

# **Methane Emissions in the United States: Sources, Solutions & Opportunities for Reductions**



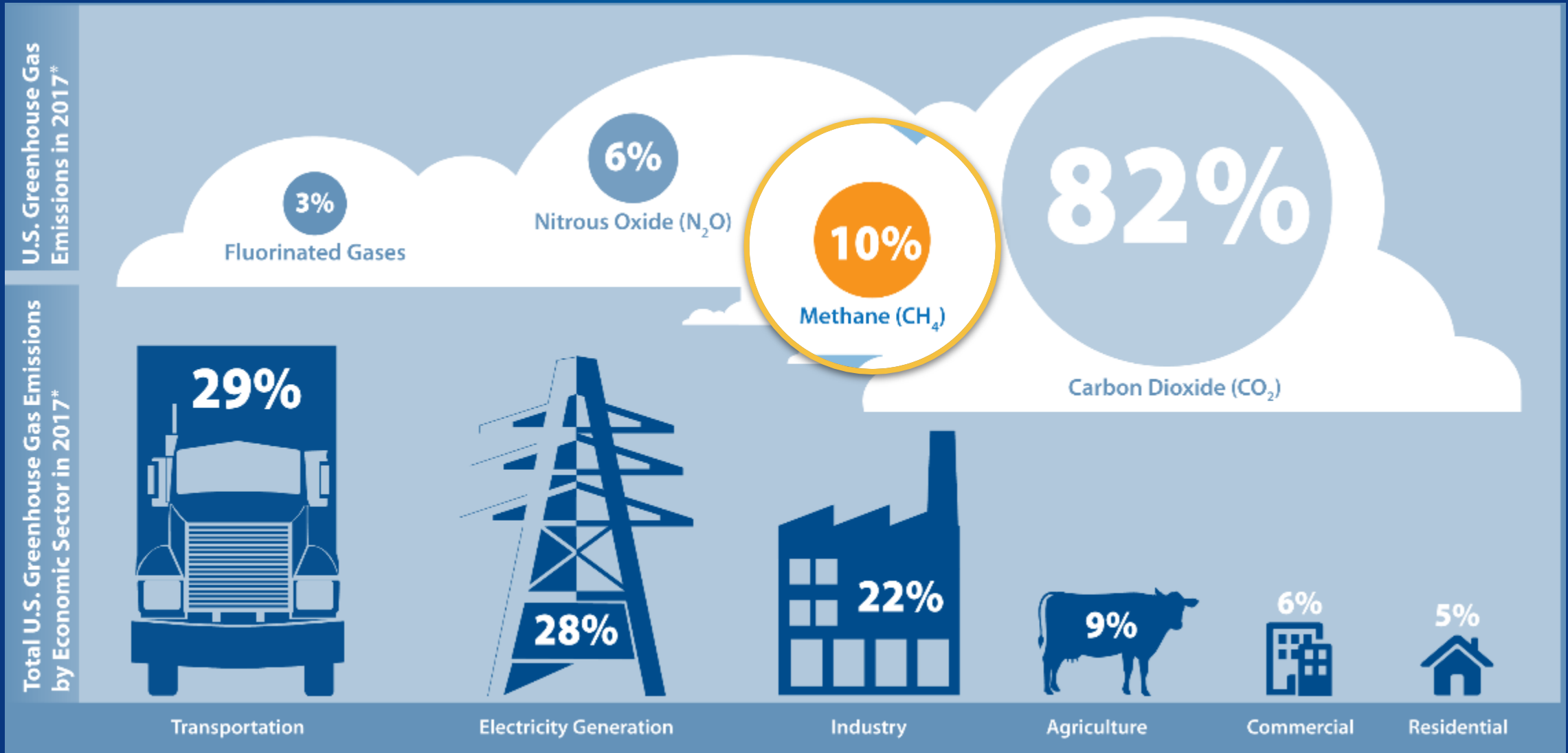
May 23, 2019



# Presentation Overview

- U.S. methane emissions & sources
- Why methane matters
- Methane mitigation by emission source
- Spotlight on Renewable Natural Gas
- Helpful tools and resources

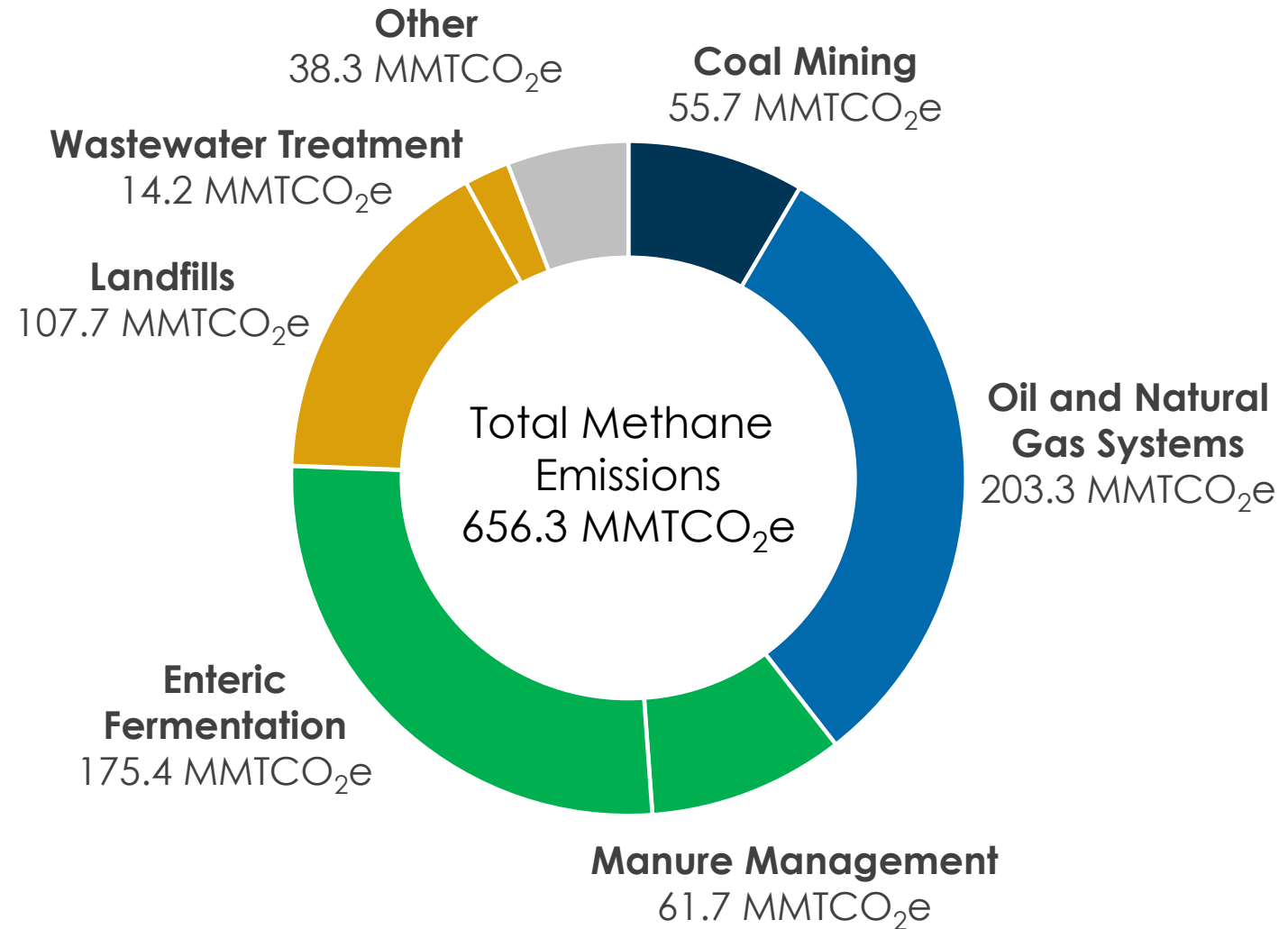
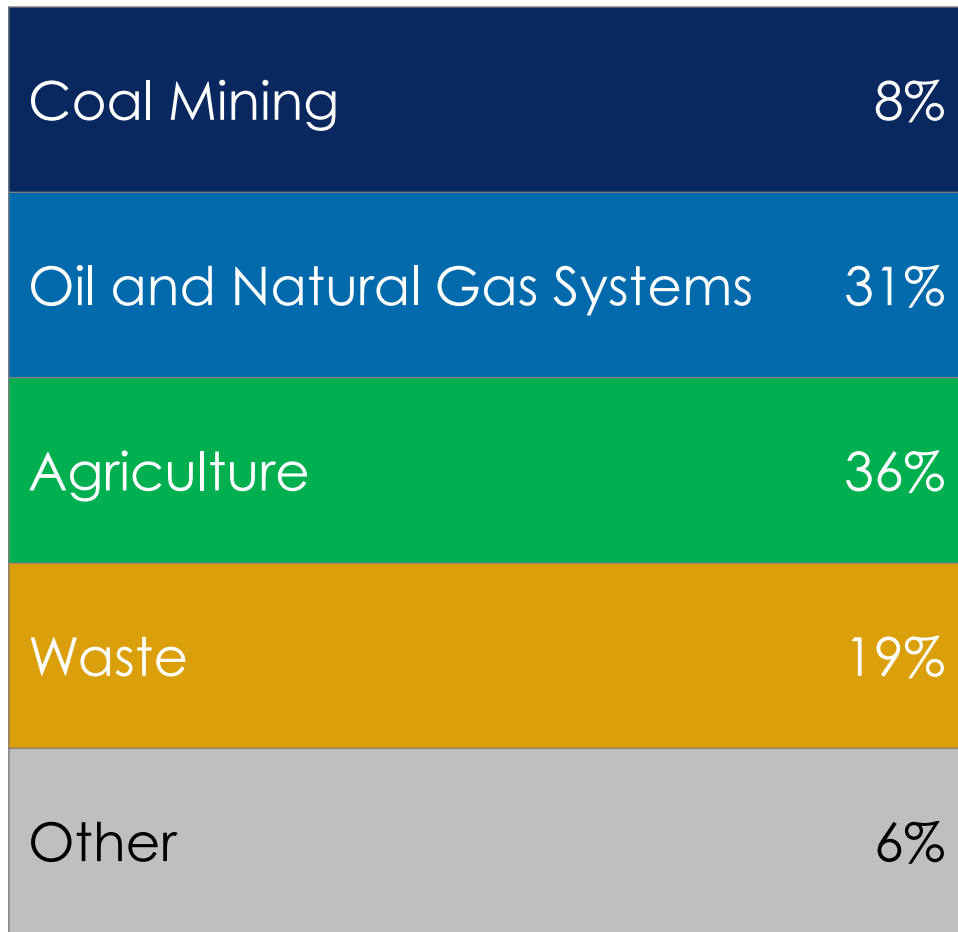
# U.S. Greenhouse Gas Emission Sources



\*Percentages may not add to 100% due to independent rounding and the way the inventory quantifies U.S. territories (not shown) as a separate sector.

Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017

# 2017 U.S. Methane Emissions, by Source



Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017

# Why Methane Matters



## Positive Outcomes of Capturing and Using Methane

- ✓ Better air and water quality
- ✓ Improved human health
- ✓ Increased worker safety
- ✓ Enhanced energy security
- ✓ Economic growth
- ✓ Reduced odors

### Methane Emissions

Trap 28 times more heat than carbon dioxide over 100 years

Contribute to ground-level ozone pollution

Create industrial safety problem

### Methane Mitigation

Opportunity to capture and convert methane to useful energy

The background of the slide is a high-angle photograph of Earth from space, showing the curvature of the planet, blue oceans, and white clouds. The text is overlaid on a white rectangular area at the top and a dark blue rectangular area at the bottom.

# **Methane Mitigation by Emission Source**

- Coal Mines
- Oil and Natural Gas Systems
- Agriculture (Manure Management and Enteric Fermentation)
- Waste (Wastewater Treatment and Landfills)

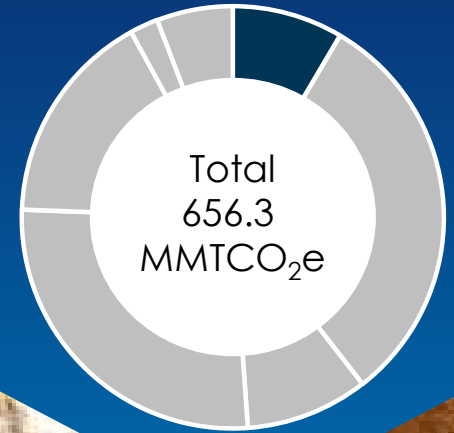
# Coal Mines

Methane is released from coal and surrounding rock strata due to mining activities. In abandoned mines and surface mines, methane might also escape to the atmosphere through natural fissures or other diffuse sources.



8%

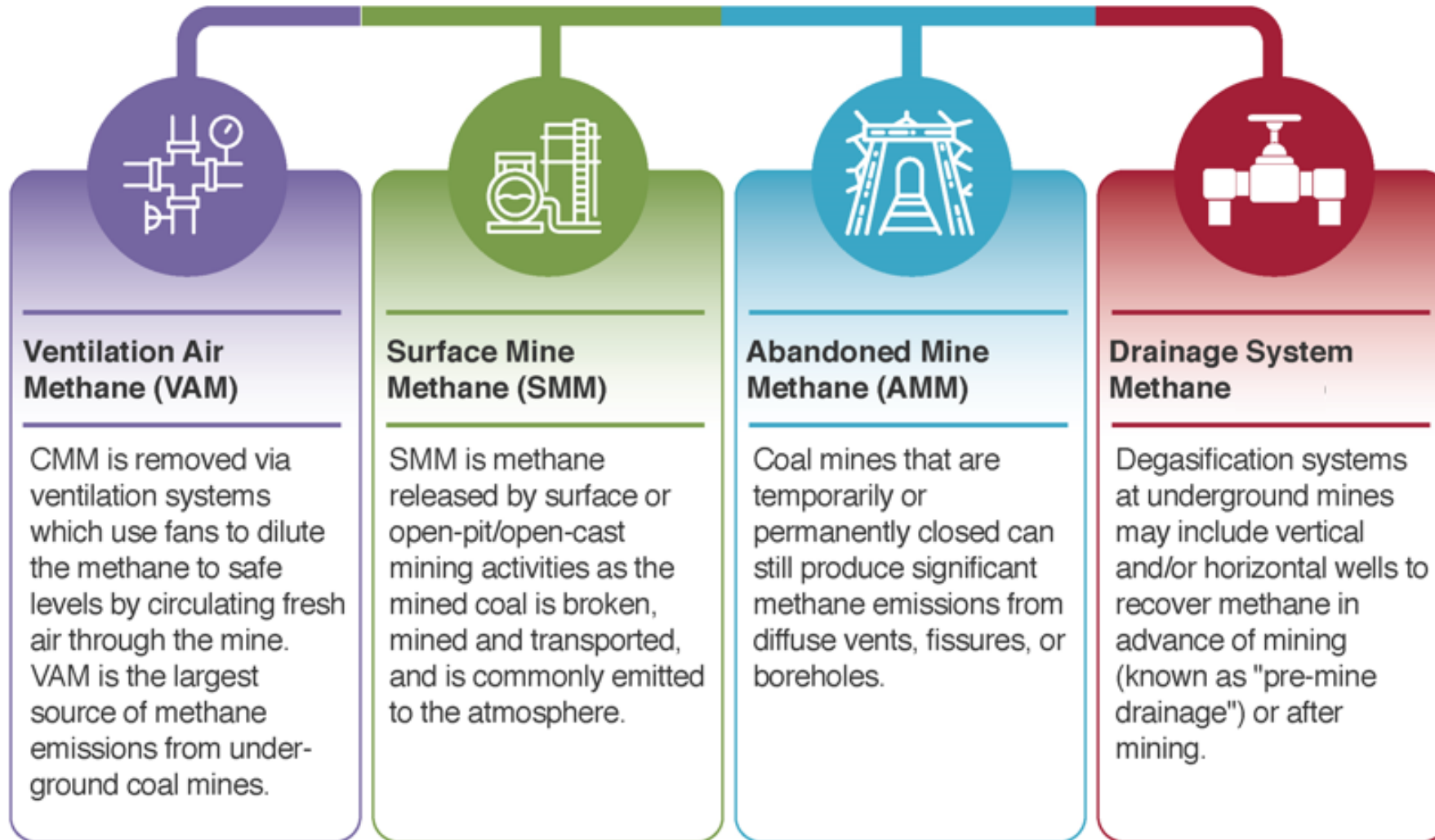
55.7 MMTCO<sub>2</sub>e



Total  
656.3  
MMTCO<sub>2</sub>e

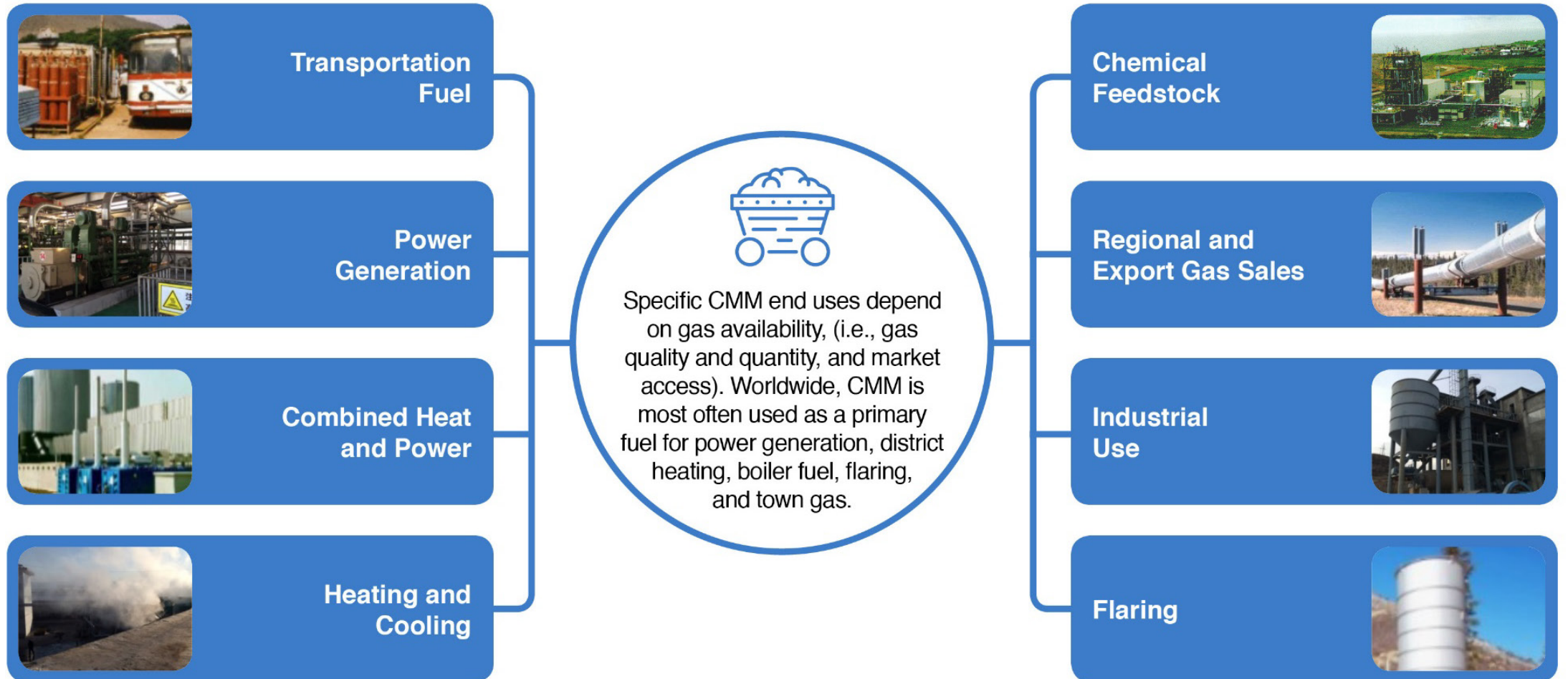


## Sources of Coal Mine Methane (CMM)





# CMM END USE OPTIONS



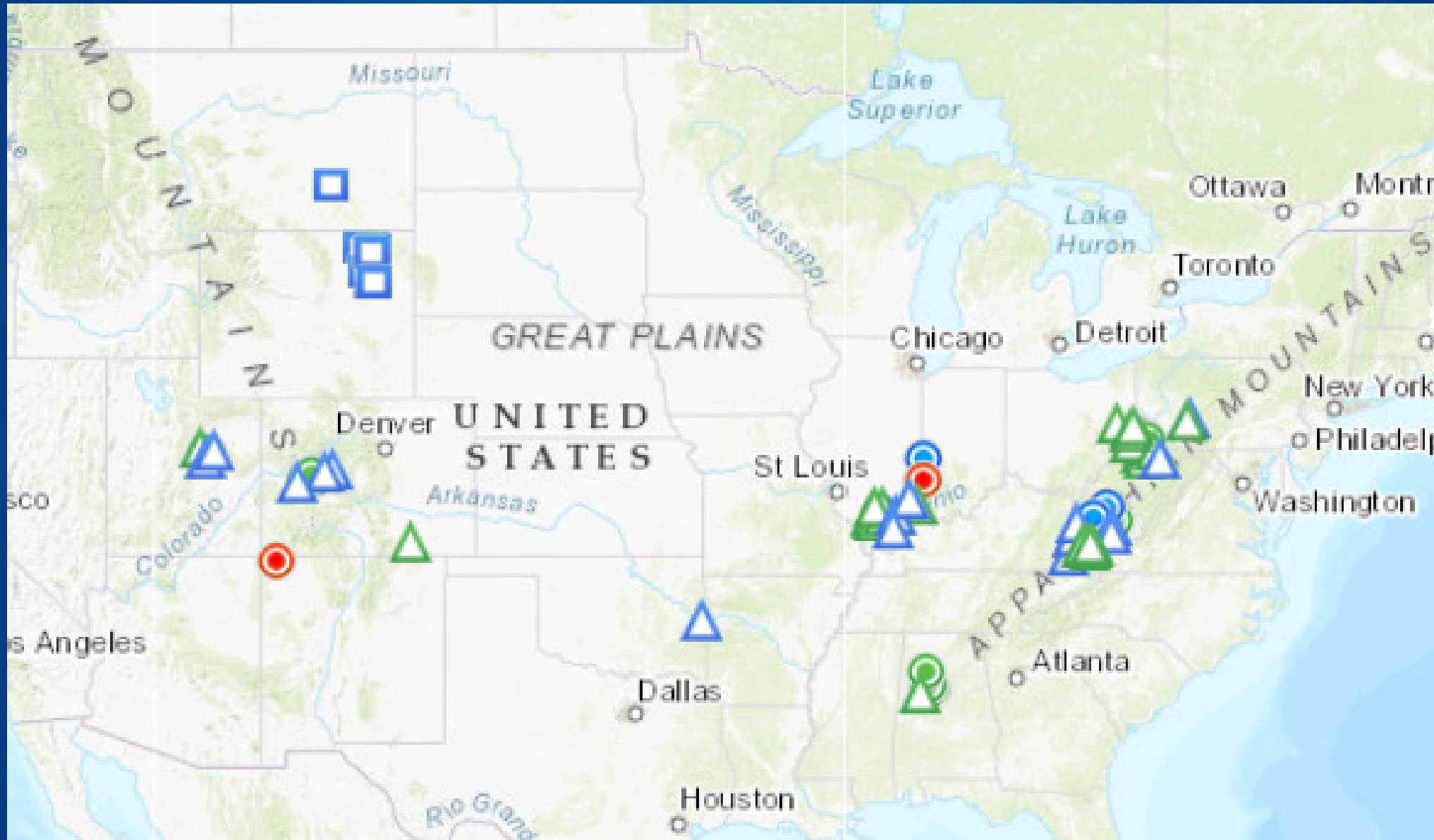
# Capturing and Recovering CMM

- U.S. CMM and AMM recovery and use projects reduced methane emissions by about 1.3 billion cubic meters (BCM) in 2016
- Roughly 80% of methane from U.S. coal mine degasification systems is recovered and used today, compared to ~25% in 1993

## U.S. Mine Methane Recovery and Destruction Projects (2016)

	Active Underground	Abandoned Underground
Mines with Projects	15	45
Projects	20	18
<b>End Uses</b>		
Pipeline	13	15
Electric Generation	1	2
Heater	2	0
Boiler/Dryer	1	0
Flare	2	1
VAM	1	0

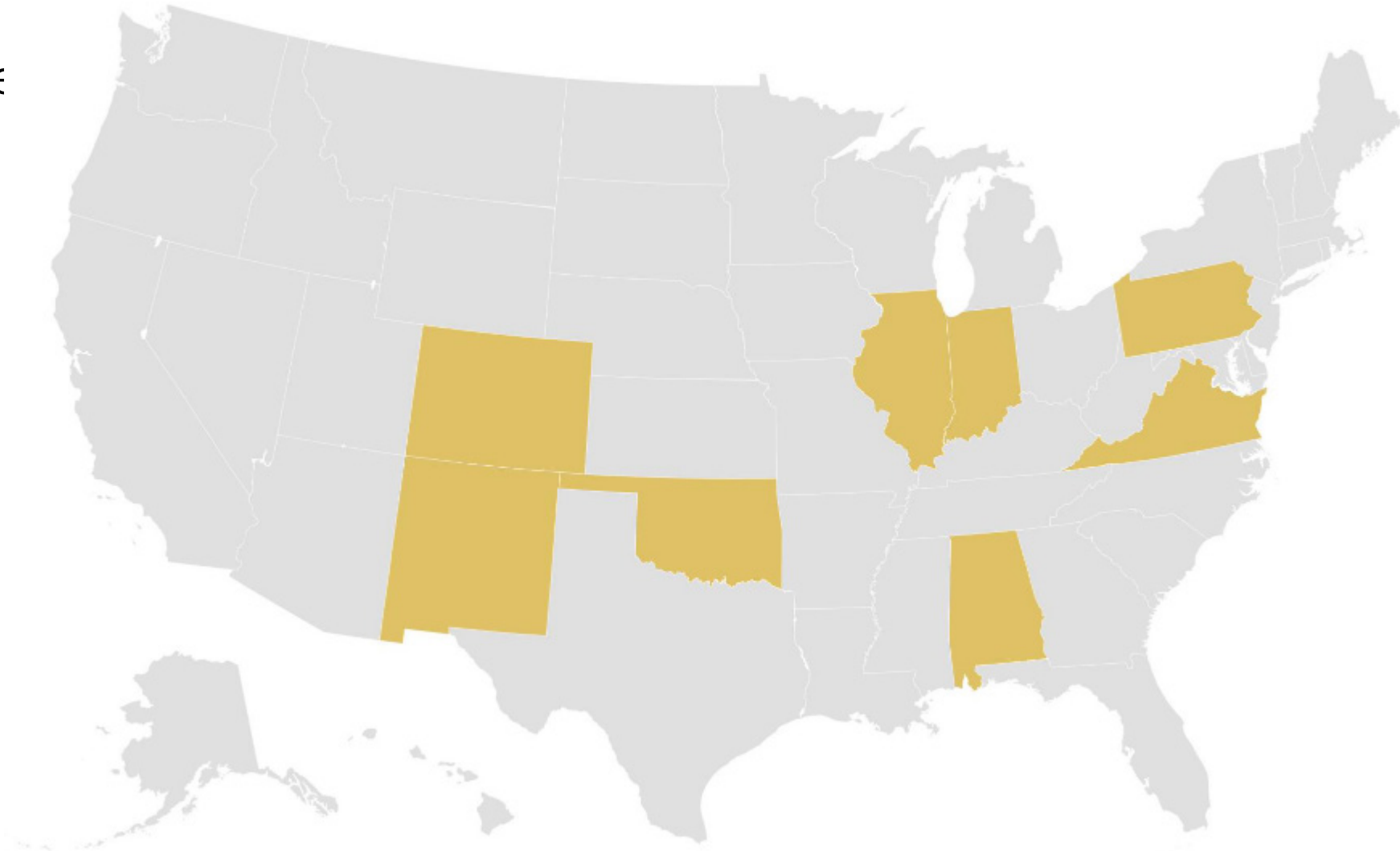
# Current and Potential CMM Projects (2015)



# CMM Recovery Project Candidates

Underground coal mines  
these states appear to be  
good candidates:

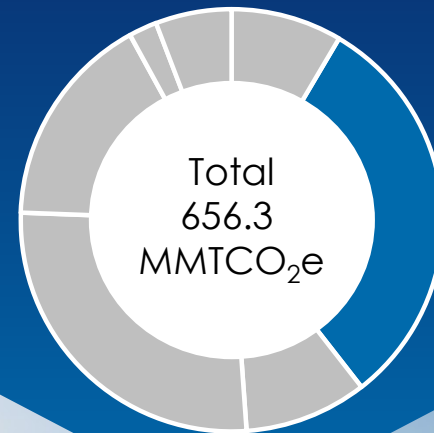
- Alabama
- Colorado
- Illinois
- Indiana
- New Mexico
- Oklahoma
- Pennsylvania
- Virginia





31%

203.3 MMTCO<sub>2</sub>e

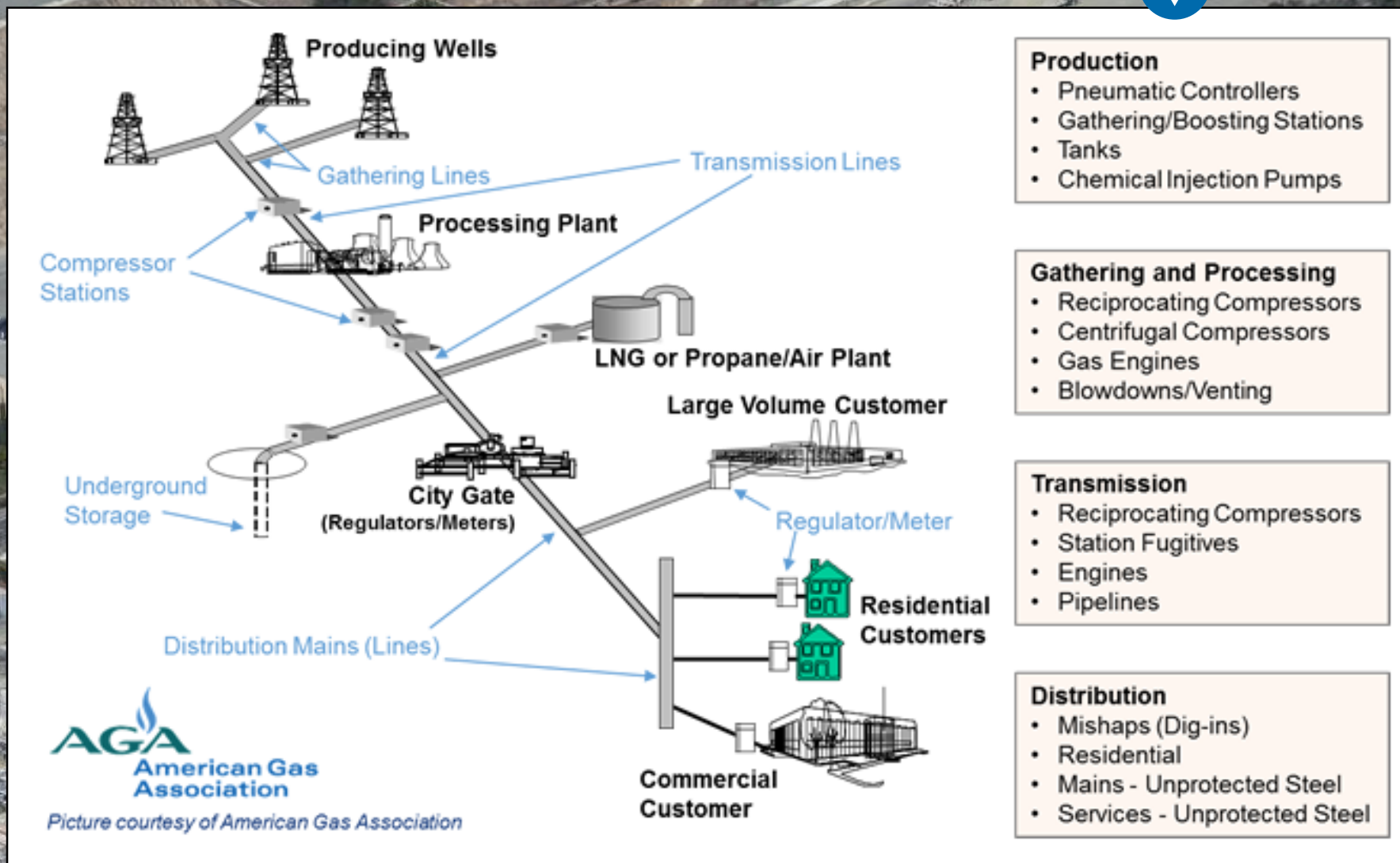


# Oil and Natural Gas Systems

Methane emissions—occurring from production, through processing and transmission, to distribution—primarily result from normal operations, routine maintenance, fugitive leaks, and system upsets.

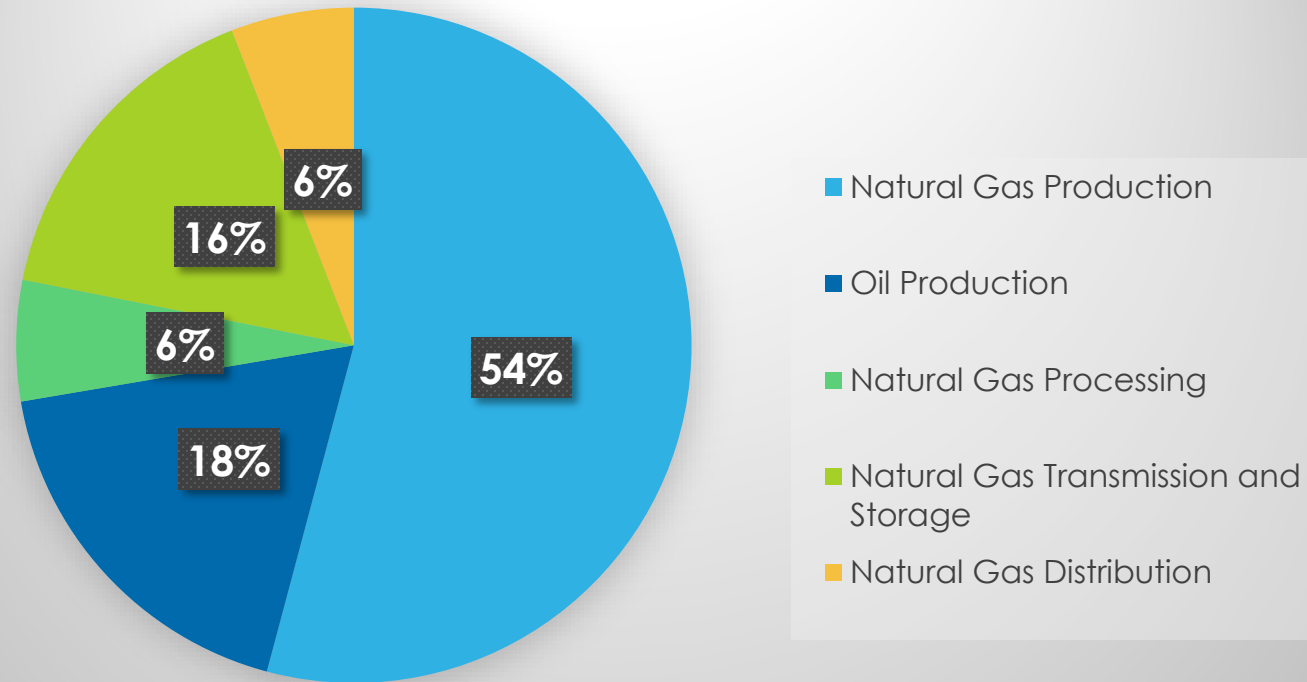
# Oil and Natural Gas Industry Segments

## Top methane emission sources by industry segment



# Methane Emissions from Oil and Natural Gas Systems

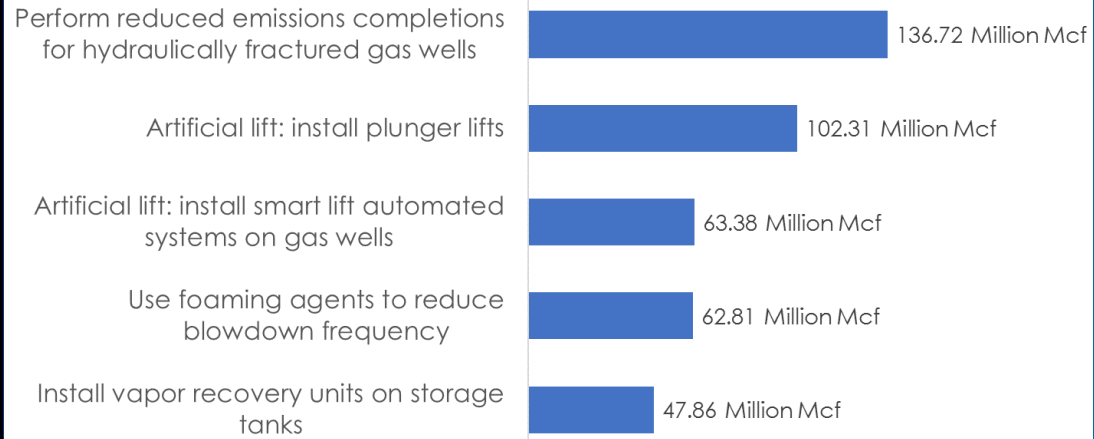
2017 Methane Emissions by Segment



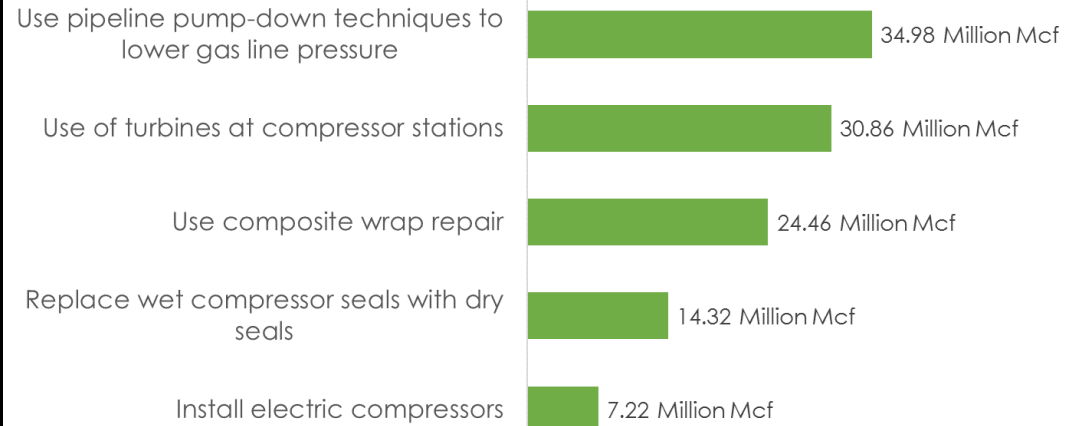
Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017

# Top 5 Technologies and Practices for Methane Reductions Voluntarily Reported by Natural Gas STAR Partners, 2008-2017

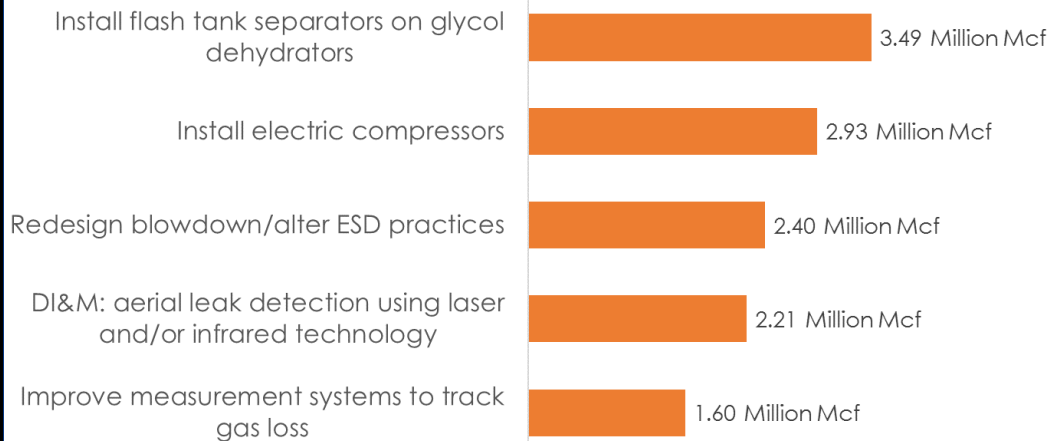
## Production



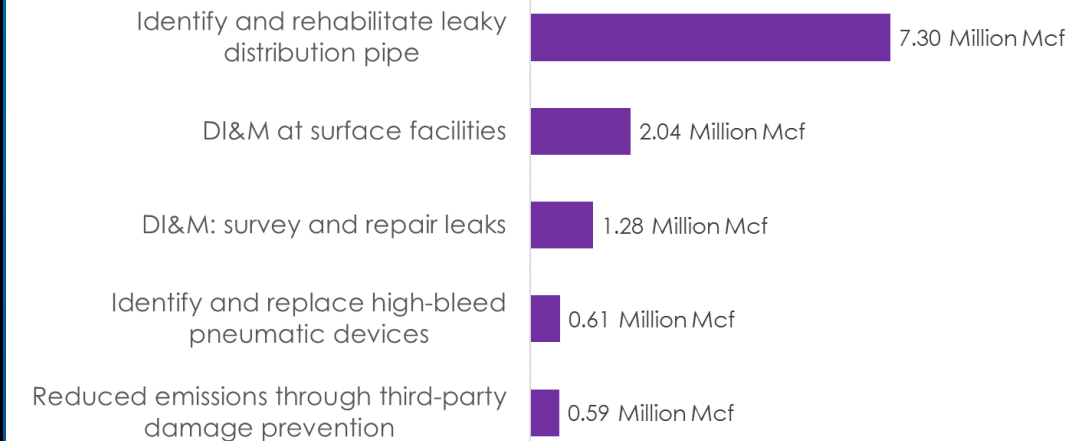
## Transmission



## Gathering & Processing



## Distribution







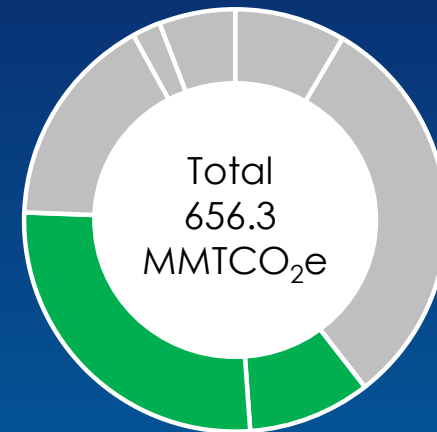
# Agriculture

## Enteric Fermentation and Manure Management

Biogas (methane) is created when manure decomposes or through enteric fermentation.

36%

237.1 MMTCO<sub>2</sub>e



Enteric Fermentation  
175.4 MMTCO<sub>2</sub>e

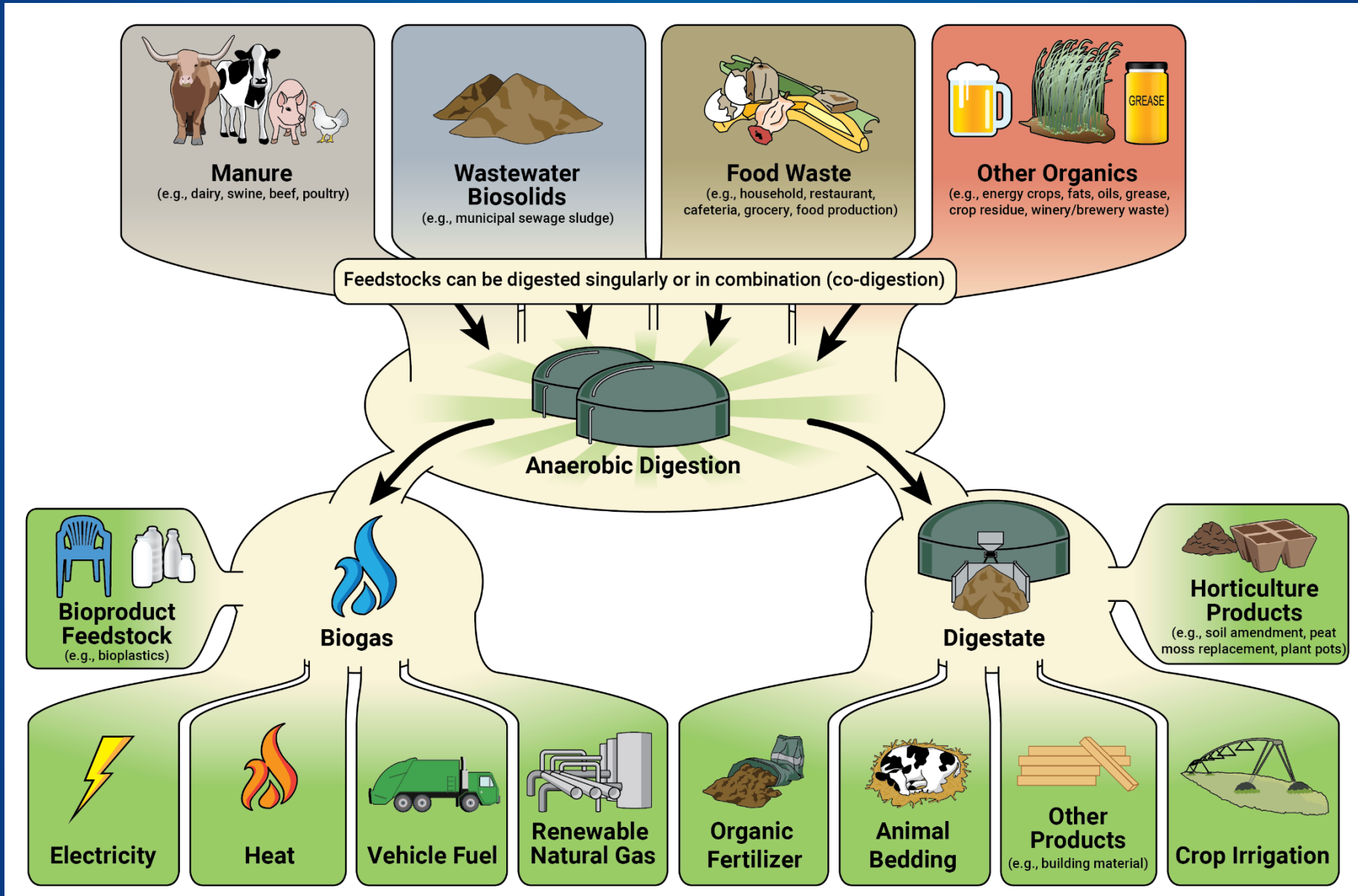
Manure Management  
61.7 MMTCO<sub>2</sub>e

# Enteric Fermentation

- Fermentation that takes place in the digestive systems of ruminant animals (e.g., cattle, sheep, buffalo)
- Enteric fermentation emissions have increased by 6.9% since 1990, generally following the increasing trends in cattle populations
- The amount of methane produced/emitted by an individual animal depends primarily upon the animal's digestive system, and the amount/type of feed it consumes
- R&D is underway to identify value-added feed changes



# Anaerobic Digestion



# Beneficial Outcomes of Biogas Recovery on Livestock Farms

Diversified Farm Revenue



Rural Economic Growth



Conservation of Agricultural Land



Energy Independence



Sustainable Food Production

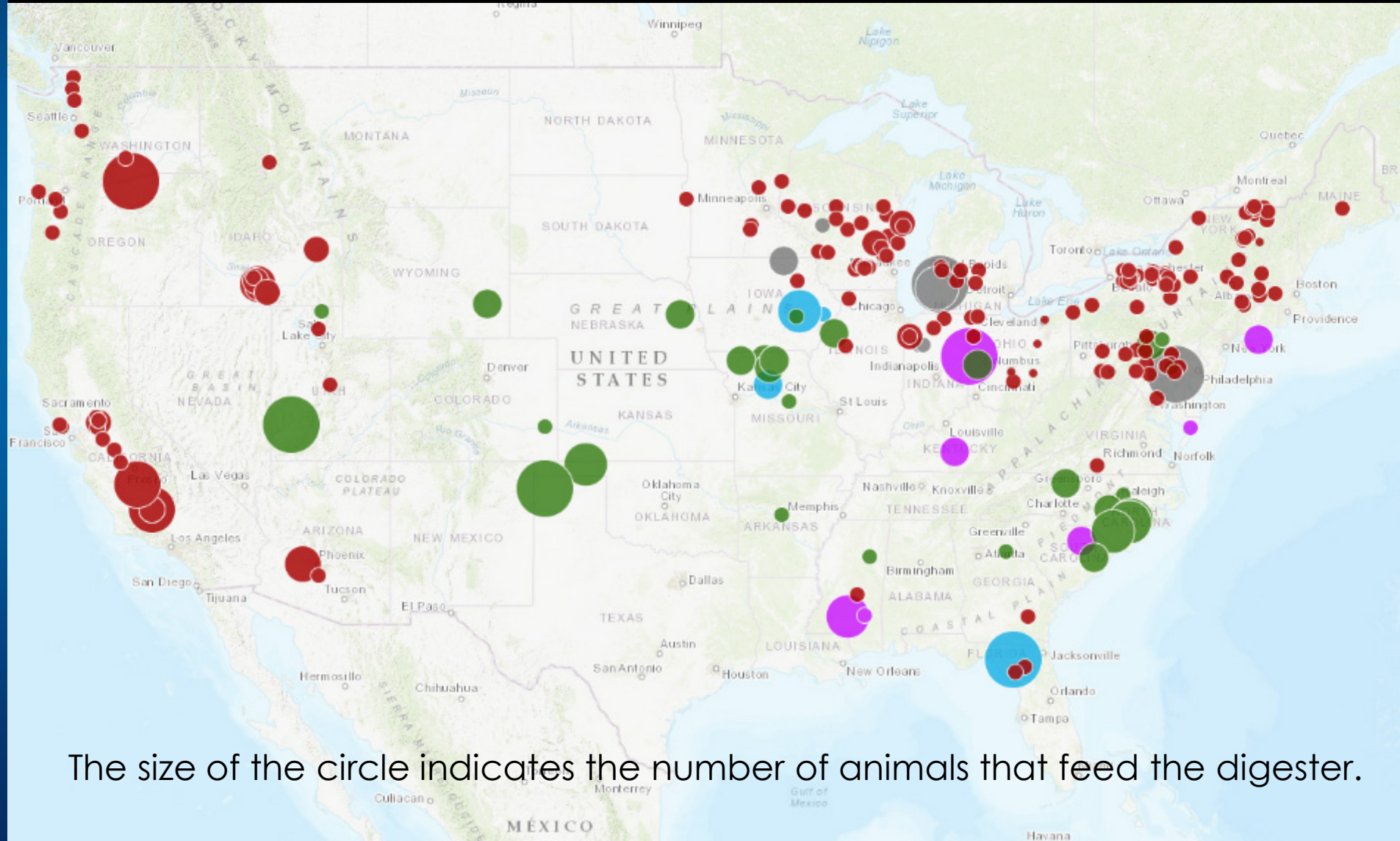


Farm-Community Relationships

● Dairy ● Hog ● Beef ● Poultry ● Mixed

# Anaerobic Digester Projects on Livestock Farms in the United States

248 operational projects in the United States (January 2019)

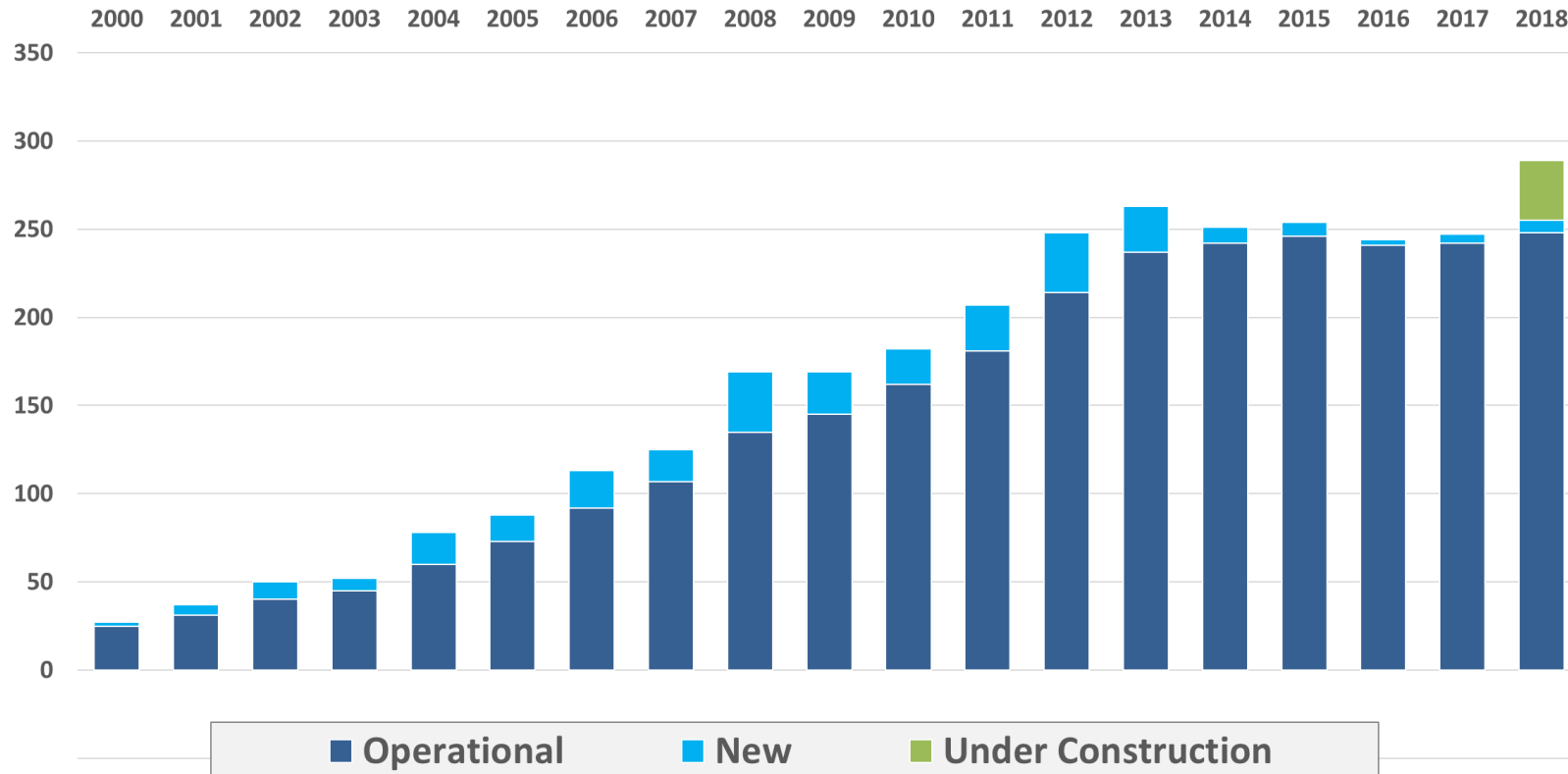


The size of the circle indicates the number of animals that feed the digester.



# Farm Digester Market is Growing

Cumulative Number of Anaerobic Digesters on Livestock Farms in the U.S.



34

anaerobic digestion projects currently under construction

248

anaerobic digestion projects currently operational

+

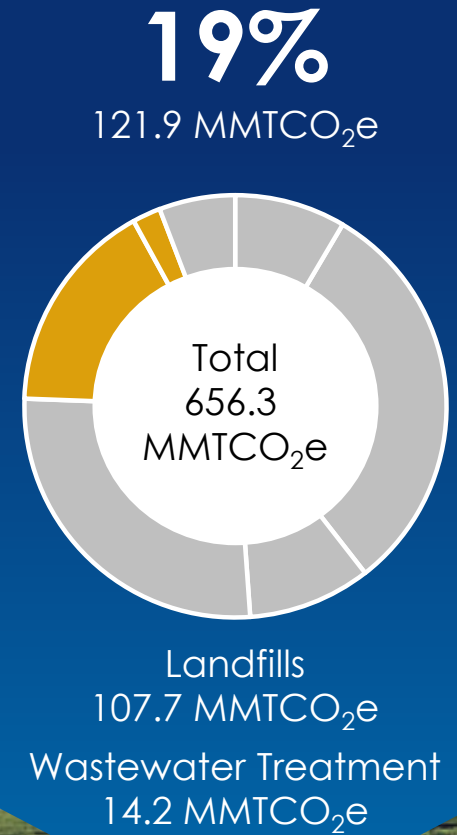
~8,100

Potential biogas systems

# Waste

## Wastewater Treatment and Landfills

Methane is generated from wastewater treatment and landfills through the anerobic decomposition of organic material.



# Wastewater Treatment

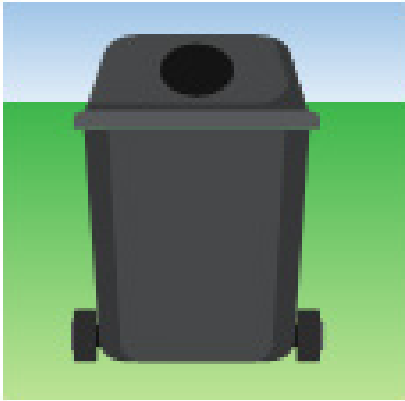
- Methane is emitted during the handling and treatment of municipal wastewater through the anerobic decomposition of organic material
- Over 1,200 WRRFs have AD that treats wastewater solids and produce biogas
  - More than half of these flare off the biogas produced; more than half use the biogas as an energy resource
- These uses of biogas generated at WRRFs are documented in a database maintained by the Water Environment Federation (WEF)



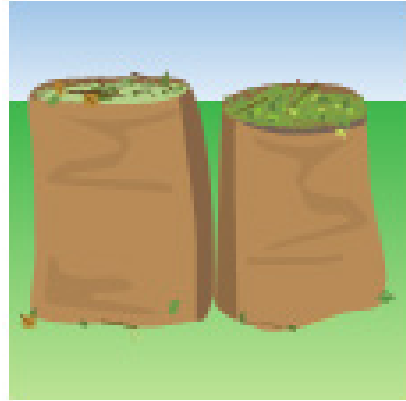


# Municipal Solid Waste

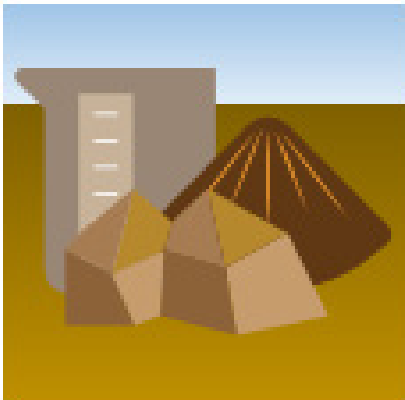
Municipal Solid Waste



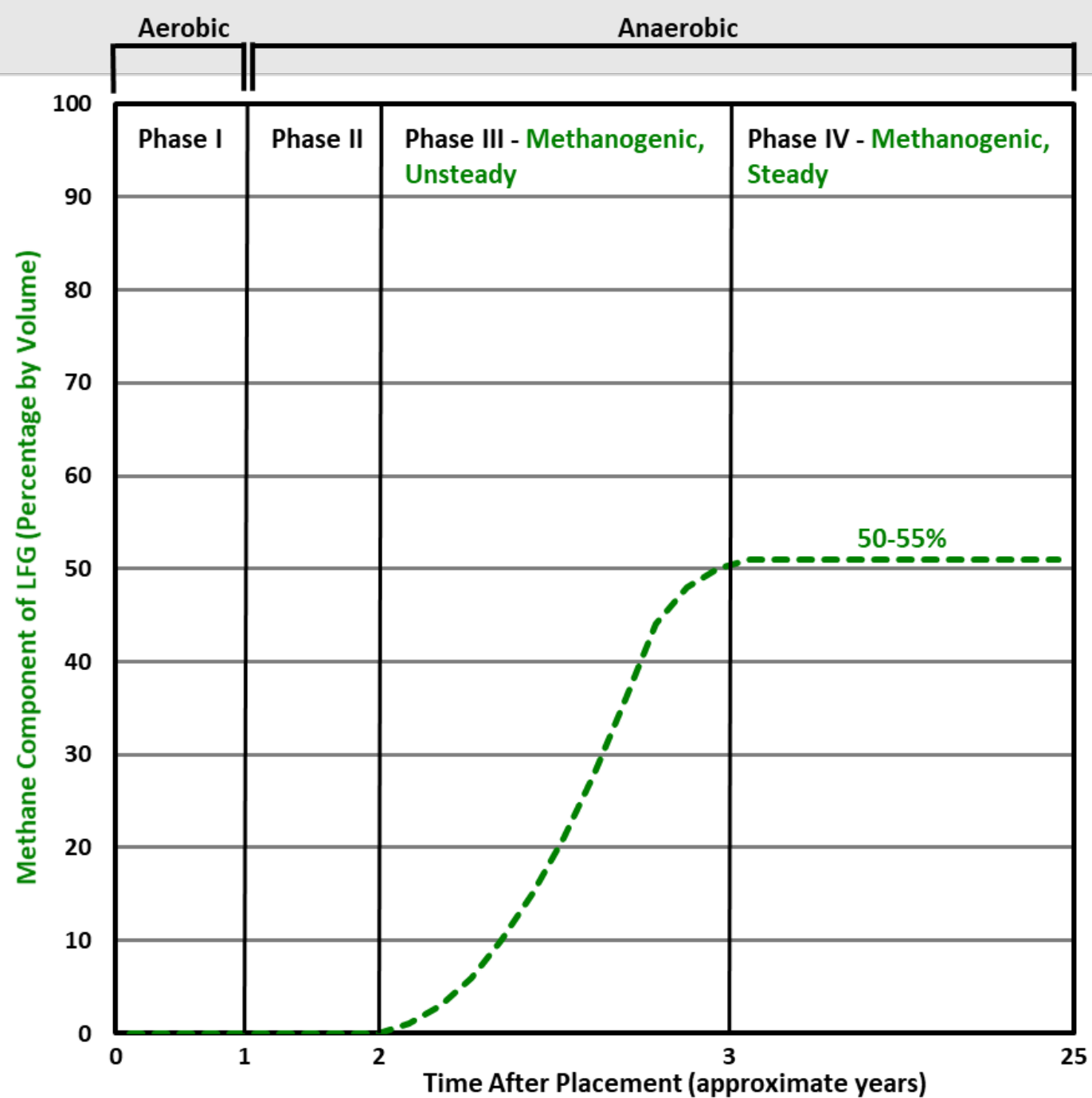
Yard and Crop Wastes



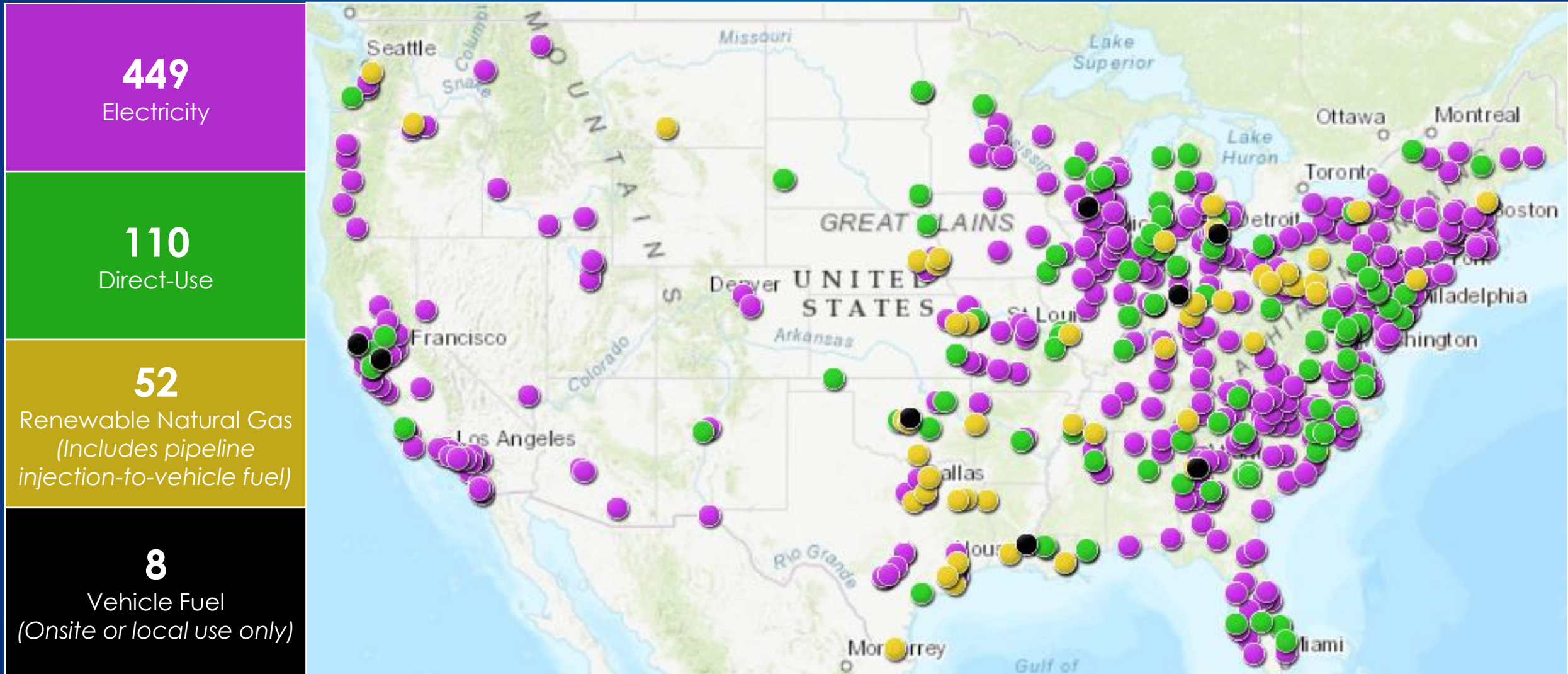
Sewage Sludge



Food and Food Processing Wastes



# 619 Total Landfill Gas Energy Projects in the United States



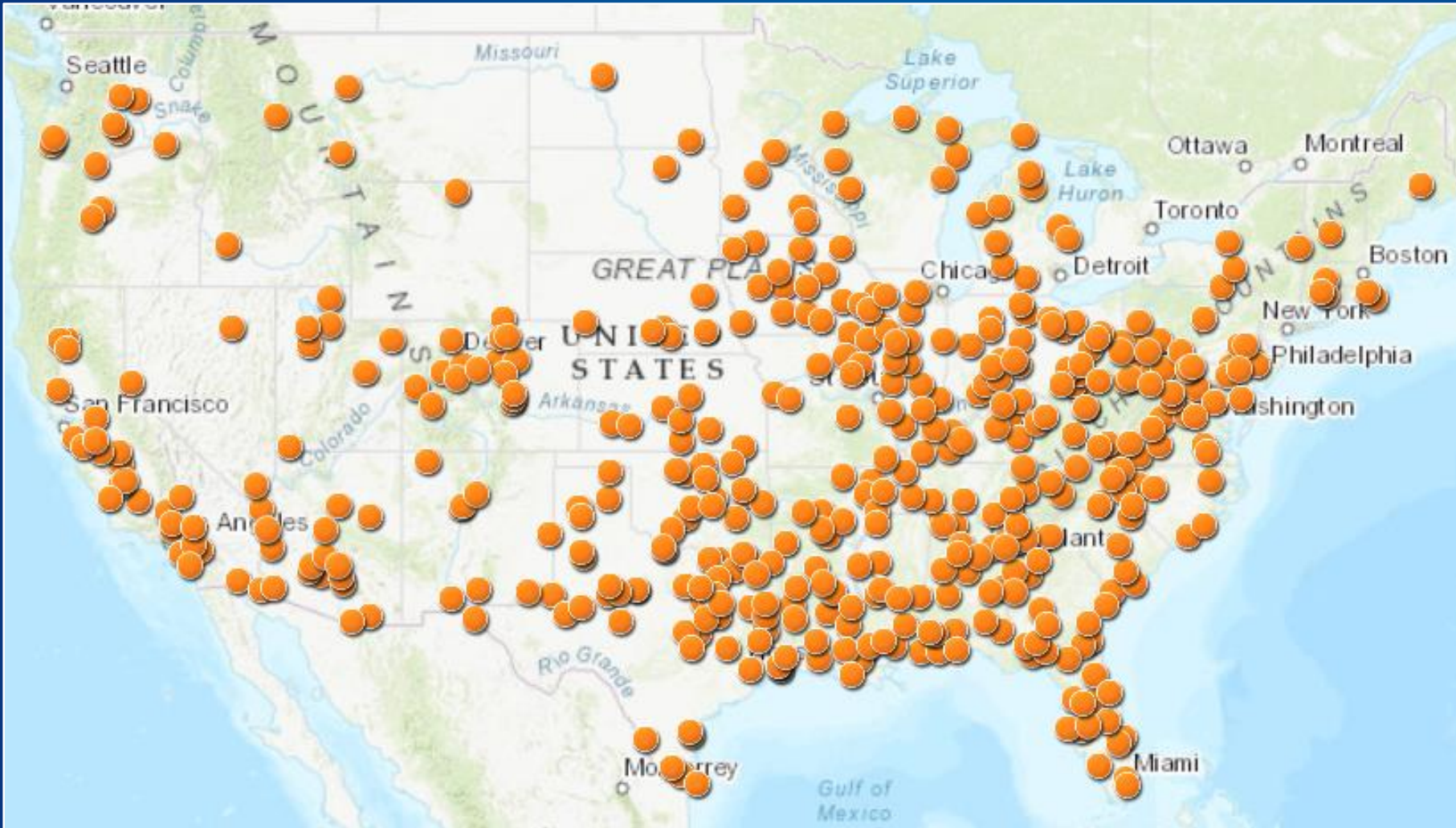
LFG energy project count from LMOP's Landfill and Landfill Gas Energy Database as of February 2019

# Landfill Gas Energy Project Outputs and Methane Reductions



LFG energy project count from LMOP's Landfill and Landfill Gas Energy Database as of February 2019

# Candidate Landfills



**~ 480 Candidate Landfills**

(900 MW or 500 mmscfd,  
45 MMTCO<sub>2</sub>e/year Potential)

## What is a candidate landfill?

- Landfill is accepting waste or has been closed for five years or less
- Has at least one million tons of waste
- Does not have an operational, under-construction or planned project
- Can be designated based on interest by the site

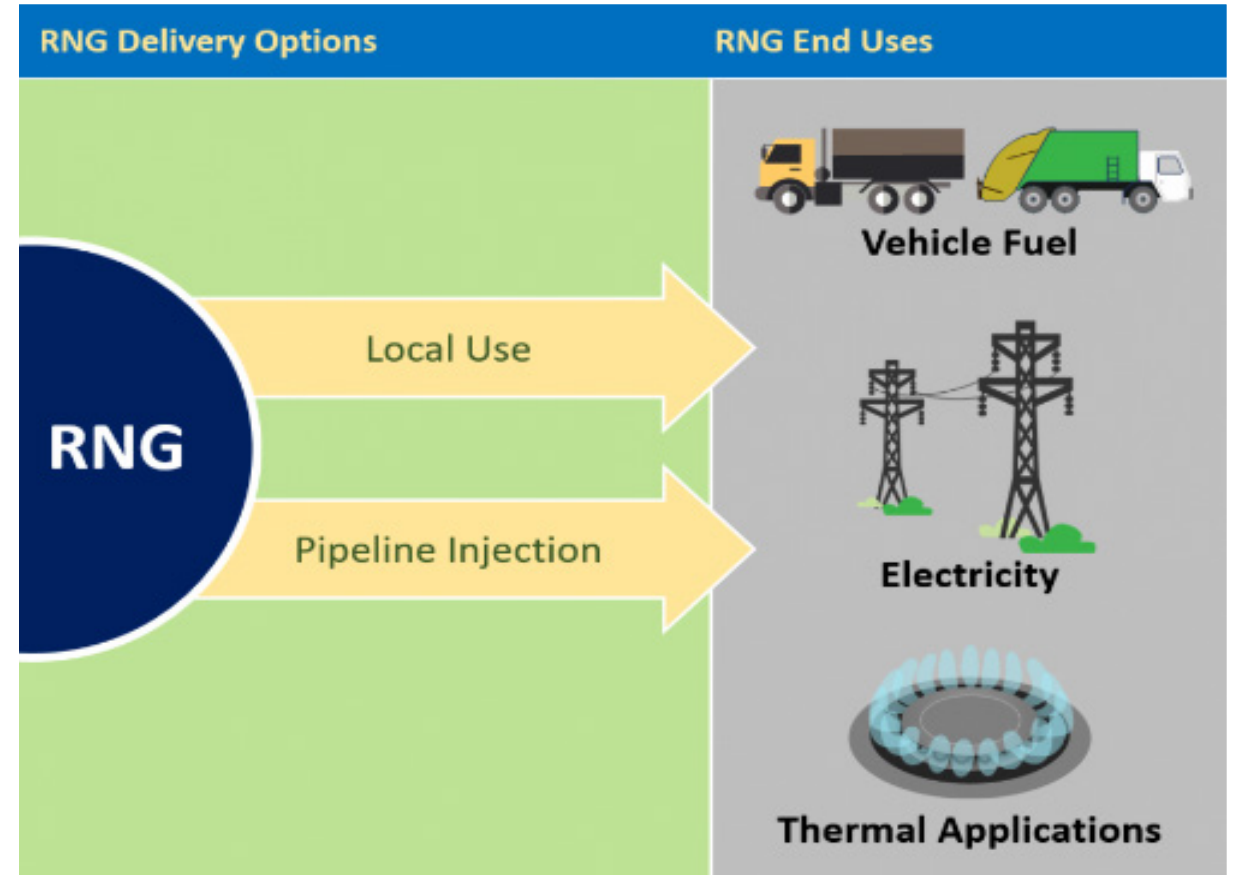
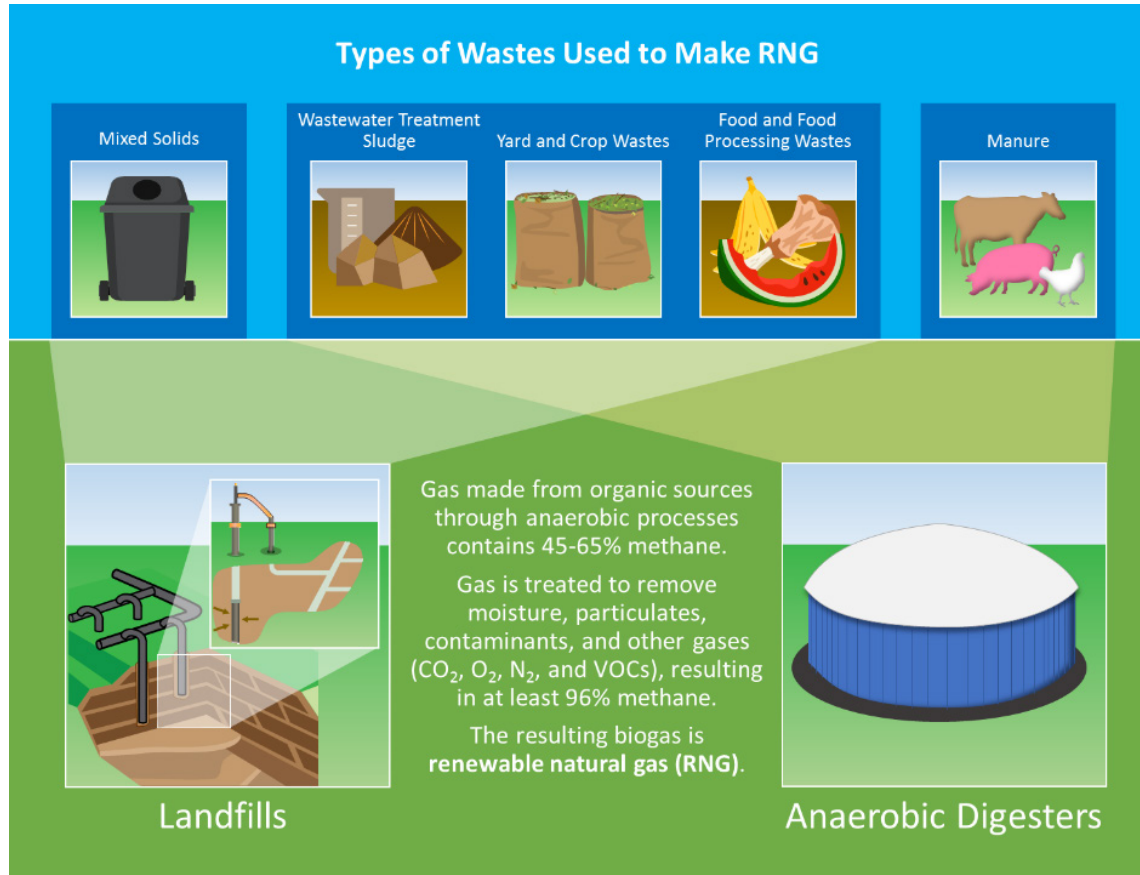
LFG energy project count from LMOP's Landfill and Landfill Gas Energy Database as of February 2019



# Spotlight

Renewable Natural Gas (RNG)

# Renewable Natural Gas



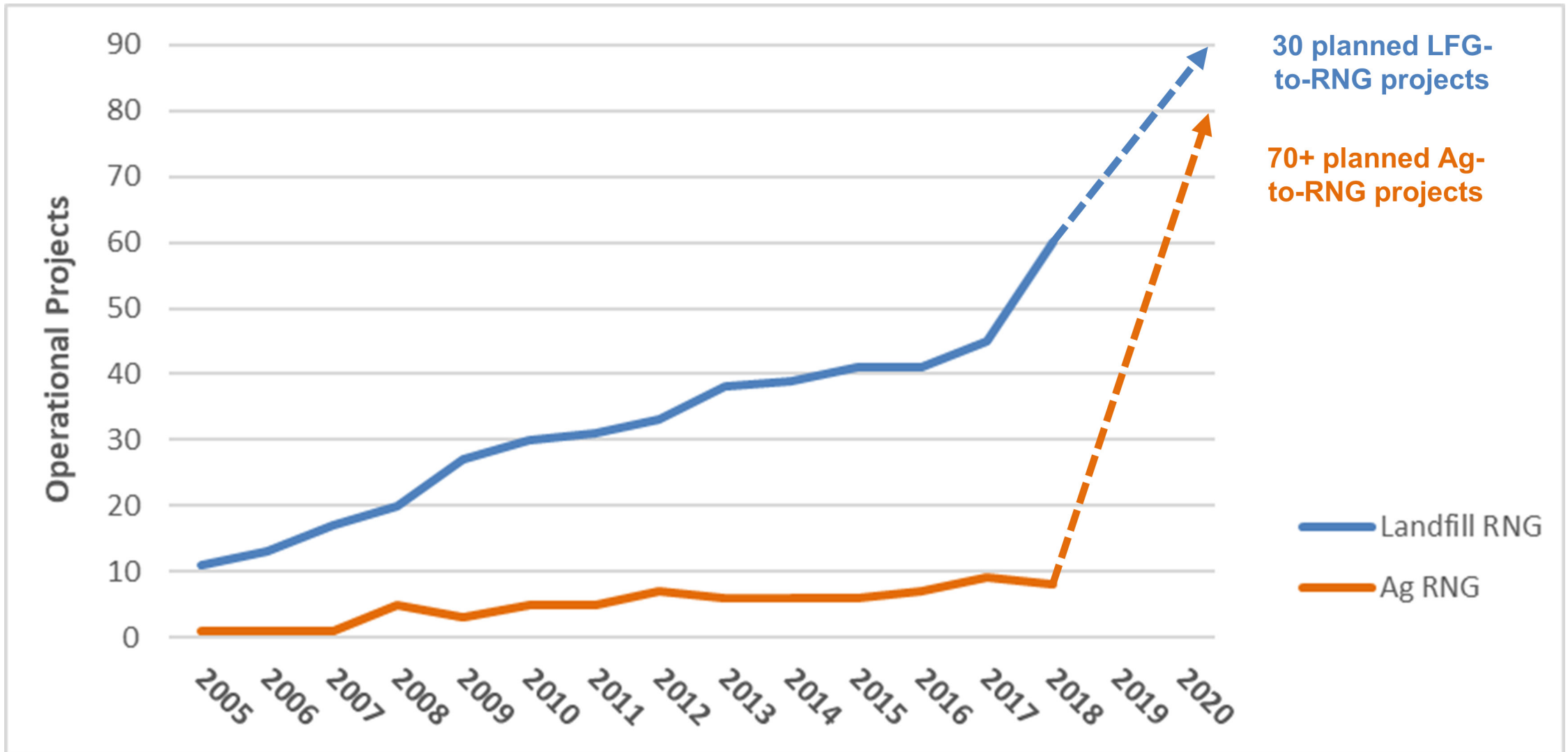
# Drivers: RNG Project Interest and Growth

- Financial incentives: Federal (RFS) and state incentives (e.g., California LCFS) for renewable vehicle fuel have spurred project development
  - Incentives can be as high as 23x greater than the value of the gas
  - In January 2019, the price for natural gas was ~ \$3 (Henry Hub)
- Local Distribution Companies (LDCs) are increasingly interested in RNG to reduce carbon intensity and as an opportunity to offer their customers renewable energy
- Corporate sustainability: RNG can be used to meet company sustainability goals

Credit Type	Value Added (\$/MMBtu)*
<b>Federal: EPA Renewable Fuel Standard (RFS2)</b>	
RFS RIN – D3 ( <i>Cellulosic Biofuel: landfill gas, manure only</i> )	\$16.42 to \$28.00
RFS RIN – D5 ( <i>Advanced Biofuel: food waste</i> )	\$4.55 to \$6.62
<b>State: California Low Carbon Fuel Standard (LCFS)</b>	
Landfill Gas to CNG	\$7.58 to \$7.74
High Solids AD to CNG	\$18.68 to \$19.08
Animal Waste to CNG	\$68.27 to \$69.74

\*Based on data from: U.S. EPA (<https://www.epa.gov/fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information>) and California Air Resources Board (<https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm>).

# Projected Growth of RNG Projects: Landfills and Ag







# Helpful Tools and Resources

- Greenhouse Gas Reporting Program - FLIGHT
- Non-CO<sub>2</sub> Global Mitigation Report
- Voluntary Technical Partnership Programs

# View Published Data in FLIGHT

US Greenhouse Gas Reporting Program  
<https://ghgdata.epa.gov/ghgp/>



flight

Facility Level Information on Greenhouse Gas Emissions



2017 Greenhouse Gas Emissions from Large Facilities

Share View U.S. GHG Inventory View Other GHGRP Data Products Help



Now you can visit ghgdata.epa.gov from your mobile device. Click here to learn how to create a bookmark to our page on your mobile device.

Data Year: 2017  
Data Type: All Emitters  
Search Options: Find a Facility or Location

Browse to a State: Choose State  
Emissions by Fuel Type: Choose Fuel Type  
Filter By: Greenhouse Gas  
Emission Range: Emission Range  
Filter By Status: All Facilities

Data View: Map, List, Trends, Bar Chart, Pie Chart

Apply Search, Reset Form, Export Data

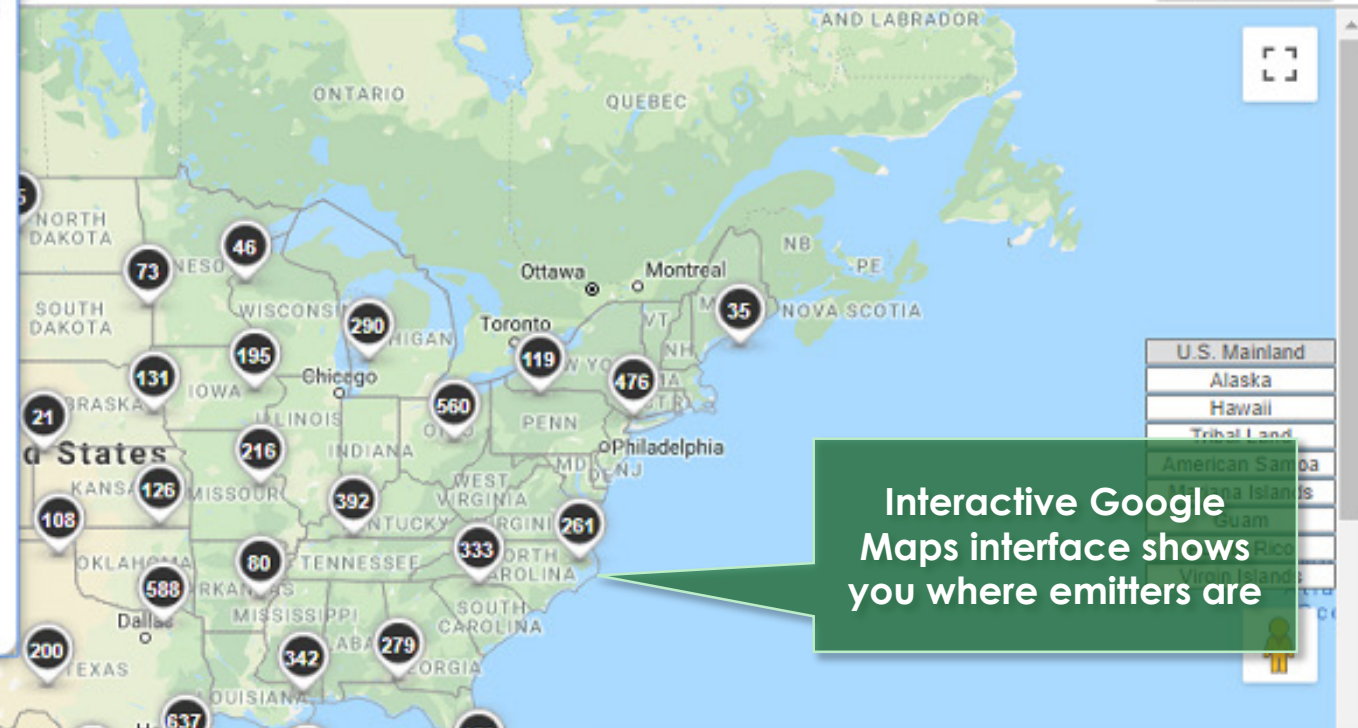
Map, Satellite

Filter data by State

Filter data by gas (e.g., methane)

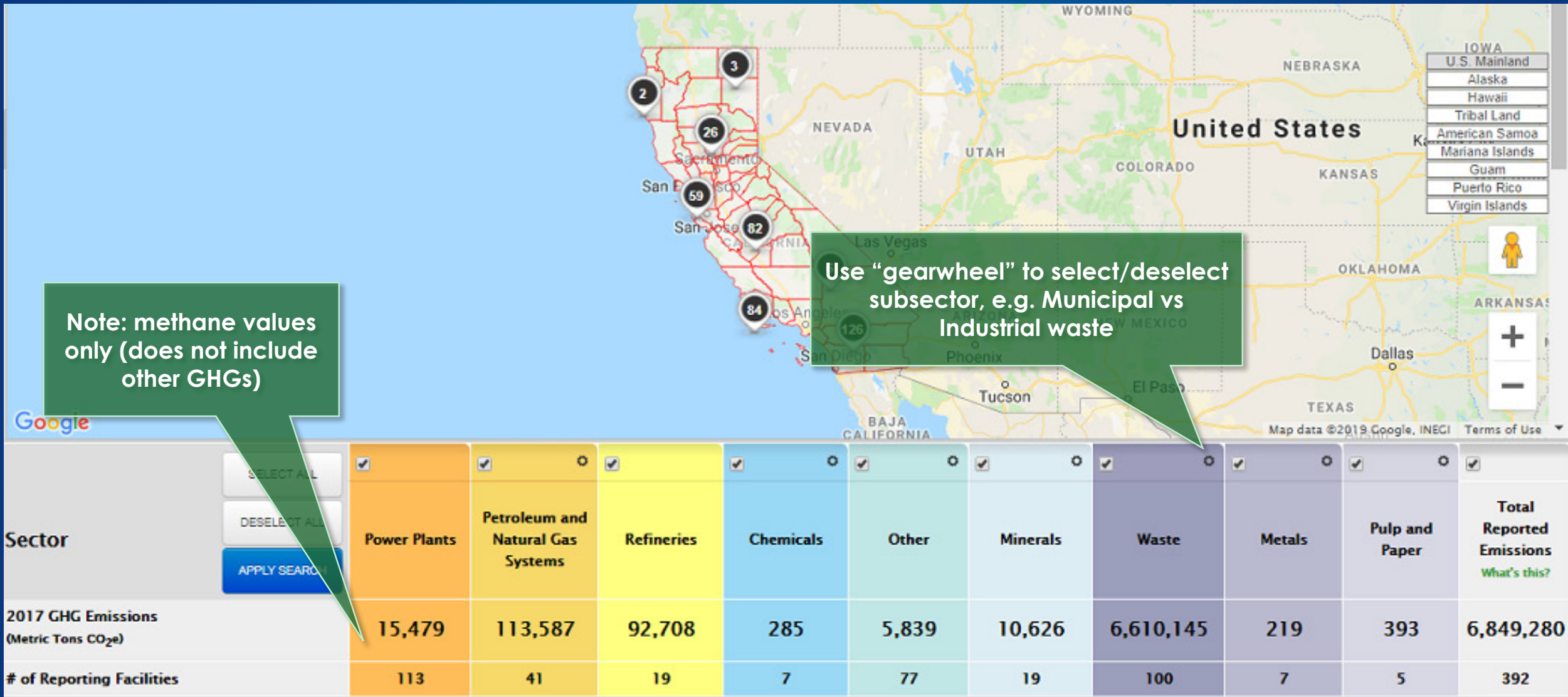
Greenhouse Gases

- Carbon Dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrous Oxide (N<sub>2</sub>O)
- Fluorinated GHGs
  - HFCs
  - PFCs
  - SF<sub>6</sub>
  - NF<sub>3</sub>
  - Other Fully Fluorinated GHGs
  - HFEs
  - Very Short Lived Compounds
  - Other

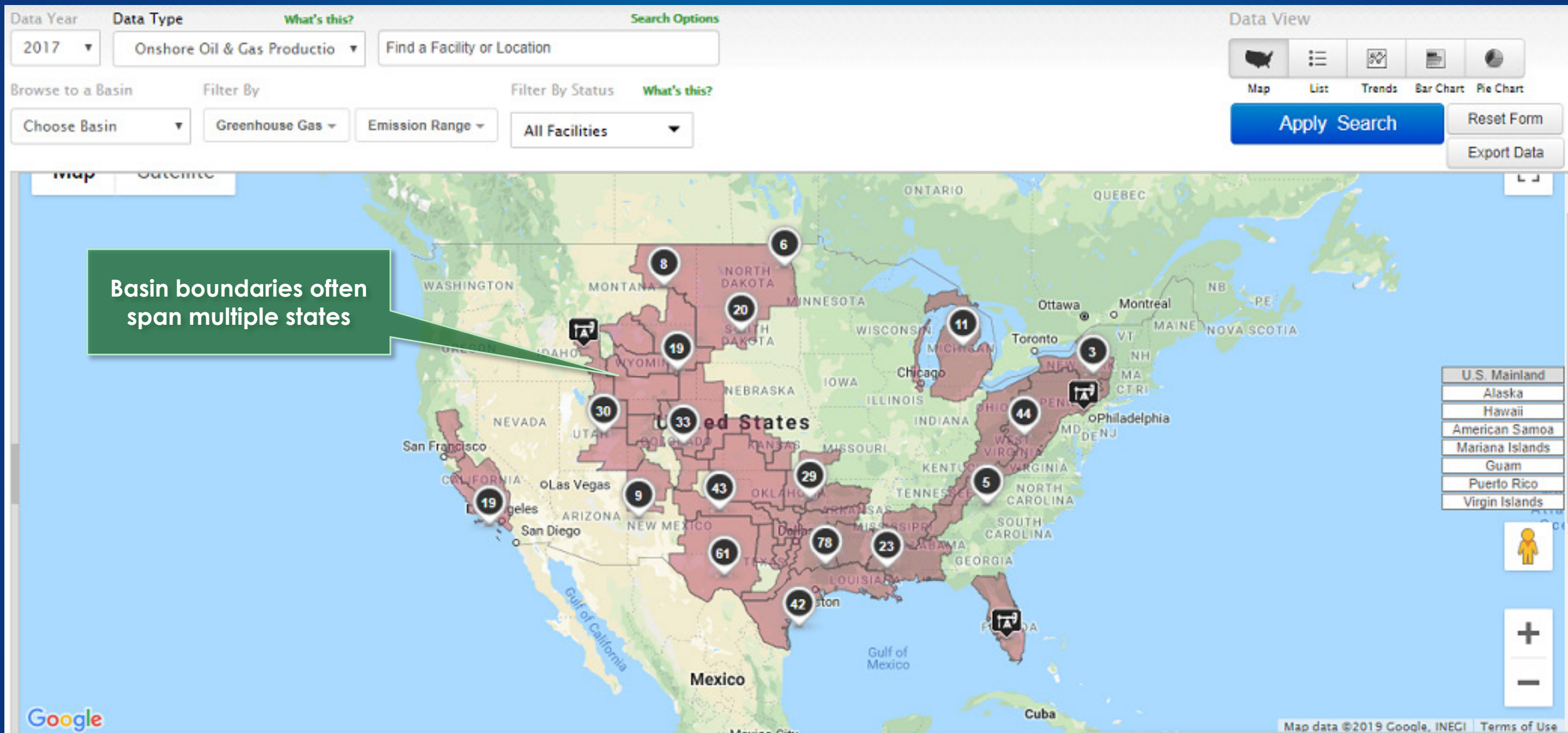


Interactive Google Maps interface shows you where emitters are

# FLIGHT Example: CALIFORNIA Methane Emissions

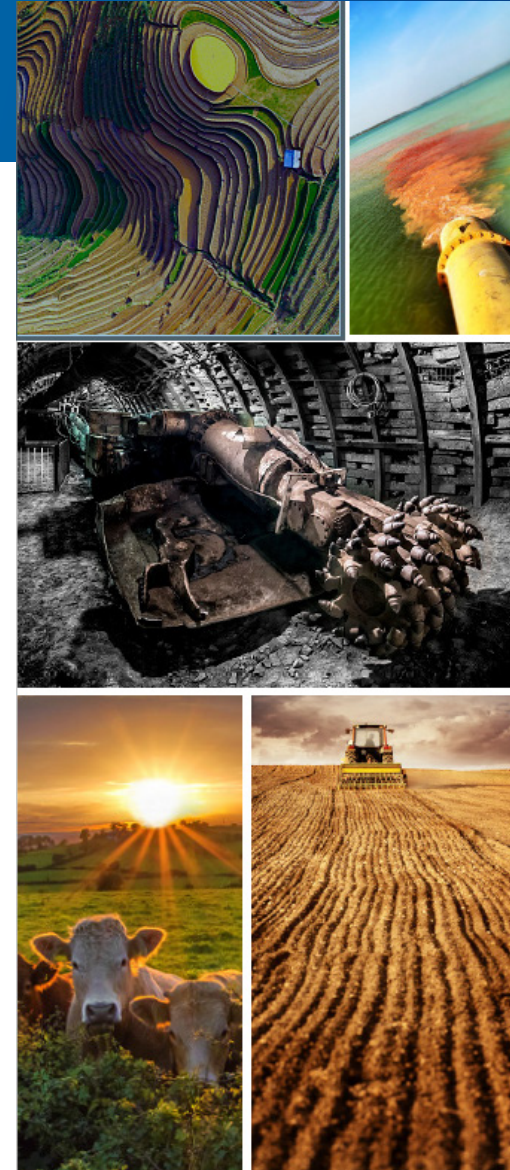


# FLIGHT Example: Onshore Oil & Gas Production (Basin Level)



# Non-CO<sub>2</sub> Global Mitigation Report

- EPA has developed a global mitigation analysis for non-CO<sub>2</sub> GHGs; for methane emissions, covered sectors include:
  - Coal mining; Oil and natural gas systems; Solid waste management; Wastewater; Agriculture
- Provides improved data to better understand the costs and opportunities for reducing non-CO<sub>2</sub> greenhouse gas emissions
- Report is global, but U.S. data set is available disaggregated at state level
- EPA is preparing an update; timing for the publication of the 2019 version is TBD



United States  
Environmental  
Protection Agency  
Office of Atmospheric  
Programs (6207J)  
Washington, DC 20005



EPA-430-S-14-001  
August 2019

## Global Mitigation of Non-CO<sub>2</sub> Greenhouse Gases

2010-2030  
Executive Summary

# Information for the Coal Mining Sector

[www.epa.gov/cmop](http://www.epa.gov/cmop)



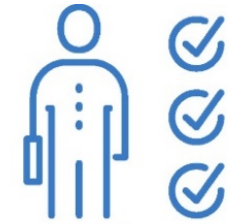
## U.S. CMM PROJECT OPPORTUNITIES MAP

The U.S. CMM Project Opportunities Map provides information about current projects and potential opportunities to develop CMM recovery and utilization projects at active U.S. coal mines.



## CMM CASH FLOW MODEL

The CMM Cash Flow Model enables you to evaluate the potential economic viability of recovering and beneficially using CMM at a specific site in one of eight ways.



## INDUSTRY CONTACTS LIST

The Industry Contacts list provides a sortable list of CMM/CBM industry and government contacts.

# Information for the Oil and Natural Gas Sector

[www.epa.gov/gasstar](http://www.epa.gov/gasstar)



## Recommended Technologies

- Lessons Learned Studies
- Technology fact sheets
- Organized by equipment type

## Technical Presentations

- Links to hundreds of presentations from industry experts, program partners, and stakeholders
- Searchable by title, speaker, and event

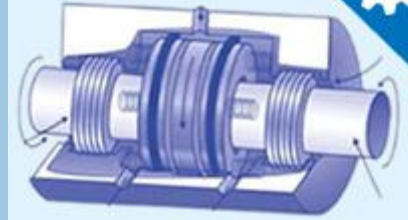
## Outreach and Events

- Webinars (Program Updates and Data Analytics)
- Technology Transfer Workshops
- Partnership Workshops

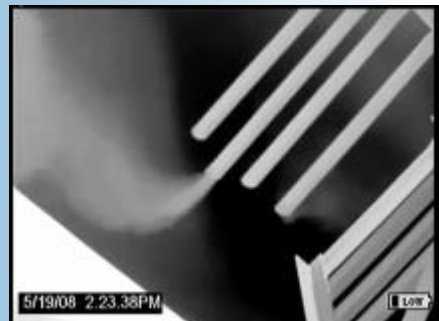
## Methane Emissions Videos

- Remote sensing leak detection
- Infrared methane videos

## Technologies



## Presentations



# Information for the Agriculture Sector

[www.epa.gov/agstar](http://www.epa.gov/agstar)



## Success Stories

- Project profiles
- Interviews with operators

## Market Trends

- National data for anaerobic digester projects
- Opportunities

## Technical Information

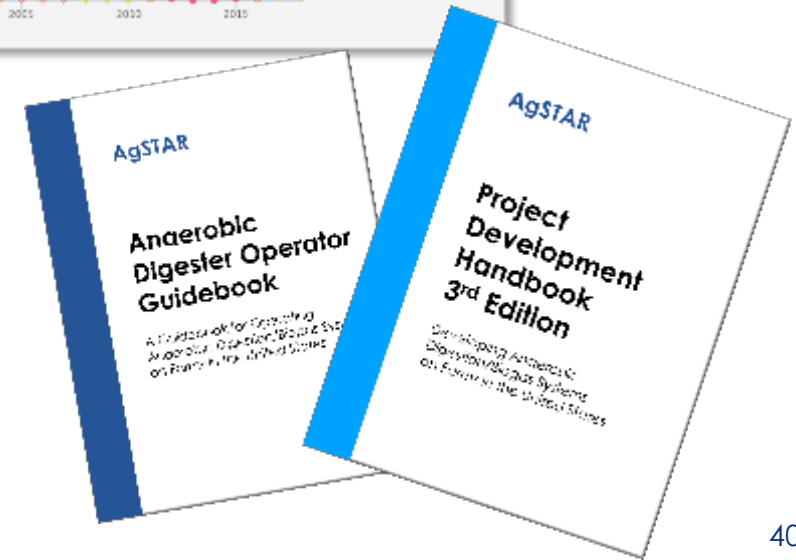
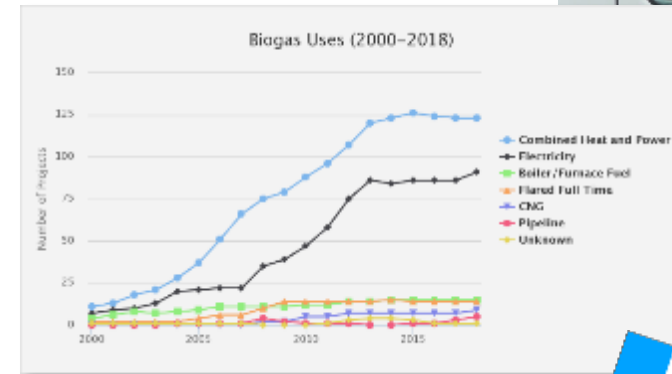
- Guidelines and permitting
- Updated project handbook (coming soon)
- Operators guidebook (coming soon)

## Collaboration

- Webinars
- Industry events



Meet An Anaerobic Digester Operator





# Information for the Landfill & LFG Energy Sector

[www.epa.gov/lmop](http://www.epa.gov/lmop)



## Data

- Excel files and GIS map
- LFG energy projects
- Candidate landfills



## Technical Publications

- Project Development Handbook
- Fact sheets



## Network

- Webinars and Other Events
- 1,000+ LMOP Partners
- Listserv messages



## Tools

- LFGcost-Web
- RNG Flow Rate Tool
- LFG Energy Benefits Calculator
- Conversion Tool



# Thank You

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