

# *LMOP and Landfill Gas Energy in the United States*

U.S. Environmental Protection Agency  
Landfill Methane Outreach Program



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# Partnership Program

# EPA's Landfill Methane Outreach Program

- Established in December 1994
- Voluntary program that creates partnerships among states, energy users/providers, the landfill gas (LFG) industry and communities

*Mission: To work cooperatively with industry stakeholders and waste officials to reduce or avoid methane emissions from landfills by encouraging the recovery and beneficial use of biogas generated from organic municipal solid waste.*

# LMOP Partners

- Industry Partners
  - Community Partners
  - Energy Partners
  - Endorser Partners
  - State Partners
- 
- Join at [epa.gov/lmop/join-landfill-methane-outreach-program](https://epa.gov/lmop/join-landfill-methane-outreach-program)

- **Benefits of LMOP Partnership:**
  - Recognition of Partner's commitment to and understanding of renewable energy benefits
  - Identification on LMOP website – description, contact information
  - Use of LMOP logo on Partner website (within guidelines)
  - LMOP support for groundbreakings / ribbon cuttings
  - Listserv messages from LMOP on LFG-related topics

# Landfill Gas Basics

# Landfill Gas 101

- LFG is a by-product of the anaerobic decomposition of municipal solid waste (MSW):
  - ~50% methane (CH<sub>4</sub>)
  - ~50% carbon dioxide (CO<sub>2</sub>)
  - <1% non-methane organic compounds (NMOCs)

- Methane is an important constituent of LFG that can be used for energy
- 1 million tons of MSW generates LFG that could be used to produce\*:

~0.78 megawatts (MW) of electricity

-or-

~432,000 cubic feet per day of LFG

-or-

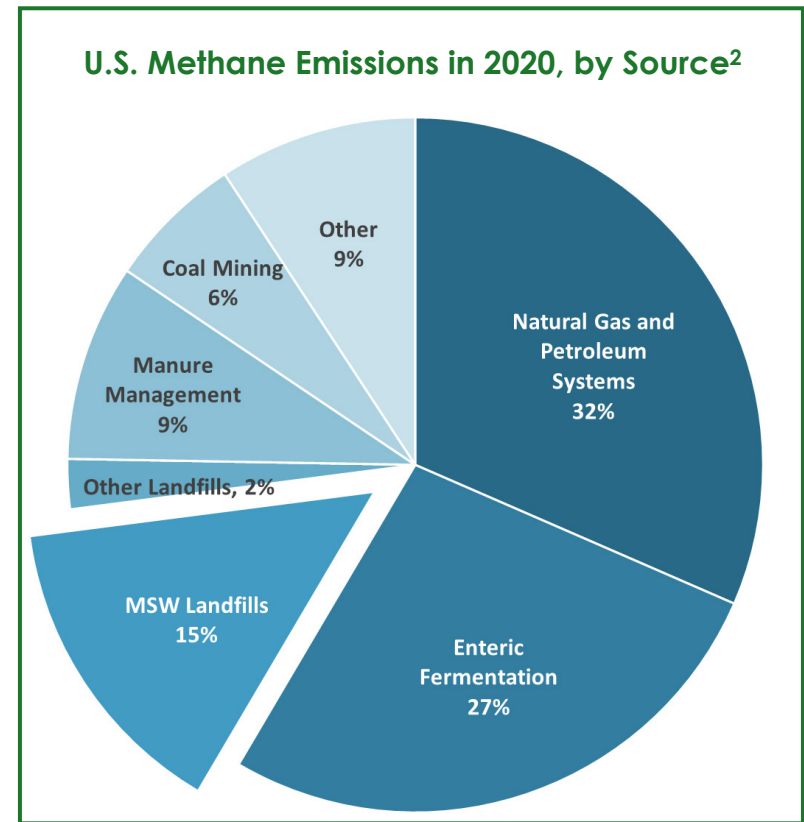
433,700 gallons of gasoline equivalent (GGEs) per year of CNG

\*Source: LMOP Interactive Conversion Tool, U.S. EPA LMOP. [epa.gov/lmop/list-tools-related-landfill-gas-and-waste-management](https://epa.gov/lmop/list-tools-related-landfill-gas-and-waste-management) and LFGcost-Web, Version 3.5. U.S. EPA LMOP. [epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model](https://epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model).



# Why EPA is Concerned about Landfill Gas

- About half of the MSW generated in the United States is deposited in a landfill (50% in 2018)<sup>1</sup>
- LFG contains hazardous air pollutants and volatile organic compounds, which create health and safety hazards
- MSW landfills are an important source of methane emissions, accounting for ~14.5% of U.S. methane emissions in 2020<sup>2</sup>



1. Advancing Sustainable Materials Management: 2018 Fact Sheet. December 2020. U.S. EPA.  
<https://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures-report>.
2. Inventory of U.S. Greenhouse Gas Emissions and Sinks. April 2022. U.S. EPA.  
<https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

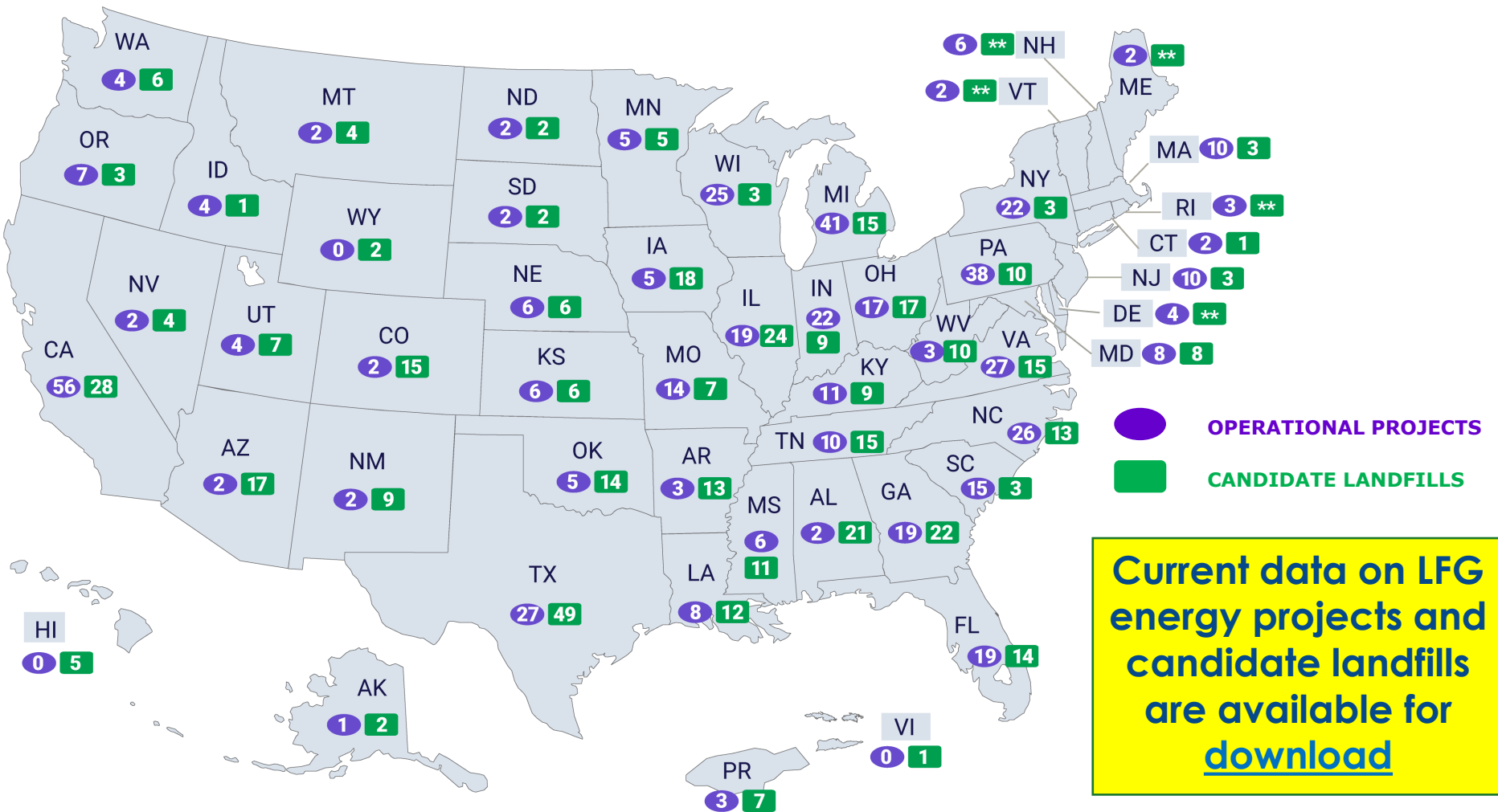
# LFG Energy Project Development



# LFG Energy Basics and Project Development

- LFG is collected from landfills via extraction wells within the waste mass, piping to convey the gas to a central location and a blower system that “pulls” the gas out
- With a heating value of ~500 Btu/scf – it’s an energy source!
- The energy content of LFG can be recovered through a variety of technologies and end uses
- LFG energy projects can be developed through different types of agreements and contracts between landfill owners/operators, project development firms, financiers, utilities, direct end users of gas, contractors and others
- LMOP’s LFG Energy Project Development Handbook provides more information: <https://www.epa.gov/lmop/landfill-gas-energy-project-development-handbook>

# LFG Energy Projects



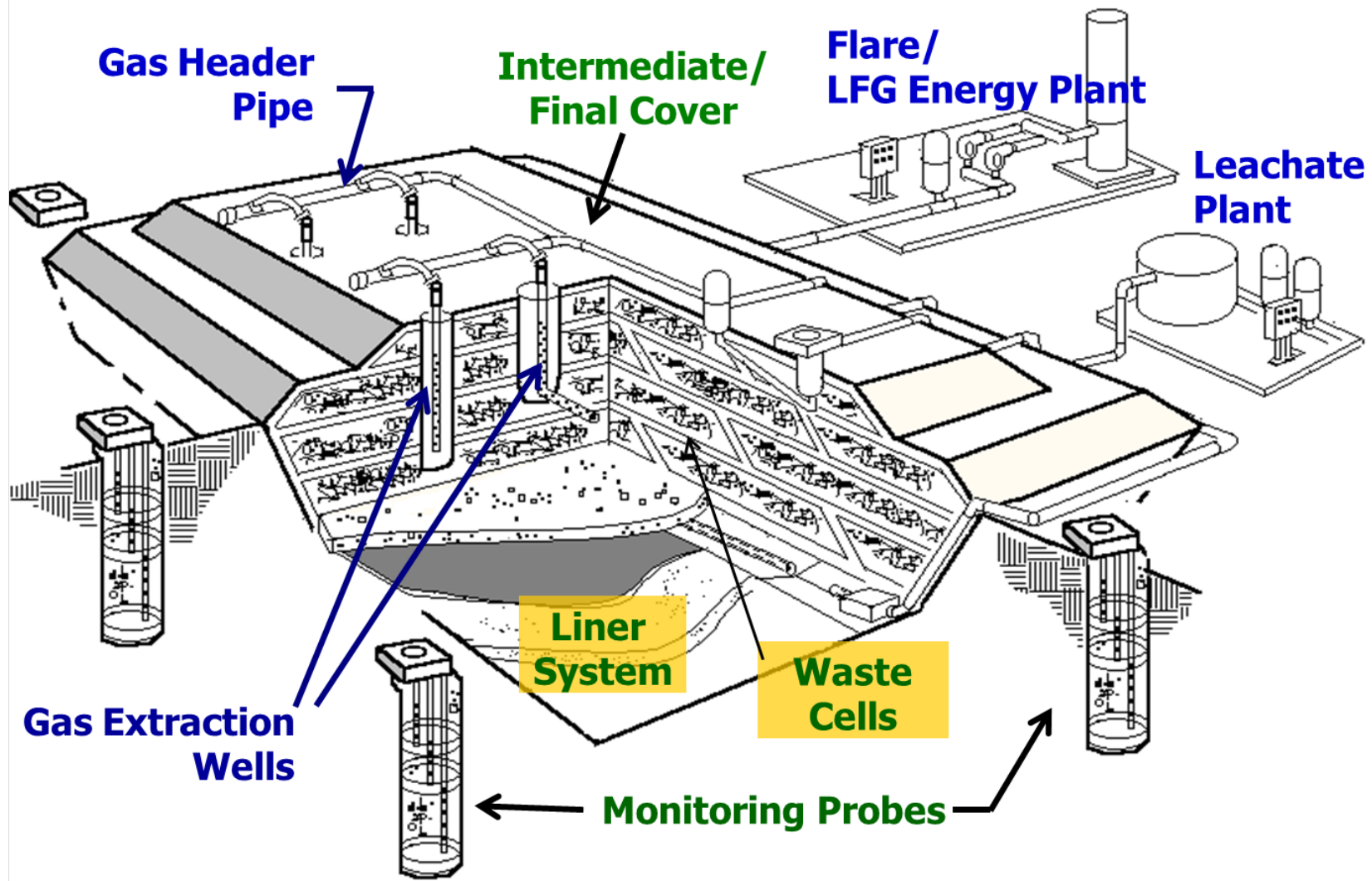
Current data on LFG energy projects and candidate landfills are available for [download](#)

# Landfill Gas Energy Co-Benefits

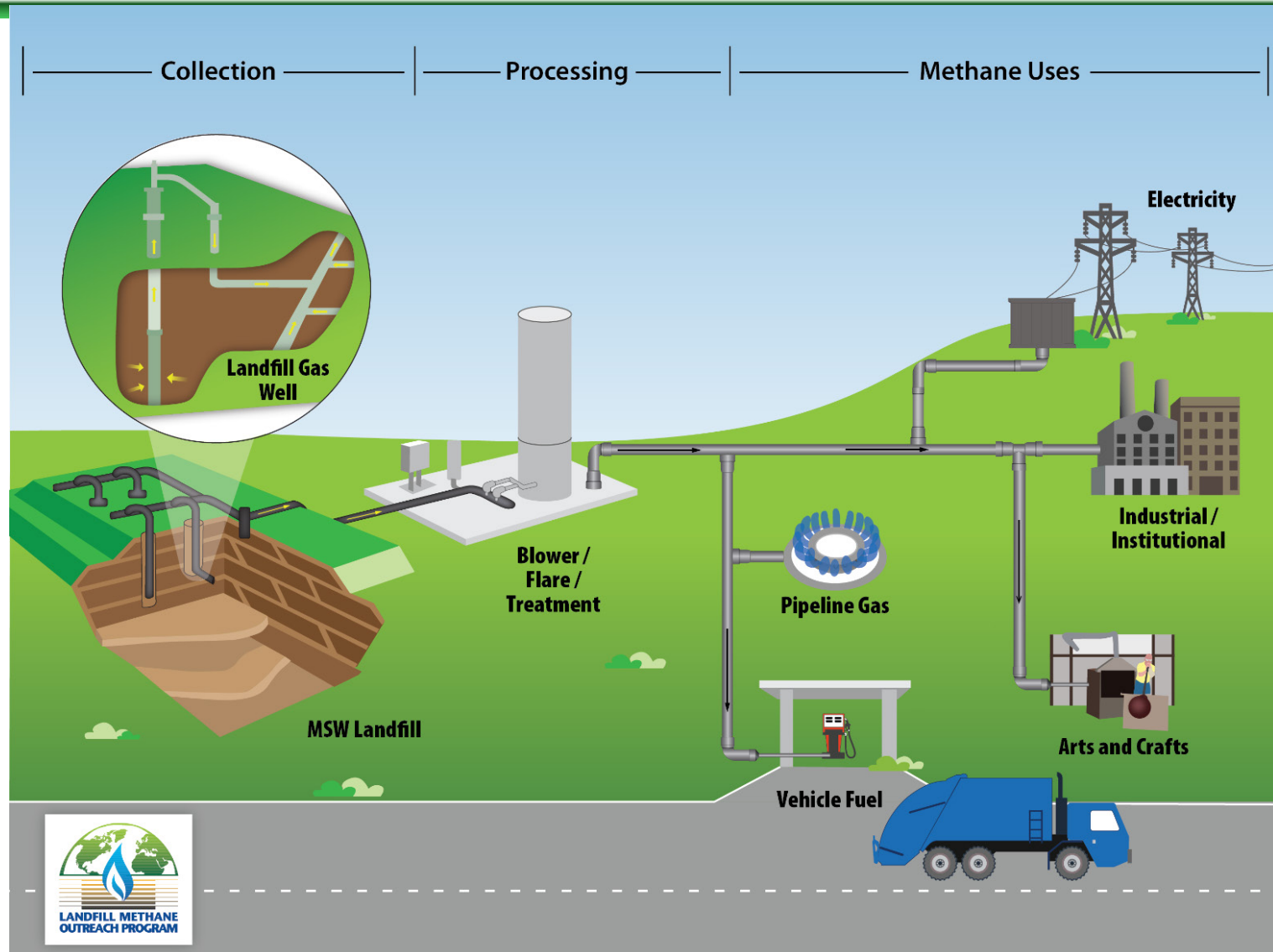
- Local, renewable, consistent source of energy
  - LFG is produced 24/7 and projects have online reliability of >90%
  - Reduces demand on conventional power plants
  - Helps utilities meet RPS requirements
- Economic benefits in the community and beyond
  - Job creation during construction plus continued operation
  - Selling LFG (and renewable aspects) is source of revenue
  - Renewable CNG for vehicle fuel use costs less at the pump than diesel
  - Government and businesses can realize cost savings
- Local environmental benefits
  - Projects can be part of solution for mitigating landfill odors
  - Lower exhaust emissions from LFG-sourced NG vehicles



# Modern Sanitary Landfill with an LFG Energy Project



# LFG End Use Options



# Example Electricity Generation Technologies

**Internal  
Combustion Engine  
(range from 100 kW  
to 3 MW)**



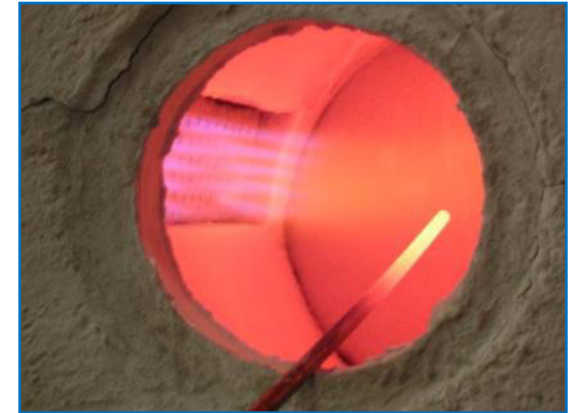
**Gas Turbine  
(range from 800 kW  
to 10.5 MW)**



**Microturbine  
(range from 30 kW  
to 250 kW)**

# Example Medium-Btu End Uses of LFG

- Boiler applications – replace natural gas, coal, fuel oil
- Glassblowing, pottery, blacksmithing, hydroponics, aquaculture
- Direct thermal (dryers, kilns)
- Leachate evaporation
- Greenhouse
- Infrared heaters
- Ethanol production



Glassblowing - Jackson County, NC



Greenhouse  
Jackson County, NC



Infrared Heater - Lorton, VA

# Example Renewable Natural Gas End Uses of LFG

- Natural gas pipeline injection
- Vehicle fuel (CNG, LNG)



**CNG Fueling Station**  
St. Landry Parish, LA



**RNG Pipeline Project**  
Rochester, NH



**BioCNG System**  
Dane County, WI



# Typical Electric Project Components & Costs

- 3-MW, engine, 15-year project\*:
  - Total capital cost = ~\$6 million (\$2020)
    - Gas compression & treatment, engine & generator = ~\$5.7 million
    - Interconnect equipment = ~\$287,200 (interconnect costs can vary widely)
  - Annual operation & maintenance (O&M) cost (initial year of operation) = ~\$745,000/year



Reciprocating Engine –  
Maysville, KY

# Typical Direct-Use Project Components & Costs

- 800-scfm, 5-mile pipeline, 15-year project\*:
  - Total capital cost = ~\$4 million (\$2020)
    - Gas compression & treatment = ~\$1,367,000
    - Pipeline = ~\$526,000/mile
    - Plus end-of-pipe combustion equipment retrofits, if needed
  - Annual O&M cost (initial year of operation) = ~\$156,000/year



Boiler – Raleigh, NC

# Typical RNG Pipeline-Injection Project Costs

- 2,800-scfm, 2-mile pipeline, 15-year project\*:
  - Total capital cost = ~\$16.6 million (\$2020)
    - RNG processing equipment and compression = ~\$14.2 million
    - Interconnection equipment = \$408,000 (does not include initial pipeline interconnect fees, which can vary widely depending on utility)
    - Pipeline = ~\$1 million/mile
  - Annual O&M cost for labor, parts, electricity and pipeline injection fee (initial year of operation) = ~\$3.47 million/year



RNG Plant – Phoenix, AZ

# Revenue, Funding and Incentives for LFG Energy

## Sources of Revenue:

- Direct sale of commodity – LFG, power or RNG
- Renewable Energy Certificates (RECs) for electricity or thermal
- RINs under Renewable Fuel Standard (RFS)
- State Vehicle Fuel Credit programs (e.g., California Low Carbon Fuel Standard)
- GHG reduction credits

## Funding:

- Renewable Electricity Production Tax Credit (PTC) or Investment Tax Credit (ITC)
- Federal or state grants
- Loans (e.g., U.S. DOE Loan Guarantee program)

## Other Incentives (for Utilities):

- Voluntary green gas programs
- Interconnection cost offset
- Renewable Portfolio Standards/Goals

# Regulations that May Affect LFG Energy Projects

- LFG energy projects may be affected by a variety of federal, state or local air quality regulations
- Applicable federal Clean Air Act regulations may include:
  - New Source Performance Standards (NSPS) / Emission Guidelines (EG)
  - Title V
  - Maximum Achievable Control Technology (MACT)
  - New Source Review (NSR)
  - Prevention of Significant Deterioration (PSD)
- For more information, see LMOP's quick reference sheet: [epa.gov/lmop/list-publications-related-landfill-gas-and-waste-management#quick](https://www.epa.gov/lmop/list-publications-related-landfill-gas-and-waste-management#quick)

# Key LMOP Resources

# LMOP Resources

- LMOP Landfill and LFG Energy Project [Database](#)
- [Tools](#): Toolkit for Expiring LFG Electricity PPAs, *LFGcost-Web*, Biogas Toolkit, benefits calculator, conversion tool
- Technical and outreach [publications](#)
- Webinars and other [events](#)
- Network of 1,000+ [Partners](#)
- Listserv – sign up to [receive](#) and view [message archive](#)

# National Landfill and LFG Energy Project Database

## Landfill and LFG Energy Project Data

Download details about projects and landfills

**Includes data for more than 2,600 U.S. landfills**

- Excel files cut the LMOP data in various ways to help you find what you are looking for
- Cross-references EPA's Greenhouse Gas Reporting Program (GHGRP)

	A	B	C	D	E	F	G	H	I	J	K
	GHGRP ID	Landfill ID	Landfill Name	State	Physical Address	City	County	Zip Code	Latitude	Longitude	Ownership Type
2	1007341	1994	Anchorage Regional Landfill	AK	15500 E. Eagle River Loop Road	Eagle River	Anchorage	99577	61.293281	-149.60214	Public
3	1007341	1994	Anchorage Regional Landfill	AK	15500 E. Eagle River Loop Road	Eagle River	Anchorage	99577	61.293281	-149.60214	Public
4	1010389	11941	Capitol Disposal Landfill	AK	5600 Tonsgard Court	Juneau		99801	58.3528	-134.4947	Private
5		10980	Central Landfill - MatSu Borough	AK	1201 N. 49th State Street Just off the Palmer-Wasilla Highway	Palmer	Matanuska-Susitna	99645	61.59	-149.21	Public
6	1005349	12216	Central Peninsula Landfill (CPL)	AK	46915 Sterling Highway	Soldotna	Kenai Peninsula	99669	60.44714	-151.10369	Public
7		10960	Kodiak Island Borough Landfill	AK	1203 Monashka Bay Road	Kodiak	Kodiak Island	99615	57.80874	-152.40761	Public
8	1004380	11020	Merrill Field Landfill	AK	800 Merrill Field Drive	Anchorage	Anchorage	99501	61.21266	-149.84012	Public
9	1006806	10961	South Cushman Landfill	AK	455 Sanduri Street	Fairbanks	Fairbanks North Star	99701	64.80476	-147.70085	Public
10		11000	Unalaska Landfill	AK	1181 Summer Bay Road	Unalaska	West	99685	53.88463	-166.50657	Public
11		27	Athens/Limestone County MSWLF	AL	Strain Road off Highway 31	Athens	Limestone	35611	34.7634	-86.9399	Public
12		16	Bishop Landfill Company	AL	379 Pleasant Grove Cutoff Road	Albertville	Marshall	35950	34.27823	-86.33707	Private
13	1004245	2005	Black Warrior Solid Waste Facility	AL	3301 Landfill Drive						
14		2006	Blount County/Nectar/Hayden LF & TS	AL	2390 Armstrong Loop						
15	1004415	2408	Brundidge Landfill	AL	515 Cleanwater Drive						



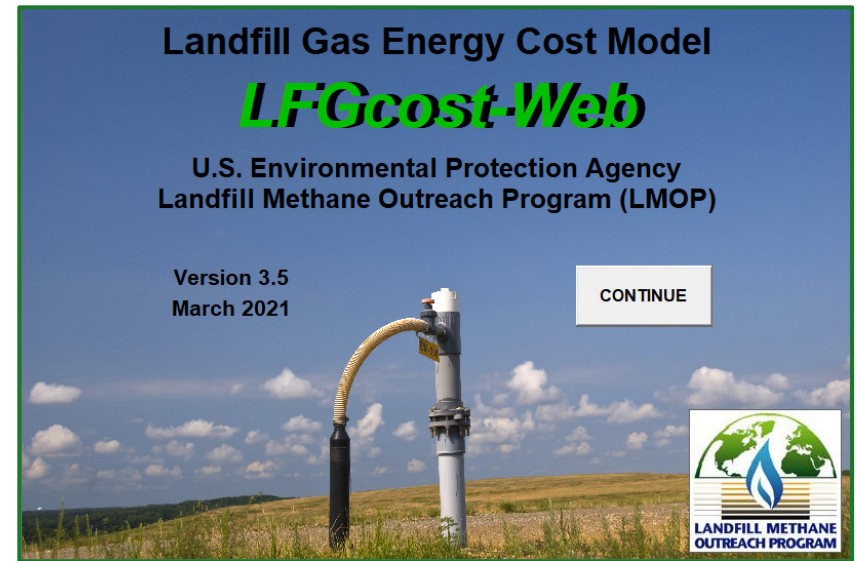


# LFG Energy Cost Model

## LFGcost-Web

*Evaluate the initial economic feasibility of an LFG energy project*

- A user-friendly Microsoft® Excel platform
- *LFGcost-Web* can analyze 11 energy recovery project types with or without a gas control collection system



***LFGcost-Web* is available online to all stakeholders and is transparent, allowing users to edit optional inputs**

# Toolkit for Expiring LFG Electricity Power Purchase Agreements (PPAs)

This resource provides information on options that landfill owners and owners of LFG electricity projects may have when their PPA is nearing expiration.

If conditions are feasible for LFG energy project operations:



Continue to generate electricity



Develop new LFG energy project type

Or, if conditions are not feasible for LFG energy project operations:

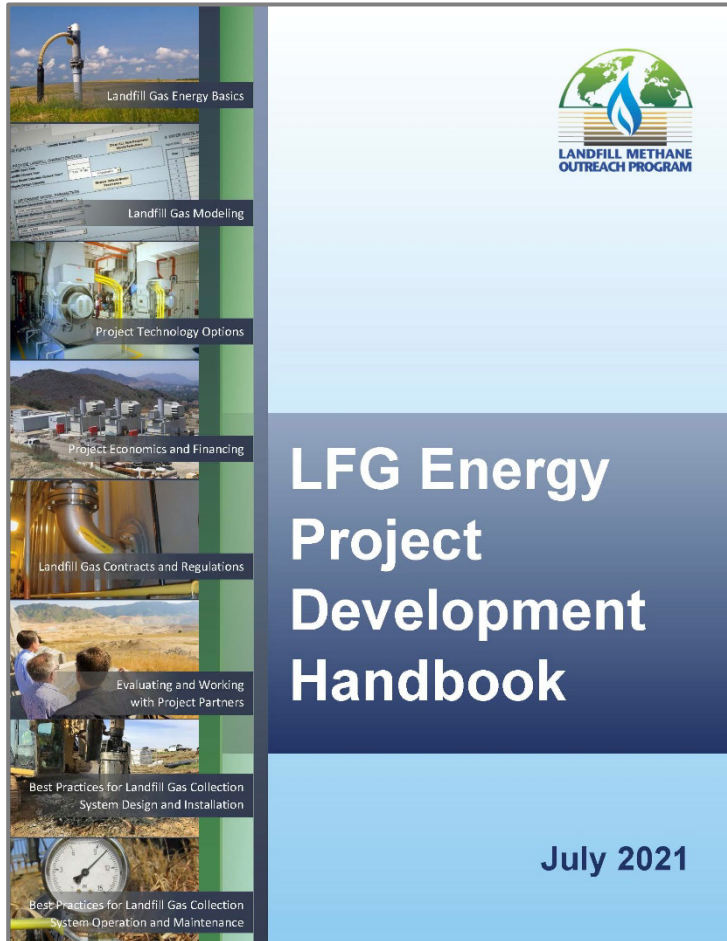


Shut down your LFG energy project

Presents three main choices:

- Continue to generate electricity
- Develop new LFG energy project type
- Shut down energy project
- Lists criteria, pros and cons, and economic considerations for each option
- Provides multiple options and examples where available
- Includes responsible ways to continue mitigating methane emissions

# LFG Energy Project Development Handbook

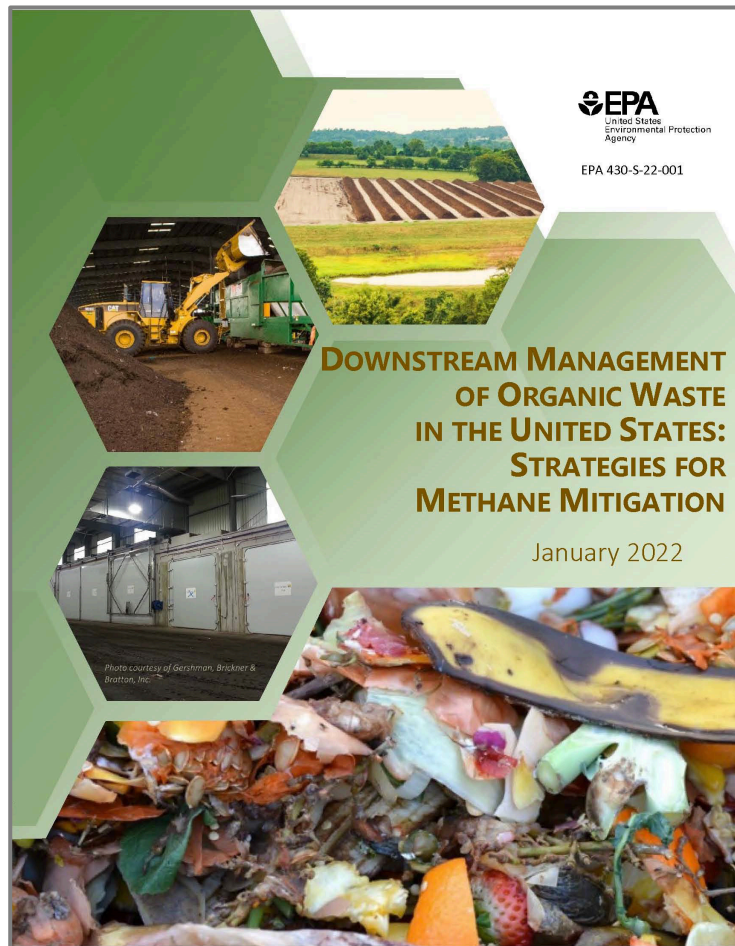


## Project Development Handbook

*Improve understanding to develop successful projects*

- Provides project-specific considerations
- Helps stakeholders who are new to LFG energy projects
- Highlights useful online resources and successful LFG energy projects
- Added new chapters in 2020 on best practices for gas collection systems

# Downstream Management of Organic Waste: Strategies for Methane Mitigation

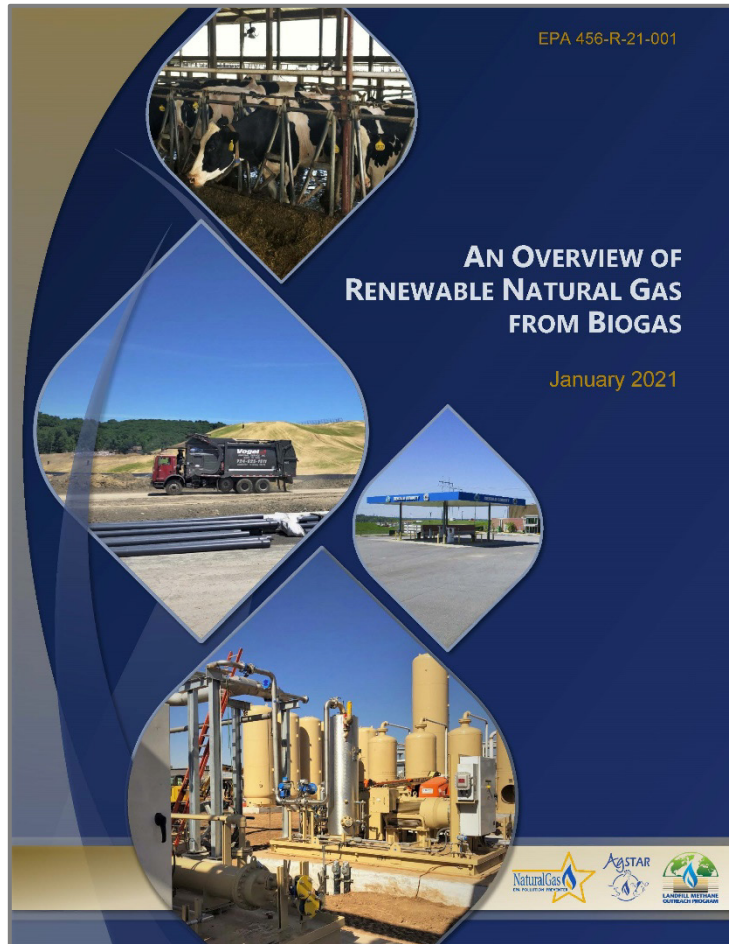


## Organic Waste Management

*Learn about alternative ways to manage organic waste*

- Technical information about collection practices, processing technologies, benefits of and barriers to diversion, policies and incentives, and tools and resources for evaluating options
- Primary purpose of document is to help reduce landfill methane generation or mitigate landfill methane emissions
- Composting and anaerobic digestion can produce useful end products and spur investment and job creation

# An Overview of Renewable Natural Gas from Biogas



## Renewable Natural Gas from Biogas

*Gain understanding of the biogas-to-RNG process*

- Main feedstocks/sources
- Options for delivering and using RNG
- Benefits of RNG projects
- Counts of operational and potential projects by feedstock type
- Processes and technologies
- Policies and incentives
- Example projects

# How Can We Work Together?

- Facilitating information sharing – LMOP Database, webinars, listserv messages
- Providing technical information about LFG energy project development and other opportunities to reduce emissions from MSW landfills
- Analyze resource availability through LFG modeling
- Performing initial feasibility analysis using *LFGcost-Web*

**LMOP welcomes your feedback on our website, resources, tools, etc.**

[epa.gov/lmop/forms/contact-us-about-landfill-methane-outreach-program](https://epa.gov/lmop/forms/contact-us-about-landfill-methane-outreach-program)