DOE Methane Emissions Quantification and Mitigation Programs

Responsible and Sustainable Natural Gas: Challenges and Opportunities in Africa

Technology Innovation Panel

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NATIONAL ENERGY TECHNOLOGY LABORATORY

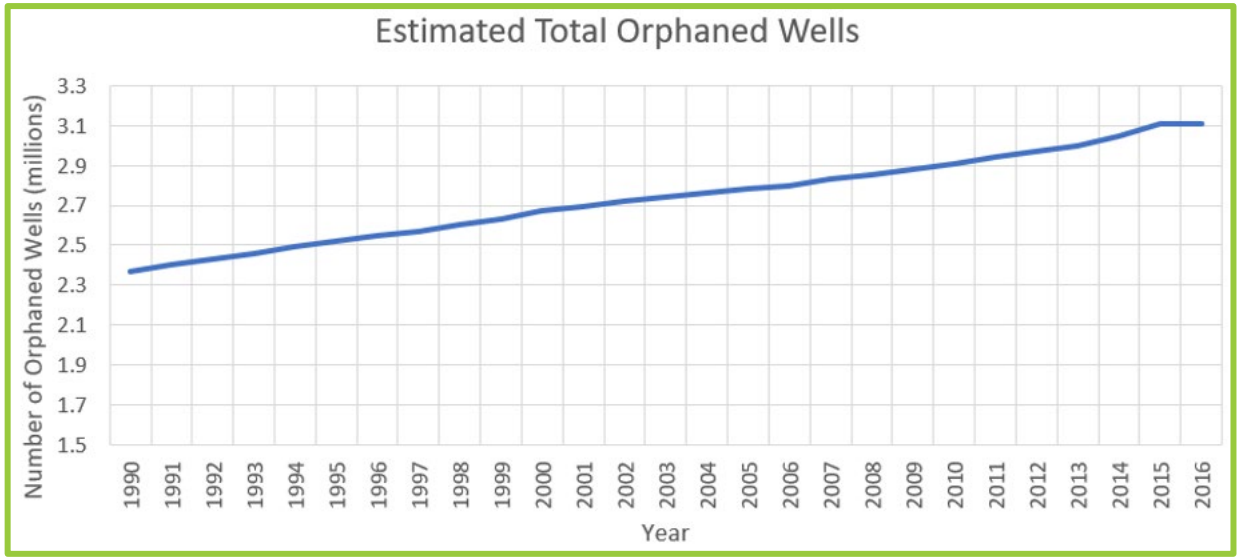
Detection and Quantification Program Goals

Natural Gas Technologies Budget Line

- **Development of direct and remote measurement sensor technologies for the collection, dissemination, and analysis of emissions data**
  - It estimated that half of biggest emitters in the Permian Basin are due to malfunctioning equipment and by fixing 123 of the largest emitters nearly 55 tons of methane emissions could be mitigated (5.5% of US EPA's estimated total emissions for the US)[1]
- **Collect data, research, and analytics that support EPA's Greenhouse Gas Inventory**
- **Collect research, technology development, and data analytics on finding and quantifying emissions from orphan wells**
  - Studies estimate that there are up to 746,000 undocumented and unidentified orphaned wells in the US[2]

Plume emissions measured from a flyover conducted by NASA JPL for the Methane Source Finder project within the Permian Basin, Texas. Methane Source Finder

Estimated total orphaned wells in the US based on Enverus (Drilling Info) and historical sources and provided by the US EPA GHGI.

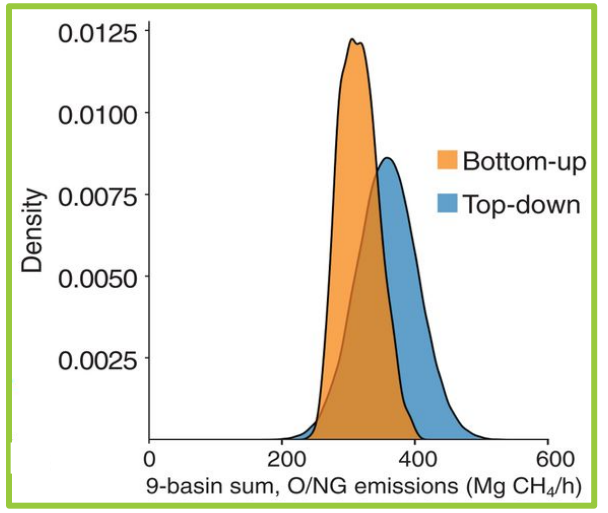


1) Study Identifies Methane 'Super-Emitters' in Largest US Oilfield, NASA, JPL, June 2, 2021, https://climate.nasa.gov/news/3087/study-identifies-methane-super-emitters-in-largest-us-oilfield/
2) Repairing the Damage from Hazardous Abandoned Oil & Gas Wells, Ohio River Valley Institute, April 2021, https://ohiorivervalleyinstitute.org/reports/hazardous-aog-wells/

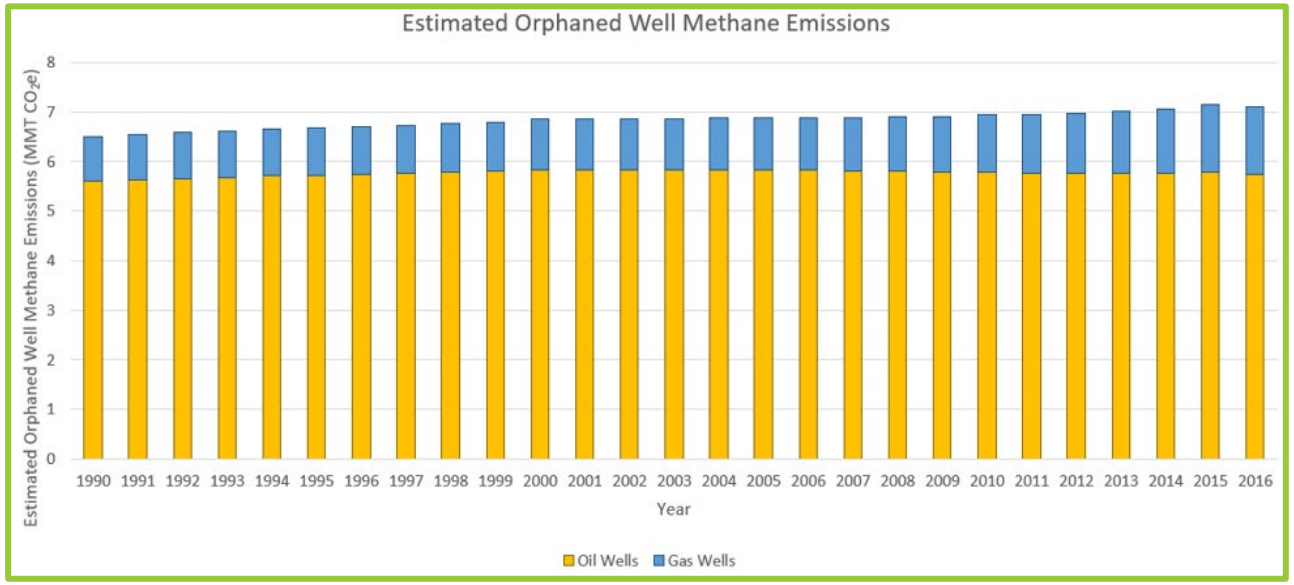
Emissions Quantification – Motivation for R&D

Natural Gas Technologies Budget Line

- A study has found that methane emissions are **underestimated by at least 60%** within the natural gas supply chain (excluding distribution and end use)[1]
  - Detection and quantification of emissions and their root causes would substantially reduce the amount of fugitive methane released[1]
- It is estimated that there are hundreds of thousands of undocumented orphaned wells leaking methane in the US that need to be located[2]
- A study showed that **annual emissions from orphaned wells are underestimated by at least 20%** and are the 11th largest source of anthropogenic methane emissions in the US[3]
- Integrating Bottom-up and Top-down measurement strategies would combine ground-based, in situ, and aerial-based detection and quantification methods to more accurately identify and quantify methane emissions



Comparison of bottom-up estimates of methane emissions from oil and natural gas sources to top-down estimates in nine U.S. oil and natural gas production areas.[1]



1) Assessment of methane emissions from the U.S. oil and gas supply chain, Ramon A. Alvarez, Et Al., Science 13 Jul 2018: 186-188
2) Management of Abandoned and Orphaned Oil and Gas Wells, The American Association for the Advancement of Science
3) Methane Emissions from Abandoned Oil and Gas Wells in Canada and the United States, James P. Williams, Amara Regehr, and Mary Kang, Environmental Science & Technology 2021 55(1), 563-570 DOI: 10.1021/acs.est.0c04265

Smart Methane Emission Detection System

Objectives

- Develop an autonomous, real-time methane leak detection technology, the Smart Methane Emission Detection System (SLED/M), which applies machine learning techniques to passive optical sensing modalities to mitigate emissions through early detection.
  - Introduce automation to the process of methane leak detection to minimize sources of human error, response time to a leak event, and maximize midstream visibility.
  - Assist in the quantification process by providing a means of collecting temporal and spatial image data of a leak event.
  - Reduce operational costs of emissions detection technologies by significantly minimizing the need for operator involvement.

An autonomous, real-time methane leak detection system that facilitates early detection of emissions before they become a larger problem.

SLED/M Methane Plume Detection (red) of a plume that cannot be readily seen on the MWIR camera (upper photo). SLED/M mounted on a drone platform for aerial, real-time methane leak detection (lower photo).

Advancing Development of Emissions Detection (ADED)

Objectives

1. Develop and test protocols for controlled testing that reliably assess leak detection and quantification (LDAQ) solutions under a range of representative field conditions at a controlled test facility;

2. Develop protocols for field trials and conduct a comprehensive, multi-solution, field trial including a range of facility types;

3. Advance the state of solution testing to be scientifically rigorous, affordable, repeatable, and adaptable to field conditions, and make this knowledge generally available to all stakeholders;

4. Propose test standards from the results of Objectives 1-3 that can be adopted and adapted by (a) state and federal regulatory agencies for regulatory approval of LDAQ solutions, and by (b) operators for internal emissions-mitigation efforts.

Testing protocols for LDAQ solutions and demonstrate a process for testing, analysis and adoption and/or regulatory approval.

Colorado State University (CSU) METEC.

Quantification of Methane Emissions from Marginal (Small Producing) Oil and Gas Wells

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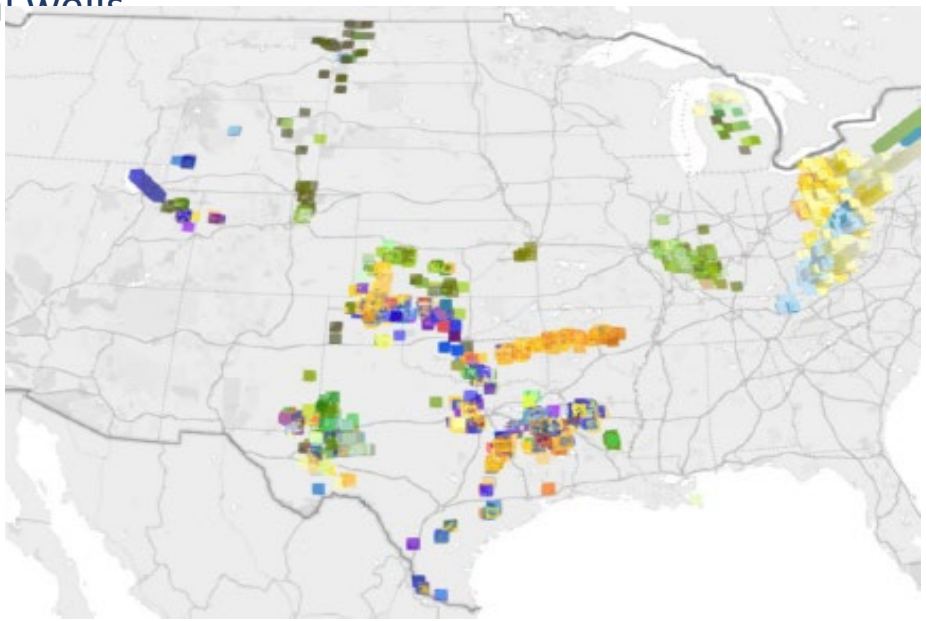
Objectives

- Measure methane emissions from marginal well sites (<90 MCF gas or <15 bbl oil per day) within various basins across the United States.
- Collect and evaluate representative, defensible, and repeatable data from marginal well sites and draw quantifiable conclusions on the extent of emissions from marginal wells across oil and natural gas producing regions, and to compare these results to published data available on the emissions from non-marginal wells.



Field Campaigns

- Three campaigns, 2019, 2020 and 2021
- Measured emissions from >500 sites and 629 wells across the U.S.
- Eight basins and 13 states
- Wellheads: 2-79 years old
- Separators: 2-72 years old

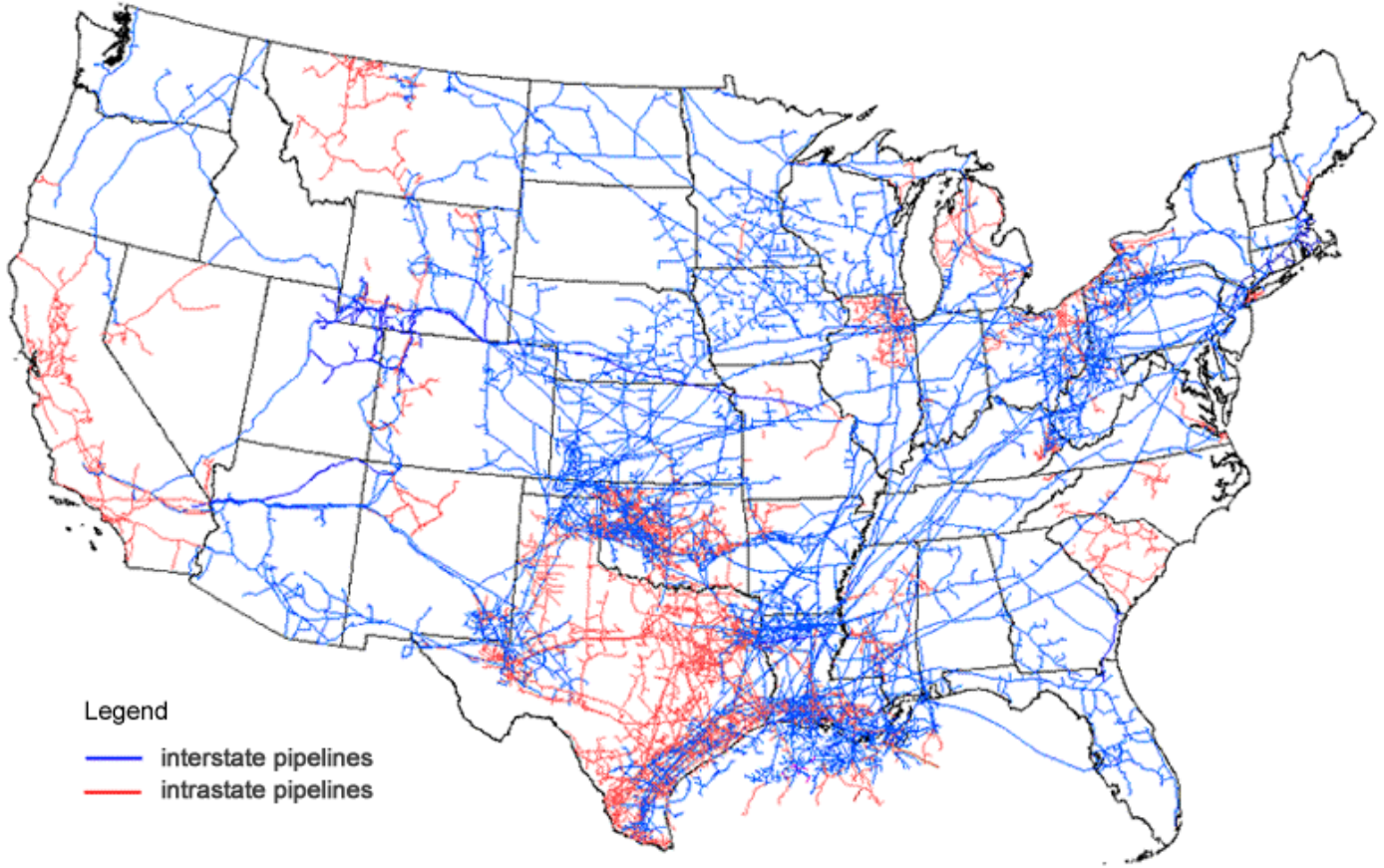
GSI ENVIRONMENTAL

Mitigation Program Goals

Natural Gas Technologies Budget Line

- Develop technologies in advanced materials, data management tools, in-pipe inspection and repair technologies, and dynamic compressor research and development
- Technology solutions to aid in the remediation and mitigation of methane emissions from orphaned wells and coal mines
- Technology solutions that mitigate associated natural gas flaring

Map of U.S. interstate and intrastate natural gas pipelines

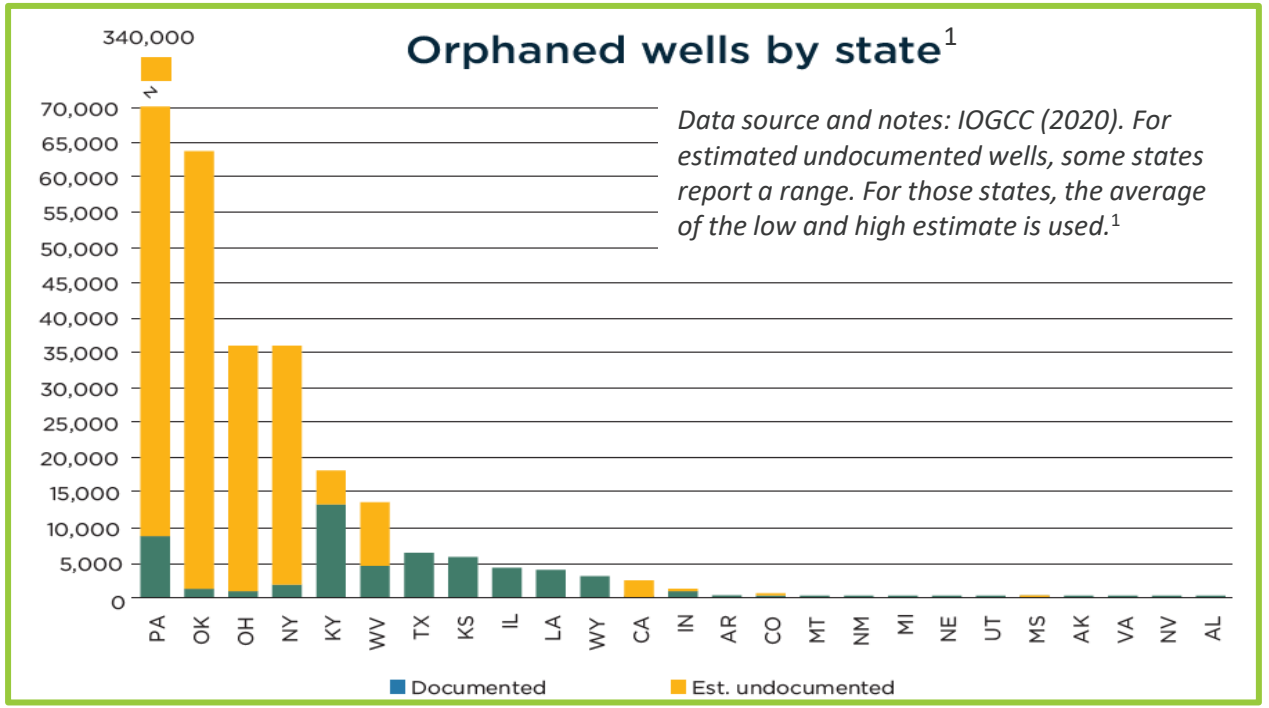


Source: U.S. Energy Information Administration, *About U.S. Natural Gas Pipelines*

Emissions Mitigation – Motivation for R&D

Natural Gas Technologies Budget Line

- According to study by the IOGCC, there are between **560,000 and 1.1M** orphaned wells in the US[1]
  - Per the US EPA, there are **2M** unplugged and abandoned wells in the US (which includes orphaned wells)[1]
  - Unplugged, abandoned wells in the U.S. leaked **5,000** times more methane than plugged wells did, according to a 2015 study cited by the EPA.[1]
- Compressors and compressor engines are estimated to be responsible for **24%** of emissions at natural gas gathering and booster stations (equivalent to **6%** of all methane emissions within the natural gas supply chain)[2]
- Compressors and their driving engines are responsible for **37%** of emissions from oil and natural gas production, processing and transport sectors.[3]
  - The next biggest source, pneumatic controllers, is responsible for 26%, but the technology for mitigation (low bleed controllers) is available and being integrated.[3]
- Mitigation of methane emissions from orphaned wells, compressors and compressor engines, as well as other pipeline components would dramatically reduce overall emissions



Oil and Natural Gas Subsector	Total Estimated 2019 Emissions ($MMTCO_2e$)	Share Related to Compressors/Engines	Emissions from Compressors/Engines (MMTCO2e)
Production	132	28%	37.0
Processing	12	74%	8.9
Transmission	37	56%	20.7
Total	**181**		**66.6**

Compressors and engines emissions per oil and natural gas subsector (2019 US EPA report).[3]

1) Wright, B., Hide and Seek: The Orphan Well Problem in America, Journal of Petroleum Technology, August 2021
2) Methane Exhaust Measurements at Gathering Compressor Stations in the United States, Timothy L. Vaughn, Benjamin Luck, Laurie Williams, Anthony J. Marchese, and Daniel Zimmerle, *Environmental Science & Technology* 2021 *55* (2), 1190-1196DOI: 10.1021/acs.est.0c05492
3) EPA, 2019, Estimates of Methane Emissions by Segment in the United States | US EPA

Low-Cost Retrofit Kit for Integral Reciprocating Compressors to Reduce Emissions and Enhance Efficiency

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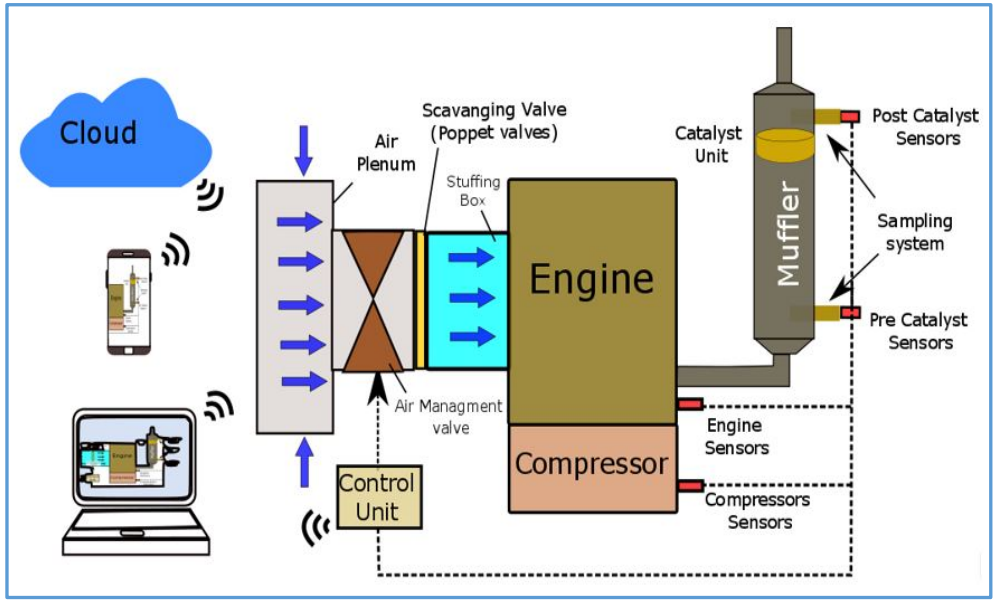
Objectives

- Develop and validate a novel, low-cost (<$75-100/BHP, depending on the IRC's size), field-installable (installation time <3 hours), remotely-controlled, retrofit kit with integrated sensors for Integral Reciprocating Compressors (IRCs) used in the production, gathering, transmission, and processing sections of the natural gas industry.
  - Aims to reduce emissions and improve operating efficiencies, combustion stability, and operational envelope of IRCs, while saving cost.
  - Utilize various computational, data analytics, and machine learning models to correlate sensor and emissions data at all operational points with the performance parameters of the compressor.

The application of smart devices that can be integrated with old and new assets to provide a low-cost, field installable retrofit alternative that will reduce emissions and enhance performance of reciprocating compressors.



The UNIVERSITY of OKLAHOMA

WAGO

Mid Continent Rental Company-Tulsa

Reduction of Methane Leaks through Corrosion Mitigation Pre-Treatments for Pipelines with Field Applied Coatings

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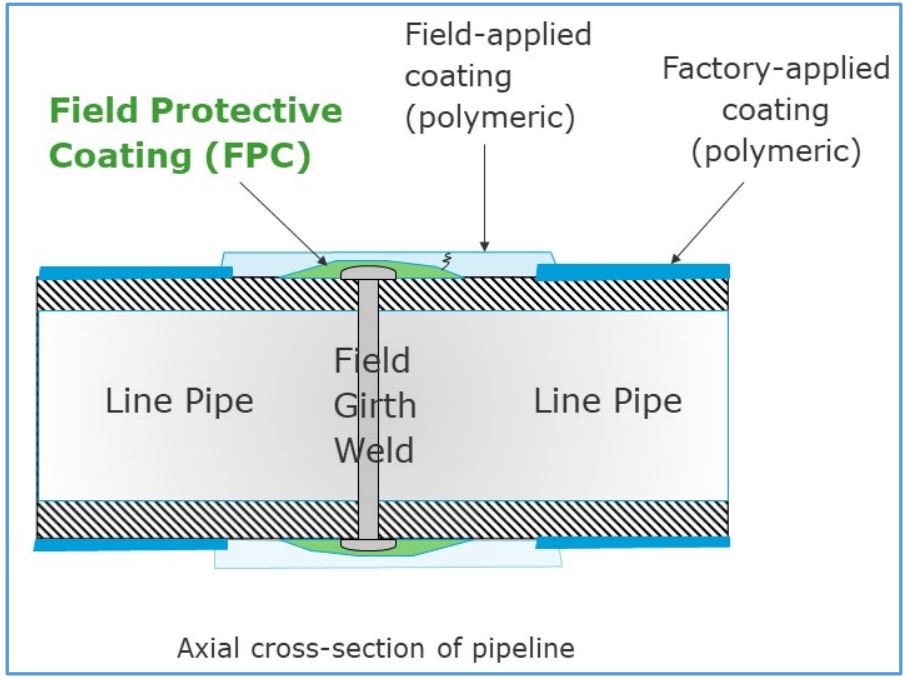
Objectives

- Develop field applied alloy coatings, referred to as Field Protective coatings (FPC), for application in steel natural gas pipelines that will mitigate corrosion from pipeline repair, poor initial construction, and pipeline burial conditions.
  - Focuses on girth welds that are generated during initial pipeline construction as the pipeline sections are welded together in addition to areas of pipeline repair or pipeline section replacement.
  - Additional metallic FPC under the normal field topcoat is expected to reduce the number of methane releases from gas transmission pipelines by better protecting the girth welds in the pipeline from corrosion.

This project will provide a methodology for the developed coating system to be applied to an operating pipeline.



Axial cross-section of pipeline

DNV·GL ENBRIDGE LINCOLN ELECTRIC

Narasi Sridhar, MC Consult, LLC.

Questions?

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