E-18. Establish Methane Recovery in Landfills

GHG Mitigation Potential

Varies

Variable reduction in GHG emissions from landfill waste decomposition depending on the capture program and system size

Co-Benefits (icon key on pg. 34)

Climate Resilience

Establishing CH_4 recovery provides backup fuels if extreme weather events disrupt main sources of fuel.

Health and Equity Considerations

Combustion of CH_4 may increase local air pollution. Potential effects of combustion emissions on adjacent sensitive receptors needs to be evaluated during project design.

Measure Description

This measure involves the capture and treatment of landfill gas (LFG) emitted from decomposition of organic waste in landfills. Landfill gas contains about 50 percent CH_4 by volume, which has a GWP 25 times that of CO_2. This measure addresses emissions savings from LFG that is captured and either flared or combusted for energy. Flaring LFG will reduce the amount of CH_4 emitted into the atmosphere. Combusting LFG to generate electricity for onsite energy needs reduces GHG emissions in two ways: it reduces direct CH_4 emissions, and it displaces electricity demand and the associated indirect GHG emissions from electricity production. Municipal solid waste management teams should calculate the GHG savings from both flaring and combustion for energy recovery to see the relative benefits for each option.

Subsector

Methane Recovery

Scale of Application

Project/Site

Implementation Requirements

See measure description.

Cost Considerations

Landfills that have no current system for capturing CH_4 would face high installation costs for a CH_4 recovery system. Costs would be much lower for landfills that already have a system for trapping or cleaning captured gases. In California, CH_4 reclaimed from waste could represent a large additional revenue stream for landfills if the gases are managed and sold as offsets or RECs on the Low Carbon Fuel Standard or U.S. Renewable Fuel Standards markets.

Expanded Mitigation Options

Additional reductions may be achieved if the LFG is used as a transportation fuel or injected into a regional natural gas pipeline for downstream uses. Quantitative methods for these alternatives are not specifically addressed by this measure.

GHG Reduction Formula

$A1 = [(\mathbf{G} \times O \times L) + (\mathbf{G} \times P \times M)] \times Q$

$B = \mathbf{G} \times N$

$A2 = B \times R \times S \times T$

$A3 = A1 + A2$

$C = [\mathbf{D} \times [\mathbf{E} \times I \times J \times \mathbf{F} \times K] \times (1 - H)] \times L$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A1	Emissions from LFG flaring or combustion	[ ]	MT CO_2e	calculated
B	Energy savings from flaring or combustion of LFG for energy	[ ]	MMBtu	calculated
A2	Additional emissions from LFG combustion if energy is generated	[ ]	MT CO_2e	calculated
A3	Total emissions from LFG use (flaring and energy use)	[ ]	MT CO_2e	calculated
C	CH_4 generation potential emissions	[ ]	MT CO_2e	calculated
User Inputs				
D	Municipal Solid Waste affected by measure	[ ]	tons	user input
E	CH_4 correction factor	0.6–1	unitless	IPCC 2007
F	Fraction of CH_4 in landfill gas	0.4–0.6	unitless	IPCC 2007
G	LFG flared of combusted for energy	[ ]	standard cubic foot (scf)	U.S. EPA 2018
Constants, Assumptions, and Available Defaults				
H	Oxidation rate	0.10	percent	IPCC 2007
I	Dissolved organic carbon (DOC)	19.8%	percent	CalRecycle 2014
J	Fraction of DOC that is ultimately degraded	0.6	unitless	IPCC 2007
K	Stoichiometric ratio between CH_4 and carbon	16/12	g of CH_4 per g of C	conversion
L	GWP of CH_4	25	unitless	IPCC 2007
M	GWP of N_2O	298	unitless	IPCC 2007
N	Heating value of LFG	0.000485	MMBtu per scf	U.S. EPA 2018

ID	Variable	Value	Unit	Source
O	CH_4 emission factor for LFG combustion	0.001552	g CH_4 per scf	U.S. EPA 2018
P	N_2O emission factor for LFG combustion	0.000306	g N_2O per scf	U.S. EPA 2018
Q	Conversion from g to MT	10^{-6}	MT per g	conversion
R	MWh to MMBTU	3.412142	MWh per MMBtu	conversion
S	Carbon intensity of local electricity provider	Table E-4.3 and E-4.4	lb CO_2e per MWh	CA Utilities 2021
T	Conversion from lb to MT	0.000454	MT per lb	conversion

Further explanation of key variables:

- (E) – The CH_4 correction factor accounts for CH_4 generation from managed or unmanaged landfills. For example, unmanaged landfills produce less CH_4 from a given amount of waste than managed landfills because a larger fraction of waste decomposes aerobically in the top layers of a landfill.
  - Managed = 1.0
  - Unmanaged (≥5 meter (m) deep) = 0.8
  - Unmanaged (<5 m deep) = 0.4
  - Uncategorized = 0.6
- (C) – The generation potential follows the IPCC 2007 "good practices" guidelines for estimating CH_4 emissions for a landfill that does not have LFG capture technology.
- (F) – The fraction of CH_4 in landfill gas is based on the organic matter content of the landfill. This fraction can range from 0.4 to 0.6, but the default is usually taken as 0.5.
- (I) – CalRecycle published a 2016 study on the composition of California's overall disposed waste stream. From this study, an average California DOC was calculated to determine organic content of waste in landfills.
- (D) – This input is the amount of waste that the user will know will have some amount of LFG capture technology.

GHG Calculation Caps or Maximums

None.

Example GHG Reduction Quantification

In this example, a user decides to implement an LFG capture program and use the LFG to produce energy to offset utility electricity usage. The landfill contains 1,000 short tons of waste, is managed and has 0.5 fraction of CH_4 in the LFG with a 75 percent collection efficiency. Twenty million scf LFG was combusted. The project is in Redding Electric Utility's service territory and would begin operation by 2024. It would therefore have an electricity carbon intensity of 341 lb CO_2e per MWh (S). This example scenario results in a total net GHG reduction (A3) of 5,126.6 MT CO_2e.

$$A1 = \left[\left(\mathbf{20{,}000{,}000\ scf} \times 0.001552\frac{g\ CH_4}{scf} \times 25\right) + \left(\mathbf{20{,}000{,}000\ scf} \times 0.000306\frac{g\ N_2O}{scf} \times 298\right)\right] \times 10^{-6} = 2.6\ MT\ CO_2e$$

$$B = \mathbf{20{,}000{,}000\ scf} \times 0.000485\frac{MMBtu}{scf} = 9{,}700\ MMBtu$$

$$A2 = 9{,}700\ MMBtu \times 3.412142\frac{MWh}{MMBtu} \times 341\frac{lb}{MWh} \times 0.000454\frac{MT}{lb} = 5{,}124\ MT\ CO_2e$$

$$A3 = 2.6\ MT\ CO_2e + 5{,}124\ MT\ CO_2e = 5{,}126.6\ MT\ CO_2e$$

$$C = \left[\mathbf{1{,}000\ tons} \times \left[1 \times 19.8\% \times 0.6 \times \mathbf{0.5} \times \frac{16}{12}\ \frac{g\ CH_4}{g\ C}\right] \times (1 - 0.1)\right] \times 25 = 1{,}782\ MTCO_2e$$

Quantified Co-Benefits

Energy and Fuel Savings

Energy savings from flaring or combustion of LFG for energy are calculated above as (B).

Sources

- CalRecycle 2014. *2014 Disposal-Facility-Based Characterization of Solid Waste in California.* November 4, 2015. Available: https://www2.calrecycle.ca.gov/Publications/Details/1546. Accessed: January 2021.
- Environmental Protection Agency (U.S. EPA). 2018. *Center for Corporate Climate Leadership. Emission Factors for Greenhouse Gas Inventories.* March 9. Available: https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf. Accessed: January 2021.
- California Utilities. 2021. Excel database of GHG emission factors for delivered electricity, provided to the Sacramento Metropolitan Air Quality Management District and ICF. January through March 2021.
- Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. Available: https://www.ipcc.ch/report/ar4/wg1/. Accessed: January 2021.