E-19. Establish Methane Recovery in Wastewater Treatment Plants

GHG Mitigation Potential

Large

Potentially large reduction in GHG emissions from plant operations

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 air pollution. Potential effects of combustion emissions on adjacent sensitive receptors needs to be evaluated during project design.

Measure Description

This measure requires capturing CH_4 from an existing wastewater treatment plant and either (1) combusting or flaring it to prevent escape into the atmosphere or (2) combusting or flaring it and using the heat to generate electricity for onsite energy needs. Using the combusted CH_4 as an energy source reduces GHG emissions by displacing electricity demand and the associated indirect GHG emissions from electricity production. This measure is most applicable to wastewater treatment plants that have anaerobic digestion infrastructure, which facilitates the biological decomposition of the wastewater and produces the CH_4 that is either flared or harnessed for energy.

Subsector

Methane Recovery

Scale of Application

Project/Site

Implementation Requirements

See measure description. Also, this measure may not be appropriate for wastewater treatment plants that use lagoons to process wastewater.

Cost Considerations

Wastewater treatment plants that have no current system for capturing CH_4 would face high installation costs for a CH_4 recovery system. Costs would be lower for plants that already have a system for trapping or cleaning captured gases. In California, CH_4 reclaimed from wastewater treatment could represent a large additional revenue stream for the plants 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 CH_4 is processed and used as a transportation fuel or injected into a regional natural gas pipeline for downstream uses. Captured waste biogas may also be used to support the production of biodegradable biopolymers, which serve as natural alternatives to conventional plastics.

GHG Reduction Formula

$A1 = C \times [D - (E \times F \times G \times H \times (1 - I) \times J \times K \times L)]$ (Emissions Reduction)

$B = (C \times E \times F \times G \times M \times N \times O)$ (Energy Savings, if applicable)

$A2 = B \times P \times Q \times R$ (Additional Emissions Reduction, if applicable)

$A3 = A1 + A2$ (Total Net Emissions Reduction)

$A4 = \frac{A3}{C \times D}$ (% Reduction)

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A1	Emissions reduction from CH_4 flaring or combustion	[ ]	MT CO_2e	calculated
B	Energy savings from CH_4 capture, combustion and energy generation	[ ]	kWh	calculated
A2	Additional emissions reduction if energy is generated	[ ]	MT CO_2e	calculated
A3	Total net emissions reduction	[ ]	MT CO_2e	calculated
A4	Percent reduction in GHG emissions from wastewater	0-100	%	calculated
User Inputs				
C	Wastewater affected by measure	[ ]	liters	user input
Constants, Assumptions, and Available Defaults				
D	Wastewater emission factor	2.85×10^{-6} or 1.93×10^{-6}	MT CO_2 per liter gal per liter	U.S. EPA 2020
E	Conversion from liters to gal	0.26417	sf per gal	conversion
F	Digester gas	0.01	unitless	U.S. EPA 2020
G	Fraction CH_4	0.65	%	U.S. EPA 2020
H	Density of CH_4	662	g CH_4 per m^3 CH_4	U.S. EPA 2020
I	Destruction efficiency	0.99	unitless	U.S. EPA 2020
J	Conversion from ft^3 to m	0.02832	m^3 per ft^3	conversion
K	Conversion from g to MT	$1e^{-6}$	g per MT	conversion
L	GWP of CH_4	25	unitless	IPCC 2007
M	Heating value of CH_4	1,028	BTU per ft^3 CH_4	ICLEI 2013
N	Conversion from kWh to BTU	0.000293	kWh per BTU	conversion
O	Efficiency factor	0.85	unitless	assumption
P	Conversion from kWh to MWh	0.001	MWh per kWh	conversion

ID	Variable	Value	Unit	Source
Q	Carbon intensity of local electricity provider	Tables E-4.3 and E-4.4	lb CO_2e per MWh	CA Utilities 2021
R	Conversion from lb to MT	0.000454	MT per lb	conversion

Further explanation of key variables:

- (A1) – The emissions calculated for this variable represent the emissions reduction that is achieved from the combustion of CH_4. Combusting the CH_4 prevents it from entering the atmosphere; however, during the combustion process, some fraction of CH_4 is not fully combusted and can leak into the atmosphere. The formula for this variable accounts for the fraction that is not fully combusted.
- (B) – This variable represents the energy savings that result from the combustion of CH_4 and then using the heat produced to generate energy. If CH_4 will only be combusted or flared but not used for energy, then there would not be energy savings for this measure. The user should set this variable to zero if there will be no energy generation.
- (A2) – The emissions reductions calculated for this variable represent the emissions that are offset from the generation of energy from the captured CH_4 instead of from typical fossil fuel sources. Combusting the CH_4 avoids the need for fossil fuel sources of energy that would have been generated in the absence of this measure.
- (A3) – The net emissions reductions achieved by this measure are calculated in this variable.
- (D) – The factors represent the emissions per liter of wastewater that is treated at facilities with either primary treatment or without primary treatment. These values are as follows.
  - Primary treatment factor: 1.93 x 10-6
  - Without primary treatment factor: 2.85 x 10^{-6}
- (E) – The digester gas variable represents the amount of digester gas that is generated per gal of wastewater. The value given here is determined by assumptions from the U.S. EPA's GHG inventory, with the amount of digester gas generated per person per day is 1 cubic foot and the amount of wastewater generated per person per day is 100 gallons (gal) (for publicly owned treatment works). Dividing these values (1/100) is equal to 0.01 cubic feet of digester gas per gal of wastewater.

GHG Calculation Caps or Maximums

None.

Example GHG Reduction Quantification

The user implements CH_4 capture and energy generation infrastructure at an existing wastewater treatment plant that processes 100 million liters of wastewater per year. The existing plant currently has primary treatment. The project is in the Silicon Valley Power's service territory, and the selected electricity provider emission factor is for the year 2026 (224 lb CO_2e per MWh) (Q). The example measure emission reduction is calculated below.

$$B = \left(100 \times 10^6 \text{ liters} \times \frac{0.26417 \text{ gal}}{\text{liter}} \times 0.01 \frac{\text{ft}^3}{\text{gal}} \times 0.65 \times \frac{1{,}028 \text{ BTU}}{\text{ft}^3 \text{ CH4}} \times \frac{0.000293 \text{ kWh}}{\text{BTU}} \times 0.85\right) = 43{,}962 \text{ kWh}$$

$$A1 = 100 \times 10^6 \text{ liters} \times \left[1.93 \times 10^{-6} \frac{\text{MT CH}_4}{\text{liter}} - \left(\frac{0.26417 \text{ gal}}{\text{liter}} \times 0.01 \frac{\text{ft}^3}{\text{gal}} \times 0.65 \times 662 \frac{\text{g CH}_4}{\text{m}^3 \text{ CH}_4} \times (1 - 0.99) \times \frac{0.02832 \text{ m}^3}{\text{ft}^3} \times \frac{10^{-6} \text{ MT}}{\text{g}} \times 25\right)\right] = 192 \text{ MT CO}_2\text{e}$$

$$A2 = 43{,}962 \text{ kWh} \times 0.001 \frac{\text{MWh}}{\text{kWh}} \times 224 \times 0.000454 \frac{\text{MT}}{\text{lb}} = 4 \text{ MT CO}_2\text{e}$$

$$A3 = 192 \text{ MT CO}_2\text{e} + 4 \text{ MT CO}_2\text{e} = 196 \text{ MT CO}_2\text{e}$$

$$A4 = \frac{196 \text{ MT CO}_2\text{e}}{100 \times 10^6 \text{ liters} \times 1.93 \times 10^{-6} \frac{\text{MT CO}_2\text{e}}{\text{liter}}} = 102\%$$

Quantified Co-Benefits

Successful implementation of this measure could achieve energy savings if the user's project includes CH_4-based energy generation infrastructure. This quantified co-benefit is derived in the steps above that are necessary to quantify GHG reductions.

Sources

- 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.
- International Council for Local Environmental Initiatives (ICLEI). 2013. *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. Appendix F: Wastewater and Water Emission Activities and Sources*. Available: https://icleiusa.org/publications/us-community-protocol/. Accessed: January 19, 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.
- U.S. Environmental Protection Agency (U.S. EPA). 2020. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018 – Chapter 7. Waste*. Available: https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-chapter-7-waste.pdf. Accessed: January 19, 2021.