LMOP and Landfill Gas Energy in the United States

U.S. Environmental Protection Agency
Landfill Methane Outreach Program

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

- **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 (CH_4)
  - ~50% carbon dioxide (CO_2)
  - <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-

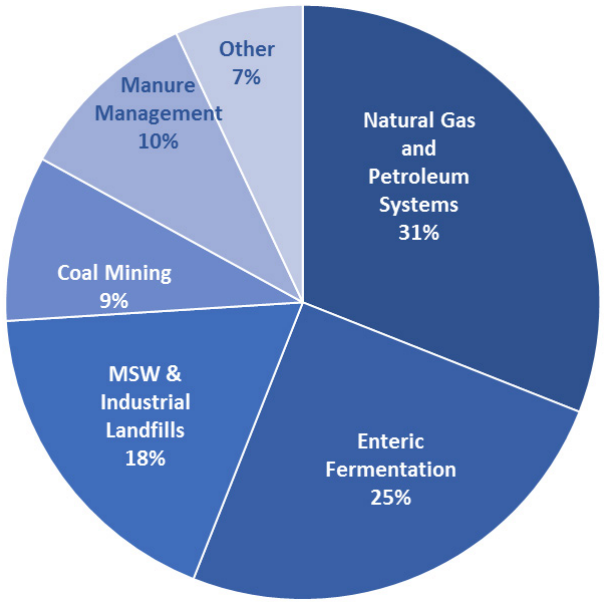
433,700 gallons of gasoline equivalent (GGEs) per year of CNG

***Source:** *LMOP Interactive Conversion Tool*, U.S. EPA LMOP. epa.gov/lmop/list-publications-tools-and-resources and *LFGcost-Web*, Version 3.2. U.S. EPA LMOP. epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model.

Why EPA is Concerned about Landfill Gas

- More than half of the MSW generated in the United States is deposited into a landfill, 52.6% in 2014[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 ~15.4% of U.S. methane emissions in 2015[2]

U.S. Methane Emissions in 2015, by Source[2]



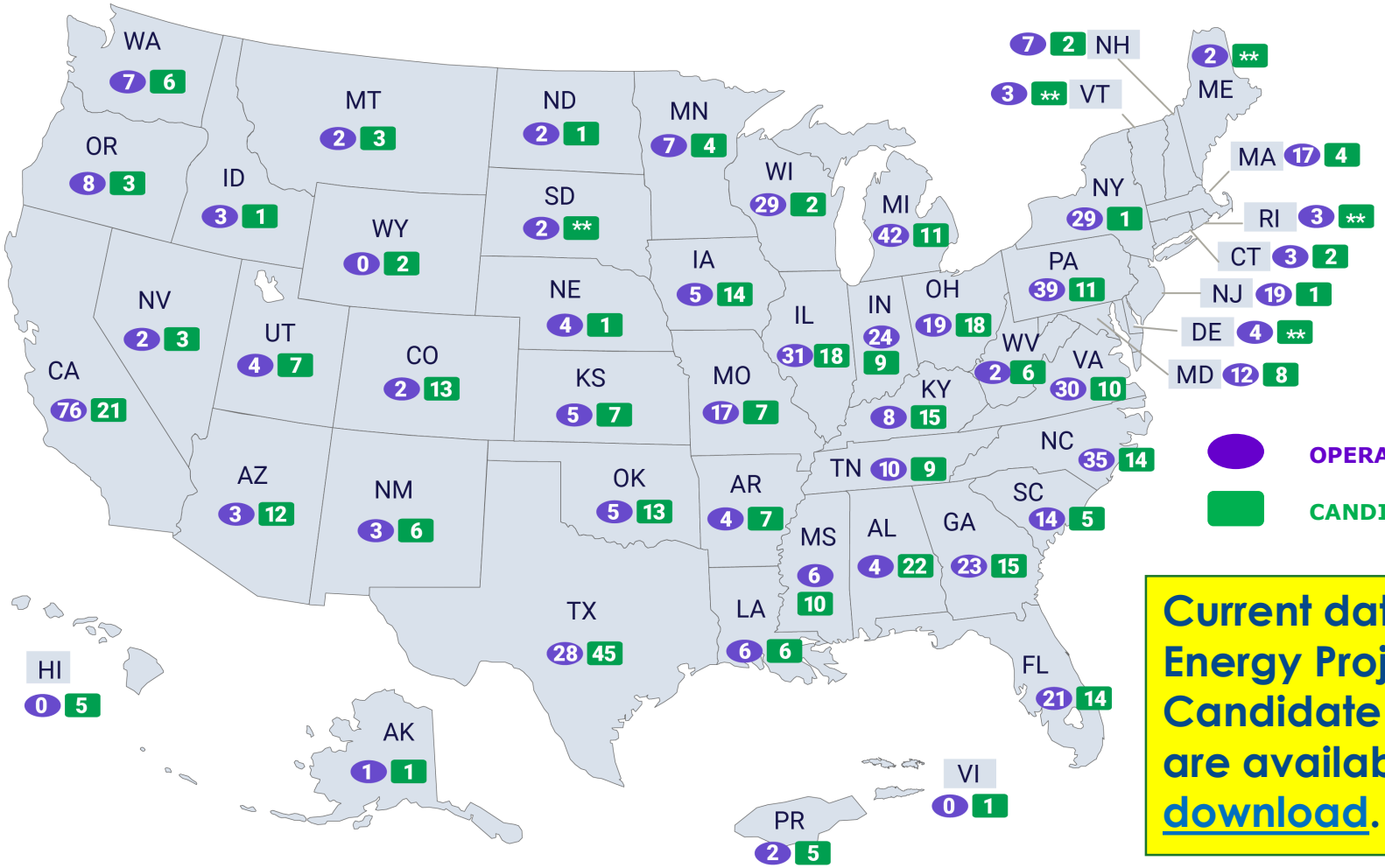
1. Advancing Sustainable Materials Management: 2014 Fact Sheet. November 2016. U.S. EPA. https://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures-report.
2. Inventory of U.S. Greenhouse Gas Emissions and Sinks. April 2017. U.S. EPA. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

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.

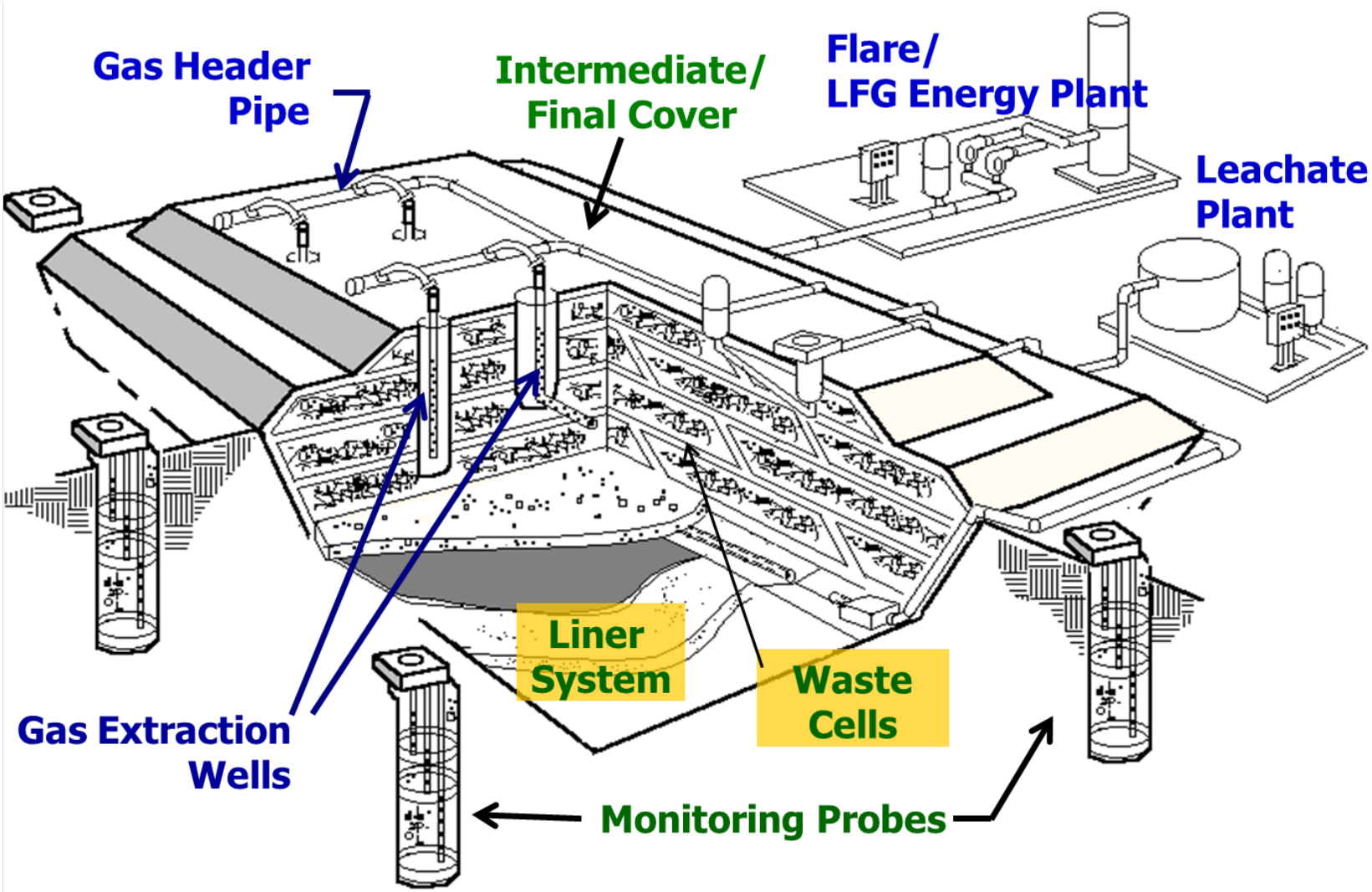
These data are from LMOP's database as of June 2017.

Landfill Gas Energy Co-Benefits

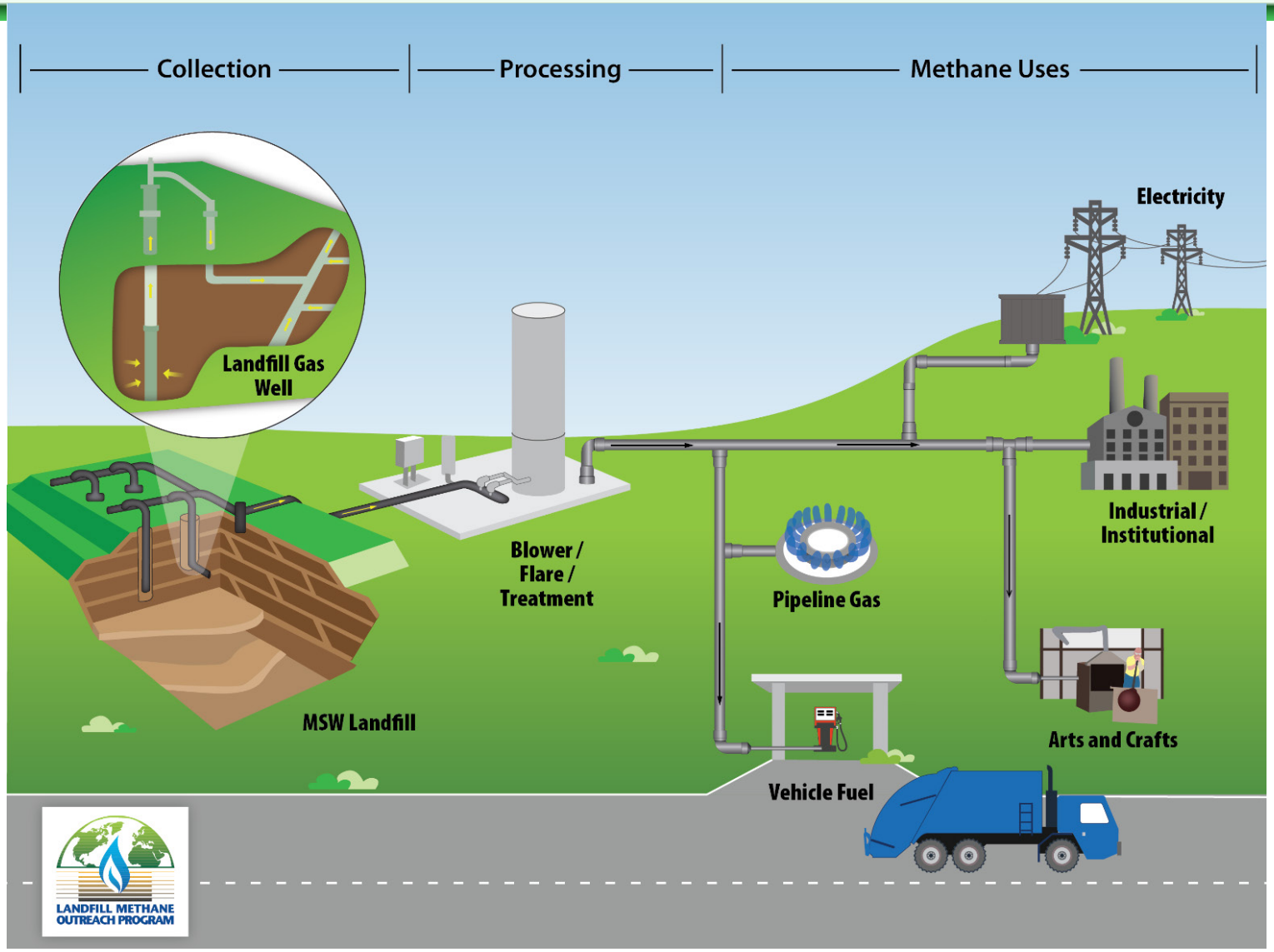
- Local, renewable, consistent source of energy
  - LFG is produced 24/7 and projects have online reliability of >90%
  - Reduces demand on conventional power plants
  - Helps utilities meet RPS requirements

- Economic benefits in the community and beyond
  - Job creation during construction plus continued operation
  - Selling LFG (and renewable aspects) is source of revenue
  - Renewable NG for vehicle fuel costs less than gasoline or 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

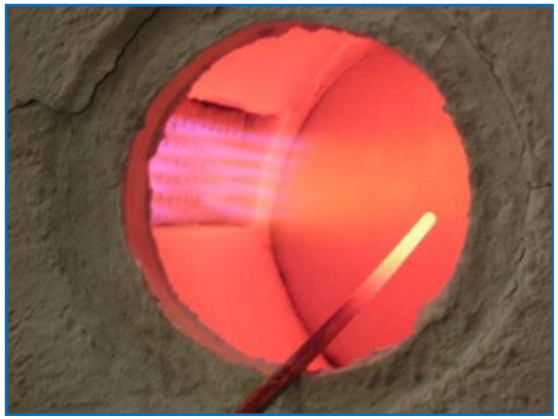
Internal Combustion Engine (range from 100 kW to 3 MW)

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 High-Btu End Uses of LFG

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

High-Btu Pipeline Project
Rochester, NH

CNG Fueling Station
St. Landry Parish, LA

BioCNG System
Dane County, WI

Typical Electric Project Components & Costs

- 3-MW, engine, 15-year project*:
  - Total capital cost = ~$5.25 million ($2013)
    - Gas compression & treatment, engine & generator = ~$5 million
    - Interconnect equipment = ~$250,000
      (interconnect costs can vary widely)
  - Annual operation & maintenance cost (initial year of operation) = ~$626,500/year

Reciprocating Engine – Maysville, KY

***Source:** *LFGcost-Web*, Version 3.2. U.S. EPA LMOP. epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model. **Analyses performed using *LFGcost-Web* are considered estimates and should be used for guidance only.**

State-wide Economic Impacts of Constructing 3-MW Engine Project

Direct*

- $1.85 million expenditures
- 6+ jobs

Ripple Effects*

- $4.3 million+ economic output
- 22+ jobs

***Source:** *LFGcost-Web*, Version 3.2. U.S. EPA LMOP. epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model. **Analyses performed using *LFGcost-Web* are considered estimates and should be used for guidance only.**

Typical Direct-Use Project Components & Costs

- 800-scfm, 5-mile pipeline, 15-year project*:
  - Total capital cost = ~$3.4 million ($2013)
    - Gas compression & treatment = ~$1,118,000
    - Pipeline = ~$600,000/mile
    - Plus end-of-pipe combustion equipment retrofits, if needed
  - Annual operation & maintenance cost (initial year of operation) = ~$124,600/year

Boiler – Raleigh, NC

***Source:** *LFGcost-Web*, Version 3.2. U.S. EPA LMOP. epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model. **Analyses performed using *LFGcost-Web* are considered estimates and should be used for guidance only.**

State-wide Economic Impacts of Constructing 1,000-scfm Direct-Use Medium-Btu Project

Direct*

$1.32 million expenditures

9.5+ jobs

Ripple Effects*

$2.8 million+ economic output

20+ jobs

*Source: *LFGcost-Web*, Version 3.2. U.S. EPA LMOP. epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model. **Analyses performed using *LFGcost-Web* are considered estimates and should be used for guidance only.**

Resources for Funding LFG Energy Projects

Sources of Revenue:

- Direct sale of LFG
- Sale of power generated from LFG
- Renewable Energy Certificates (RECs)
- RINs under Renewable Fuel Standard (RFS)
- California Low Carbon Fuel Standard credits
- Greenhouse gas reduction credits

Funding and Incentives:

- Renewable Electricity Production Tax Credit (PTC)
- Federal or state grants
- Low-cost bond programs
  - Clean Renewable Energy Bonds (CREBs)
  - Qualified Energy Conservation Bonds (QECBs)
- Loans
  - U.S. DOE Loan Guarantee program

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/quick-reference-sheet-regulations-affecting-landfills-and-projects

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

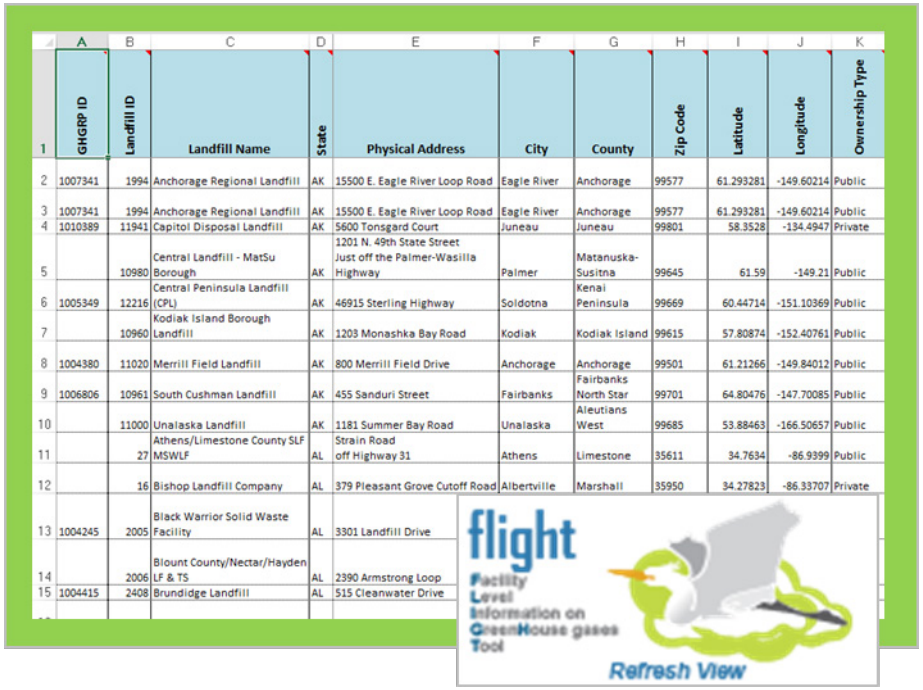
National Landfill and LFG Energy Project Database

Landfill and LFG Energy Project Data

Download details about projects and landfills

Includes data for more than 2,400 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)



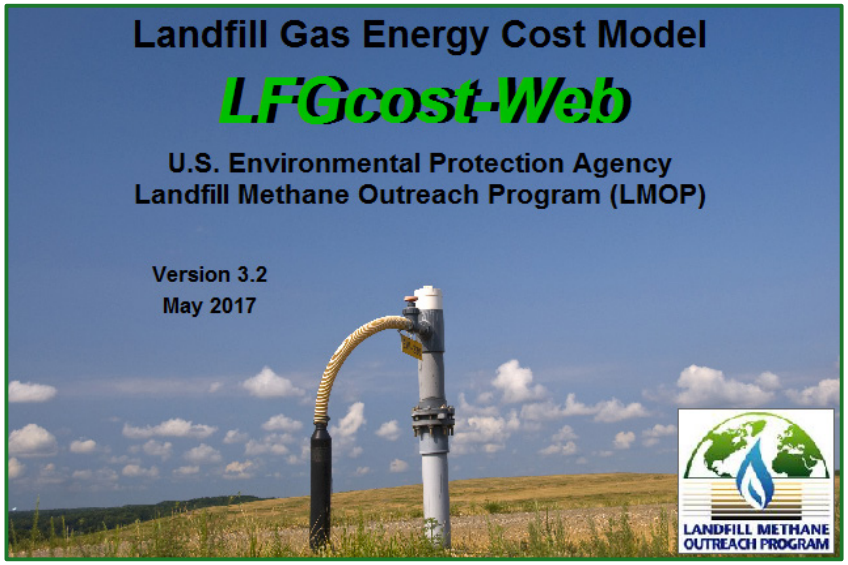
	A	B	C	D	E	F	G	H	I	J	K
1	GHGRP ID	Landfill ID	Landfill Name	State	Physical Address	City	County	Zip Code	Latitude	Longitude	Ownership Type
2	1007341	1994	Anchorage Regional Landfill	AK	15500 E. Eagle River Loop Road	Eagle River	Anchorage	99577	61.293281	-149.60214	Public
3	1007341	1994	Anchorage Regional 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	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	Aleutians West	99685	53.88463	-166.50657	Public
11		27	Athens/Limestone County SLF 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

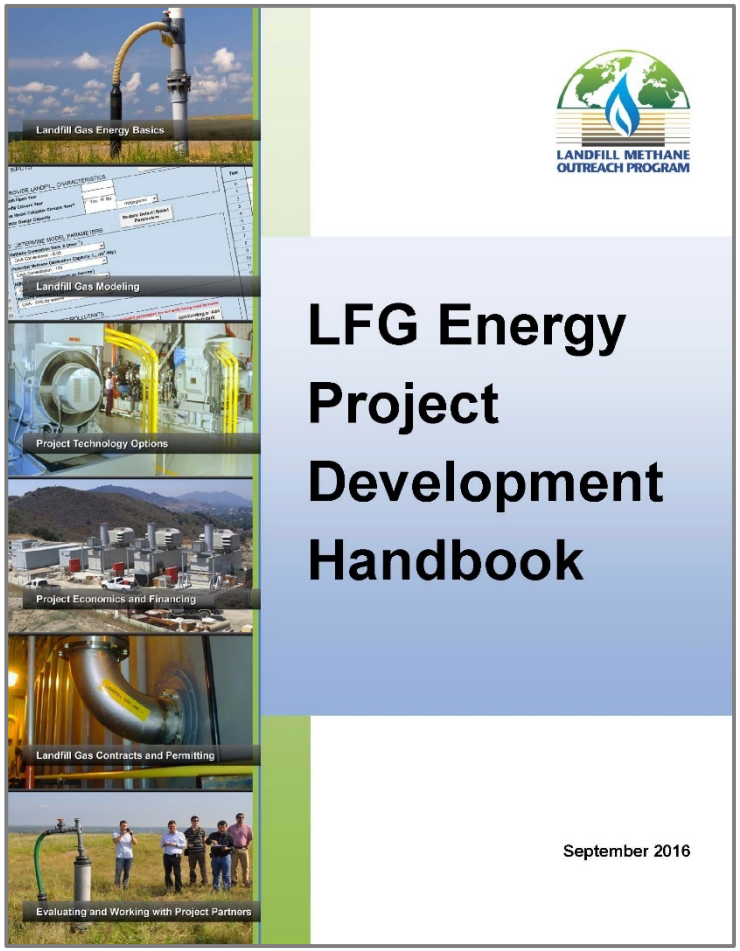
Evaluate the initial economic feasibility of an LFG energy project

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

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