Natural Gas Infrastructure Research and Development Program

Midstream R&D Workshop

Houston, TX

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Natural Gas Infrastructure R&D

Office of Oil and Natural Gas

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U.S. DEPARTMENT OF ENERGY | Fossil Energy

OFFICE OF OIL & NATURAL GAS

DOE Natural Gas Infrastructure Team

Tim Reinhardt- HQ Director of Supply & Delivery

Christopher Freitas – HQ Senior Program Manager

Jared Ciferno – NETL Technology Manager

Eric Smistad – NETL Natural Gas Portfolio Manager

Natalie Pekney – NETL Technical Portfolio Lead

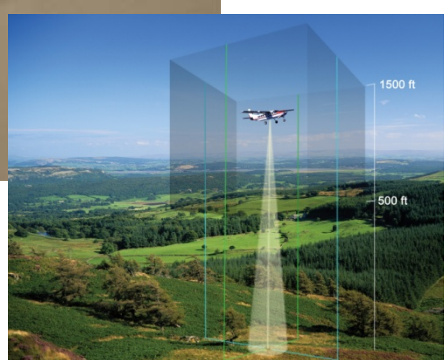
NETL Team Technical Coordinators:

Natalie Pekney, Methane Emissions Quantification

Paul Ohodnicki –Methane Emissions Mitigation

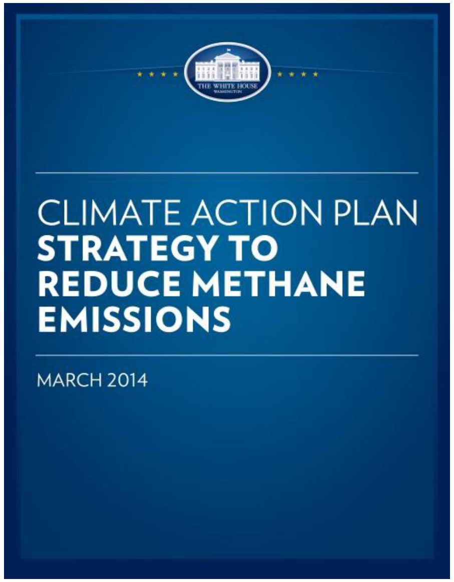
Tim Skone – Life Cycle Assessment

Historical Reference:
DOE Natural Gas Infrastructure R&D, 1999-2005



- Six year program accelerated technology development and created a platform for continued R&D by DoT and industry
- Conducted large scale, blind demonstrations of emerging technologies for leak detection and pipeline inspection sensors
- Technologies taken to commercialization:
  - Aerial gas leak detection – Airborne Natural Gas Emission Lidar (ANGEL)
  - Mobile remote methane leak detection system
  - Explorer II pipeline inspection robot for un-piggable pipes
  - Timberline Tool keyhole squeeze off tool for large diameter PE pipe and keyhole external repair tool (thermoplastic patch) for damaged PE pipe

Historical Reference:
Primary Driver of Methane Emissions R&D



President's Climate Action Plan

"Curbing emissions of methane is critical to our overall effort to address global climate change. … To achieve additional progress, the Administration will":

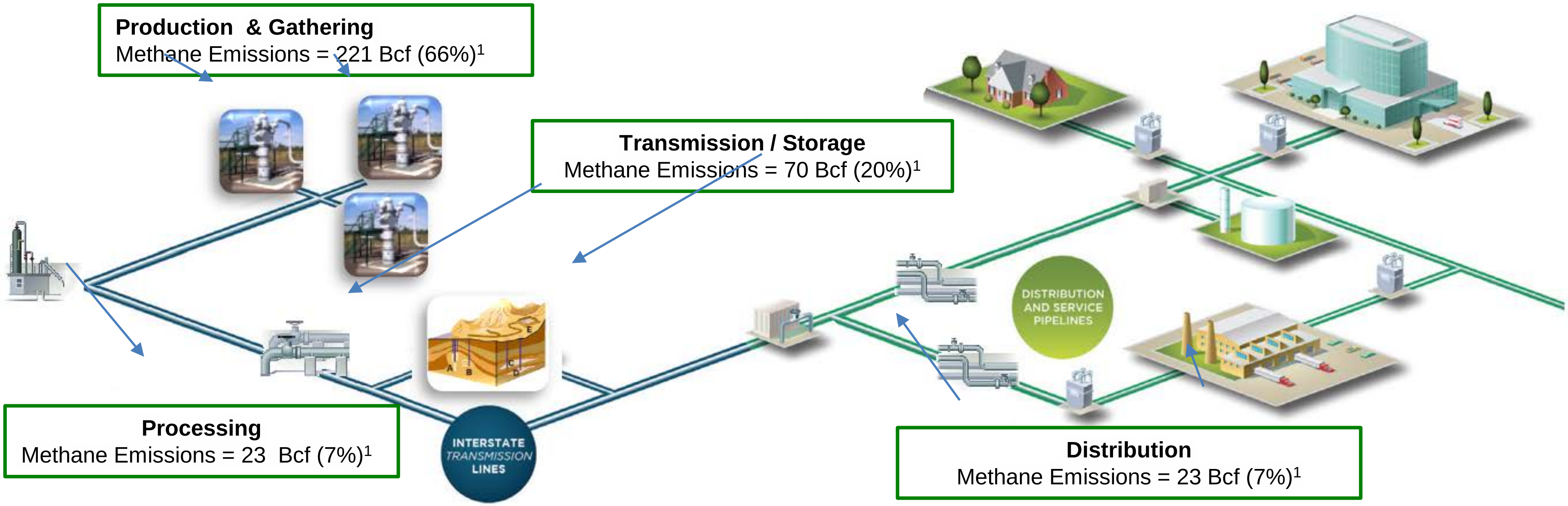
- Develop a comprehensive Interagency Methane Strategy (completed March 2014)
- Pursue a collaborative approach with state governments and the private sector and cover all methane emitting sectors
- Meet a 2025 target for the O&G sector to reduce methane emissions by 40 to 45% below 2012 levels (*established January 2015*)

Interagency Methane Strategy – Three Pillars

Assessing Current Emissions Data and Addressing Data Gaps	Identifying Technologies and Best Practices for Reducing Emissions	Identifying Existing Authorities and Incentive-based Opportunities for Reducing Emissions

Natural Gas Sector Methane Emissions

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



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

Methane Emissions Mitigation Program

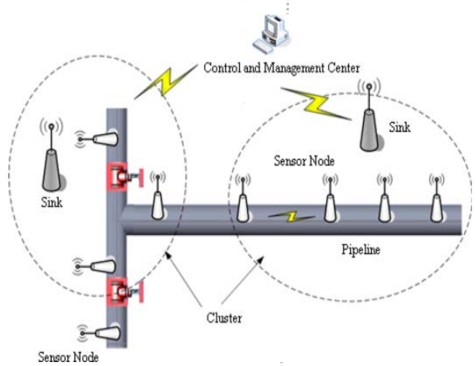
– MISSION –

Develop new technologies to reduce methane emissions from midstream infrastructure to enhance the efficiency of natural gas delivery in the United States.

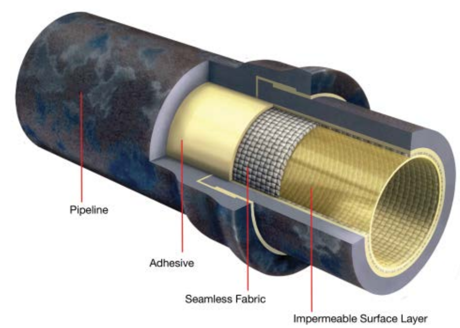
Research Elements

Develop advanced equipment technologies

Develop advanced sensors to communicate operational data and pipeline properties



Develop next generation pipeline liners and coatings



NETL – Industry – Universities

Methane Emissions Quantification

– MISSION –

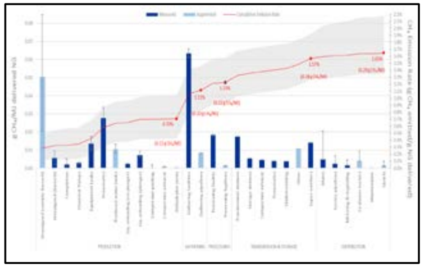
Quantification of Methane Emissions Across the Natural Gas Value Chain
Inform EPA's Greenhouse Gas Inventory

Research Elements

Characterize emissions from equipment and legacy wells

Regional differences in methane emissions

Life-Cycle Assessments



NETL – Industry – Universities – National Labs

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DOE Technology Readiness Levels

Technology Readiness Levels (TRL)

FOA Awards TRL Levels (TRL 4–6)

TRL	Definition	Description
1	Basic principles observed and reported	Core Technology Identified. Scientific research and/or principles exist and have been assessed. Translation into a new idea, concept, and/or application has begun.
2	Technology concept and/or application formulated	Invention Initiated. Analysis has been conducted on the core technology for practical use. Detailed analysis to support the assumptions has been initiated. Initial performance attributes have been established.
3	Analytical and experimental critical function and/or characteristic proof-of-concept validated	Proof-of-Concept Validated. Performance requirements that can be tested in the laboratory environment have been analytically and physically validated. The core technology should not fundamentally change beyond this point. Performance attributes have been updated and initial performance requirements have been established.
4	Basic technology components integrated and validated in a laboratory environment	Technology Validated in a Laboratory Environment. The basic technology components have been integrated to the extent practical (a relatively low-fidelity integration) to establish that key pieces will work together, and validated in a laboratory environment. Performance attributes and requirements have been updated.
5	Basic technology components integrated and validated in a relevant environment	Technology Validated in a Relevant Environment. Basic technology component configurations have been validated in a relevant environment. Component integration is similar to the final application in many respects. Data sufficient to support planning and design of the next TRL test phase have been obtained. Performance attributes and requirements have been updated.
6	Prototype validated in a relevant environment	Prototype Validated in Relevant Environment. A prototype has been validated in a relevant environment. Component integration is similar to the final application in most respects and input and output parameters resemble the target commercial application to the extent practical. Data sufficient to support planning and design of the next TRL test phase have been obtained. Performance attributes and requirements have been updated.
7	System prototype validated in an operational system	System Prototype Validated in Operational Environment. A high-fidelity prototype, which addresses all scaling issues practical at pre-demonstration scale, has been built and tested in an operational environment. All necessary development work has been completed to support Actual Technology testing. Performance attributes and requirements have been updated.
8	Actual technology successfully commissioned in an operational system	Actual Technology Commissioned. The actual technology has been successfully commissioned for its target commercial application, at full commercial scale. In almost all cases, this TRL represents the end of true system development.
9	Actual technology operated over the full range of expected operational conditions	Commercially Operated. The actual technology has been successfully operated long-term and has been demonstrated in an operational system, including (as applicable) shutdowns, startups, system upsets, weather ranges, and turndown conditions. Technology risk has been reduced so that it is similar to the risk of a commercial technology if used in another identical plant.

FOA Awards- 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

FOA Awards -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

Natural Gas Midstream Infrastructure Grand Challenges

Looking Forward-Science and Technology Needs

- Advanced Materials-that may enable transmission pipelines to transport natural gas along with other critical fuels and fluids
- Data Science and Management - Tools that can employ data to identify pipeline integrity concerns
- Sensors and Controls -Development of sensing controls, automated systems, remote monitoring capabilities, that can also accommodate fuel flexibility in pipelines.
- Novel Monitoring Technologies for underground gas storage wells to sense breaches in cement before they occur
- Pipeline Inspection and Repair -Technologies that improve inside the pipe inspection and with tools that can mitigate leaks and pipe anomalies
- Compressors - More efficient and flexible compressor design to make infrastructure more adaptable to varying pipeline conditions and to accommodate additional fuels and critical fluids

Thank You

For further information please contact:

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