An Overview of Landfill Gas Energy in the United States

U.S. Environmental Protection Agency
Landfill Methane Outreach Program (LMOP)

LANDFILL METHANE OUTREACH PROGRAM

File Last Updated: July 2013

Why EPA is Concerned about Landfill Gas

- Why is methane a greenhouse gas?
  - Methane absorbs terrestrial infrared radiation (heat) that would otherwise escape to space (GHG characteristic)
- Methane as a GHG is over 20x more potent by weight than CO_2
- Methane is more abundant in the atmosphere now than anytime in the past 400,000 years and 150% higher than in the year 1750
- Landfills were the third largest human-made source of methane in the United States in 2011, accounting for 17.5% generated

EPA's Landfill Methane Outreach Program

- Established in Dec 1994 – will begin 20th year in Dec 2013
- Voluntary program that creates partnerships among states, energy users/providers, the landfill gas (LFG) industry, and communities

Mission: To reduce methane emissions by lowering barriers and promoting the development of cost-effective and environmentally beneficial LFG energy projects.

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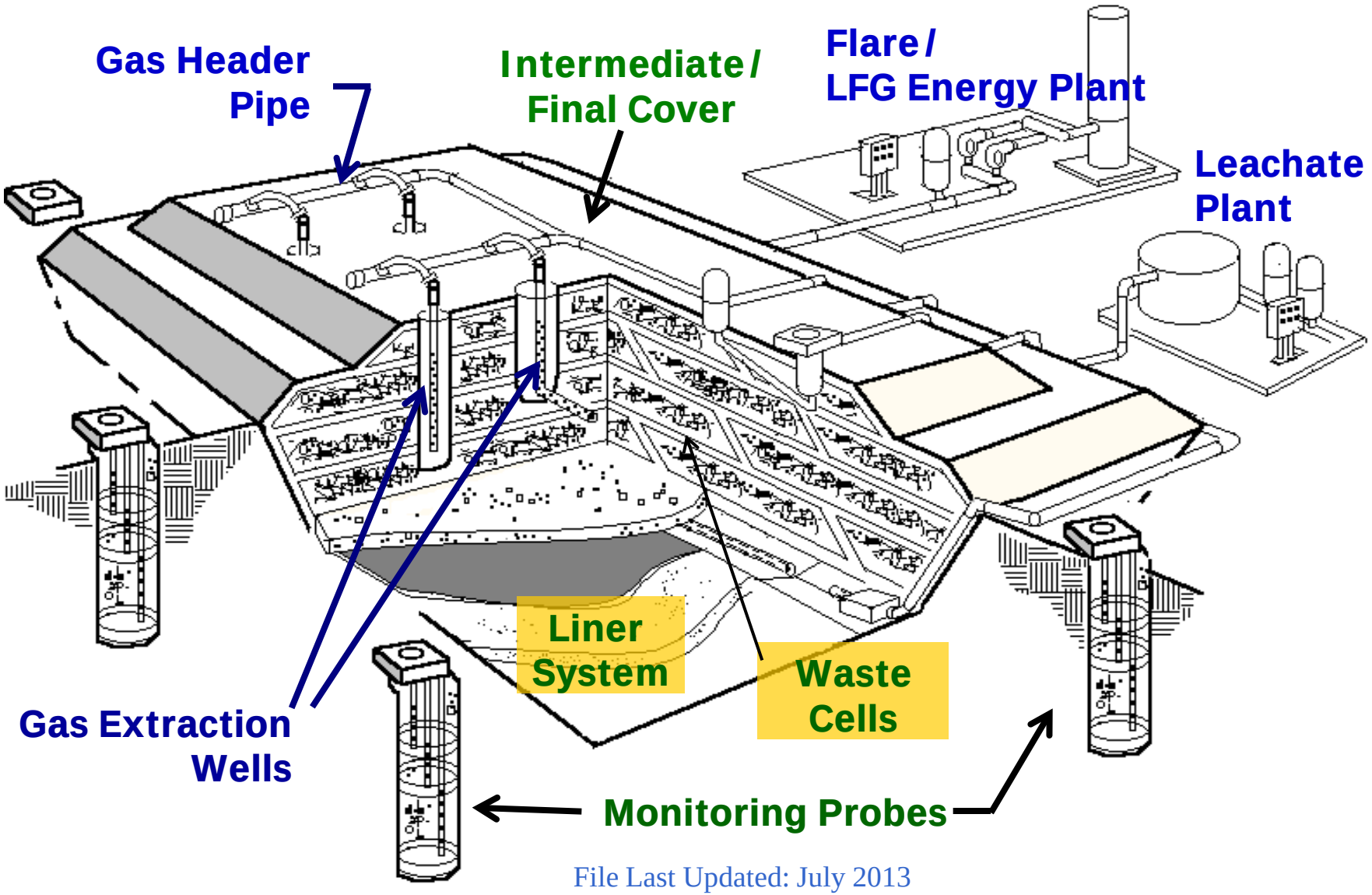
LANDFILL METHANE OUTREACH PROGRAM

Modern Sanitary Landfill



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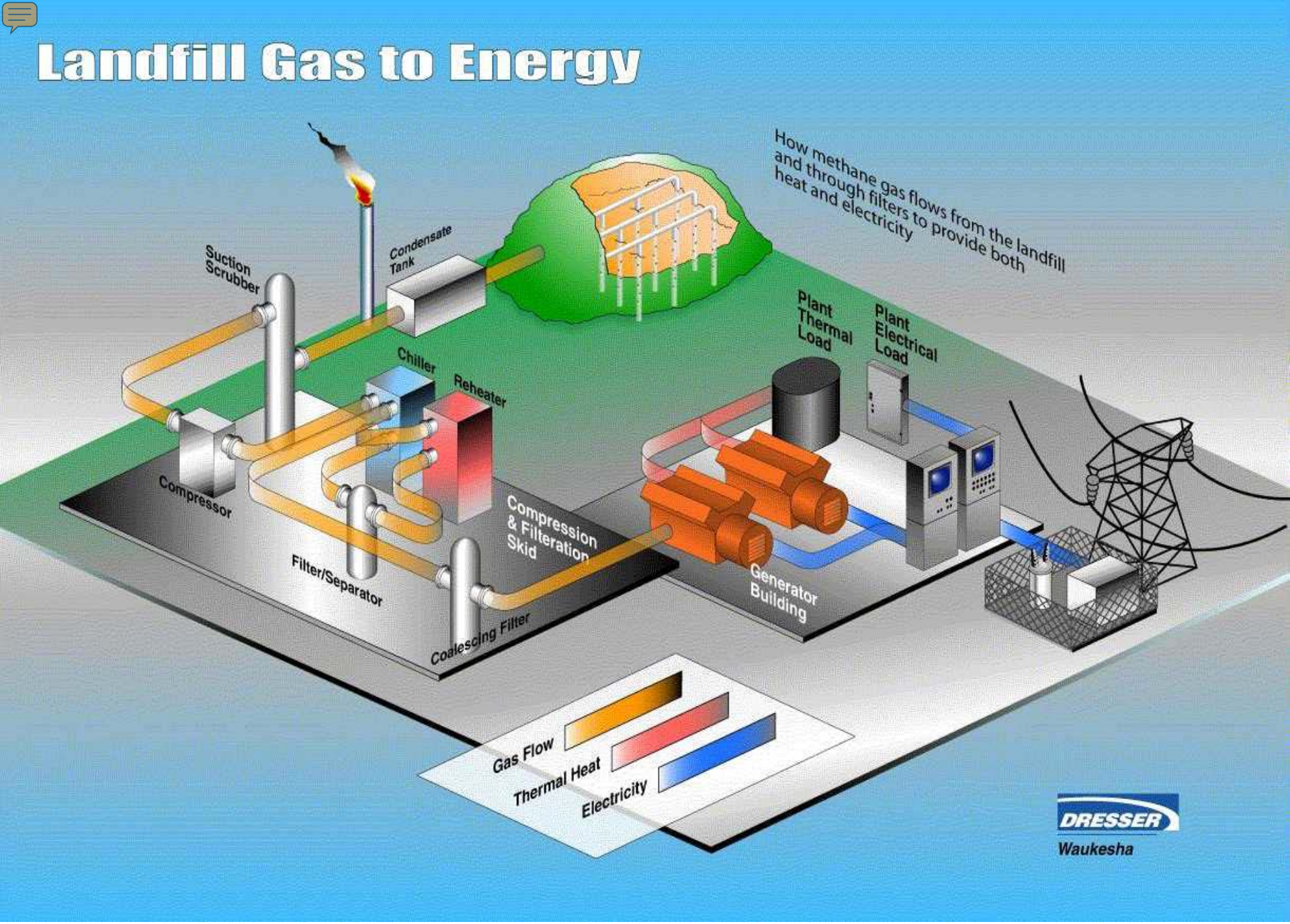
Landfill Gas 101

- LFG is a by-product of the decomposition of municipal solid waste (MSW):
  - ~50% methane (CH_4)
  - ~50% carbon dioxide (CO_2)
  - <1% non-methane organic compounds (NMOCs)
- For every 1 million tons of MSW:
  - ~0.78 megawatts (MW) of electricity
  - ~432,000 cubic feet per day of LFG
- If uncontrolled, LFG contributes to smog and global warming, and may cause health and safety concerns

Landfill Gas to Energy



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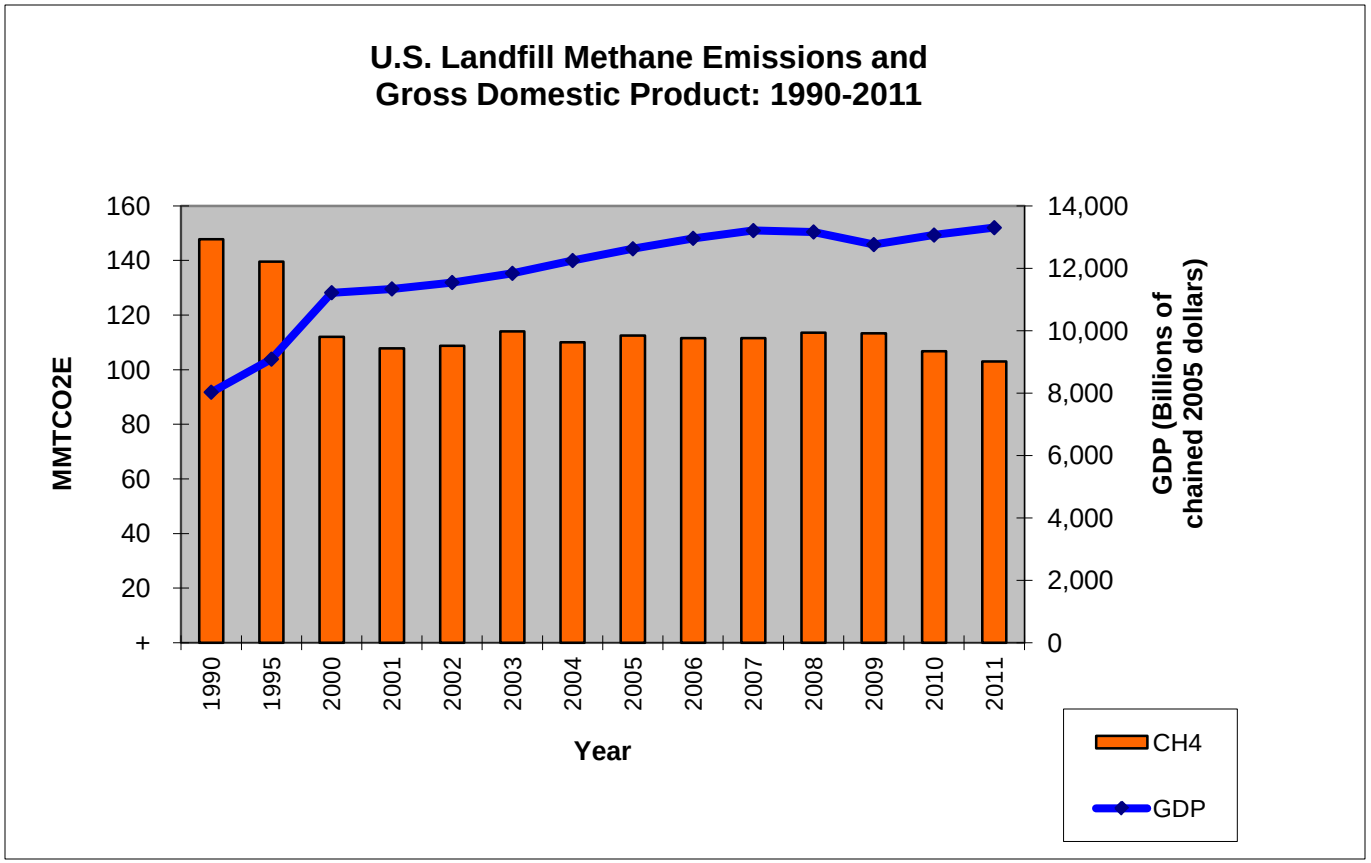
LANDFILL METHANE OUTREACH PROGRAM

Targeting Methane… Producing Measurable Results

Since 1990, U.S. landfill methane emissions have decreased by 30% while GDP increased by 66%



Sources: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011, U.S. EPA, April 2013; DOC/Bureau of Economic Analysis. Interactive National Income and Product Accounts Table. Last revised on June 26, 2013.

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LANDFILL METHANE OUTREACH PROGRAM

LFG Has Helped Produce…

- Aluminum
- Alternative fuels (biodiesel, CNG, ethanol, and LNG)
- Aquaculture (e.g., tilapia)
- Arts & crafts (blacksmithing, ceramics, glass)
- Beer
- Biosolids (drying)
- Bricks, cement, concrete
- Camera film
- Carpet
- Cars and trucks
- Chemicals
- Chocolate
- Consumer goods and containers
- Denim
- Electronics
- Fiberglass, nylon, and paper
- Furthering space exploration
- Garden plants, Venus flytraps
- Green power
- Ice cream, milk, and tea
- Infrared heat
- Juice (apple, cranberry, orange)
- Pet food
- Pharmaceuticals
- Pierogies and snack food
- Soy-based products
- Steel
- Tomatoes (hydroponic)
- **Taxpayer savings and increased sustainability!**

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LANDFILL METHANE OUTREACH PROGRAM

Landfill Gas and Green Power A Winning Combination

- Dual benefit ➔ destroys methane and other organic compounds in LFG
- Offsets use of non-renewable resources (coal, oil, gas), reducing emissions of SO_2, NO_X, PM, CO_2
  - LFG is a recognized renewable energy resource (Green-e, EPA Green Power Partnership, 37 states, NRDC)
  - LFG is generated 24/7 and projects have online reliability over 90%
  - LFG can act as a long-term price and volatility hedge against fossil fuels

LANDFILL METHANE OUTREACH PROGRAM

Typical Electric Project Components & Costs

3-MW, engine, 15-yr project:

- Total capital cost = ~$5.15 million
  - Gas compression & treatment, engine, & generator = ~$4.89 million
  - Interconnect equipment = ~$255,000*
- Annual operation & maintenance cost = ~$526,000/year

*interconnect costs can vary widely

[$2010 capital costs; O&M is the cost in the initial year of project operation (2011).]

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Typical Direct-Use Project Components & Costs

800-scfm, 5-mi pipeline, 15-yr project:

- Total capital cost = ~$2.7 million
  - Gas compression & treatment = ~$1,000,000
  - Pipeline = ~$337,000/mile
  - (Plus end-of-pipe combustion equipment retrofits, if needed)
- Annual operation & maintenance cost = ~$112,000/year

[$2010 capital costs; O&M is the cost in the initial year of project operation (2011).]

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Potential LFG Revenue

Potential Revenue Source	Electric	Direct-Use
Sale of electricity (2.5 – 11 cents/kWh)	X	
Sale of Renewable Energy Certificates (RECs) Compliance market: $1 – $60 / MWh ($2012) Voluntary market: >$1 / MWh ($2012)	X	
Premium pricing for renewables through RPS/RPG or voluntary green power markets	X	
Tax credits or incentives	X	CNG/ LNG
Renewable Fuel RIN sales ($0.60 - $1.00/gal)	(electric vehicles)	CNG/ LNG
Sale of LFG ($1.50 – 4.00 / MMBtu)		X
Greenhouse gas reduction credits	X	X
Energy cost savings	X	X

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Jobs and Revenue Creation

- A typical 3-MW LFG electricity project is estimated to have the following economic & job creation benefits during the construction year:
  - Add more than $1.5 million in new project expenditures for the purchase of generators, and gas compression, treatment skid, and auxiliary equipment
  - Directly create at least 5 jobs for the construction and installation of the equipment
  - Ripple effect: increase the state-wide economic output by $4.1 million & employ 20-26 people throughout the state & local economies

[$2013 (year of construction)]

Jobs and Revenue Creation *(cont.)*

- A typical 1,040-scfm LFG direct-use project is estimated to have the following economic & job creation benefits during the construction year:

	5-mile pipeline	10-mile pipeline
New project expenditures	$1.1 million +	$2.2 million +
Direct installation jobs	At least 7	At least 13
Ripple effect – economic output & employed people	$2.8 million & 17-22 people	$5.2 million & 32 to 41 people

[$2013 (year of construction)]

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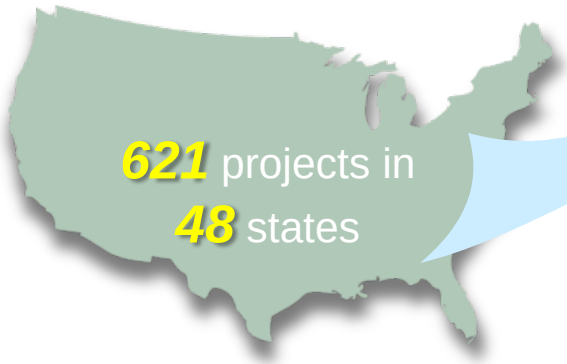
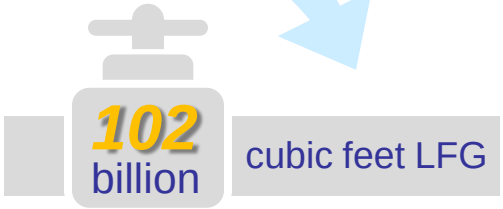
State of the National LFG Industry (July 2013)

LANDFILL METHANE OUTREACH PROGRAM



Annually supply

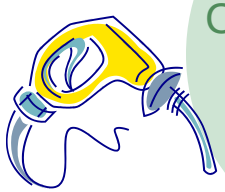


Estimated 2013 Annual Environmental Benefits:

Carbon sequestered annually by ***89 million*** acres of U.S. forests

or CO_2 emissions from ***253 million*** barrels of oil consumed

or CO_2 emissions from ***12.2 billion*** gallons of gasoline consumed



Estimated 2013 Annual Energy Benefits:

Powering ***1,180,000*** homes &

Heating ***746,000*** homes

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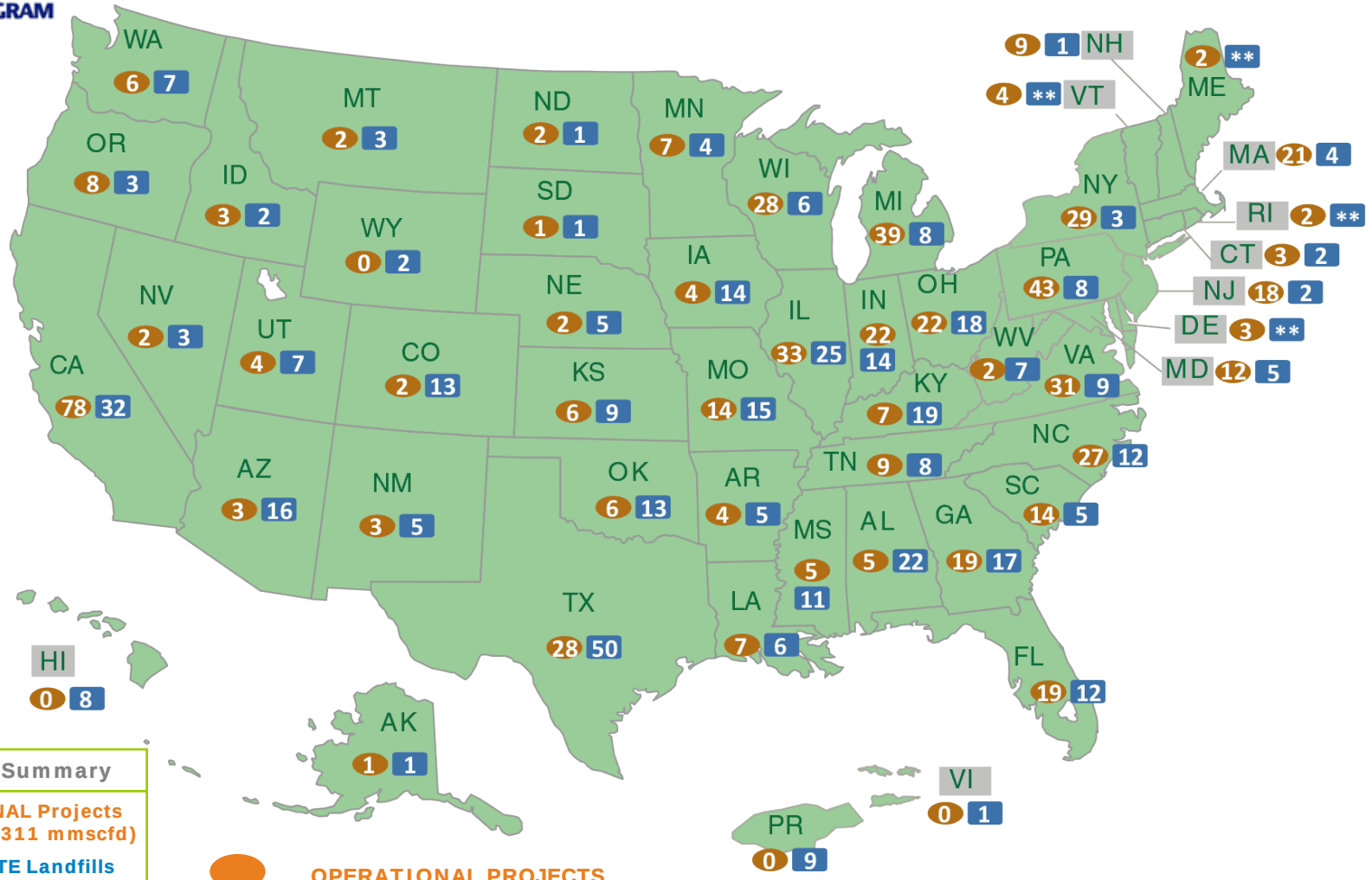
LFG Energy Projects and Candidate Landfills

LANDFILL METHANE OUTREACH PROGRAM



Nationwide Summary

621 OPERATIONAL Projects (1,978 MW and 311 mmscfd)

~450 CANDIDATE Landfills (850 MW or 470 mmscfd, 36 MMTCO$_2$e/yr Potential)

OPERATIONAL PROJECTS

CANDIDATE LANDFILLS*

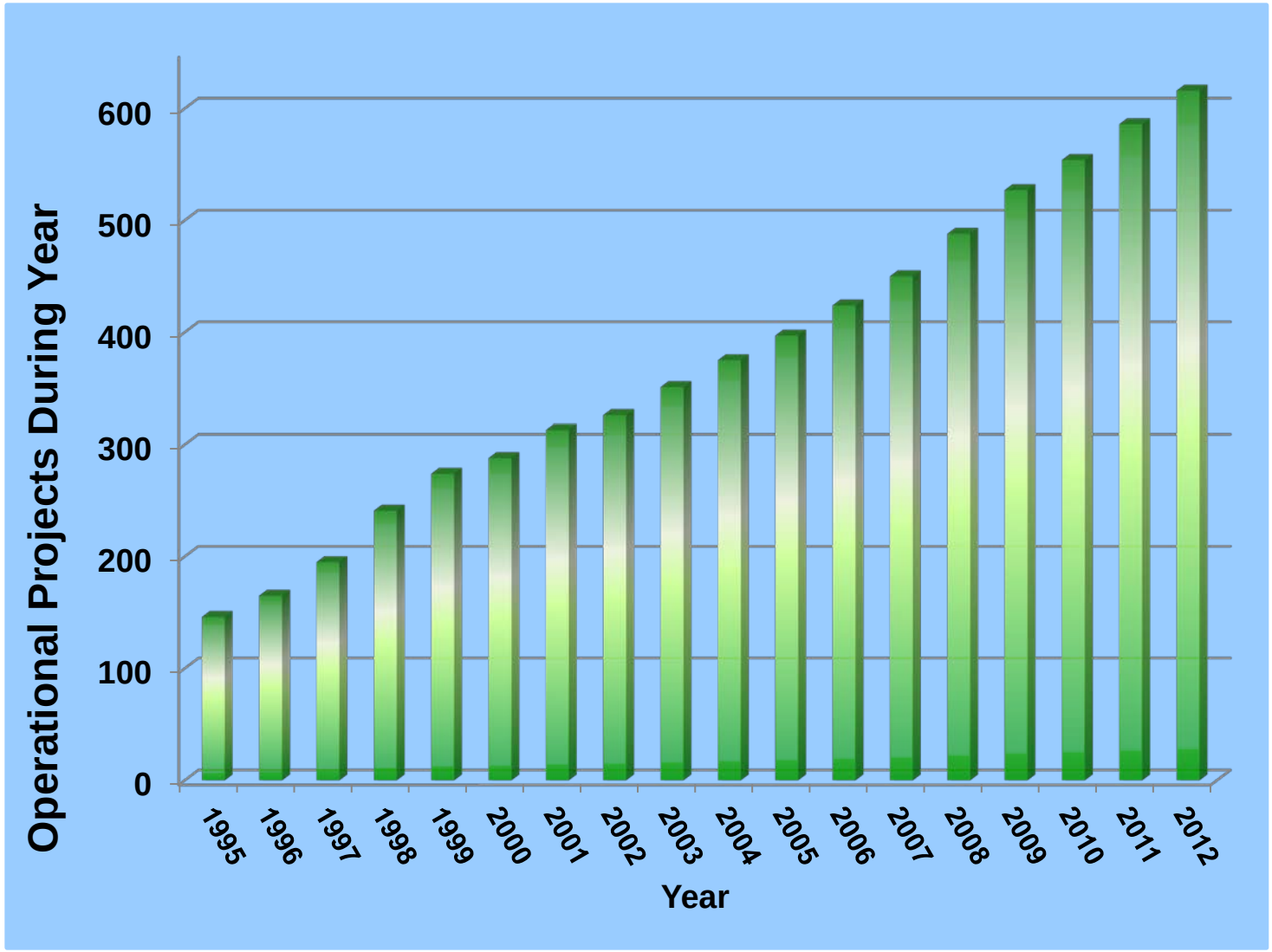
* Landfill is accepting waste or has been closed 5 years or less, has at least 1 mm tons of waste, and does not have an operational, under-construction, or planned project; can also be designated based on actual interest by the site.

** LMOP does not have any information on candidate landfills in this state.

These data are from LMOP's database as of July 16, 2013.

LANDFILL METHANE OUTREACH PROGRAM

LFG Energy Project Growth Over Time



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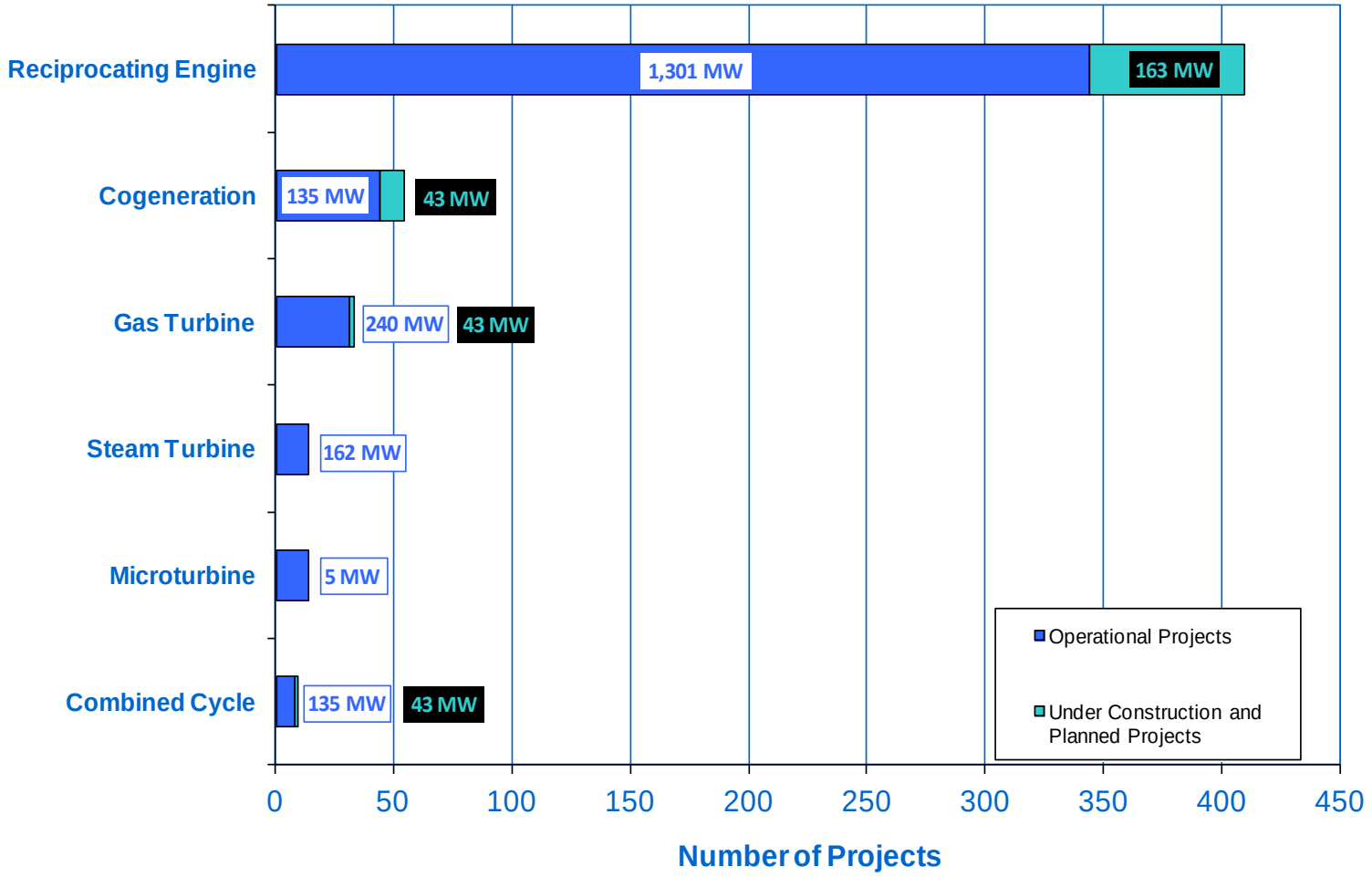
LANDFILL METHANE OUTREACH PROGRAM

Technology Trends
Electricity Projects



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Diversity of Project Types
Electricity Generation

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)

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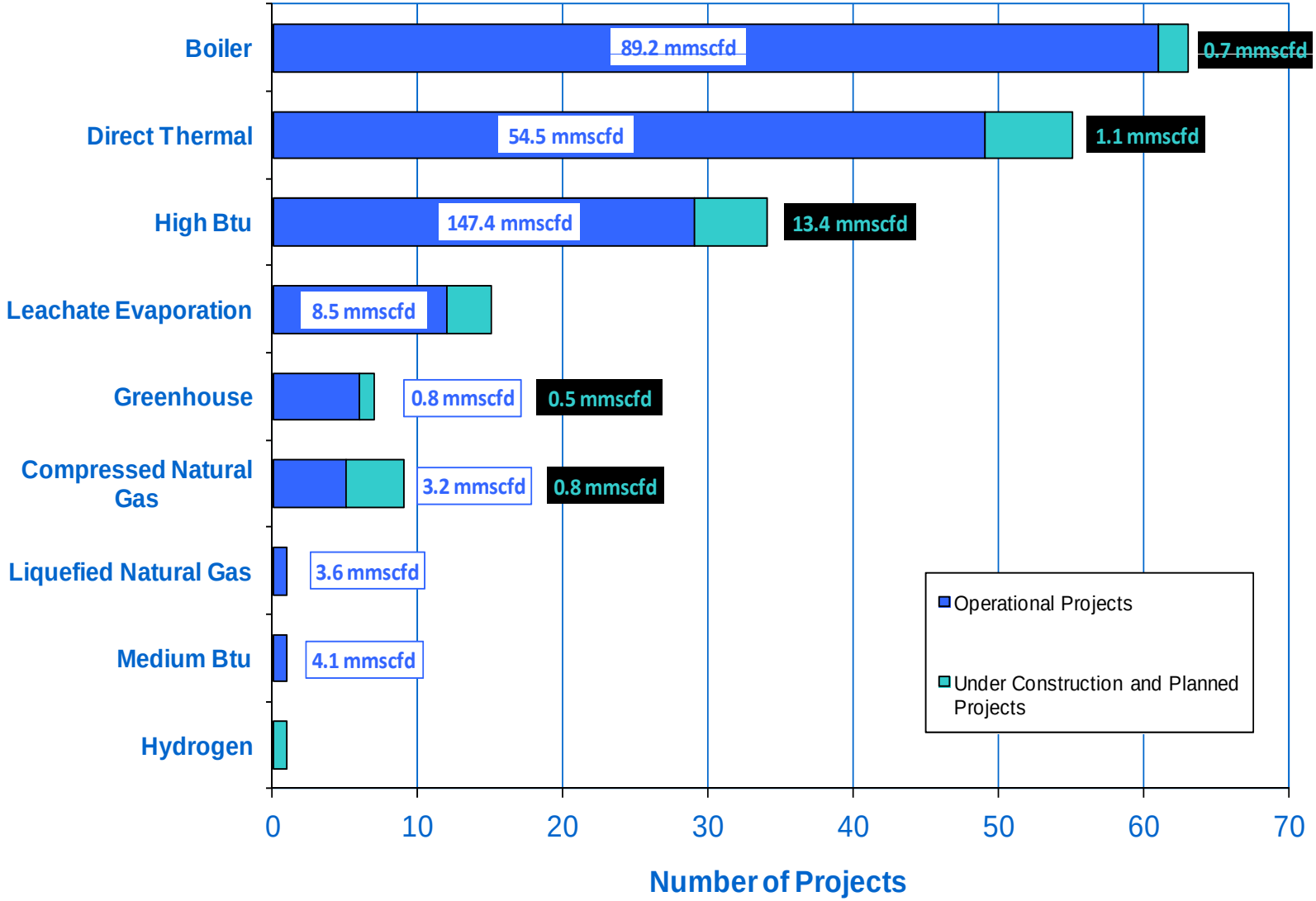
LANDFILL METHANE OUTREACH PROGRAM

Technology Trends
Direct-Use Projects



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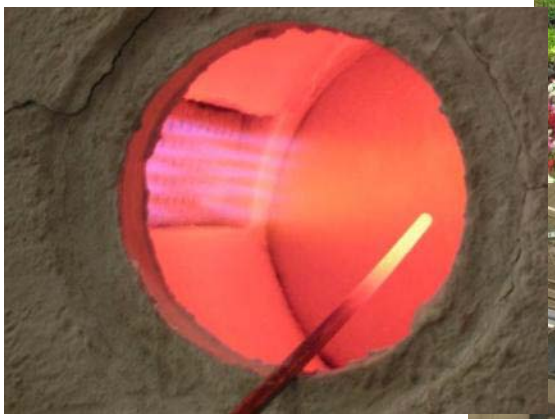
Diversity of Project Types
Direct Use of LFG

- Direct-use projects are growing!
  - Boiler applications – replace natural gas, coal, fuel oil
  - Direct thermal (dryers, kilns)
  - Natural gas pipeline injection (medium- & high-Btu)
  - Ethanol production
  - Greenhouse
  - Infrared heaters
  - Leachate evaporation
  - Vehicle fuel (LNG, CNG)
  - Glassblowing & pottery
  - Blacksmithing
  - Hydroponics
  - Aquaculture (fish farming)

Greenhouse
Jackson County, NC



Glassblowing
Jackson County, NC

Infrared heater - Lorton, VA

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Market Overview / Industry Trends

- 300% increase in # of LFG energy projects (1995-2012)
- Electricity projects continue to dominate – 75% now
- Direct use of LFG has slowed, mainly due to LOW NG prices ($5.00/MMBtu in ‘13 vs. peak of $13.06/MMBtu in ‘08)
- Alternative vehicle fuel taking off
  - CNG $2.10/GGE vs. diesel $3.99/gal in Spring 2013
  - RINs under Renewable Fuel Standard 2
- Corporate sector interest challenged with low gas prices and financial constraints
- Low carbon and REC prices in most of country
- Maturing industry – consolidations within the waste companies and project developers

Emerging Technologies: LFG for Vehicle Fuel

- POET plant in Sioux Falls, SD uses LFG from local landfill to create ethanol (Feb. 2009)
- Waste Management & Linde produce 13,000 gal LNG per day for garbage trucks (Altamont LF, Sept. 2009)
- Central LF, CA LFG-to-CNG pilot project fuels Sonoma County school buses (Sept. 2009)
- Dane County, WI's pilot project produces 100 GGE/day bioCNG from 20 cfm LFG to fuel on-site vehicles (Mar. 2011); Upgrading to produce 250 GGE/day
- Biofuels Washington will create 900 diesel gal equivalents/day of CNG to fuel 159 trucks using 570 cfm LFG from the LRI Landfill, WA (2014)

Regulations that Affect LFG Energy

- LFG energy projects may be affected by a variety of federal, state, and local air quality regulations
- Applicable federal Clean Air Act regulations 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)

Helpful Links to Regulations Affecting LFG Energy Projects

- PSD and Title V GHG Tailoring Rule: http://www.epa.gov/nsr/ghgpermitting.html
- 2010/2011 Internal Combustion Engines NESHAP: http://www.epa.gov/ttn/atw/rice/ricepg.html
- 2011 Internal Combustion Engines NSPS: http://www.epa.gov/ttn/atw/nsps/sinsps/sinspspg.html
- 2012 Major Source Boiler/Process Heater NESHAP: http://www.epa.gov/ttn/atw/boiler/boilerpg.html
- NSPS/EG for MSW Landfills: http://www.epa.gov/ttn/atw/landfill/landflpg.html
- NESHAP for MSW Landfills: http://www.epa.gov/ttn/atw/landfill/lndfillpg.html

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GHG Regulatory Update

- GHG Reporting Program (subpart HH)

  http://www.epa.gov/climatechange/emissions/ghgrulemaking.html

  - MSW landfills required to report emissions & other data if annual CH_4 generation ≥ 25,000 metric tons CO_2e
  - 2012 data submitted by April 1, 2013 included inputs to emission equations that were originally deferred – data will be available later in 2013
  - 2011 & 2010 data – available at http://www.epa.gov/climatechange/emissions/ghgdata/index.html
  - Can drill down to MSW landfills in your area using EPA's FLIGHT - http://ghgdata.epa.gov/ghgp/main.do
  - ~1,200 MSW landfills reported GHG emissions in 2011
  - LMOP will update its database and identify any new candidate landfills using 2012 GHGRP data

LFG and State Renewable Portfolio Standards

- LFG is eligible as a renewable resource in 37 states, the District of Columbia, Guam, Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands
- Renewable Portfolio Standard (RPS) – requires utilities to supply a percentage of power from renewable resources
  - 29 states plus DC, Guam, N. Mariana Islands, Puerto Rico, and U.S. Virgin Islands have an RPS
- Renewable Portfolio Goal (RPG) – same as RPS except an objective not a requirement
  - 8 states have an RPG

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Public and Private Entities Moving to Reduce GHG Emissions

- Voluntary Markets
  - In 2012, U.S. purchased more offsets (all types) – $143 million – than buyers in any other single country
  - LFG project offsets purchased in 2012 (2.8 $MtCO_2e$) represented 13% of U.S. project type market share
  - LFG projects supplied 5% of global VERs in 2012
  - Avg. credit price for LFG projects: ~$1.50-3.00/tCO2e

Registries with LFG Capture and/or Utilization Projects (as of July 2013)	
American Carbon Registry	12
Climate Action Reserve	146 (87 are registered)
Verified Carbon Standard	18

- Compliance Markets
  - RGGI (2009), California AB-32 (2012)
  - Methane projects likely an eligible offset category

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Financial Incentives

- Section 45 Production Tax Credit (PTC)
  - Electricity generation – 1.1 cents/kWh
  - Began construction by 12/31/13; 10-yr window for credits
- Excise Tax Credit to the Seller of CNG or LNG (PL 111-312, § 701)
  - $0.50 per gallon of gasoline equivalent for fuel sold or used by 12/31/13
  - Investment tax credit for fueling stations - 30% of cost up to $30,000
- Renewable Energy Production Incentive (REPI)
  - Online by 10/1/16; payment for 1st 10 years of operation
  - Subject to allocation, no allocations since 2010
- Many State grants, tax exemptions, and other funding mechanisms
  - www.epa.gov/lmop/publications-tools/funding-guide/index.html updated frequently

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Renewable Fuel Standard 2 (RFS2)

- Companies in the U.S. petroleum market must produce a given quantity of renewable fuel OR purchase credits
  - RFS2 requires 36 billion gallons of renewable fuel to be blended into transportation fuel by 2022
  - Volumes tracked as Renewable Identification Numbers (RINs) – 13 RINs per MMBtu
  - Biogas (including LFG) sold as transportation fuel is eligible for Green Tag Attributes or RINs
- Proposed rule in June 2013 to modify RFS2 - www.epa.gov/oms/fuels/renewablefuels/regulations.htm
  - Will allow RINs from renewable diesel, naphtha & electricity (for electric vehicles) made from LFG


FUJIFILM
HILL AIR FORCE BASE, Utah
OGDEN AIR LOGISTICS CENTER
DART
NASA
GEO SPECIALTY CHEMICALS
Stouffer's
Kimberly-Clark
BORAL
NOVOLYTE technologies
Rolls-Royce
Envision GUNDERSEN HEALTH SYSTEM
DEPARTMENT OF JUSTICE FEDERAL BUREAU OF PRISONS
GM
NEW HOLLAND CONCRETE A Better Building Partner
LAFARGE
H.R. EWELL INC.
ANHEUSER BUSCH Companies
STYRON
Look Who's Using Landfill Gas!
Coca-Cola
InterfaceFLOR
Honeywell
INTERNATIONAL
CONE corporatedenimfinishingjacquards
The Solae Company
AJINOMOTO
MARS snackfood
SC Johnson A FAMILY COMPANY
DUPONT The miracles of science
AFP advanced food products llc
Cargill
BMW The Ultimate Driving Machine
POET Energy inspired.
MARINE CORPS LOGISTICS BASE ALBANY, GEORGIA
MALLINCKRODT
Tropicana
Ford
Tyson
SUNOCO
UFR URBAN FOREST RECYCLERS INCORPORATED A HILL COMPANY
L&S SWEETENERS
Jenkins Brick Company
CNH

Look Who's Talking about LFG!

LANDFILL METHANE OUTREACH PROGRAM

Electricity – Reciprocating Engine

Anne Arundel County's Millersville LF, Severn, MD

LMOP 2012 Project of the Year

- County persisted for 12 years on quest for project
- 3.2 MW goes to PJM
- Financed with local bond sales and $2 million in American Recovery and Reinvestment Act (ARRA) funding
- Team of government agencies & private companies collaborated

Northeast Maryland Waste Disposal Authority

ANNE ARUNDEL COUNTY MARYLAND

Landfill Energy Systems

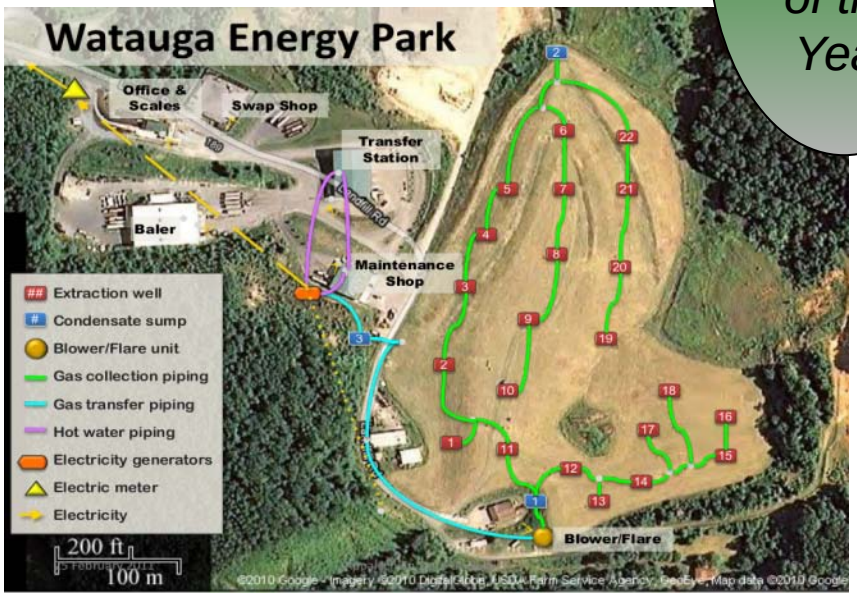
LANDFILL METHANE OUTREACH PROGRAM

Electricity – Unique Engine Type

Watauga County Landfill, Boone, NC

LMOP 2012 Project of the Year

- Self-developed by the County with assistance from Appalachian State University Energy Center
- (2) LFG-fueled, modified automotive engines generate 186 kW; plan to recover waste heat



energy Appalachian STATE UNIVERSITY

CORPORATE SEAL OF WATAUGA COUNTY 1849 NORTH CAROLINA

- Provides the county $72,000 in profits annually
- Model for other small-scale projects in NC as well as providing tours to the community

LANDFILL METHANE OUTREACH PROGRAM

Electricity – On-Site Combined Heat & Power

Lycoming County Landfill, Montgomery, PA

- (4) engines generate 6.2 MW with recovered heat used for county facilities
- (2) of the engines are directly connected to the high security prison complex

LMOP 2012 Project of the Year

PPL Renewable Energy

CATERPILLAR®

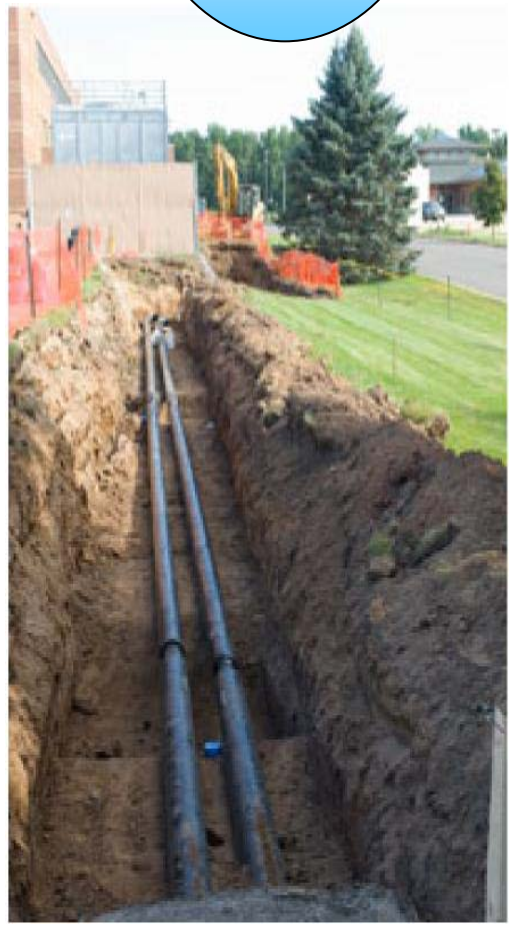
- Provides 80% of Federal Bureau of Prisons' Allenwood Correction Complex' electricity and 90% of landfill's power & thermal needs
- Supports county and federal government plans to reduce environmental impacts, improve energy efficiency, create jobs, and increase revenues

Electricity – Off-Site Combined Heat & Power

La Crosse County LF, La Crosse, WI

LMOP 2012 Project of the Year

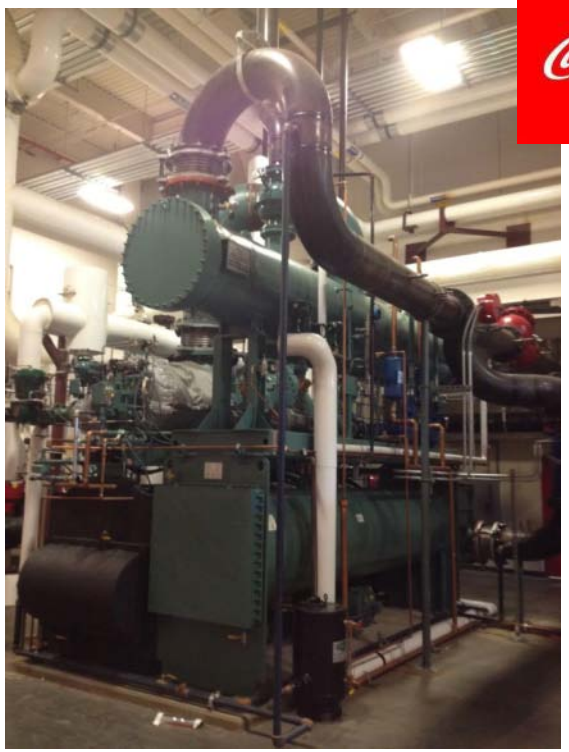
- LFG piped 2 miles – under an interstate – to Gundersen for electricity generation from (1) 1.1-MW engine and on-site production of heat and hot water
- In 2012: County earned $176,000 from sale of LFG while Gundersen earned $400,000 from sale of electricity & saved $100,000 in heating costs



- Gundersen Onalaska Campus is 100% energy independent thanks to LFG energy

Electricity – Combined Cooling, Heat, and Power

Hickory Ridge Landfill, Conley, GA



LMOP 2012 Project of the Year

- Permitted (3) engines in a severe ozone non-attainment area in 100 days
- LFG provides a continuous supply of renewable electricity, steam, and chilled water to the Coca-Cola Atlanta Syrup Branch facility

- LFG treatment & combustion at 2 separate sites connected by 6-mile pipeline

Electricity – Combined Cycle
Olinda Alpha LF, Brea, CA

LANDFILL METHANE OUTREACH PROGRAM

ORANGE COUNTY Waste&Recycling
Our Community. Our Commitment.

BROADROCK RENEWABLES™ LLC

DCO Energy

ANAHEIM PUBLIC UTILITIES
ANAHEIM.NET/UTILITIES

- High-efficiency (45%) combined cycle process captures waste exhaust heat from (4) gas turbines to create additional electricity – 32.5 MW total
- 2-stage siloxane removal system & post-combustion SCR for NO_x control
- $10 million ARRA funding & Section 1603 grant
- Annual County revenues ~$2.75 million
- Innovative re-use of water saves 32,000 gal/day

LMOP 2012 Project of the Year

Solar Turbines
A Caterpillar Company

LANDFILL METHANE OUTREACH PROGRAM

Alternative Fuel – CNG

St. Landry Parish Landfill, Washington, LA

LMOP 2012 Project of the Year

BioCNG™

- Converts 50 scfm LFG into 250 gallons of gasoline equivalent/day of CNG
- CNG fuels government vehicles including Sheriff department cars, light duty trucks, and solid waste district utility trucks
- Self-developed with help from several contractors

ST. LANDRY PARISH SOLID WASTE

gt environmentalfinance, LLC

RPH

CORNERSTONE Environmental Group, LLC

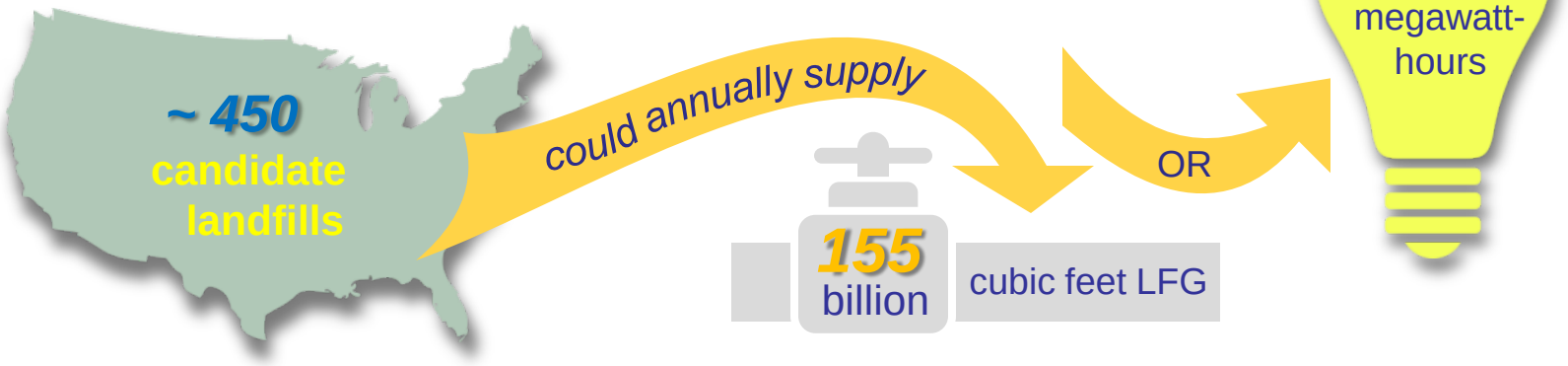
Landfill Energy Systems, Novi, MI

- Operates and maintains 38 U.S. LFG energy projects: electricity, direct-use, and high Btu facilities
- Processes >141 mmscfd LFG, generating 1.46 MMBtu of renewable natural gas & 2 million MWh of renewable electricity per year
- One of the oldest and largest privately owned developers of LFG energy projects
- Has developed 49 projects in 18 states

LMOP 2012 Industry Partner of the Year

LANDFILL METHANE OUTREACH PROGRAM

Many Untapped LFG Resources



Potential Annual Environmental Benefits:

Carbon sequestered annually by ***30 million*** acres of U.S. forests

or CO_2 emissions from ***86 million*** million barrels of oil consumed

Potential Annual Energy Benefits:

Powering ***500,000*** homes

OR

Heating ***1,100,000*** homes

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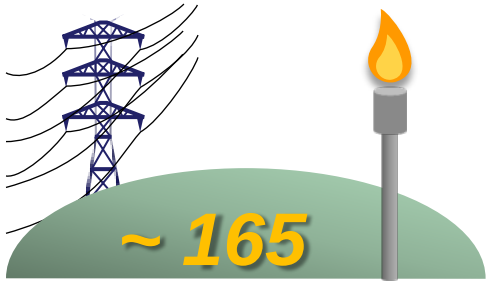
Many Untapped LFG Resources *(cont.)*

LANDFILL METHANE OUTREACH PROGRAM

Landfill Group:		Energy Potential:	
 ~ 165 have energy project with excess LFG	can generate	OR 81,000 MMBtu/day	320 MW
 ~ 570 have gas collection but no energy project	can generate	OR 225,000 MMBtu/day	890 MW
 ~ 895 have no gas collection	can generate	OR 184,000 MMBtu/day	725 MW

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Untapped LFG – Carbon Credit Resources

LANDFILL METHANE OUTREACH PROGRAM

525 *landfills*
– no operational project
and not required by federal regulation to collect and combust LFG

Reduction Potential:

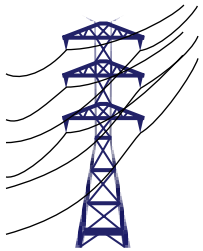
1,400,000
short tons of methane per year
(26 MMTCO$_2$e/yr)

AND

Energy Potential:

OR

102
billion
cubic feet per year
(~ 6,900 MMBtu/hr)



650
MW
(~ 5.3 million MWh/yr)

File Last Updated: July 2013

LMOP Tools and Services

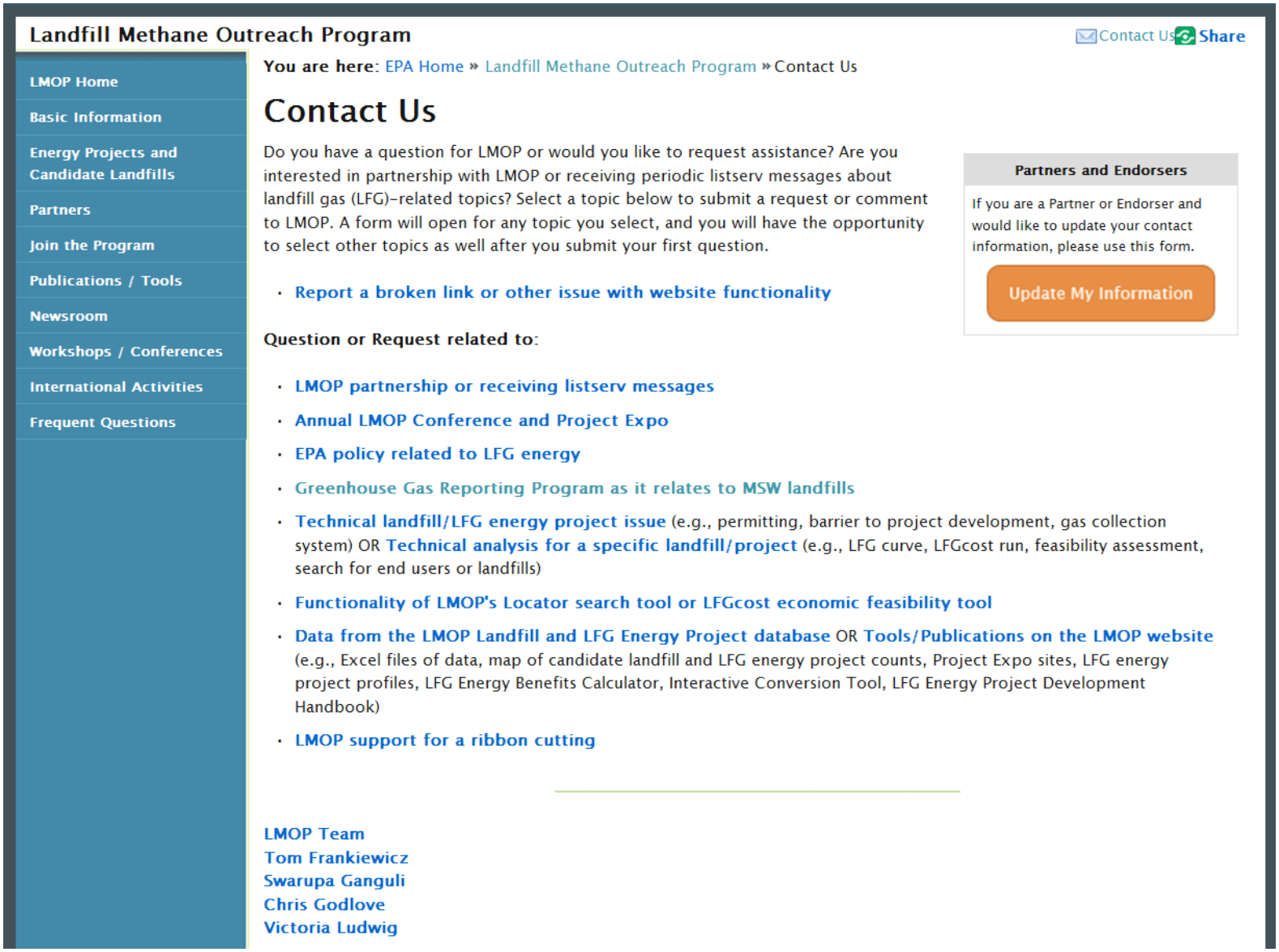
- Website: www.epa.gov/lmop
- Direct project assistance
- Technical and outreach publications
- Project and candidate landfill database
- Network of 1,000+ Partners
- Listserv
- Support for ribbon cuttings/other PR
- Presentations at conferences
- State training workshops
- *Annual LMOP Conference, Project Expo & Partner Awards*

How Can We Work Together? Direct Project Assistance

- Analyze landfill resource – gas modeling
- Identify potential matches – *LMOP Locator* (tool available on website!)
- Assess landfill and end user facilities
- Look at project possibilities
  - Direct-use (boiler, heating, cooling, direct thermal)
  - Combined Heat & Power (engine, turbine, microturbine)
  - Electric (engine, turbine, microturbine)
  - Alternative Fuels (medium- or high-Btu, CNG, LNG)
- Initial feasibility analyses – *LFGcost*
  - New boiler retrofit cost analysis

For More Information

www.epa.gov/lmop/contact.html



Landfill Methane Outreach Program

Contact Us Share

- LMOP Home
- Basic Information
- Energy Projects and Candidate Landfills
- Partners
- Join the Program
- Publications / Tools
- Newsroom
- Workshops / Conferences
- International Activities
- Frequent Questions

You are here: EPA Home » Landfill Methane Outreach Program » Contact Us

Contact Us

Do you have a question for LMOP or would you like to request assistance? Are you interested in partnership with LMOP or receiving periodic listserv messages about landfill gas (LFG)–related topics? Select a topic below to submit a request or comment to LMOP. A form will open for any topic you select, and you will have the opportunity to select other topics as well after you submit your first question.

Partners and Endorsers

If you are a Partner or Endorser and would like to update your contact information, please use this form.

Update My Information

- Report a broken link or other issue with website functionality

Question or Request related to:

- LMOP partnership or receiving listserv messages
- Annual LMOP Conference and Project Expo
- EPA policy related to LFG energy
- Greenhouse Gas Reporting Program as it relates to MSW landfills
- Technical landfill/LFG energy project issue (e.g., permitting, barrier to project development, gas collection system) OR Technical analysis for a specific landfill/project (e.g., LFG curve, LFGcost run, feasibility assessment, search for end users or landfills)
- Functionality of LMOP's Locator search tool or LFGcost economic feasibility tool
- Data from the LMOP Landfill and LFG Energy Project database OR Tools/Publications on the LMOP website (e.g., Excel files of data, map of candidate landfill and LFG energy project counts, Project Expo sites, LFG energy project profiles, LFG Energy Benefits Calculator, Interactive Conversion Tool, LFG Energy Project Development Handbook)
- LMOP support for a ribbon cutting

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