Mexico Landfill Project Reporting Protocol

Collecting and Destroying Methane
from Landfills

Version 1.0

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Abbreviations and Acronyms

CDM	Clean Development Mechanism
CH_4	Methane
CNG	condensed natural gas
CO_2	carbon dioxide
EG	Emission Guidelines
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
INE	Mexico's National Institute of Ecology
INEGI	Mexico's National Institute of Statistics, Geography and Informatics
IPCC	Intergovernmental Panel on Climate Change
LFG	Landfill Gas
LNG	liquefied natural gas
MG	mega gram (1,000,000 grams or one tonne, or "t")
MSW	municipal solid waste
m^3	cubic meter
m^3_s	standard cubic meter (20^{o}C, 1 atm)
N_2O	nitrous oxide
NG	natural gas
NMOC	non-methane organic compounds
NOM-083	Mexican Official Standard 083-SEMARNAT-2003
QA/QC	Quality Assurance/Quality Control
Reserve	Climate Action Reserve
SEDESOL	Mexico's Ministry of Social Development
SEMARNAT	Mexico's Ministry of Environment and Natural Resources
SENER	Mexico's Ministry of Energy
VOC	volatile organic compound

1 Introduction

The Climate Action Reserve (Reserve) Landfill Gas Project Reporting Protocol provides guidance to account for and report greenhouse gas (GHG) emission reductions associated with installing a landfill gas collection and destruction[1] system at a landfill.

The Reserve is a nonprofit private organization that 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 Reserve's protocols.

Project developers that install landfill gas capture and destruction technologies use this document to register GHG reductions with the Reserve. This protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive annual, independent verification by the Reserve approved verifiers. Guidance for verifiers to verify reductions is provided in the corresponding Landfill Project Verification Protocol.

This project protocol facilitates the creation of GHG emission reductions, and ensures that they are calculated in a complete, consistent, transparent, accurate, and conservative manner that incorporates relevant sources.[2]

Project developers must comply with all local, state, and federal municipal solid waste (MSW), air and water quality regulations in order to register GHG reductions with the Reserve. To register GHG reductions with the Reserve, project developers are not required to take an annual entity-level GHG inventory of their MSW operations.

[1] For this protocol, methane destruction can take place through a combustion reaction, such as in burners, boilers, turbines, etc. or through reduction and oxidation reactions, such as in fuel cells.
[2] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG accounting principles.

2 The GHG Reduction Project

Landfills are used as a method for final solid waste disposal. In Mexico, around 57% of MSW is disposed of in landfills. Available data from the National Institute of Statistics and Geography (INEGI) for the period 1996-2006 indicates an increase in waste disposal at landfills in recent years. [3]

In landfills, 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 organic compounds (NMOC), nitrogen (N_2), oxygen (O_2) and other trace gases. If not collected and destroyed, over time, this landfill gas is released to the atmosphere. According to the National Institute of Ecology, the agency responsible for the National Greenhouse Gas Inventory, landfill emissions represented around 24% of the total methane emissions in 2002. The greenhouse gas (GHG) emissions for this category, in CO_2 equivalent, increased 96% related to 1990, as a result of an increase of solid waste disposal in landfills.[4]

There is considerable uncertainty regarding the actual amount of fugitive methane emissions from landfills. Therefore, this protocol does not address fugitive landfill methane emissions. Instead, it addresses the methane that is captured and destroyed in excess of any regulatory requirements.

2.1 Project Definition

For the purpose of this protocol, the GHG reduction project is the installation of a landfill gas control system for capturing and destroying methane gas that commences operation on or after August 15, 2008. Captured landfill gas could be destroyed 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, for the project to be eligible to register GHG reductions under this protocol, the ultimate fate of the methane must be destruction.[5]

Landfill gas collection and destruction systems typically consist of wells, pipes, blowers, caps and other technologies that enable or enhance the collection of landfill gas and convey it to a destruction 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 destroy landfill gas, such as turbines, reciprocating engines, fuel cells, boilers, heaters, or kilns, these devices will be where landfill gas is destroyed. Most projects that produce energy or process heat also include a flare to destroy gas during periods when the gas utilization project is down for repair or maintenance. Figure 2.1 provides a summary of different qualifying and non-qualifying destruction devices under this Protocol.

[3] INEGI 2009. Sistema Nacional de Información Estadística y Geográfica. Residuos. http://www.inegi.org.mx/inegi/default.aspx?s=est&c=6116 (March 2009)
[4] INE, 2006. Tercera Comunicación Nacional a la Convención Marco de las Naciones Unidas sobre Cambio Climático. http://www.ine.gob.mx/cclimatico/comnal3.html
[5] It is possible that at some point landfill gas may be used in the manufacture of chemical products. However, given that these types of projects are few, if any, these projects are not addressed in this protocol.

Qualifying methane destruction devices	NOT-qualifying destruction devices
Active burners Turbines Reciprocating engines Kilns Boilers Heaters Fuel cells	Passive flares

Figure 2.1 Methane destruction devices

Direct use arrangements which entail the piping of landfill gas to be destroyed by an industrial end user at an off-site location are also an eligible approach to destruction of the landfill gas. For instances of 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), must include a legally binding agreement to assure that the GHG reductions will not be claimed by more than one party.

In addition to reducing methane, the installation and operation of a landfill gas collection and destruction system could impact anthropogenic carbon dioxide and methane emissions associated with the consumption of electricity and fossil fuels. Depending on the project's particular circumstances, this effect could either increase or decrease operational GHG emissions. Section 4, The GHG Assessment Boundary, delineates the scope of the accounting framework.

2.2 The Project Developer

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

2.3 Additional GHG Reduction Activities in the Solid Waste Sector

The Reserve 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 destroy methane from landfills is but one of many GHG emission reduction projects that could occur within the solid waste sector.

However, GHG reduction activities not associated with the installation of a landfill gas collection and destruction system do not meet this protocol's definition of the GHG reduction project. Furthermore, production of power for the electricity grid, which results in the displacement of fossil-fueled power plant GHG emissions, is a complementary and separate GHG project activity to destroying methane gas from landfills and is not currently included within this protocol's accounting framework. The Reserve anticipates the development of a supplement to this protocol to account for and register these reductions for Mexico.

Landfill operations that meet the US EPA definition of a bioreactor are not eligible to use this protocol, as it is unclear what effects the bioreactor may have on the net total and temporal distribution of fugitive methane emissions relative to project baseline conditions. As defined by the EPA, a bioreactor is any MSW landfill or portion of a MSW landfill with a minimum average moisture content of at least 40 percent by weight. This moisture content of 40% could be achieved through a high re-circulation of leachate or adding any other liquids[6] in a controlled fashion to accelerate or enhance the anaerobic biodegradation of the waste.[7]

The Reserve anticipates that separate project protocols will be developed in the future to facilitate further solid waste sector emission reduction opportunities to balance and complement the Landfill Project Protocol. These may include composting, anaerobic digestion, recycling and waste-to-energy.

[6] Liquids other than leachate. Leachate includes landfill gas condensate.
[7] 40 CFR 63.1990 and 40 CFR 258.28a.

3 Eligibility Rules

Project developers using this protocol must satisfy the following eligibility rules to register reductions with the Reserve. These criteria apply only to projects that meet the definition of a GHG reduction project as defined in Section 2.

Eligibility Rule I:	Location	→	*Mexico.-based landfill*
Eligibility Rule II:	Project Operation Start Date	→	*August 15, 2008*
Eligibility Rule III:	Additionality	→	*Meet performance standard*
		→	*Exceed regulatory requirements*

3.1 Location

All projects located at landfill operations in Mexico are eligible to register reductions with the Reserve. The scope of the analysis of landfill practices that formed the basis of the performance standard (Section 3.3.1) covered landfill operations in Mexico. Therefore, the Reserve will estimate GHG reductions from all Mexico-based projects that follow the guidance in this protocol in the same manner.

3.2 Project Start Date

On August 15, 2008, the State of California and the Border States of Baja California, Sonora, Nuevo León, Tamaulipas, Chihuahua and Coahuila, working with Pacific Gas and Electric and the California Climate Action Registry signed a Memorandum of Understanding (MOU), agreeing to work cooperatively to develop quantification and certification protocols for greenhouse gas (GHG) emission reduction projects in Mexico. The establishment of this agreement to support GHG reduction activities is the basis for the project start date criterion.

Eligible projects must have a start date on or after August 15, 2008. The project start date is defined as the date at which a qualifying destruction device becomes operational.

Projects that began operating before being listed with the Reserve, but after August 15, 2008, are considered pre-existing projects. Pre-existing projects will be eligible to become listed with the Reserve for a period of 12 months from the effective date of this protocol (Version 1.0). This is to ensure that the Reserve is providing “early actors” (those that implemented a GHG reduction project prior to a project protocol being available for their project activity) enough time to list their project.[8] After this 12 month grace period, pre-existing projects are required to submit for listing within 6 months of becoming operational. Those that fail to list within this 6 month period will be considered non-additional and excluded from eligibility. Projects that began operating before August 15, 2008, are not eligible to register reductions according to this

[8] A project is considered “listed” when the project developer has created an account with the Reserve, submitted the required Project Submission Form and related required documents, paid the project submission fee, and the Reserve has approved the project for listing.

protocol. For the Reserve's purpose, the commencement of operation means a constructed system that is capturing and destroying methane gas from the landfill operation.

3.3 Additionality

The Reserve strives to support only projects that yield surplus GHG reductions that 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
2. The Regulatory Test

3.3.1 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 California Registry uses a technology-specific threshold, sometimes also referred to as a practice-based threshold, which serves as "best practice standard" for managing landfill gas fugitive emissions. A project developer passes the Performance Standard Test by installing a landfill gas collection and destruction system at a landfill that is not required to do so by regulations.

There are two possible scenarios under which the practice-based performance threshold is met:

1. If the landfill is not currently collecting and destroying any landfill gas, the project is considered additional.[9]

2. If the landfill was previously collecting and destroying methane using a destruction device which would qualify under this protocol (as illustrated in Figure 2.1), the project is additional under the following conditions:
   a. The previous system does not, on its own, qualify as a project under this protocol. Expanding the well-field constitutes a system expansion rather than initiation of a new project.
   b. The new GHG project requires the addition of a separate destruction device.
   c. Only the landfill gas destroyed beyond the maximum capacity of the pre-project destruction device is considered additional (i.e. those reductions resulting from the implementation of the new GHG reduction project). The maximum capacity of the pre-project system must be netted out of emission reductions according to Equation 5.3.

These conditions ensure that the reductions resulting from the new GHG project can be accounted for separately from current collection and destruction.

[9] For landfills that are currently collecting and venting, but not combusting landfill gas, the installation of a landfill gas combustion device is an eligible project activity.

The Reserve defined the performance standard based upon an evaluation of landfill practices in Mexico. A summary of the performance standard analysis is provided in Appendix A.

All projects that pass this test are eligible to register reductions with the Reserve for the lifetime of the project crediting period, even if the Performance Standard Test changes during mid-period. As stated in Section 7, Reporting Parameters, the project crediting period is ten years or until failure of the regulatory additionality test. The crediting period commences at the project start date regardless of whether sufficient monitoring data is available to register credits.

The Reserve will periodically re-evaluate the appropriateness of the performance standard threshold by updating the market penetration analysis in Appendix A. The Reserve recognizes the importance of waste diversion and recycling programs. Therefore, as part of its periodic assessments of the performance threshold, the Reserve will use a stakeholder process to evaluate whether implementation of this protocol has resulted in negative environmental effects, such as increased emissions of criteria pollutants and/or methane. The assessment will pay particular attention to the status of other GHG reduction project protocols including composting, anaerobic digestion, recycling and waste-to-energy, which would act to balance and complement the Landfill Project Reporting Protocol. If it is determined that negative environmental effects have occurred, the Reserve will identify and implement revisions to the protocol to prevent such effects from occurring in the future, or may suspend implementation of the protocol if necessary.

3.3.2 The Regulatory Test

All GHG reduction projects are subject to a regulatory test to ensure that the emission reductions achieved by a project would not have occurred in the baseline case due to federal, state or local regulations. The Monitoring Plan (Section 6) must incorporate into the monitoring procedures a mechanism for ensuring and demonstrating that the project at all times passes the Regulatory Test. The preferred method for demonstrating compliance with the Regulatory Test is a regulatory audit, performed on a periodic basis. At a minimum, an executive-level representative must formally attest to compliance with the Regulatory Test on an annual basis. The Reserve has developed an official Attestation of Regulatory Compliance form to be used for this purpose.

3.3.2.1 Federal Regulations

At the federal level, there are several regulations in Mexico for MSW and landfills which influence the eligibility of methane collection and destruction projects as voluntary GHG reduction projects. The federal level is in charge of conducting the national policies regarding waste, and issuing the General Laws and Mexican Official Standards (NOM by its Spanish acronym) related to the integral management of any type of waste. These regulations include:

- The 1917 Political Constitution of the Mexican United States. In Article 115 it enumerates the responsibilities and attributions of the municipalities and indicates that these are responsible for providing the required services for cleaning, collection, transference, treatment and final disposal of urban waste. In the same article, the Constitution indicates that the municipalities should comply with the norms and regulations issued by the Federation.

- General Law of Ecological Equilibrium and Environmental Protection. Published in January 1988 and with entry into force after three months, this law states that waste should be controlled as it constitutes the main source of soil contamination. In addition, it establishes the need to prevent and reduce the solid, municipal and industrial waste generation; to incorporate techniques and procedures for its re-use and recycling, as well as to regulate its efficient management and final disposal.

- General Law for Solid Waste Prevention and Integral Management; published in October 2003, and with entry into force in January 2004. This law classifies waste in three categories: hazardous, of special management, and urban waste. This law promotes waste recovery as well as the development of by-products markets under the criteria of economic, technological and environmental efficiency, and adequate financing schemes.

- Mexican Official Standard NOM-083-SEMARNAT-2003, with entry into force in December 2004. The standard provides specifications for environmental protection related to the site selection, design, construction, monitoring, closure and complementary works of a final disposal site for urban solid waste and of special management.

As to LFG control, the NOM 083 is the only standard that establishes general specifications for its management. Article 7.2 of NOM 083, within the section related to the construction and operation of waste disposal sites, mentions that the biogas control should be guaranteed through its flaring in wells or by centralized burners. This article is applicable for landfills receiving more than 10 tonnes per day. Although Mexican standards are not retroactive, this standard also requires retrofitting of the existing disposal sites. [10]

3.3.2.2 State and Local Regulations

The formulation and enforcement of policies related to waste at the state level are designated to the State governments through the State Political Constitution, the State Environmental Law, and the State Waste Programs. Among the state waste laws, the following should be noted:

- Law for the integral waste management of the State of Querétaro, published on February 2004
- Law of prevention and integral management of the solid urban waste and of special management of the State of Veracruz, published in June 2004
- Law for the integral waste management in the State and municipalities of Guanajuato, published in May 2005
- Law of the solid waste of the State of Colima, published in April 2006
- Law for the integral waste of the State of Jalisco, published in February 2007

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[10] There are several technical and financial reasons why this standard has not been adopted and/or exceeded in landfills and final disposal sites in Mexico. There are technical reasons, such as the fact that the size and design of the pre-existing wells prior to entry into force of the NOM083-2003 prevent the installation of burners, external factors that were not considered in the design, such as the wind conditions that turn off the passive flares, and issues related to the intermittency and low volume of biogas production that do not assure ignition at the passive flares. The lack of financial resources is another reason for the lack of complete compliance with the NOM083. In addition, the standard does not establish the minimum quantity that should be collected and destroyed, nor the specific technologies to be used. Finally, at the federal level, SEMARNAT, responsible for elaborating the technical standards, does not have mechanisms to penalize those municipalities that do not adopt the standard.

- Law for the integral waste management of the State of Baja California, published in September 2007
- Law of solid waste for the State of Morelos, published in October 2007
- The Federal District of Mexico City, as a federal entity and capital of the Mexican United States, published its Law of Solid Waste in 2003.

The majority of these state laws promote waste management and disposal practices for solid municipal and industrial waste; however, they do not establish specific guidelines for biogas control at landfills. Some laws, such as the one in the State of Querétaro, mention that the federal level should establish technical standards for biogas management. The Law of the Federal District states that the disposal of solid waste that releases gases and provokes fires should be avoided.

Municipalities are responsible for the management of urban solid waste, including the elaboration of applicable legal regulations, as well as the issuance of authorizations and concessions to conduct the waste collection, transference, treatment and final disposal, the establishment of the registration of large waste generators, and their participation in the enforcement and application of sanctions. Some of the legal instruments include: the Municipal Organic law, Rules of Cleaning, Police and Good Governance. As in the case of state legislation, these municipal regulations do not include guidelines for biogas management and control, but focus mainly on cleaning. However, as it is established in the constitution, municipalities should comply with the standards and regulations published by the Federation, i.e. the NOM 083.

Projects that are in non-compliance with the General Law of Ecological Equilibrum and Environmental Protection or the NOM 083 related to air or water quality regulations in final disposal sites (landfills and controlled sites) are not eligible to register GHG reductions with the Reserve. 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 god” will not affect GHG reduction registration and crediting. Once the project developer verifies regulatory compliance, GHG reductions associated with the portion of the crediting period for which the project developer was in compliance will be considered valid.

Project developers pass the Regulatory Test by demonstrating that:

1. they apply the adjustment for the compliance with the Mexican Official Standard 083 described in Equation 5.1 as $NOM_{discount}$

2. there are no federal, state or regional regulations or permitting requirements requiring the landfill to control emissions or requiring the installation of a landfill gas collection and destruction system at the project location

3. if adding a destruction 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

4. the project meets all applicable federal, state, and local regulations or ordinances

If an eligible project has begun operation at a landfill that later becomes subject to a regulation, ordinance or permitting condition that would call for the installation of a landfill gas control system, emission reductions can be reported to the Reserve up until the date that the landfill gas control system is legally required to be operational. The regulatory additionality test must be applied annually, at the beginning of each emission reduction accounting cycle.

4 The GHG Assessment Boundary

The GHG assessment boundary delineates the GHG sources and gases included in the calculation of the net change in emissions associated with installing a landfill gas collection and destruction system.

The GHG assessment boundary for the project includes all emission sources from the operation of the landfill gas collection system to the ultimate destruction of the landfill gas.

CO_2 emissions associated with the generation and destruction of landfill gas are considered biogenic emissions[11] (as opposed to anthropogenic) and will not be included in the GHG reduction calculation. This is consistent with the Intergovernmental Panel on Climate Change's (IPCC) guidelines for captured landfill gas.[12]

This protocol does not account for CO_2 reductions associated with the displacement of fossil-based grid-delivered electricity or natural gas. This is classified as an indirect emission reduction activity because the change in GHGs occurs from sources owned and controlled by the power producer or the end user of the natural gas. Capturing and using methane to displace fossil-based electricity on the grid or natural gas in gas transmission and distribution systems could potentially be considered complementary and separate GHG reduction projects.

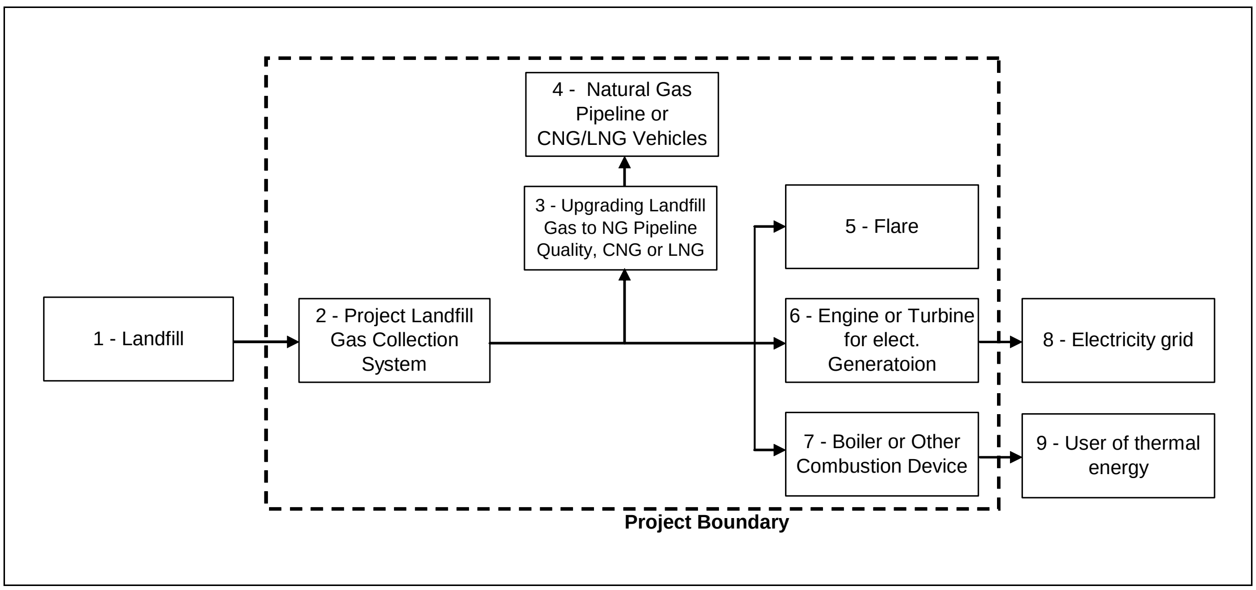

Figure 4.1. General illustration of the GHG assessment boundary.

[11] 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.
[12] *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; p.5.10, ftnt.

Table 4.1 Main GHG sources associated with the source categories. This table specifies the gases included in the calculation procedure.

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, gathering and upgrade system	CO_2	Yes	*All CO_2 emissions (direct and indirect) due to fossil fuel destruction 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 destruction 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 CO_2 emissions (direct and indirect) due to fossil fuel destruction 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 destruction, 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 destruction of landfill gas in flare	CO_2	No	*Biogenic emissions are excluded.**
		CH_4	Yes	*Based on destruction efficiency of flare.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.****
	• Emissions resulting from the destruction of fossil fuel in flare	CO_2	Yes	*All CO_2 emissions due to fossil fuel destruction are included.*
		CH_4	Yes	*Un-destroyed CH_4 from natural gas use is based on destruction efficiency of flare.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small****

GHG Source Category	GHG Source	Gas	Included in Project Boundary	Comment
6. Engine or Turbine for Electricity Generation	• Emissions resulting from the destruction of landfill gas in engine or turbine	CO_2	No	*Biogenic emissions are excluded.**
		CH_4	Yes	*Based on destruction efficiency of engine or turbine*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.****
	• Emissions resulting from the destruction of fossil fuel in engine or turbine	CO_2	Yes	*All CO_2 emissions due to fossil fuel destruction are included.*
		CH_4	Yes	*Un-destroyed CH_4 from natural gas use is based on destruction efficiency of engine or turbine.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.****
7. Boiler or Other Destruction Device	• Emissions resulting from the destruction of landfill gas in boiler or other destruction device	CO_2	No	*Biogenic emissions are excluded.**
		CH_4	Yes	*Based on destruction efficiency of boiler device.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.****
	• Emissions resulting from the destruction of fossil fuel in boiler or other destruction device	CO_2	Yes	*All CO_2 emissions due to fossil fuel destruction are included.*
		CH_4	Yes	*Un-destroyed CH_4 from natural gas use is based on destruction efficiency of boiler.*
		N_2O	No	*Excluded, as this emission source is assumed to be very small.****
8. Electricity Grid	• Displacement of GHG emissions from fossil fuel destruction 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. User of Thermal Energy	• Displacement of GHG emissions from fossil fuel destruction 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.*

***** Carbon dioxide emissions from the destruction 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

*** Nitrous Oxide emissions are excluded from this protocol as they are considered to be very small. Also, the level of uncertainty associated with the nitrous oxide emission factors that are currently available is substantial.

******** The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed 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 compounded and multiplied. 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.[13]

4.1 Leakage

Leakage is an increase in GHG 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 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 which is the displacement of activities and their associated GHG emissions outside of the project boundary.

Landfill methane collection and destruction projects are not expected to result in leakage of GHGs outside the GHG assessment boundary.

[13] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

5 GHG Reductions Calculation Method[14]

Project GHG reductions are verified and registered with the Reserve, at a minimum on an annual basis, but may be verified and registered more frequently if desired.

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 becoming increasingly refined and 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 emission 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. As new technologies and/or widely accepted modeling methods become available for the estimation of fugitive methane emissions from landfills, the California Registry will consider updating the protocol to incorporate these new approaches into the methane emission reduction quantification methodologies.

5.1 Baseline Emissions

Traditional baseline emission calculations are not required for this protocol for the quantification of methane reductions. The baseline scenario assumes that all uncontrolled methane emissions are released to the atmosphere except for the portion of methane that would be oxidized by bacteria in the soil of uncovered landfills, absent the project.[15] Also, a deduction is required to account for the methane that would be destroyed to achieve compliance with NOM-083.

This NOM-083 discount factor accounts for the methane destruction occurring in a system of wells and burners sufficient to achieve compliance with NOM-083-2003. Based on the Reserve’s research, this factor assumes compliance could be established by installation of passive wells with solar spark flares. Based on consultation with Mexican landfill managers, engineers, and industry experts, it was established that such passive wells achieve collection efficiency approximately 25% that of the active collection systems that will be installed under this protocol. Further, given the intermittency of flame presence and low combustion efficiency, an overall destruction efficiency of 25% of collected methane was suggested by industry experts. Under these assumptions, compliance with NOM-083 would require the destruction of 6.25% of methane collected in the project scenario. For conservativeness, the adjustment factor for compliance with NOM-083 has been rounded up to 7%.

[14] The Reserve’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).

[15] Landfill cover systems incorporating synthetic liners as part of the final cover systems should use a default methane oxidation rate of zero. A 10% methane oxidation factor shall be used for all other landfills. 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 well managed landfills. The 10% factor is based on Intergovernmental Panel on Climate Change (IPCC) guidelines (2006).

As noted in section 3.3.1, projects may fall into two categories based on the pre-project state of the landfill and level of landfill gas management. These categories require a slightly different methodology for calculating relevant baseline emissions.

1. Landfills where no previous collection or destruction took place prior to project implementation must deduct the following from baseline emissions:
    a. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.
    b. The amount of methane that would have been destroyed to achieve compliance with NOM 083.
2. Landfills where previous collection and destruction took place in a qualifying destruction device must deduct the following from baseline emissions:
    a. The amount methane that could have been destroyed if the pre-project destruction device was operating at full capacity (Equation 5.3).
    b. The amount of methane that would have been destroyed to achieve compliance with NOM 083.
    c. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

These conditions ensure that the reductions resulting from the GHG project can be accounted for separately from current collection and destruction. Only the landfill gas destroyed beyond that resulting from the pre-project collection and destruction system is considered additional (i.e. those reductions resulting from the implementation of a new GHG reduction project).

As stated above, landfill operations that meet the EPA definition of a bioreactor are not eligible to use this protocol, as it is unclear what effects the bioreactor may have on the fugitive methane emissions relative to baseline conditions.

This protocol accounts for the difference in electricity consumption between the baseline scenario and the project by assuming no electricity consumption in the base case and deducting the annual indirect CO_2 emissions due to the project activity from the annual project emission reductions.

5.2 Project Emissions

Certain GHG emissions may occur or increase as a result of the project activity, and therefore must be deducted from the overall project reductions. These added emissions are typically a result of the increased use of fossil-derived energy used to power project blowers, monitoring equipment, support vehicles, or gas treatment. As such, the following categories of emissions must be accounted for under this protocol:

- total annual indirect carbon dioxide emissions resulting from consumption of electricity from the grid
- total annual carbon dioxide emissions from the on-site destruction of fossil fuel
- total annual carbon dioxide emissions from the combustion of supplemental natural gas
- total annual methane emissions from the incomplete combustion of supplemental natural gas

However, unlike the emissions from incomplete destruction of supplemental natural gas, those resulting from incomplete destruction of landfill gas or the fugitive release of landfill gas do not need to be accounted for. It is assumed that these would have been released to the atmosphere in the baseline scenario as well.

5.3 Project Emission Reductions

Project emission reductions are GHG emission reductions that occur within the GHG assessment boundary as a result of the installation of the landfill gas control system. Project emission reductions are calculated on an annual, ex-post basis.

As shown in the following equations, project GHG emission reductions equal:

- the total amount of uncontrolled methane collected from the landfill and destroyed 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
- methane emissions from incomplete destruction of natural gas, if applicable, minus
- indirect carbon dioxide emissions from the use of electricity from the grid, minus
- the adjustment factor for the compliance with NOM 083; minus
- the adjustment factor for pre-project methane destruction, if applicable, minus
- the discount factor to account for uncertainties associated with the project monitoring equipment

Equation 5-1. Project GHG emission reductions

$$ER_y = [(CH_4 Dest_{PR}) * 21 * (1 - OX) * (1 - DF) * (1 - NOM_{discount})] - FFCO_2 - ELCO_2 - PRE_{discount}$$

Where,

		Units
ER_y =	total annual project GHG emission reductions	tCO_2e/yr
$CH_4\ Dest_{PR}$ =	total annual methane emissions destroyed by the project landfill gas collection and destruction system – see Equation 5.2	tCH_4/yr
21 =	Global Warming Potential factor of methane to carbon dioxide equivalent[16]	
OX =	factor for the oxidation of methane by soil bacteria. Equal to 0.10 for all landfills except those that are covered with a synthetic liner as part of the final cover systems where OX = 0.	
$PRE_{discount}$ =	adjustment to account for pre-project LFG destruction device (see Equation 5.3). Equal to zero if no pre-project LFG destruction system is in place prior to project implementation.	tCO_2e/yr
DF =	discount factor to account for uncertainties associated with the project monitoring equipment. Either 0, 0.05, 0.10, 0.15, 0.20, or 0.25. Equal to zero if using continuous methane monitor with no missing data, all calibration tests are within a 5% margin of error, and equipment is maintained, operated and calibrated according to the manufacturer specifications (see Section 6, Project Monitoring).	
$NOM_{discount}$=	discount factor for the regulatory requirements of NOM 083 = 0.07	

[16] IPCC Second Assessment Report: Climate Change 1996.

Equation 5.1 (continued)

$$FFCO2 = \frac{\sum_i \left(FF_{PR,i} * EF_{FF,i}\right)}{1000}$$

Where,

			Units
$FFCO_2$	=	total annual carbon dioxide emissions from the destruction of fossil fuel	tCO_2/yr
$FF_{PR,i}$	=	total annual fossil fuel consumed by the project landfill gas collection and destruction system, by fuel type i[17]	GJ/yr
$EF_{FF,i}$	=	fuel specific emission factor, by fuel type i[18]	kg CO_2/GJ fossil fuel
1000	=	conversion factor from kg to metric tonnes	

$$ELCO_2 = \frac{\left(EL_{PR} * EF_{EL}\right)}{1000}$$

Where,

			Units
$ELCO_2$	=	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 destruction system	MWh
EF_{EL}	=	carbon emission factor for electricity used[19]	kg CO_2/MWh
1000	=	conversion factor from kilograms to metric tonnes	kg CO_2/tCO_2

[17] For converting the quantity of fuel consumed from volume (l, m^3) or mass (kg, g) units to energy units (GJ, MJ) use the net calorific values specific for Mexico. Appendix B, Table B.2
[18] Emission factors for Mexico, Appendix B, table B.1
[19] Annual emissions factors from power generation calculated by the Mexico GHG Program (a public-private GHG accounting and reporting initiative from SEMARNAT-CESPEDES-WRI-WBCSD) are available at: http://www.geimexico.org/factor.html.

Equation 5-2. Total annual methane emissions destroyed

$$CH_4Dest_{PR} = \left(CH_4Dest_{flare} + CH_4Dest_{electricity} + CH_4Dest_{thermal} + CH_4Dest_{upgrade}\right) * (0.717 * 0.001)$$

Where,

		Units
$CH_4\ Dest_{flare}$ =	the net quantity of methane destroyed by flaring	$m^3{}_s$/yr
$CH_4\ Dest_{electricity}$ =	the net quantity of methane destroyed by generation of electricity	$m^3{}_s$/yr
$CH_4\ Dest_{thermal}$ =	the net quantity of methane destroyed for the generation of thermal energy	$m^3{}_s$/yr
$CH_4\ Dest_{upgrade}$ =	the net quantity of methane destroyed by upgrading landfill gas to natural gas pipeline quality and injecting it into the pipeline for destruction by end users	$m^3{}_s$/yr
0.717 =	density of methane at standard conditions, 0^oC, 1 atm	$kgCH_4/m^3\ CH_4$
0.001 =	Conversion factor	tCH_4 / $kgCH_4$

$$CH_4Dest_i = \left(Q_i * DE_i\right) - FFCH_{4,i}$$

Where,

		Units
$CH_4\ Dest_i$=	the net quantity of methane destroyed by device i	$m^3{}_s$/yr
Q_i =	total quantity of methane sent to destruction device i	$m^3{}_s$/yr
$FFCH_{4,i}$ =	emissions from incomplete destruction of supplemental natural gas sent to destruction device i. Equal to zero if no supplemental natural gas used.	$m^3{}_s$ /yr
DE_i =	default methane destruction efficiency for device i[20] Enclosed flare = 0.995 Open flare = 0.960 Lean Burn IC engines for electricity = 0.936 Rich Burn IC engines for electricity = 0.995 Large Gas turbine for electricity = 0.995 Microturbine for electricity = 0.995 Thermal boiler = 0.98 Upgraded to natural gas transmission and distribution system = 0.98[21] Upgraded to CNG and LNG for vehicles = 0.95	

[20] If available, the official source tested methane destruction efficiency shall be used in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for each of the combustion devices used in the project case.

[21] 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 compounded and multiplied. The methane destruction efficiency for bio gas injected into the natural gas transmission

Equation 5.2 (continued). Total annual methane emissions destroyed

$$Q_i = \sum_t LFG_{i,t} * PR_{CH4,t}$$

Where,

			Units
$LFG_{i,t}$	=	total quantity of landfill gas fed to the destruction device i, in time interval t – see Equation 5-4 for additional guidance on adjusting the LFG flow for temperature and pressure	m^3_s/t
t	=	time interval for which LFG flow and concentration measurements are aggregated. Equal to one day for continuously monitored methane concentration and one week for weekly monitored methane concentration.	
$PR_{CH4,t}$	=	the average methane fraction of the landfill gas in time interval t as measured	$m^3 CH_4 / m^3$ LFG

$$FFCH_{4,i} = FF_i * FFG_{CH4} * (1 - DE_i)$$

Where,

			Units
FF_i	=	total annual quantity of supplemental natural gas delivered to the destruction device i.	m^3_s/yr
FFG_{CH4}	=	the average methane fraction of the supplemental natural gas as provided for by fuel vendor	$m^3 CH_4 / m^3$ FFG
DE_i	=	methane destruction efficiency (use destruction efficiency provided in Equation 5-2) of destruction device i.[22]	

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.

[22] The default destruction efficiencies for enclosed flares and electricity generation devices 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 California Registry.

Equation 5-3. Pre-project adjustment for destruction in the baseline scenario

$$PRE_{discount} = \sum_{t} \left[\left(LFG_{PP\max,t} - LFG_{PP2,t} \right) * PR_{CH4,t} \right] * 0.717 * 0.001 * 21$$

Where,

		Units
$PRE_{discount}$ =	Adjustment to account for the deduction of the un-utilized capacity of the pre-project destruction device. This deduction is to be applied only when a new destruction device is used during project activity. Equal to zero if there is no pre-project installation. See Box 1 below for an example of the application of the adjustment.	tCO_2e
$LFG_{PPmax,t}$ =	the maximum landfill gas flow capacity of the pre-project methane destruction device (standardized at sea level according to the manufacturer specifications) in time interval t	m^3/t
$LFG_{PP2,t}$ =	the actual landfill gas flow of the pre-project methane destruction device in time interval t	m^3/t
$PR_{CH4,t}$ =	the average methane fraction of the landfill gas in time interval t as measured	m^3 CH_4 / m^3 LFG
t =	time interval for which LFG flow and concentration measurements are aggregated. Equal to one day for continuously monitored methane concentration and one week for weekly monitored methane concentration.	
0.717 =	Density of methane at standard conditions, 0^oC, 1 atm	$kgCH_4$ / m^3 CH_4
0.001 =	Conversion factor	tCH_4 / $kgCH_4$
21 =	Global Warming Potential factor of methane to carbon dioxide equivalent	

Equation 5-4. Adjusting the landfill gas flow for temperature and pressure.

If the landfill gas flow metering equipment does not internally correct for the temperature and pressure of the landfill gas, separate pressure and temperature measurements must be used to correct the flow measurement. The temperature and pressure of the landfill gas must be measured continuously.

Important: Apply the following equation only if the landfill gas flow metering equipment does not internally correct for temperature and pressure.

$$LFG_s = LFG_{unadjusted} * \frac{273.15}{T} * \frac{P}{1}$$

Where,

		Units
LFG =	adjusted volume of landfill gas collected for the given time interval, measured at 0°C (273.15 K) and 1 atm	m^3_s
$LFG_{unadjusted}$ =	unadjusted volume of landfill gas collected for the given time interval	m^3
T =	measured temperature of the landfill gas for the given time period (K = °C + 273.15)	K
P =	measured pressure of the landfill gas in for the given time interval	atm

Box 1. Applying the pre-project adjustment

This adjustment was designed to help differentiate system upgrades from truly new and additional projects, while encouraging project developers to use their landfill gas beneficially. In short, this methodology assumes that any gas which *could* have been destroyed in the pre-project qualifying device is not additional; diversion of that gas to a new destruction device represents an upgrade. Therefore, this term deducts from calculated project reductions that portion of gas which, in the absence of the new destruction device still could have been destroyed.

Example:

An active flare with a capacity of 30 m^3/min was installed at a landfill in 2007. Therefore, because this flare was operational before August 15, 2008, the landfill gas control system is ineligible as a project under this protocol. However, in 2009, an electric generator with a 60 m^3/min capacity was installed, and all landfill gas was diverted to this device. The addition of the electric generator meets the eligibility requirements of this protocol, and therefore qualifies as a new project (Figure 2.1). Because the pre-project flare is a qualifying destruction device under this protocol and is not eligible as a project due to other eligibility criteria (i.e. operational date), it must be accounted for using the pre-project adjustment.

In 2009, 25 m^3/min sent to generator, and 0 m^3/min was sent to the flare. In the year 2010, due to landfill expansion and installation of additional wells, the generator destroyed 40 m^3/min while the flare was non-operational. In 2011, further well expansion allowed the generator to operate at full capacity and the flare was used to destroy an additional 10 m^3/min of landfill gas.

Calculations:

Year	Generator Destruction (m^3/min)	Flare Capacity (m^3/min)	Flare Destruction (m^3/min)	Deduction (m^3/min)	Project Reductions (m^3/min)
2009	25	30	0	30	-5 (0)
2010	40	30	0	30	10
2011	60	30	10	20	40

Note: this example and the calculations are significantly simplified for illustrative purposes. The example values are calculated on a cubic meter per minute of landfill gas basis. Reporters are actually required to report the cumulative value of methane gas sent to the destruction device for each time interval t.

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verifiers to confirm that the stipulations of Sections 6 and 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping occurs. The Monitoring Plan does not require ISO or any other certification, but must cover all aspects of monitoring and reporting contained in this protocol. Further, the Monitoring Plan must provide a mechanism by which to annually evaluate and attest to the status of the regulatory test. At a minimum the Monitoring Plan must include a written account of the frequency of data acquisition, the record keeping plan (see Section 7.2 for minimum record keeping requirements), the frequency of instrument calibration activities and the role of the individual performing each specific monitoring activity. The Monitoring Plan shall also include QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision.

Project developers are responsible for monitoring the performance of the project and operating the landfill gas collection and destruction system in a manner consistent with the manufacturer's recommendations for each component of the system. Methane emission reductions from landfill gas capture and control systems must be monitored with measurement equipment that directly meters:

- the total rate landfill gas flow, measured and recorded continuously (i.e., every 15 minutes) or totalized and recorded at least daily, adjusted for temperature and pressure, prior to delivery to the destruction device(s)
- the fraction of methane in the landfill gas measured with a continuous analyzer or, alternatively, with daily or weekly measurements using a calibrated portable gas analyzer
- the rate of landfill gas flow, measured and recorded continuously (i.e., every 15 minutes) or totalized and recorded at least daily, adjusted for temperature and pressure, that is delivered to each destruction device, and
- the rate of landfill gas flow, temperature, pressure and methane concentration prior to injection into the natural gas transmission and distribution system or distributed as CNG or LNG for use in vehicles

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 (by volume) collected from the landfill on a periodic basis as specified by the operator.

The continuous methane analyzer should be the preferred option for monitoring methane concentrations, as the methane content of landfill gas captured can vary by more than 20% during a single day due to gas capture network conditions (dilution with air at wellheads, leakage on pipes, etc.). [23, 24] When using the alternative approach of weekly methane concentration measurement using a calibrated portable gas analyzer, project developers must

[23] Methane fraction of the landfill gas to be measured on a wet/dry basis (must be measured on same basis as flow, temperature, and pressure). 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, $0^{o}C$ and 1 atm.

[24] Consolidated baseline methodology for landfill gas project activities, Clean Development Mechanism, Version 07, Sectoral Scope 13 (2007).

account for the uncertainty associated with these measurements by applying a 10% discount factor to the total quantity of methane collected and destroyed.

Figure 6.1 represents the suggested arrangement of the landfill gas flow meters and methane concentration metering equipment.

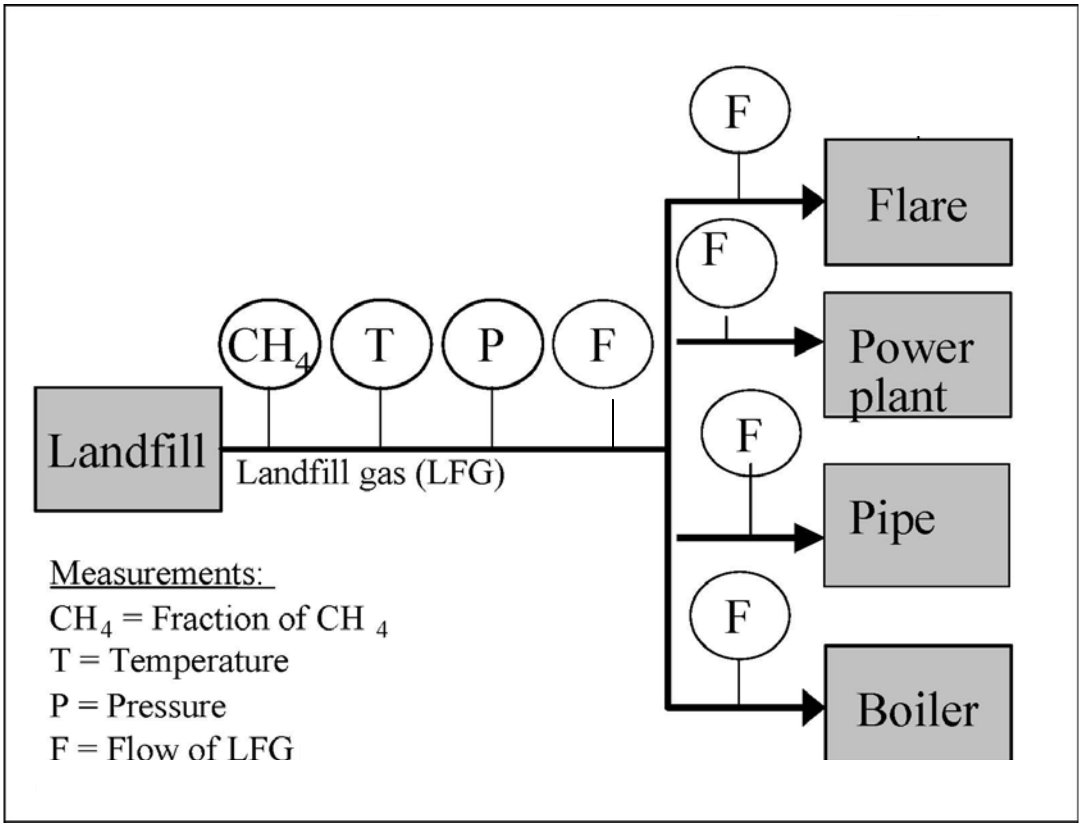

Figure 6.1. Suggested arrangement of LFG metering equipment.

Note: The number of flow meters must be sufficient to track the total flow as well as the flow to each destruction device. The above scenario includes one more flow meter than would be necessary to achieve this objective

Source: Consolidated baseline methodology for landfill gas project activities, Clean Development Mechanism, Version 07, Sectoral Scope 13 (2007).

Qualifying projects may use monthly methane concentration measurements using a calibrated portable gas analyzer until January 1, 2010, after which a continuous methane analyzer or weekly measurement using a calibrated portable gas analyzer is required. In the case where monthly methane concentration measurements are used, project developers must account for the uncertainty associated with these measurements by applying a 20% discount factor to the total quantity of methane collected and destroyed.

The hourly operational activity of the landfill gas collection system and the destruction devices shall be monitored and documented to ensure actual landfill gas destruction. GHG reductions will not be accounted for during periods which the destruction device was not operational. This period is defined as the time between the flow reading preceding and following the outage.

The measurement equipment is sensitive for gas quality (humidity, particulate, etc.), so a strong QA/QC procedure for the calibration of this equipment should be built into the monitoring plan. At a minimum, monitoring instruments shall be inspected, cleaned and calibrated quarterly. All gas flow meters and continuous methane analyzers must be:

- Cleaned, inspected, and field checked on a quarterly basis, using either a portable flow velocity instrument (such as a pitot tube) or manufacturer specified guidance, and
- Calibrated by the manufacturer or a certified calibration service provider on an annual basis

If a portable calibration instrument is used, such as a pitot tube or a calibrated portable gas analyzer, the portable instrument shall be calibrated at least annually at an ISO 17025 accredited laboratory. In addition, portable gas analyzers must be field calibrated prior to each use, and cleaned, inspected and professionally serviced according to manufacturer specifications.

In situations where the flow rate or methane concentration monitoring equipment has failed a calibration test (tested to be outside of allowable 5% margin of error), or is missing data, the project developer should apply the data substitution methods provided for in Appendix C. If for any reason the destruction device monitoring equipment (for example, the thermal coupler on the flare) is inoperable, then no emission reductions can be registered for the period of inoperability.

If available, the official source tested methane destruction efficiency shall be used in Equations 5.2 and 5.2a in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for any of the destruction devices used in the project case.

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.2 (adapted from ACM0001, V.6).

Table 6.2. Monitoring data to be collected and used to estimate emission reductions.

Parameter	Description	Data unit	calculated (c) measured (m) estimated (e)	Measurement frequency	Comment
$LFG_{PR\ total}$	Total amount of Project landfill gas collected	m^3	m	Continuously	Measured continuously by a flow meter and recorded at least once every 15 minutes, or totalized and recorded at least daily. Data to be aggregated by time interval t (see Equation 5.2).
LFG_{PP2}	Post-project installation amount of landfill gas destroyed by the original collection system	m^3	m/c	Continuously	Measured continuously by a flow meter and recorded at least once every 15 minutes, or totalized and recorded at least daily. Measured for calculation of discount factor in Equation 5.3.
LFG_{PPmax}	Maximum landfill gas flow capacity of the pre-project qualifying methane destruction device	m^3	c	At beginning of first reporting cycle	Calculated based on manufacturer's and/or engineers specifications for the destruction device and blower system (standardized at sea level). The maximum capacity of the limiting component, either the destruction device or blower, shall be used.
LFG_{flare}	Amount of landfill gas flared	m^3	m	Continuously	Measured continuously by a flow meter and recorded at least once every 15 minutes, or totalized and recorded at least daily. Data to be aggregated by time interval t (see Equation 5.2) for each flare.
$LFG_{electricity}$	Amount of landfill gas destroyed in power plant	m^3	m	Continuously	Measured continuously by a flow meter and recorded at least once every 15 minutes, or totalized and recorded at least daily. Data to be aggregated by time interval t (see Equation 5.2) for each power plant.
$LFG_{thermal}$	Amount of landfill gas destroyed in boiler	m^3	m	Continuously	Measured continuously by a flow meter and recorded at least once every 15 minutes, or totalized and recorded at least daily. Data to be aggregated by time interval t (see Equation 5.2) for each boiler.
$LFG_{upgrade}$	Amount of upgraded landfill gas delivered to NG Transmission and Distribution System or CNG/LNG vehicles	m^3	m	Continuously	Measured continuously by a flow meter and recorded at least once every 15 minutes, or totalized and recorded at least daily. Data to be aggregated by time interval t (see Equation 5.2) for each system.
PR_{CH4}	Methane fraction in the landfill gas	m^3 CH_4 / m^3 LFG	m	Continuously or weekly	Measured by continuous gas analyzer or a calibrated portable gas analyzer. Data to be averaged by time interval t (see Equation 5.2) for the reporting cycle. Methane fraction of the landfill gas to be measured on wet/dry basis[25]. Measured to determine the density of methane D_{CH4}.

[25] Landfill gas flow, methane concentration, temperature, and pressure may be measured on either a wet or dry basis. However, all parameters must be measured and calculated in the *same* basis.

Parameter	Description	Data unit	calculated (c) measured (m) estimated (e)	Measurement frequency	Comment
T	Temperature of the landfill gas	°C	m	Continuously	Measured to adjust the flow of LFG. No separate monitoring of temperature is necessary when using flow meters that automatically adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized cubic meters (0°C, 1 atm).
P	Pressure of the landfill gas	atm	m	Continuously	Measured to adjust the flow of LFG. No separate monitoring of pressure is necessary when using flow meters that automatically measure adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized cubic meters (0°C, 1 atm).
t	Time interval	day or week		N/A	If methane concentration is measured continuously, t=1 day, if it is measured weekly, t=1 week.
EL_{PR}	Total amount of electricity required to meet project requirement	MWh	m	Monthly	Obtained from either onsite metering or utility purchase records. Required to determine CO_2 emissions from use of electricity to operate the project activity.
EF_{EL}	Carbon emission factor of electricity	kg CO_2/MWh	c	Annually	Use the specific emissions factors for power generation in Mexico (see section 5.3).
FF_x	Total annual quantity of supplemental natural gas delivered to destruction device	m^3/yr	m	Continuously	Metered prior to delivery to destruction device. Required to determine CH_4 emissions from incomplete destruction of supplemental natural gas at each destruction device.
FF_{PR}	Total amount of fossil fuel required to meet project requirement	m^3_s or liters	c	Monthly	Calculated from monthly record of fossil fuel purchased and consumed. Required to determine CO_2 emissions from use of fossil fuels to operate the project activity.
Regulations	Project developer attestation to compliance with regulatory requirements relating to landfill gas project	n/a	n/a	At the begining of each reporting 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 GHG reduction project. The project developer shall provide a signed attestation to their compliance status for the above mentioned federal, state and local regulations, ordinances and permit requirements.
Operation of the energy plant	Operation of the energy plant	Hours	m	Hourly	This is monitored to ensure methane destruction is claimed for methane used in electricity plant only when it is operational.
Operation of the boiler	Operation of the boiler	Hours	m	Hourly	This is monitored to ensure methane destruction is claimed for methane used in boiler only when it is operational.

Parameter	Description	Data unit	calculated (c) measured (m) estimated (e)	Measurement frequency	Comment
Operation of the flare	Operation of the flare	Hours	m	Hourly	This is monitored to ensure methane destruction is claimed for methane used in flare only when it is operational.
DE	Optional: Source test data for destruction device methane destruction efficiency	% destruction efficiency	m	Annually	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 destruction devices used in the project case. If using source test data for destruction efficiencies in Equation 5.2, all source test documentation shall be provided to the verifier.

7 Reporting Parameters

This section provides guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Net methane and carbon dioxide emission reductions within the GHG assessment boundary should be reported. Project developers must submit verified emission reduction reports to the Reserve annually.

7.1 Project Submittal Documentation

Project developers shall provide the following information to the California Registry before registering reductions associated with installing a landfill gas collection and destruction system.

- Completed project submittal form (Appendix D)
- Signed Attestation of Title document
- Complete project verification report (annually)
- Positive verification opinion document (annually)
- Signed Attestation of Regulatory Compliance (annually)

At a minimum, the above project documentation will be available to the public via the Reserve's online reporting tool. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve.

Project developers shall submit annual project reports through the Reserve. Project submittal forms and project registration information can be found at: http://www.climateactionreserve.org/how-it-works/projects/register-a-project/documents-and-forms/.

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification.

System information the project developer should retain includes:

- All data inputs for the calculation of the project emission reductions
- Copies of all solid waste, air, water, and land use permits, notices of violations, and any administrative or legal consent orders dating back at least 3 years prior to the project start date, and for each subsequent year of project operation
- Project developer attestation of compliance with regulatory requirements relating to the landfill gas project
- Collection and control device information (installation dates, equipment list, etc.)
- LFG flow meter information (model number, serial number, manufacturer's calibration procedures)
- Methane monitor information (model number, serial number, calibration procedures)
- Destruction device monitor information (model number, serial number, calibration procedures)
- LFG flow data (for each flow meter)

- LFG flow meter calibration data (for each flow meter)
- Methane monitoring data
- Methane monitor calibration data
- Destruction device monitoring data (for each destruction device)
- Destruction device monitor calibration data (for each destruction device)
- CO_2e monthly and annual tonnage calculations
- Initial and annual verification records and results
- All maintenance records relevant to the LFG control system, monitoring equipment, and destruction devices

Calibrated portable gas analyzer information that the project developer should retain includes:

- Date, time, and location of methane measurement
- Methane content of LFG (% by volume) for each measurement
- Methane measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.3 Reporting Cycle

For the purposes of this protocol, project developers report GHG reductions associated with installing a landfill gas collection and destruction system that occurred the preceding year. Although projects must be verified annually at a minimum, the Reserve will accept verified emission reduction reports on a sub-annual basis, should the project developer choose to have a sub-annual verification schedule (i.e. monthly, quarterly, etc.).

7.4 Project Crediting Period

Project developers are eligible to register GHG reductions with the Reserve according to this protocol for a period of ten years or until regulatory compliance is required due to failure of the regulatory additionality test. If an eligible project has begun operation at a landfill that later becomes subject to a regulation, ordinance or permitting condition that would call for the installation and operation of a landfill gas control system, emission reductions can be reported to the Reserve up until the date that the landfill gas control system is legally required to be operational.

The project crediting period begins when the landfill gas collection and destruction system becomes operational regardless of whether sufficient monitoring data is available to register credits.

7.5 Non-Climate Action Registry Reporting

The Reserve 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 emission reductions associated with the project activity that occur outside of the Reserve. Upon submittal of project listing documentation to the Reserve, project developers are required to provide a signed attestation to the Reserve stating that the GHG reductions being registered are not being registered elsewhere. If the Reserve determines that duplicative emission reduction registration has occurred, all duplicate reductions reported with the Reserve will be made void.

In the event that GHG reductions from the project were previously registered with or claimed by another registry or program, or sold to a third party prior to submitting the project to the Reserve, a Project Transfer Form must be completed and submitted to the Reserve along with other project listing documentation.

Glossary of Terms

Accredited verifier	A verification firm approved by the California Registry to provide verification services for project developers.
Additionality	Landfill management practices that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic Emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 Emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Bioreactor	A MSW landfill or portion of a MSW landfill with a minimum average moisture content of at least 40 percent by weight that is re-circulating leachate or a MSW landfill or portion of a MSW landfill that is adding any liquid other than leachate (leachate includes landfill gas condensate) in a controlled fashion to accelerate or enhance the anaerobic biodegradation of the waste.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
Clean Development Mechanism (CDM)	One of the three flexible mechanisms established by the Kyoto Protocol. CDM is the market instrument in which certified emissions reductions can be achieved from a project developed in a “non-Annex I” country (developing country) with the assistance of an “Annex I” country (industrialized country). These reductions are accrued to the reduction commitment of the “Annex I” party (Art. 12 of the Kyoto Protocol) in the Kyoto Protocol’s first commitment period (2008-2012).
CO_2 Equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct Emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Emission factor (EF)	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. metric tonnes of carbon dioxide emitted per barrel of fossil fuel burned).
Emission Guidelines (EG)	Guidelines for State regulatory plans that have been developed by the U.S. EPA. For landfills, emission guidelines are codified in 40 CFR 60 Subpart Cc.
Flare	A destruction device that uses an open flame to burn combustible gases with combustion air provided by uncontrolled ambient air around the flame.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).

Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect Emissions	Emissions that are a consequence of the actions of a reporting entity, but are produced by sources owned or controlled by another entity.
Landfill	A defined area of land or excavation that receives or has previously received waste that may include household waste, commercial solid waste, non-hazardous sludge and industrial solid waste.
Landfill Gas (LFG)	Gas resulting from the decomposition of wastes placed in a landfill. Typically, landfill gas contains methane, carbon dioxide and other trace organic and inert gases.
Landfill Gas Project	Installation of infrastructure that in operating causes a decrease in GHG emissions through destruction of the methane component of landfill gas.
Liquefied Petroleum Gas (LPG)	Fuel obtained from oil distillation and after processing the natural gas liquids. It mainly consists on propane, butane or a mixture of both.
Metric tonne (MT) or "tonne"	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
Mexican Official Standard NOM-083-SEMARNAT-2003	Official Standard that provides specifications for environmental protection for the site selection, design, construction, monitoring, closure and complementary works for a final disposal site of urban solid waste and of special management.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
Nitrous oxide (N_2O)	A GHG consisting of two nitrogen atoms and a single oxygen atom.
Project Baseline	A business-as-usual GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project Developer	An entity that undertakes a project activity, as identified in the Landfill Project Protocol. A project developer may be an independent third party or the landfill operating entity.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
Verification	The process used to ensure that a given participant's greenhouse gas emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve accredited firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.

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Appendix A Development of the Performance Standard Threshold

A.1. Analysis of the Common Practice – Performance Standard

This analysis is based on available data in websites of Mexican institutions, such as the National Institute of Ecology (INE), the National Institute of Statistics and Geography (INEGI), and data provided by the Ministry of Social Development (SEDESOL).

Two types of best practices are presented to define the Performance Standard Threshold: first, the use of landfills as a final solid waste disposal technology instead of other technologies, such as open dumps or controlled sites; and second, the use of LFG recollection and destruction systems instead of the passing venting in landfills.

Use of Landfills

Definitions of the different types of final solid waste disposal methods in Mexico, according to the current legislation, are illustrated in Table A.1 and Table A.2. These tables depict the evolution of the use of the different types of disposal based on the quantity of disposed waste.

Table A.1 Definitions of the Mexican Official Standard NOM-083-SEMARNAT-2003

NOM 83	Definitions
Final Disposal Site	Site where municipal solid waste are disposed in a definitive manner.
Non-controlled site	Inadequate waste disposal site that does not comply with the requirements established in the NOM 083
Controlled site	Inadequate waste disposal site that comply with the landfill specifications regarding infrastructure and operation, but do not comply with the impermeable cover material requirements
Landfill	Infrastructure that involves methods and engineering works for the final disposal of urban solid waste and of special management in order to control environmental impacts
Venting	Controlled outflow of landfill gases produced by the anaerobic decomposition of organic fractions in the municipal solid waste

Source: SEMARNAT. Normas Oficiales Mexicanas Vigentes.
http://www.semarnat.gob.mx/leyesynormas/Normas%20Oficiales%20Mexicanas%20vigentes/NOM-083-SEMAR-03-20-OCT-04.pdf

In the last 10 years, the final disposal of solid waste in Mexico has evolved. In 1996, non-controlled sites and open dumps received around 64% of the waste, but in 2006 this percentage had diminished by half. Non-controlled sites are being closed and their use has decreased. On the other side, the construction of landfills is spreading, and the existing ones are receiving more waste. According to data in Table A.2, it can be concluded that landfills are the common practice for final solid waste disposal sites in Mexico, with a 57% penetration with regard to all of the waste disposed in 2006. Landfills, when operated technically and correctly, generate less environmental impacts and are better practices than open dumps and controlled sites for the disposal of solid waste.

Table A.2 Evolution of Final Solid Waste Disposal Sites in Mexico

Final waste disposal sites in Mexico	Disposed waste in 1996 (tonnes/year)	Percentage 1996	Disponed waste in 2006 (tonnes/year)	Percentage 2006
Landfills	8,573,000	28%	19,772,100	57%
Controlled sites	2,606,000	8%	3,763,500	11%
Non-controlled sites	20,027,200	64%	11,423,400	32%
Total	31,206,200	100%	34,959,000	100%

Source: INEGI, 2009. Sistema Nacional de Información Estadística y Geográfica. Residuos. http://www.inegi.org.mx/inegi/default.aspx?s=est&c=6116 (March 2009)

Use of LFG recollection and destruction systems

Table A.3 illustrates the waste disposal by type of final disposal site in 2008 and the common practices of LFG management.

Table A.3 Waste disposal and LFG Management Practices (2008)

Final waste disposal sites	Number	Disposed waste (tonnes/year)	Percentage[1]	LFG collection and destruction practices[2]
Landfills	128	21,822,600	60%	Passive venting
Controlled sites	26	3,545,600	10%	Passive venting
Non-controlled sites	Not available	10,880,000	30%	Not existing
Total	154	33,707,000	100%	

Sources: SEDESOL, Dirección General de Equipamiento e Infraestructura en Zonas Urbano-Marginadas (Statistics for 2008).
Notes:
[1] Percentage related to the total disposed waste quantity
[2] Common practice: There are no specific data available for each disposal site.

In Mexico, there are not inventories related to the operation of each landfill that include specific data regarding the current status of their existing venting systems (wells) and/or passive or spontaneous flaring systems. Available studies conducted by SEDESOL contain the disposed waste quantity, the daily generation and composition in the urban centers of the country.

As mentioned in section 3.3.2.1, the NOM-083-2003 includes general specifications for LFG control in waste disposal sites in order to avoid LFG venting to the atmosphere through its flaring in punctual wells or through centralized burners. Nevertheless, the standard does not establish the minimum quantity of LFG that should be collected and burnt, nor the specific technologies to be used. In practice, municipalities and landfill operators have not adopted or exceeded the NOM 083 due to the multiple reasons provided in section 3.3.2.1, and as a result the LFG is vented in landfills and controlled sites.

This analysis reveals that passive venting is the common practice for LFG management. However, this does not constitute a GHG emissions reduction measure as CH_4 is directly released to the atmosphere. Hence, there are no LFG collection and destruction systems in final disposal sites in Mexico in the reference scenario. A project that implements a LFG collection and destruction system will pass the Performance Threshold.

A.2. Analysis of the impact of Clean Development Mechanism (CDM) projects in the common practices – Performance Standard after the entry into force of the Kyoto Protocol

The impact of landfill gas projects was calculated using information provided by INE related to the national GHG inventory from the waste sector. In 2004, the penetration level of LFG collection and destruction projects prior to the entry into force of the Kyoto Protocol was 0.5% regarding the total emissions and 0.7% with regard to the landfill emissions only. This percentage was constituted by the first LFG collection and destruction project developed by Simeprodeso in the Monterrey landfill at the State of Nuevo León, started in 2003. This project had a demonstrative character for promoting the development of CDM projects, and had financial support from the World Bank, the Global Environmental Fund (GEF), SEDESOL and the National Bank for infrastructure and public utilities (BANOBRAS).

As of March 2009, only 5 years later, 11 CDM landfill projects have been registered in the CDM Executive Board. The penetration related to the GHG reductions of these projects was estimated as of 2.5% of the total emissions of this sector (see Tables A.4 and A.5).

Table A.4 Summary of CDM landfill projects in Mexico (2009)

CDM Project type	Number of landfills	Percentage (by number of landfills)	GHG emissions reductions (tonnes CO_2e/year)	Percentage (by emissions)
Only active flaring	3	27%	312,195	25%
Active flaring and power generation[1]	4	33%	344,810	22%
Active flaring and energy	4	33%	742,910	53%
Total	11	100%	1,399,945	100%
Estimated market penetration of LFG collection and destruction projects implemented through CDM[2]			**2.5%**	

Sources: UNFCCC, 2009. CDM Project Search. http://cdm.unfccc.int/Projects/projsearch.html (March 2009); INE, 2005. Escenarios de Emisiones y Medidas de Mitigación de Gases de Efecto Invernadero en Sectores Clave – Sector Desechos http://www.ine.gob.mx/cclimatico/descargas/e2005a2.pdf (March 2009)

Notes:
[1] The second stage (power generation) will only be conducted if power purchase agreements are agreed, according to the Project Design Documents (PDDs).
[2] Reference emissions for this estimation were those reported by INE for 2004 (base year). Emissions from the Monterrey project were deducted; this project was registered at the CDM Executive Board on February 2009.

Table A.5 Details of registered CDM projects related to LFG Collection and Destruction (2009)

CDM EB Registration date	Project ID	Location	LFG final use	tCO_2e/ year
July 15, 2006	0425	Aguascalientes, Aguascalientes	Active flaring and power generation*	162,593
October 2, 2006	0523	Ecatepec de Morelos, Estado de Mexico	Active flaring and energy	209,353
October 5, 2007	1240	Zapopan, Jalisco	Active flaring and energy	137,735
November 30, 2007	1241	Tultitlán – Estado de Mexico	Active flaring and power generation*	41,681
November 30, 2007	1123	Ciudad Juárez, Chihuahua	Active flaring and energy	170,499
January 31, 2008	1371	Mérida, Yucatán	Active flaring	106,340
February 25, 2008	1307	Durango, Baja California	Active flaring and power generation*	83,340
Under review	1699	Puerto Vallarta, Jalisco	Active flaring	52,267
November 6, 2008	1944	Milpillas, Estado de Morelos	Active flaring	153,588
February 12, 2009	2186	Monterrey, Nuevo Leon	Active flaring and energy	225,323
March 21, 2009	2271	Tecamac, Estado de Mexico	Active flaring and power generatioin*	57,196

Source: UNFCCC, 2009. CDM Project Search. http://cdm.unfccc.int/Projects/projsearch.html (March 2009)

*Note: The second stage (energy use) will only be conducted if power purchase agreements are agreed, according to the Project Design Documents (PDDs).

Appendix B Fuel Emission factors for Mexico

Table B.1 Fuel emission Factor for Stationary and Mobile Combustion

Fuel	**Emission Factors [kg CO_2/GJ]**
Stationary Combustion [a]	
Crude oil	73.30
Natural gas liquids	64.20
Gasoline	69.30
Kerosene	71.90
Diesel	74.10
Residual fuel oil	77.40
Liquefied Petroleum Gas (LPG)	63.10
Naphtha	73.30
Lubricants	73.30
Petroleum coke	97.50
Coking coal	94.60
Bituminous coal	94.60
Sub-bituminous coal	96.10
Natural gas	56.10
Waste oils	73.30
Mobile combustion [b]	
Gasoline passenger car (without catalyst – Before 1990)	58.07
Gasoline passenger car (with oxidation 2-way catalyst – 1991-1992)	66.82
Gasoline passenger car (with used 3-way catalyst – open or closed cycle – 1993 – 1997)	70.07
Gasoline passenger car (with new 3-way closed cycle catalyst – After 1998)	71.07
Gasoline light duty trucks (without catalyst – Before 1990)	57.07
Gasoline light duty trucks (with improved technology, without catalyst – 1991-1992)	60.82
Gasoline light duty trucks (with used 3-way catalyst – open or closed cycle – 1993-1997)	68.97
Gasoline light duty trucks (with new 3-way catalyst – After 1998)	70.52
Gasoline heavy duty trucks and buses (without catalyst – Before 1992)	55.56
Gasoline heavy duty trucks and buses (with catalyst – After 1993)	60.87
Diesel vehicles (passenger cars, light and heavy trucks – with or without emissions control)	72.10
LPG vehicles (passenger cars and heavy trucks – without control and with 3-way catalyst)	61.23
Natural gas vehicles (passenger cars and heavy trucks – with 3-way catalyst)	56.10
Motorcycles (with or without emissions control)	72.10
Compressed natural gas vehicles (CNG) [c]	56.10
Liquefied natural gas vehicles (LNG) [c]	56.10
Airplanes (jetfuel) [c]	71.90

[a.] IPCC, 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*, Volumen 2, Chapter 2, Stationary Combustion, Table 2.5, pages 2.22-2.23.

[b] INE, 2005. Inventario Nacional de Emisiones de Gases de Efecto Invernadero 2002, Sector Transporte. INE-SEMARNAT, México. (Annexes, Tables 4-12, pages IA3-95 – IA3-99). Available on line: http://www.ine.gob.mx/cclimatico/inventario3.html

[c.] IPCC, 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*, Volumen 2, Chapter 3, Mobile combustion, Table 3.2.1, pages 3.16.

Table B.2 Fossil fuels net calorific values

Fuel	**Net calorific value**
Solid fuels	
National thermal coal	19.405 GJ/metric tonne
National metallurgic coal	23.483 GJ/metric tonne
Petroleum coke	31.424 GJ/metric tonne
Coking coal	26.521 GJ/metric tonne
Liquid fuels [a]	
Crude oil	0.03871 GJ/liter
Gasoline	0.03161 GJ/liter
Kerosene	0.03381 GJ/liter
Diesel	0.03555 GJ/liter
Residual fuel oil	0.03944 GJ/liter
Liquefied Petroleum Gas (LPG) [b]	0.02627 GJ/liter
Naphtha	0.03161 GJ/liter
Lubricants	0.03888 GJ/liter
Gaseous fuels	
Natural gas [c]	0.03391 GJ/m^3

[a] 1 barrel = 158.9873 liters
[b] Fuel obtained from oil distillation and after processing the natural gas liquids. It mainly consists on propane, butane or a mixture of both. It is mainly used in the residential and commercial sectors as well as in vehicles for passenger and freight transportation.

Sources:
SENER, 2006. *Balance Nacional de Energía 2007*, Dirección General de Información y Estudios Energéticos, SENER, México. Box 21, page 100. Available at:
http://www.energia.gob.mx/webSener/res/PE_y_DT/pub/Balance_2007.pdf (March 2009)

Appendix C Data Substitution and Failed Calibration

This appendix provides guidance on calculating emission reductions when data integrity has been compromised either due to missing data points or a failed calibration. No data substitution is permissible for equipment such as thermocouples which monitor the proper functioning of destruction devices. Rather, the methodologies presented below are to be used only for the methane concentration and flow metering parameters.

Failed Calibration
If any device fails a calibration test (i.e., tested to be outside of the allowable 5% margin of error), the following guidance must be followed. These adjustments must be made for the entire period from the last successful calibration until such time as the meter is properly calibrated.

1. For calibrations that indicate underreporting (lower flow rates, or lower methane concentration):
    a. the metered values must be used without correction.

2. For calibrations that indicate over-reporting (higher flow rates, or higher methane concentration):
    a. the metered values must be adjusted based on the greatest calibration drift recorded at the time of calibration.

Missing Data
The Reserve expects that projects will have continuous, uninterrupted data for the entire verification period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously. If data is missing for both parameters, no reductions can be credited.

Further, substitution may only occur when two other monitored parameters corroborate proper functioning of the destruction device and system operation within normal ranges. These two parameters must be demonstrated as follows:

1. Proper functioning can be evidenced by thermocouple readings for flares, energy output for engines, etc.
2. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
3. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology maybe applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours immediately before and following the outage
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness.
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness.
Greater than one week	No data may be substituted and no credits may be generated

The lower confidence limit should be used for both methane concentration and flow readings for landfill projects, as this will provide the greatest conservativeness.