

LMOP and Landfill Gas Energy in the United States

U.S. Environmental Protection Agency
Landfill Methane Outreach Program



File Last Updated • February 2021

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

- **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 groundbreaking or 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 (CH₄)
 - ~50% carbon dioxide (CO₂)
 - <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-

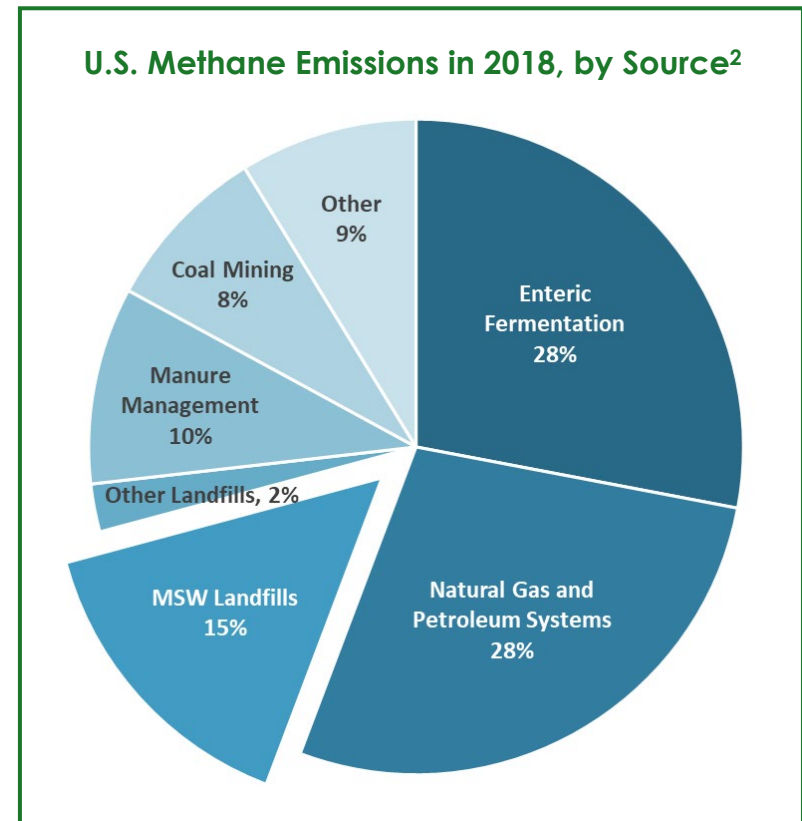
433,700 gallons of gasoline equivalent (GGEs) per year of CNG

*Source: LMOP Interactive Conversion Tool, U.S. EPA LMOP. [epa.gov/lmop/list-publications-tools-and-resources](https://www.epa.gov/lmop/list-publications-tools-and-resources) and LFGcost-Web, Version 3.4. U.S. EPA LMOP. [epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model](https://www.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)¹
- 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 ~15.1% of U.S. methane emissions in 2018²



1. Advancing Sustainable Materials Management: 2018 Fact Sheet. November 2020. U.S. EPA.
<https://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures-report>.

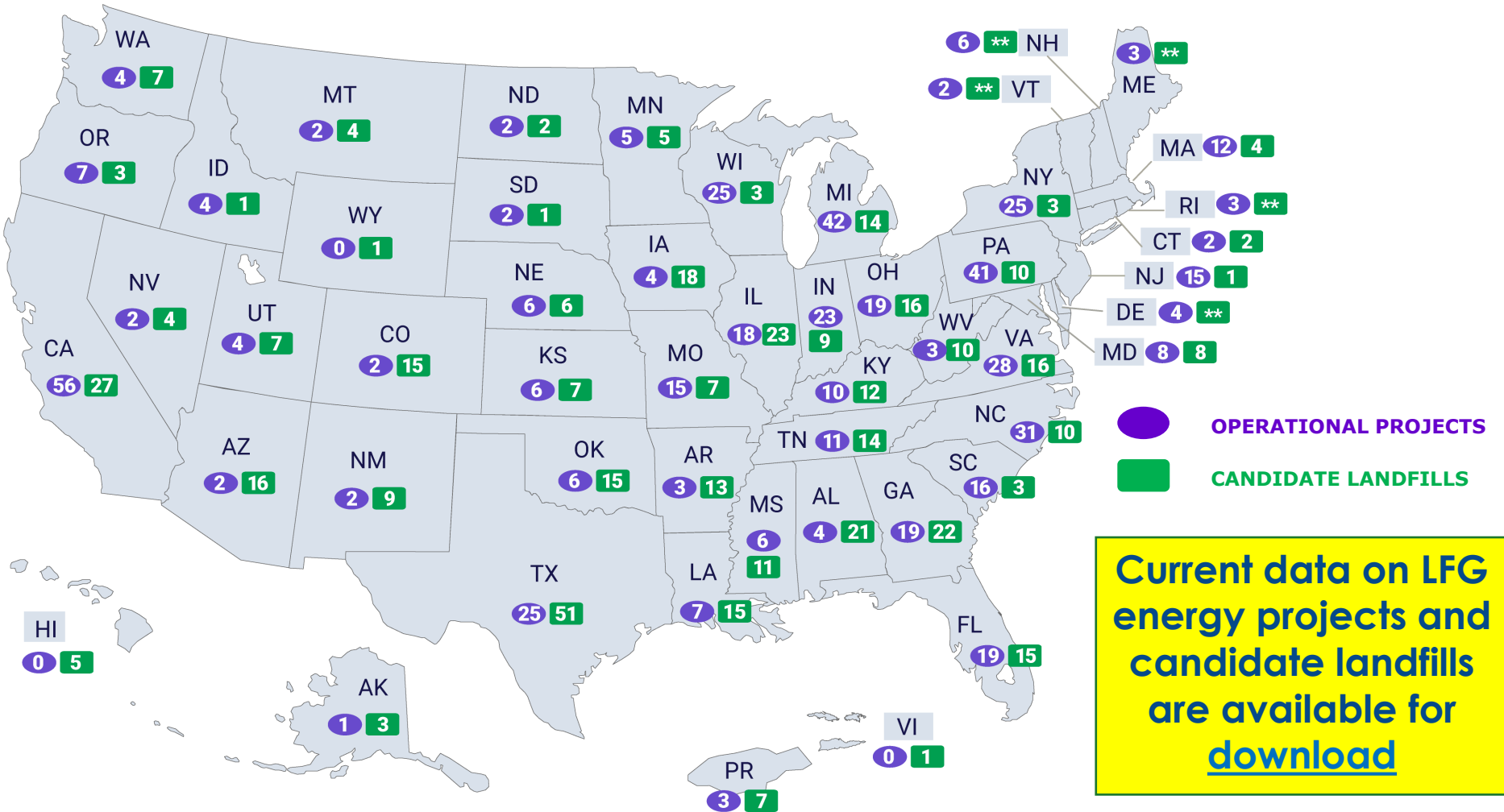
2. Inventory of U.S. Greenhouse Gas Emissions and Sinks. April 2020. U.S. EPA.
<https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

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



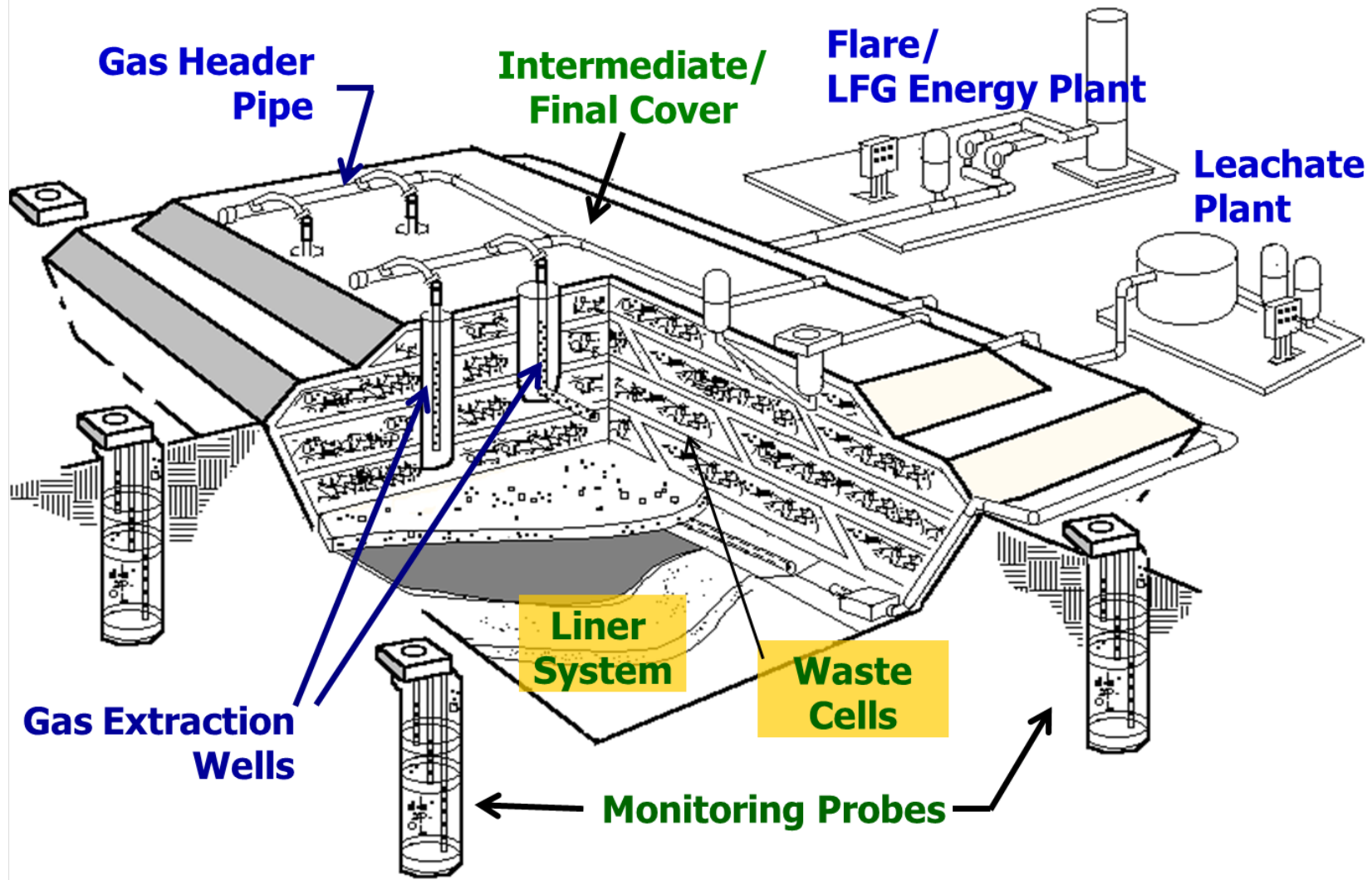
Current data on LFG energy projects and candidate landfills are available for [download](#)

Landfill Gas Energy Co-Benefits

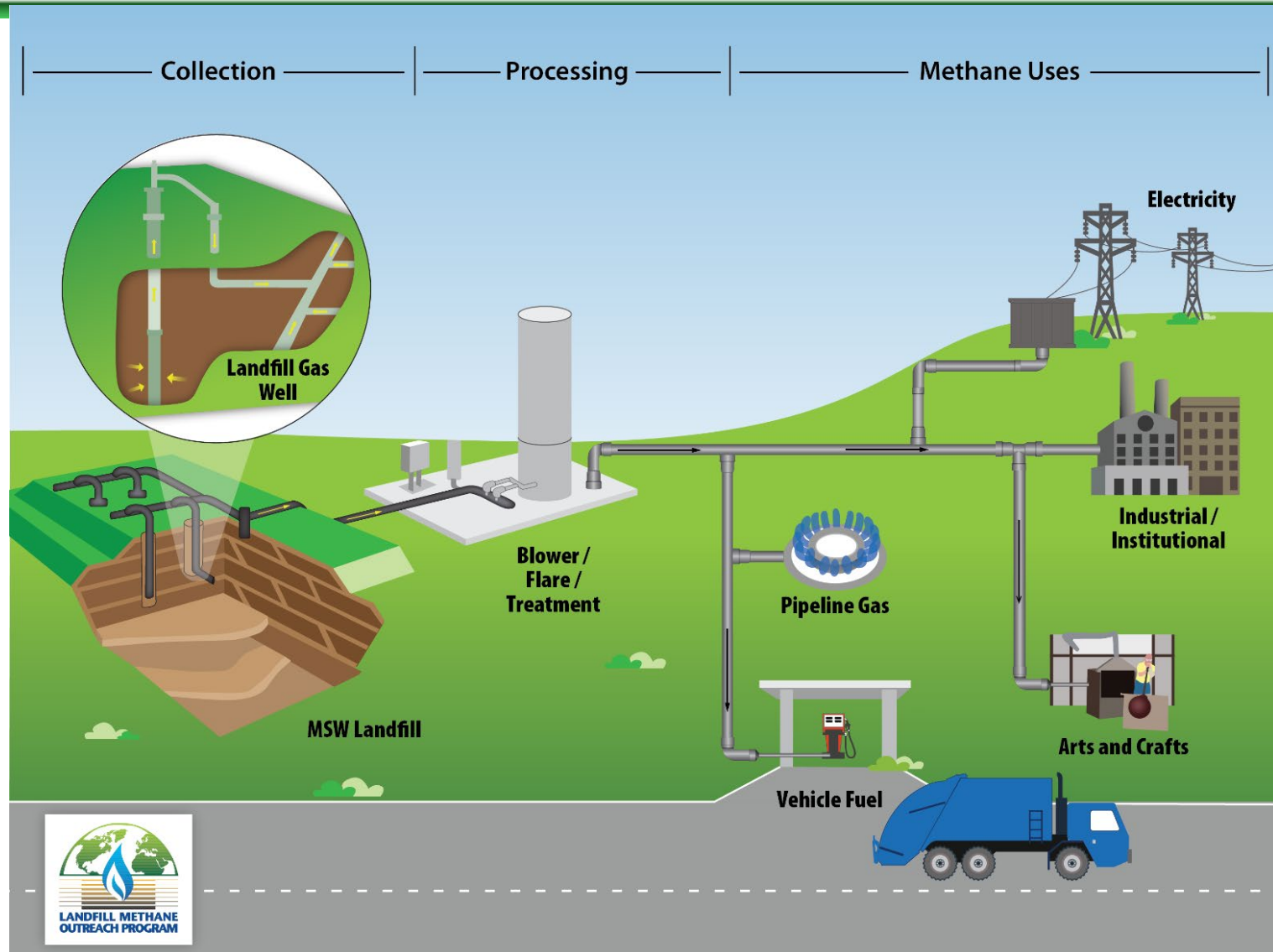
- Local, renewable, consistent source of energy
 - LFG is produced 24/7 and projects have online reliability of >90%
 - Reduces demand on conventional power plants
 - Helps utilities meet RPS requirements
- Economic benefits in the community and beyond
 - Job creation during construction plus continued 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)**



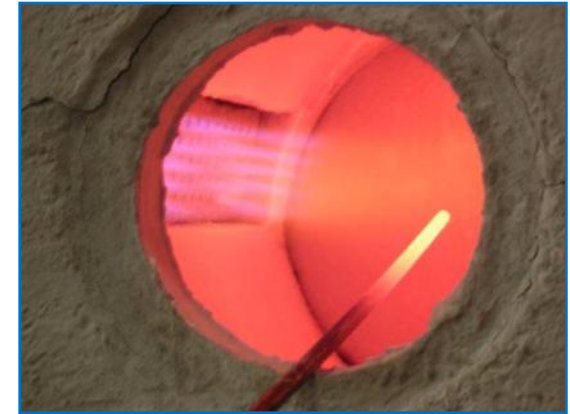
**Gas Turbine
(range from 800 kW
to 10.5 MW)**



**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

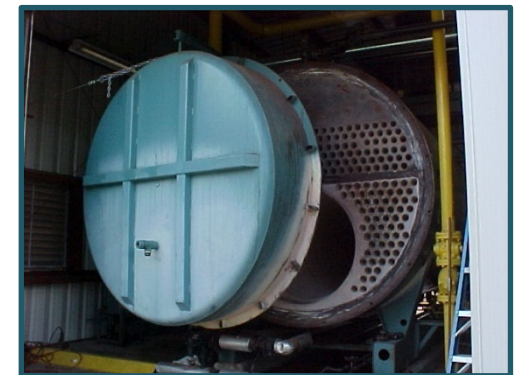
- 3-MW, engine, 15-year project*:
 - Total capital cost = ~\$6 million (\$2020)
 - Gas compression & treatment, engine & generator = ~\$5.7 million
 - Interconnect equipment = ~\$287,200 (interconnect costs can vary widely)
 - Annual operation & maintenance (O&M) cost (initial year of operation) = ~\$745,000/year



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

Key LMOP Resources

LMOP Resources

- LMOP Landfill and LFG Energy Project [Database](#)
- [Tools](#): *LFGcost-Web*, 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 | Alberville | 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 | | | | | | |

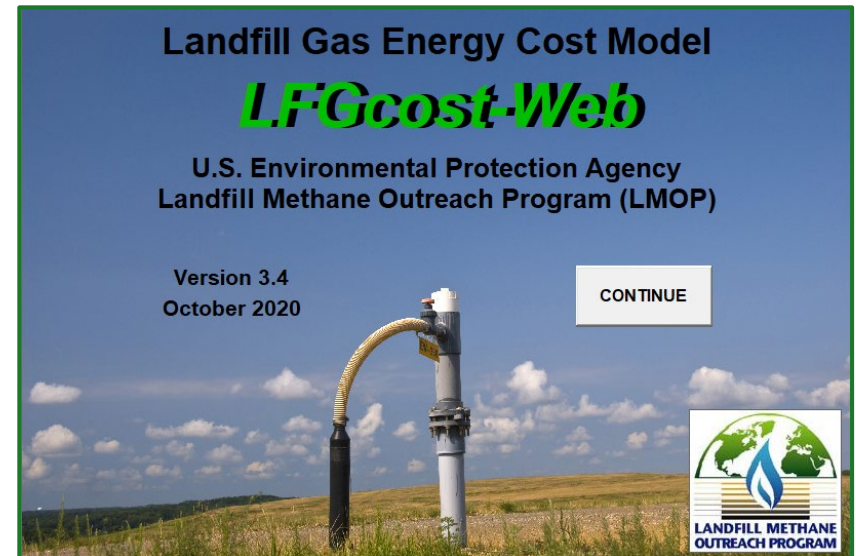


LFG Energy Cost Model

LFGcost-Web

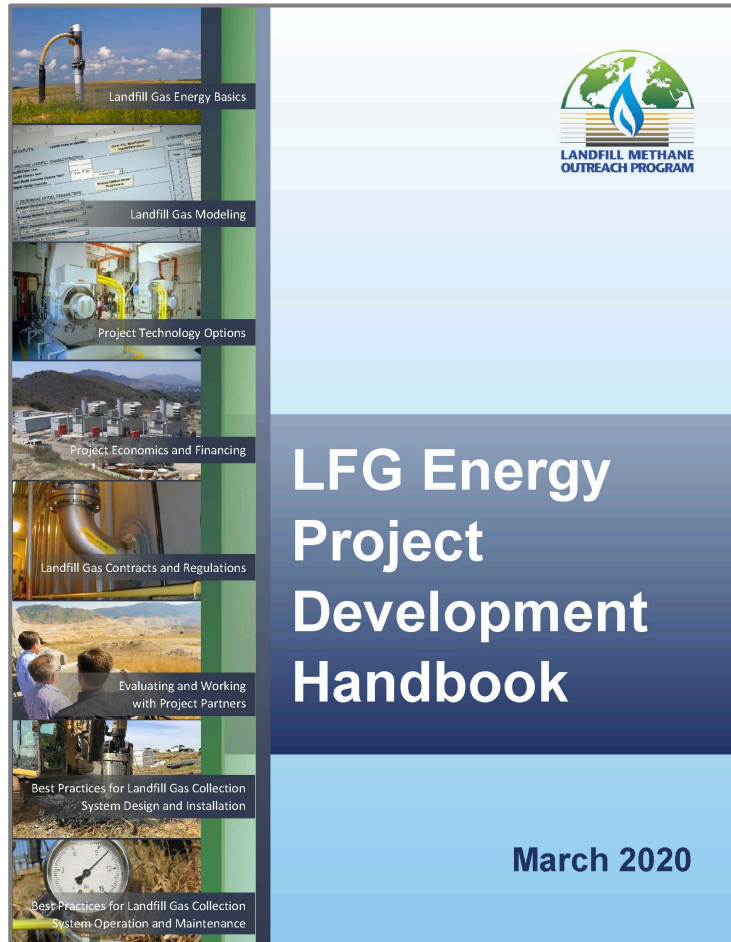
Evaluate the initial economic feasibility of an LFG energy project

- A user-friendly Microsoft® Excel platform
- LFGcost-Web can analyze 12 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

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

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