentration (PPMV)	Flow (CFM)	**lbs/mo.**	Cost/mo.	Installation cost	**Total Cost**
0	*50*	*100*	**48.84207**	1395	5000	**88700**
1	*250*	*200*	**488.4207**	6000	12000	**372000**
2	*500*	*200*	**976.8414**	10500	12000	**642000**
3	*800*	*200*	**1562.946**	12000	12000	**732000**
4	*250*	*700*	**1709.472**	15000	25000	**925000**
5	*500*	*700*	**3418.945**	34000	25000	**2065000**
6	*800*	*700*	**5470.312**	53000	25000	**3205000**

[34] NMOC concentration (ppmV) normalized to hexane.
[35] Shepard, Austin. "Activated Carbon Adsorption For Treatment of VOC Emissions" CARBTROL
[36] The total cost over a 5 year operating period does not consider the time value of money, inflation, or maintenance costs.
[37] Because the total cost associated with the 6th scenario was so far beyond the scale of the other estimates, the 6th data point was dropped before the linear curve was fit. This had a negligible effect on the slope and fit of the linear curve.

Figure 1: Total Costs vs. NMOC Mass Flow of gas stream (lbs NMOC/month)