

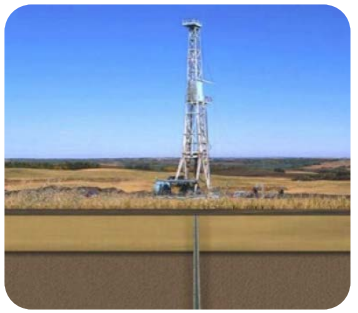

DOE Methane Emissions Quantification R&D

EPA Stakeholder Workshop on Natural Gas and Petroleum Systems in the 1990 – 2016 GHG Inventory
June 22, 2017

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U.S. DEPARTMENT OF ENERGY | Fossil Energy
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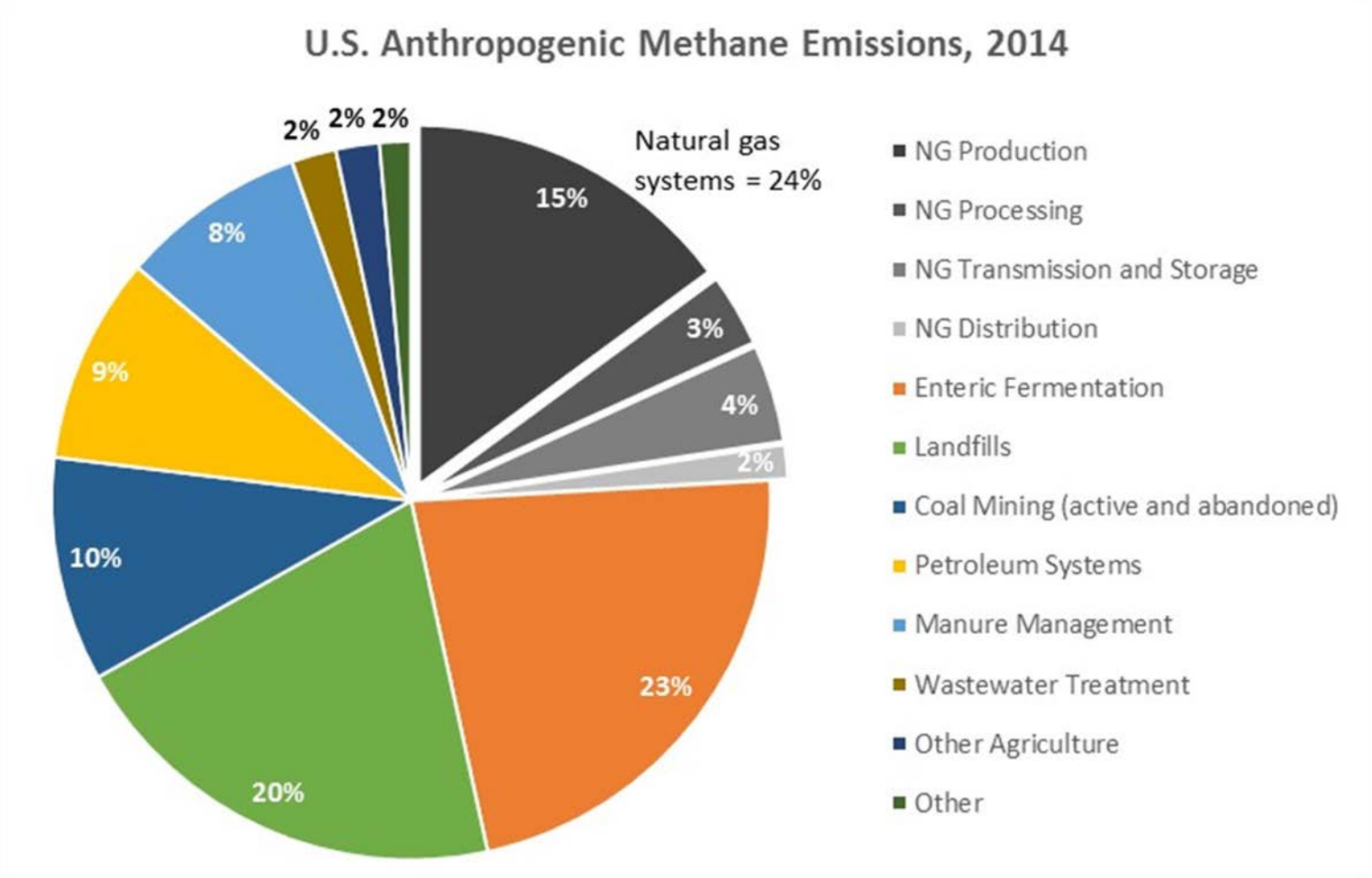
Presentation Outline

- Methane Research Drivers
- DOE Actions to Reduce Methane Emissions and Research Initiatives
  - Methane Quantification
  - Methane Mitigation

The Latest Estimates of U.S. Methane Emissions



Methane represents roughly 10% of all U.S. anthropogenic GHG emissions.

Source: EPA, 2016 (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014)

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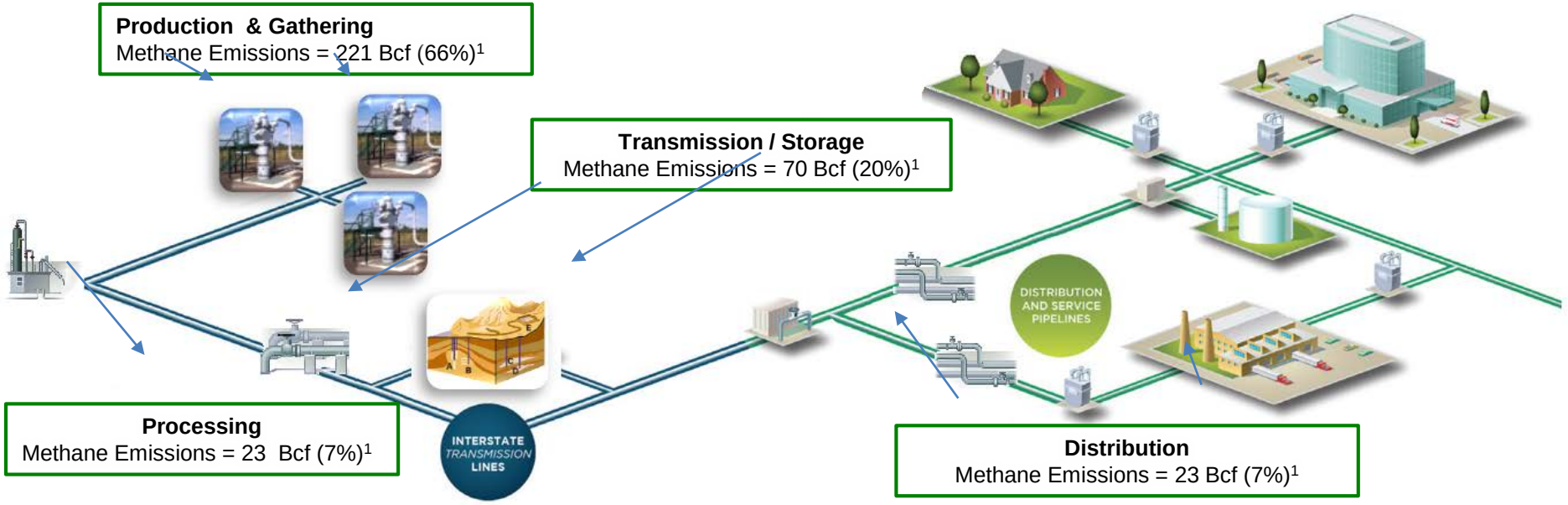
Natural Gas Sector Methane Emissions

25% of Total U.S. Emissions, 337 BCF (6,497 Gg), ~1.2% loss from extraction to distribution in 2015 (U.S. EPA Greenhouse Gas Inventory)

Production & Gathering
Methane Emissions = 221 Bcf (66%)[1]

Transmission / Storage
Methane Emissions = 70 Bcf (20%)[1]



Processing
Methane Emissions = 23 Bcf (7%)[1]

Distribution
Methane Emissions = 23 Bcf (7%)[1]

Wells
422,000 gas wells
19,000+ new wells annually

Gathering
5,300 gathering stations
33,500 gathering compressors
408,000 miles of gathering pipe (typically 8-5/8" or less) 500 psi

Processing
667 Natural Gas Processing Plants[7]

Transmission & Storage
301,000 Miles of large diameter transmission pipe 24"-48"1,000 psi
2,200 compressor stations
- **6710** engines (62 billion hp-hr)
- **2,200** turbines (15 billion hp-hr)

17,700 storage wells

Distribution
1.3 million miles of distribution

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Methane Emissions Quantification

– MISSION –

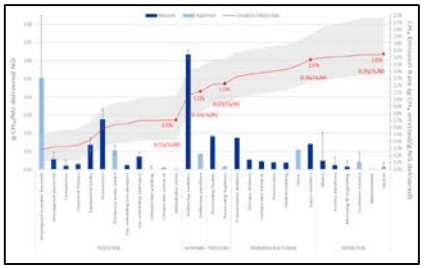
Quantification of Methane Emissions Across the Natural Gas Value Chain to Inform EPA's Greenhouse Gas Inventory

Program Approach

Characterize emissions from equipment and legacy wells

Regional differences in methane emissions

Enhanced analysis



NETL – Industry – Universities – National Labs

Methane Quantification

Awards Announced Sept. 8, 2016 -- DOE Funding Only

Gas Technology Institute (Illinois)	Conduct field campaigns to measure methane emissions from new and vintage plastic, plastic lined steel, and cast iron pipes as well as from industrial meter	$1,090,719
Colorado State University (Colorado)	Develop nationally-representative, activity-weighted, methane emission factors for each type of principal equipment located at typical gathering compressor stations suitable for use in EPA's GHGI; develop estimates of episodic emissions; test new methods to characterize intermittent device emissions.	$1,872,018
GSI Environmental Inc. (Texas)	Employ a novel combination of complementary measurement methods and technologies to detect and accurately quantify average annual methane emissions from an underground natural gas storage facility	$1,208,499
GSI Environmental Inc. (Texas)	Employ a step-wise process to improve the accuracy of methane emissions reported in EPA's GHGI	$800,480
University of Colorado Boulder (Colorado)	Collect ground-based regional scale measurements and aircraft measurements in order to estimate emissions across the underground storage sector.	$1,323,130

Pipeline and Meter Emissions

Gas Technology Institute

- Objective: Reduce uncertainty in emissions estimates by combining existing and new field data and applying advanced statistical analysis
  - Obtain industry data on **industrial meters, vintage and new plastic pipe, and cast iron/steel pipe with plastic liners.**
  - Measure methane emissions from all of these elements and estimate activities and emission factors for each category
  - Examine alternative methane emission metrics

Compressor Station Emissions

Colorado State University

- Objective: Sample methane emissions at compressor stations across the US, with repeat measurements over the course of 6-9 months, to obtain a longitudinal study of specific stations
  - Direct measurement at the device level, of all equipment within the "fence line" of the facility – compressors, dehydrators, yard piping, etc.
  - Coordinated with industry partners for access
  - Goal is to create a national model
  - Complementary to GSI project

Gas Storage Emissions

GSI Environmental Inc.

- Objective: Quantify annual methane loss from natural gas storage facilities
  - Perform sampling events at above-ground equipment
  - Employ an in-ground sensor network to monitor surface seepage from underground leaks near wellbores
  - Characterize seasonal variability
  - Gather data at a diversity of wells representing depleted reservoir and salt cavern-type storage.

Pipeline and Compressor Emissions

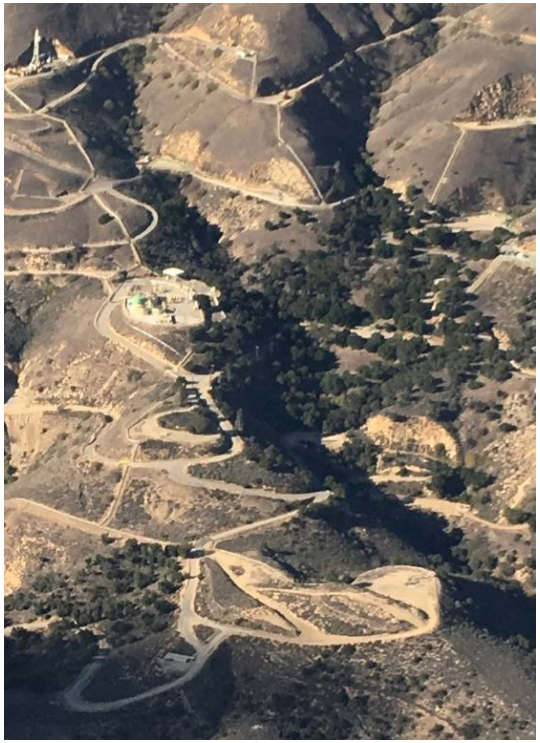
GSI Environmental Inc.

- Objective: Quantify methane leaks and losses (venting) from natural gas pipelines and compressors to reduce uncertainty in the EPA's Greenhouse Gas Inventory .
  - Complete four field campaigns
  - Sample compressor units, receiving and discharge gathering lines, separators, coalescers, slug catchers, dehydrators, liquid dump/holding vessels, methanol injection units, and fuel-gas skids.
  - Measure emissions over the full range of expected field conditions, including seasonal variability in climate and operations.

National Storage Emissions

University of Colorado

- Objective: Quantify emissions from natural gas storage facilities using ground-based regional-scale measurements at a variety of facilities over multiple months, together with broad range aircraft measurements at those and additional facilities.
  - Continuous capture of diurnal to seasonal emissions from entire facilities with component-level resolution
  - Complementary aircraft surveys to assess and characterize seasonal total emissions rates of many different facilities
  - Integration of independent yet datasets to quantify the mean state and temporal variability (diurnal to annual) of emissions from natural gas storage.



Methane Mitigation

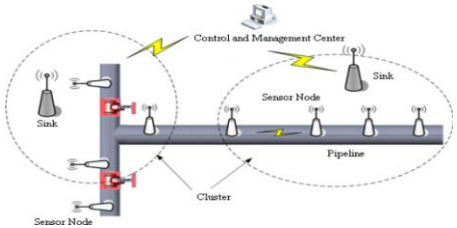
– *MISSION* –

Reduce CH_4 emissions from equipment ~ Enhance operational efficiency ~ Identify, develop and test new technologies ~ Enhance in-pipe monitoring and risk assessment

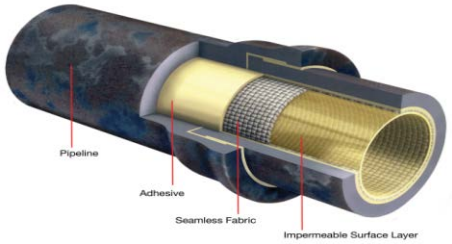
Program Approach

Reduce cost and enhance effectiveness of component leak mitigation

Develop and test advanced sensors to communicate operational data and pipeline properties



Develop and test next generation pipeline liners and coatings



NETL – Industry – Universities

Methane Mitigation Projects

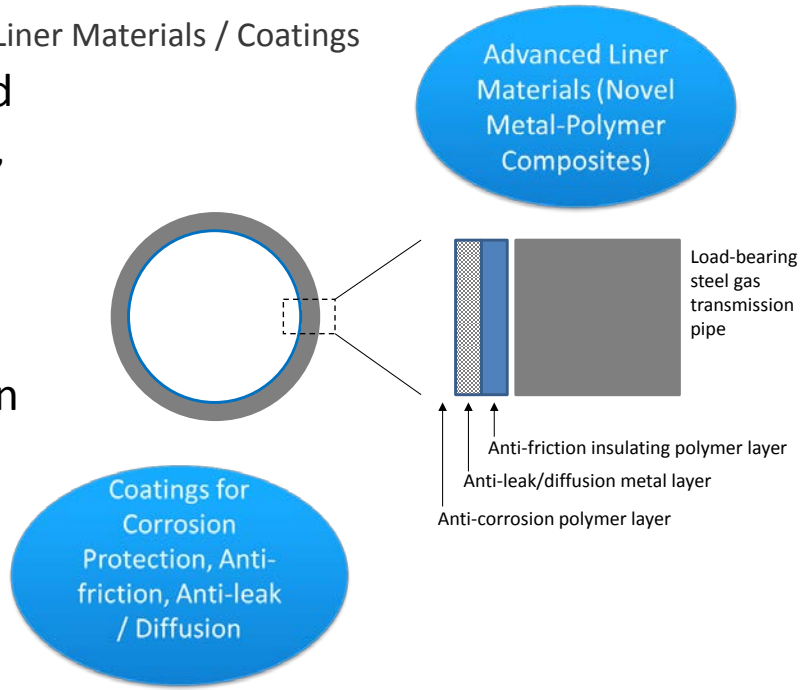
Announced September 8, 2016 -- DOE Funding Only

Oceanit (Hawaii)	Develop multifunctional coating to prevent corrosion and deposits requiring pipeline refurbishment and repair	DOE funding: $1,200,000
Southwest Research Institute (Texas)	Develop and demonstrate an optical-based methane leak detection system for midstream infrastructure	DOE funding: $629,517
PPG Industries, Inc. (Pennsylvania)	Develop and demonstrate three technology platforms which will be combined as a system to provide remote monitoring of natural gas pipeline conditions	DOE funding: $876,639
Princeton University (New Jersey)	Develop and deploy advances in chirped laser dispersion spectroscopy (CLaDS) to make an airborne-based sensor for remote detection of methane leaks	DOE funding: $1,188,735
Southwest Research Institute (Texas)	Develop a seal design for reciprocating compressor piston rods that mitigates the highest contributor to methane emissions from midstream machinery	DOE funding: $797,517
Gas Technology Institute (Illinois)	Develop and test an integrated Thermoelectric Generator/burner system in a field pilot for oil and gas field operations	DOE funding: $1,199,353
University of Pittsburgh (Pennsylvania)	Develop an advanced distributed optical fiber technology optimized for natural gas infrastructure monitoring	DOE funding: $1,200,000

DOE/NETL In-House R&D: Key Research Priorities

Mitigation:

- Develop electrochemical point sensors for quantification of corrosion rates and environmental monitoring (e.g. pH), distributed optical sensor technologies for Temp, Pressure, methane concentration, passive sensors for multi-parameter sensing.
- Initiate the development of advanced material science for pipeline liner and coatings. Invest in NETL RIC instrumentation and increase collaboration with industry (collaborative FOA)
- Begin the development of advanced pipeline inspection & repair technologies (without evacuation of the methane gas)



Final Thoughts

- DOE is funding projects that will help to address some known limitations and gaps in the U.S. Inventory of methane emissions
- Most methane leaks from natural gas systems are from a small number of sources (the “5-50 rule”)
- The time-dimension characteristics of emissions remains a significant area of uncertainty
- More direct measurements of methane emissions can help to reduce uncertainties and “bridge the gap” between top-down and bottom-up measurement studies
- Stakeholders have proposed many options for the federal government to help improve methane emissions quantification and mitigation (e.g., low-cost methane emission abatement tools for companies to more quickly identify leaks)

Questions?

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